

Market dynamics, global shocks, and supply chain constraints in agricultural commodity markets: Evidence from Northern Sierra Leone

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Abstract

This article examines the multifaceted interactions between global market forces, digital transformation, consumer behaviour shifts, and supply chain constraints in shaping agricultural commodity prices in Northern Sierra Leone. Drawing on primary survey data collected from 202 respondents across Yoni Chiefdom, Tonkolili District, in June 2025, the study employs a cross-sectional research design with chi-square analyses to investigate the relationships between occupational categories and market-related outcomes. The findings reveal that digital marketplace expansion (24.3%), changing consumer preferences (22.3%), and sustainability concerns (22.3%) constitute the dominant trends impacting local agricultural prices. While 62.9% of respondents reported that e-commerce has increased commodity prices, the local food movement emerged as the single most significant consumer trend (34.7%), followed by clean-label preferences (17.8%) and health-conscious buying (17.3%). International trade agreements (24.3%) and currency fluctuations (21.8%) were identified as the primary external market factors affecting local price dynamics. Critically, the chi-square analyses demonstrated statistically significant associations between occupation and the experience of market challenges ($\chi^2 = 13.990$, $df = 4$, $p = 0.007$) and between occupation and adaptation of farming practices ($\chi^2 = 13.438$, $df = 4$, $p = 0.009$). Despite these pressures, collaborative arrangements among agricultural stakeholders remain underdeveloped, with only 58.9% engaging in any form of collective action, predominantly through knowledge sharing (37.0%) and shared transportation (34.5%). The study contributes empirical evidence from an under-researched region to ongoing debates regarding food systems transformation in sub-Saharan Africa and offers policy recommendations for strengthening rural market integration, digital infrastructure, and cooperative frameworks to enhance food security and smallholder resilience.

Keywords: Agricultural Commodity Markets; Supply Chain Constraints; Sierra Leone; Food Systems Transformation; Digital Marketplaces; Smallholder Resilience; Sub-Saharan Africa; Price Dynamics

1. Introduction

The architecture of global food systems has undergone profound transformation over the past two decades, characterised by rapid urbanisation, dietary transitions, technological innovation, and an unprecedented degree of international market integration (Reardon et al., 2019; Barrett, 2021). These structural shifts have fundamentally altered the pathways through which agricultural commodities flow from rural producers to urban consumers, creating new opportunities whilst simultaneously exposing previously insulated local markets to external shocks and price volatility (Bellemare & Bloem, 2018; Minot, 2014). For sub-Saharan Africa, where smallholder agriculture remains the predominant livelihood strategy for approximately 60% of the population, understanding the mechanisms through

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which global market dynamics transmit to local price formation is essential for designing effective food security policies and rural development interventions (FAO et al., 2023; Béné et al., 2021).

Sierra Leone presents a particularly instructive case for examining these global-local market linkages. Following a decade of post-conflict reconstruction and recovery from the 2014–2016 Ebola epidemic, the country's agricultural sector has faced compounding pressures from climate variability, currency depreciation, inflationary trends, and the cascading effects of the COVID-19 pandemic on international trade flows (World Bank, 2023). Agriculture contributes approximately 60% of national employment and 20% of gross domestic product, yet the sector remains characterised by low productivity, weak value chain integration, limited market information systems, and pronounced rural-urban disparities in market access (World Bank, 2023). The majority of smallholder producers operate in informal markets with minimal vertical coordination, rendering them especially vulnerable to price fluctuations and supply chain disruptions (Fafchamps & Gabre-Madhin, 2006; Markelova et al., 2009).

The digital transformation of agricultural markets represents a potentially disruptive force in this context. The proliferation of mobile telephony and emerging e-commerce platforms across West Africa has created novel channels for price discovery, market access, and input procurement (Ogututu et al., 2020; Aker, 2010). However, the empirical evidence regarding the distributional consequences of digital market integration remains contested. Whilst some studies document substantial welfare gains from information and communication technology (ICT)-based market information services, others caution that the benefits of digital transformation may be concentrated among commercially oriented producers with adequate capital, education, and infrastructure access, thereby exacerbating existing inequalities within rural communities (Ogututu et al., 2020; Torero, 2020).

Concurrently, consumer behaviour in both domestic and international markets has undergone significant evolution. The nutrition transition documented across low- and middle-income countries has generated rising demand for processed, convenient, and diversified food products, whilst simultaneously stimulating countervailing preferences for locally sourced, organic, and minimally processed commodities associated with health, environmental sustainability, and food safety considerations (Popkin & Ng, 2022; Tschirley et al., 2015). These shifting demand patterns create complex signals for smallholder producers, who must navigate between traditional staple crop production and emerging market opportunities for differentiated agricultural products.

The concept of supply chain resilience has acquired renewed urgency in the wake of successive global shocks. The COVID-19 pandemic exposed critical vulnerabilities in food supply chains worldwide, from farmgate labour shortages to logistics bottlenecks and export restrictions (Béné et al., 2021; Torero, 2020). Climate-related extreme events, including droughts, floods, and pest infestations, have further disrupted production and marketing channels, particularly in rain-fed agricultural systems prevalent across the West African savannah (Lobell et al., 2011). These disruptions reverberate through local markets via commodity price spikes, reduced availability of marketed surpluses, and diminished purchasing power among rural households (Headey & Fan, 2010; Gilbert & Morgan, 2010).

Against this backdrop, this article addresses three interrelated research questions. What are the dominant market trends global, regional, and local that shape agricultural commodