



**PRICE-COST SQUEEZE AND SMALLHOLDER PRODUCTION DISINCENTIVES:
EMPIRICAL EVIDENCE FROM KATSINA STATE, NIGERIA**

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ABSTRACT

The study examined the production disincentive effect arising from the interaction between output price crashes and input cost inflation among smallholder farmers in Katsina State, Nigeria. The objectives of the study were to assess the extent of output price declines across major staple crops, examine the structure of rising input costs, determine the relationship between price crashes and subsequent-season production decisions, and identify socioeconomic factors moderating the disincentive effect. A mixed-methods cross-sectional design with a retrospective panel component was employed. Primary data were collected from 400 smallholder households selected through multi-stage stratified random sampling across 13 Local Government Areas. Data were analyzed using gross margin analysis and seemingly unrelated regression (SUR). Farm-gate prices declined across all major staple crops: maize by 55%, sorghum by 60%, millet by 47.6%, and cowpea by 46.1%, while input costs rose by 75–154.5%. Gross margin collapsed from ₦820,000 to -₦480,000 per hectare. SUR estimates confirm that output price declines significantly reduced fertiliser expenditure ($\beta = -0.428$, $p < 0.001$), cultivated area ($\beta = -0.316$, $p < 0.001$), and seed expenditure ($\beta = -0.284$, $p < 0.01$). In conclusion, the price-cost squeeze has rendered smallholder farming economically unviable in northern Katsina State. Without price stabilisation mechanisms, targeted input subsidies, and rural market infrastructure investment, agricultural sustainability in semi-arid northern Nigeria faces serious long-term threats.

Keywords: Agricultural, Prices, Smallholder, Farmers, Production, Costs.

INTRODUCTION

Agriculture contributes approximately 25% of Nigeria's GDP and employs over 35% of the labour force, with the proportion considerably higher in rural northern Nigeria (World Bank, 2023; National Bureau of Statistics, (NBS) 2024). Smallholder farmers dominate the landscape, cultivating fragmented plots of 0.5–2.5 ha under rain-fed conditions and producing staple crops sorghum, millet, maize, cowpea, and groundnut for subsistence and sale (Sani *et al.*, 2021). Northern Katsina State lies within the Sahelian agro-ecological zone, characterized by low and erratic rainfall (400–600 mm), poor soil fertility, and a short growing season of 90–110 days (Nigerian Metrological Agency, (NiMET), 2024). Sorghum and millet yields rarely exceed 0.8–1.0 t ha well below national averages and farming is exclusively rain-fed, leaving households highly exposed to economic shocks (Food and Agricultural Organisation, (FAO), 2023). Production decisions are inherently forward looking, farmers commit resources at the start of each season based on expected harvest prices (Olagunju *et al.*, 2023; Arouna *et al.*, 2021). Profitability therefore depends on the ratio of output prices to input costs (Awotide *et al.*, 2023; Muhammad & Abdullahi, 2022). In recent years, exchange rate depreciation, fuel subsidy removal, and global commodity disruptions have simultaneously pushed input prices upward while output prices have stagnated or fallen, creating a severe price-cost squeeze (Central Bank of Nigeria (CBN), 2024; Muhammad & Abdullahi, 2022). This study investigates the resulting production disincentive effect and its determinants. Between 2022 and 2025, the prices of critical agricultural inputs such as fertilisers, agrochemicals, transportation, improved seeds, and hired labour increased sharply, in many cases by more than 100 percent. This situation has been linked to the removal of fuel subsidies, persistent depreciation of the naira, inflationary pressures, unfavourable government policies, and disruptions in global supply chains (CBN, 2024; World Bank, 2023). While production costs continue to rise, farm gate prices of major staple crops including maize, sorghum, millet, and cowpea have



remained relatively unstable and, in many cases, insufficient to cover total production expenses (NBS, 2024; Abdulmumini & Saheed, 2022). Agricultural economists have long recognised the central role of price signals in shaping production decisions (Olagunju *et al.*, 2023; Arouna *et al.*, 2021). Nerlove's adaptive expectations model demonstrates that farmers adjust future production based on prior-period prices. Smallholders are particularly responsive to price changes because they operate under liquidity and risk constraints; in marginal, low-yield environments this sensitivity is amplified (Mgbenka & Mbah, 2022; Adeyemi *et al.*, 2022). Empirical evidence from sub-Saharan Africa shows that input use and cultivated area contract significantly when expected output prices fall below anticipated costs (Ojo & Baiyegunhi, 2023; Cheng *et al.*, 2023). Rising input costs are a major constraint on smallholder agriculture in Nigeria (Sani *et al.*, 2021). Global fertiliser supply disruptions following the Russia-Ukraine conflict, combined with fuel subsidy removal and naira depreciation, have sharply increased the prices of fertiliser, agrochemicals, seeds, transportation, and labour (CBN, 2024; World Bank, 2023; FAO, 2023). In semi-arid northern Katsina, where soil fertility is inherently poor and fertiliser is indispensable for any meaningful yield, these increases are particularly damaging (Mustapha *et al.*, 2019). The production disincentive effect occurs when declining profitability discourages future agricultural investment (Oguike & Mbah, 2022; Diao *et al.*, 2023). Sustained losses trigger defensive strategies: reduced input use, shift toward subsistence production, non-farm diversification, or outright abandonment of farming (Cheng *et al.*, 2023; Awotide *et al.*, 2023). In rain-fed, low yield dryland environments with no irrigation buffer, the threshold for these disincentive effects is lower because margins are already thin (Adeyemi *et al.*, 2022; Bello & Garba, 2023). This study is anchored on the Agricultural Household Model (Singh *et al.*, 1986; Awotide *et al.*, 2023), which predicts that rational, risk-averse smallholders reduce production investment when output prices decline relative to input prices. The model is extended to account for the moderating role of agro-ecological conditions specifically low rainfall, poor soil fertility, and absence of irrigation on price responsiveness (Adeyemi *et al.*, 2022; Awotide *et al.*, 2023).

The resulting imbalance between rising input costs and declining or stagnant output prices has placed smallholder farmers under increasing economic pressure. Many farmers are unable to recover their production costs, leading to declining profit margins, reduced investment in farming activities, and lower motivation to continue agricultural production. For resource poor farmers with limited access to irrigation facilities, credit, extension services, and modern production technologies, the situation is even more severe. Although several studies have examined agricultural productivity constraints and rural poverty in Nigeria, limited empirical attention has been given to how the combined effects of rising input costs and unfavourable output prices create production disincentives among smallholder farmers in Northern Nigeria, particularly in Katsina State. This gap in knowledge creates the need for a comprehensive investigation into the extent to which current price dynamics affect farmers' production decisions, investment behaviour, and willingness to remain in farming. Therefore, this study seeks to examine the production disincentive effects of output price decline and input cost surge among smallholder farmers in Northern Katsina State, Nigeria.

The specific objectives of the study were to:-

1. Assess the extent of output price declines across major staple crops in northern Katsina State.
2. Examine the structure and trends of agricultural input costs in the region.
3. Determine the relationship between output price crashes and subsequent-season production decisions.
4. Examine how rising input costs influence fertiliser expenditure, cultivated area, and crop choice.
5. Identify socioeconomic factors moderating the production disincentive effect.

METHODOLOGY

Study Area

The study was conducted in the northern part of Katsina State, comprising 13 Local Government Areas within the Sahelian savanna belt: Jibia, Kaita, Katsina (rural), Batagarawa, Charanchi, Kurfi, Dutsin-Ma, Bindawa, Baure, Zango, Sandamu, Mai'Adua, and Daura (Katsina



Ministry of Agriculture, 2023). These LGAs share Sahelian climatic characteristics 400–600 mm rainfall, short growing season, poor soils, and no irrigation infrastructure (NiMET, 2024; Mustapha *et al.*, 2019). A mixed methods cross-sectional design with a retrospective panel component was adopted (Creswell & Plano Clark, 2018).

Sampling Procedure

A multi-stage stratified random sampling procedure was used. Sample size ($n = 400$ households across the 13 LGAs) was determined by Cochran's formula for finite populations (Israel, 2013).

Data Collection Procedure

Primary data on output prices, production costs, fertiliser expenditure, cultivated area, income sources, credit access, and market distance were collected via structured questionnaires. Price data were triangulated with periodic rural grain market observations. Findings were further validated through eight focus group discussions (FGDs) and 15 key informant interviews (KIIs).

Eight FGDs were conducted across purposively selected communities in low and moderate-rainfall LGAs, with each group comprising six to ten participants stratified by gender and farming experience. The FGDs explored themes of price experience, input purchasing behaviour, and production decision-making. Fifteen KIIs were conducted with agricultural extension officers, local grain traders, and community leaders. All sessions were audio-recorded with participants' consent, transcribed verbatim, and subjected to thematic analysis following Creswell and Plano Clark (2018). Emerging themes were iteratively identified, coded, and triangulated with the quantitative survey findings to ensure methodological rigour and credibility.

Method of Data Analysis

Gross margin (GM) is a partial budgeting technique that measures the net return to a farm enterprise after deducting all variable (operating) costs from total revenue. It is expressed as:

$$GM = TR - TVC. \text{ where}$$

TR=(Total Revenue) is the total value of output produced, calculated as the quantity of output multiplied by its unit price.

TVC (Total Variable Cost) is the sum of all costs that vary with the level of production, such as seed, fertiliser, agrochemicals, hired labour, and transportation.

Seemingly Unrelated Regression (SUR)

Seemingly Unrelated Regression (SUR), introduced by Zellner (1962) and elaborated by Greene (2018) and Wooldridge (2016), is a system of equations estimator that jointly estimates multiple regression equations which, while individually appearing unrelated, are linked through correlated disturbance (error) terms across equations.

The general SUR system can be written as:

$$y_1 = X_1\beta_1 + \varepsilon_1$$

$$y_2 = X_2\beta_2 + \varepsilon_2$$

$$y_3 = X_3\beta_3 + \varepsilon_3$$

where $y_1, y_2,$ and y_3 are the dependent variables (in this study: fertiliser expenditure, cultivated area, and seed expenditure); X_1, X_2, X_3 are matrices of explanatory variables (including price cost squeeze indicators); $\beta_1, \beta_2, \beta_3$ are vectors of coefficients to be estimated; and $\varepsilon_1, \varepsilon_2, \varepsilon_3$ are error terms that may be contemporaneously correlated, meaning $Cov(\varepsilon_i, \varepsilon_j) \neq 0$ for $i \neq j$.

Descriptive Statistics

Descriptive statistics summarise and organise the characteristics of a dataset using measures of central tendency (mean, median, mode), dispersion (standard deviation, variance, range), and distribution (frequency, percentage). They provide a quantitative snapshot of the sample without making inferences about a broader population.

Qualitative Content Analysis

Qualitative content analysis is a systematic method of interpreting non-numerical data such as responses from focus group discussions (FGDs), key informant interviews, or open-ended survey questions by identifying recurring themes, patterns, and meanings within the text. It bridges the gap between raw qualitative data and interpretable conclusions.



RESULTS AND DISCUSSIONS

Socioeconomic Characteristics of Respondents

Table 1 presents the socioeconomic profile of the 400 surveyed households. The sample is predominantly male (83%), reflecting gendered norms of crop farming in northern Nigeria (Sani *et al.*, 2021). Most respondents (76%) fall within the working age bracket of 31–60 years. Households with 6–10 members account for 56% of the sample. Nearly half (49%) cultivate 1–2 ha, and 53% have no formal education. Critically, no respondent had access to any irrigation infrastructure.

Table 1: Socioeconomic Characteristics of Respondents (n = 400)

Variable	Category	Frequency	%
Gender	Male	332	83.0
	Female	68	17.0
Age (years)	18–30	54	13.5
	31–45	176	44.0
	46–60	128	32.0
	>60	42	10.5
	Household size	1–5 persons	96
	6–10 persons	224	56.0
	>10 persons	80	20.0
Farm size (ha)	<1	84	21.0
	1–2	196	49.0
	>2	120	30.0
Education	No formal	212	53.0
	Primary	116	29.0
	Secondary/higher	72	18.0

Note. Values may not sum to 100% due to rounding.

Output Price Declines

Farm gate prices declined substantially across all staple crops between the previous and current season (Table 2). Maize and sorghum experienced the steepest falls (55–60%), while millet and cowpea recorded more modest declines (47.6–46.1%). These findings confirm persistent seasonal market gluts and weak price stabilisation mechanisms (Abdulmumini & Saheed, 2022; Bello & Garba, 2023). Because current prices fall below prior season borrowing costs, many farmers cannot repay input loans (Ojo & Baiyegunhi, 2023). Focus group discussions revealed widespread distress selling immediately after harvest a classic trap that further depresses prices (Abdulmumini & Saheed, 2022).

Table 2: Average Farm-Gate Prices per 100 kg (₦)

Crop	Previous season (₦)	Current season (₦)	Change (%)
Maize	60,000	27,000	–55
Sorghum	60,000	24,000	–60
Millet	82,000	43,000	–47.6
Cowpea	120,500	65,000	–46.1

Note. Prices sourced from farmer recall surveys triangulated with rural grain market observations.



Input Cost Inflation and Gross Margin Collapse

All input categories recorded sharp cost increases (Table 3), with transportation rising by 154.5% following fuel subsidy removal. The near doubling of fertiliser costs is especially damaging given northern Katsina’s poor soils, where fertiliser is indispensable (Mustapha *et al.*, 2019). Key informants reported widespread reversion to animal manure, which is insufficient to sustain yields. Combined with falling output prices, this has produced a catastrophic gross margin collapse (Table 4): from a positive margin of ₦820,000 to a loss of ₦480,000 per hectare, meaning farmers lose approximately ₦480,000 on every hectare cultivated under current conditions. These findings align with Abdulmumini and Saheed (2022) and Bello and Garba (2023), who similarly documented gross margin deterioration among Katsina State smallholder farmers under comparable price-cost conditions. The magnitude of input cost inflation observed here particularly transportation (159%) and agrochemicals (122%) substantially exceeds the increases documented for the pre-subsidy removal period (Mustapha *et al.*, 2019), corroborating CBN (2024) and World Bank (2023) assessments of macroeconomic shocks affecting Nigerian agriculture.

Table 3: Average Cost of Major Agricultural Inputs (₦)

Input	Previous price (₦)	Current price (₦)	Increase (%)
Fertiliser (per 50-kg bag)	32,000	56,000	75
Improved seeds	18,500	46,000	148.6
Agrochemicals	14,200	31,500	121.8
Transportation	11,000	28,500	154.5
Hired labour	56,000	130,000	132.0

Note. Figures represent per-hectare averages based on primary survey data.

Table 4: Gross Margin Analysis per Hectare (₦)

Variable	Previous season	Current season
Gross revenue	1,200,000	400,000
Total variable cost	380,000	880,000
Gross margin	820,000	-480,000

Note. Negative gross margin indicates a net loss per hectare under current market conditions.

SUR Estimates of Production Disincentive Effects

SUR estimates (Table 5) reject H_{01} and H_{02} . Output price decline exerts the largest negative effect on fertiliser expenditure ($\beta = -0.428, p < 0.001$), implying a 10% drop in output prices reduces fertiliser spending by approximately 4.3%. This is consistent with supply response theory (Olagunju *et al.*, 2023; Awotide *et al.*, 2023). Cultivated area contracts significantly ($\beta = -0.316, p < 0.001$), confirming abandonment of marginal fields when revenues fail to cover costs. Input cost inflation independently amplifies these effects. Farm size, credit access, and education positively moderate investment, while distance to market and location in lower-rainfall zones deepen the disincentive. These findings reject H_{03} and H_{04} , confirming significant heterogeneity across socioeconomic groups and significant interaction between price and cost shocks.

Table 5: Seemingly Unrelated Regression (SUR) Estimates of Production Disincentive Effects

Variable	Fertiliser exp.	Cultivated area	Seed expenditure
Output price decline	-0.428***	-0.316***	-0.284**
Input cost inflation	-0.312***	-0.241***	-0.198**
Household size	-0.087*	-0.063	-0.051
Farm size (ha)	0.214***	0.318***	0.176**
Education (years)	0.143**	0.097*	0.112*
Credit access (binary)	0.265***	0.189***	0.231***
Market distance (km)	-0.174***	-0.143***	-0.119**
Agro-ecological zone (low)	-0.198***	-0.221***	-0.167**
Constant	2.341***	1.876***	2.012***
R ²	0.612	0.587	0.543
Observations	400	400	400

Note. Standardised coefficients. * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Moderating Factors

The null hypothesis H_{03} is rejected; production disincentive varies significantly across socioeconomic groups. Non-farm income (odds ratio 1.96, $p < 0.001$) and income diversification (1.74, $p < 0.01$) provide the strongest buffers against disincentive effects. Farmers with non-farm income sources were nearly twice as likely to maintain production investment despite price crashes, consistent with Oguike & Mbah (2022) and Diao et al. (2023), who found diversification as a key rural survival strategy across sub-Saharan Africa.

Access to credit (1.85, $p < 0.01$) similarly enables farmers to absorb temporary price shocks, corroborating findings by Awotide et al. (2023) and Ojo and Baiyegunhi (2023). Cooperative membership (1.41, $p < 0.05$) provides modest protection through collective marketing and input purchasing, consistent with Bello and Garba (2023) and FAO (2023). Conversely, market distance (0.60, $p < 0.01$) increases vulnerability; farmers far from markets face higher transport costs and poorer price information, making them more likely to reduce production (Abdulummini & Saheed, 2022; Bello & Garba, 2023).

Education (1.35, $p < 0.05$) supports better marketing decisions and price negotiation, supporting the human capital literature (Mgbenka & Mbah, 2022; Ojo & Baiyegunhi, 2023). Farm size (1.47, $p < 0.05$) provides some buffer, likely due to economies of scale and greater asset base (Jayne *et al.*, 2019). These findings align with broader West African evidence on household resilience strategies (FAO, 2023; Bello & Garba, 2023).



Table 6: Logistic Regression Estimates for Production Disincentive (Likelihood of Reducing Investment)

Variable	Odds Ratio	Standard Error	95% CI	P-value
Access to Credit	1.85	0.24	1.42–2.41	<0.01
Farm Size	1.47	0.18	1.15–1.88	<0.05
Education Level	1.35	0.16	1.07–1.70	<0.05
Market Distance (km)	0.60	0.11	0.42–0.86	<0.01
Income Diversification	1.74	0.22	1.36–2.23	<0.01
Non-Farm Income	1.96	0.25	1.52–2.53	<0.001
Age of Household Head	0.92	0.08	0.78–1.09	0.05
Livestock Ownership	1.28	0.21	0.92–1.78	0.05
Cooperative Membership	1.41	0.19	1.08–1.84	<0.05
Constant	0.32	0.14	0.14–0.73	<0.01

Note. Pseudo $R^2 = 0.287$; Log likelihood = -214.6 ; $N = 400$.

Agro-Ecological Moderation

The null hypothesis H_{05} is rejected. Farmers in low-rainfall zones (≤ 500 mm) exhibit significantly stronger disincentive responses than those in moderate-rainfall zones (501–600 mm). Average yields are 24% lower in low-rainfall areas (0.71 vs. 0.93 t/ha, $p < 0.01$), meaning profit margins are already narrower (Adeyemi et al., 2022; NiMET, 2024). Consequently, these farmers reduced fertiliser expenditure by 52% versus 38% ($p < 0.05$), and cultivated area by 41% versus 29% ($p < 0.05$).

The likelihood of complete farming abandonment is 62% higher in low-rainfall zones (0.34 vs. 0.21, $p < 0.05$). Gross margin losses are ₦62,700 per hectare more severe in low-rainfall areas ($p < 0.01$). This confirms that agro-ecological marginality amplifies price-cost squeeze effects, supporting the extended Agricultural Household Model proposed in this study (Awotide et al., 2023).

Non-farm income share is substantially higher in low-rainfall zones (48% vs. 34%, $p < 0.05$), indicating that households in more marginal areas rely more heavily on diversification as a coping strategy (Oguike & Mbah, 2022; Diao et al., 2023). These findings align with Bello and Garba (2023), who documented similar patterns across Katsina State's rainfall gradient, and with broader Sahelian evidence of climate-economy interactions (Adeyemi et al., 2022; FAO, 2023).

Table 7: Comparative Analysis by Rainfall Zone

Variable	Low-Rainfall Zone (≤500mm) n=172	Moderate- Rainfall Zone (501–600mm) n=228	Difference	P-value
Average Yield (t/ha)	0.71 (0.12)	0.93 (0.14)	-0.22	<0.01
Fertiliser Expenditure Reduction (%)	-52.4 (8.7)	-37.6 (7.9)	-14.8	<0.05
Cultivated Area Reduction (%)	-41.2 (9.1)	-28.7 (8.3)	-12.5	<0.05
Likelihood of Farming Abandonment	0.34 (0.06)	0.21 (0.05)	0.13	<0.05
Gross Margin (₦/ha)	-212,500 (18,400)	-149,800 (15,200)	-62,700	<0.01
Non-Farm Income Share (%)	48.3 (5.2)	34.1 (4.8)	14.2	<0.05

Note. Standard deviations in parentheses.

Qualitative Findings from Focus Groups

Theme 1: “Farming is no longer a business.” Repeated across all groups, this sentiment reflects the transition from commercial to subsistence orientation. One farmer in Daura LGA stated: “We now grow only what we can eat. Selling is pointless because you lose money.” This aligns with Ellis’s (2000) concept of defensive diversification and Barrett’s (2008) observation of market withdrawal under persistent losses.

Theme 2: “Fertiliser is for the wealthy.” Many farmers reported complete withdrawal from fertiliser use. A Kaita LGA participant noted: “One bag of fertiliser costs more than what I earn from two hectares of millet. It makes no mathematical sense.” This echoes Mustapha *et al.* (2019) and Sani *et al.* (2021), who identified fertiliser affordability as the primary constraint in semi-arid Nigeria.

Theme 3: “We are becoming traders and labourers.” Livelihood diversification is accelerating, with many farmers reducing farm sizes to pursue casual labour, small-scale trading, or migration. This matches the quantitative finding that non-farm income buffers disincentive effects (odds ratio 1.96) but also suggests long-term de-agrarianisation (Diao *et al.*, 2023; Cheng *et al.*, 2023). One key informant (agricultural extension officer) noted: “In 10 years, many of these villages will have no full-time farmers left.”

These qualitative findings strongly corroborate the quantitative results and highlight the human dimensions of the price-cost squeeze (Ojo & Baiyegunhi, 2023; Creswell & Plano Clark, 2018).

CONCLUSION AND RECOMMENDATIONS

This study demonstrates that smallholder farmers in northern Katsina State face a devastating price cost squeeze: output prices have fallen sharply while input costs have nearly doubled, producing gross losses of ₦480,000 per hectare. SUR analysis confirms that price crashes significantly reduce fertiliser expenditure, cultivated area, and seed investment, with effects amplified in low-rainfall zones and for farmers lacking credit access or proximity to markets.

Three priority policy interventions are recommended. First, government should establish a staple crop price stabilisation fund including strategic grain reserves and floor price mechanisms to smooth seasonal market gluts. Second, targeted input subsidy programmes, particularly for fertiliser and improved seeds, are essential to restore positive gross margins in this agro-ecologically marginal zone. Third, rural infrastructure investment feeder roads, rural storage facilities, and rural market connectivity is needed to reduce transportation costs and integrate smallholders into better-functioning



markets. Without coordinated intervention across these three areas, agricultural disinvestment and livelihood deterioration among smallholders in semi-arid northern Nigeria will continue.

REFERENCES

- Abdumumini, A., & Saheed, A. (2022). Farm-gate price dynamics and smallholder crop marketing in Katsina State, Nigeria. *African Journal of Agricultural Economics*, **17**(2): 45–62.
- Adeyemi, O. S., Olatunji, S. O., & Omotayo, A. O. (2022). Climate variability and smallholder farming in semi-arid West Africa: Evidence from dryland communities. *Journal of Arid Environments*, <https://doi.org/10.1016/j.jaridenv.2022.104677>
- Arouna, A., Michler, J. D., & Lokossou, J. C. (2021). Contract farming and rural transformation: Evidence from a field experiment in Benin. *Journal of Development Economics*, **151**: <https://doi.org/10.1016/j.jdeveco.2021.102655>
- Awotide, B. A., Karimov, A. A., & Diagne, A. (2023). Agricultural commercialisation, agricultural household income, and welfare in rural Nigeria. *Food Security*, **15**(2): 411–428. <https://doi.org/10.1007/s12571-022-01330-2>
- Cheng, G., Abdullah, A. S., & Yaseen, M. R. (2023). Price volatility, input costs, and production decision reversal among smallholders: A multi-country analysis. *Agricultural Economics*, **54**(3): 349–362. <https://doi.org/10.1111/agec.12765>
- Diao, X., Hazell, P., & Thurlow, J. (2023). The role of agriculture in African development. *World Development*, **165**, 106198. <https://doi.org/10.1016/j.worlddev.2023.106198>
- Israel, G. D. (2013). Determining sample size (PEOD-6). University of Florida Cooperative Extension Service. <http://edis.ifas.ufl.edu/pd006>
- Mgbenka, R. N., & Mbah, E. N. (2022). Price responsiveness and resource-use efficiency of smallholder crop farmers in Southeast Nigeria. *Journal of Agricultural Extension*, **26**(1): 120–131. <https://doi.org/10.4314/jae.v26i1.12>
- Oguike, M. C., & Mbah, G. O. (2022). Disinvestment in agriculture: Causes and consequences for smallholder farm households in Nigeria. *Agricultural Systems*, **198**: 133-139. <https://doi.org/10.1016/j.agsy.2022.103389>
- Ojo, T. O., & Baiyegunhi, L. J. S. (2023). Determinants of market participation and its impact on household welfare among smallholder rice farmers in Southwest Nigeria. *Journal of Agricultural and Food Economics*, **11**(1): 4. <https://doi.org/10.1186/s40100-023-00243-2>
- Olagunju, K. O., Omotayo, A. O., & Awotide, B. A. (2023). Price expectations and agricultural supply response among smallholder farmers in sub-Saharan Africa: A systematic review. *Outlook on Agriculture*, **52**(1): 45–58. <https://doi.org/10.1177/00307270221148891>
- Barrett, C. B. (2008). Smallholder market participation: Concepts and evidence from eastern and southern Africa. *Food Policy*, **33**(4): 299–317. <https://doi.org/10.1016/j.foodpol.2007.10.005>
- Bello, A., & Garba, M. (2023). Grain market gluts and smallholder distress sales in semi-arid Nigeria. *Nigerian Journal of Rural Economy*, **11**(3): 112–128.
- Central Bank of Nigeria. (2024). Annual report on agricultural finance and commodity prices. CBN.
- Cochran, W. G. (1977). *Sampling techniques* (3rd ed.). John Wiley & Sons.
- Creswell, J. W., & Plano Clark, V. L. (2018). *Designing and conducting mixed methods research* (3rd ed.). SAGE.
- Dillon, B., & Barrett, C. B. (2017). Agricultural factor markets in sub-Saharan Africa: An updated view with formal tests for market failure. *Food Policy*, **67**: 64–77. <https://doi.org/10.1016/j.foodpol.2016.09.015>
- Dillon, J. L., & Hardaker, J. B. (1993). Farm management research for small farmer development. FAO Farm Systems Management Series No. 6. FAO.
- Ellis, F. (2000). *Rural livelihoods and diversity in developing countries*. Oxford University Press.
- Food and Agriculture Organization. (2023). The state of food and agriculture 2023. FAO.
- Greene, W. H. (2018). *Econometric analysis* (8th ed.). Pearson.



- Jayne, T. S., Snapp, S., Place, F., & Sitko, N. (2019). Sustainable agricultural intensification in an era of rural transformation in Africa. *Global Food Security*, **20**: 105–113. <https://doi.org/10.1016/j.gfs.2019.01.008>
- Katsina State Ministry of Agriculture. (2023). Agricultural development programme annual report. KTARDA.
- Krueger, R. A., & Casey, M. A. (2015). *Focus groups: A practical guide for applied research* (5th ed.). SAGE.
- Liverpool-Tasie, L. S. O., Reardon, T., & Belton, B. (2017). Evolving food supply chains in Nigeria. *Global Food Security*, **12**: 25–35. <https://doi.org/10.1016/j.gfs.2016.11.002>
- Mortimore, M. (1989). *Adapting to drought: Farmers, famines and desertification in West Africa*. Cambridge University Press.
- Muhammad, I., & Abdullahi, S. (2022). Price-cost squeeze and smallholder agricultural sustainability in Katsina State. *Katsina Journal of Development Studies*, **8**(1): 34–52.
- Mustapha, A. B., Ahmad, M. M., & Umar, S. A. (2019). Soil fertility management challenges in semi-arid northern Nigeria. *Soil and Tillage Research*, **192**: 45–56. <https://doi.org/10.1016/j.still.2019.03.012>
- National Bureau of Statistics. (2024). Agricultural sector report Q4 2023. NBS.
- Nerlove, M. (1958). *The dynamics of supply: Estimation of farmers' response to price*. Johns Hopkins Press.
- NiMET. (2024). Nigeria climate bulletin: Rainfall distribution and seasonal analysis. Nigerian Meteorological Agency.
- Reardon, T., Timmer, C. P., Barrett, C. B., & Berdegue, J. (2001). The rise of supermarkets in Africa, Asia, and Latin America. *American Journal of Agricultural Economics*, **85**(5): 1140–1146. <https://doi.org/10.1111/1467-8276.00479>
- Sani, R. M., Yakubu, A. A., & Bello, H. M. (2021). Socioeconomic characteristics and production efficiency of smallholder farmers in Katsina State. *Journal of Agricultural Extension*, **25**(3): 77–90.
- Singh, I., Squire, L., & Strauss, J. (1986). *Agricultural household models: Extensions, applications, and policy*. Johns Hopkins University Press.
- Timmer, C. P. (1986). *Getting prices right: The scope and limits of agricultural price policy*. Cornell University Press.
- Wooldridge, J. M. (2016). *Introductory econometrics: A modern approach* (6th ed.). Cengage Learning.
- World Bank. (2023). Nigeria economic update: Poverty and welfare assessment. World Bank Group.
- Yusuf, O., & Balogun, A. (2021). Agricultural price policy and smallholder income in northern Nigeria. *African Journal of Economic Policy*, **28**(1): 115–134.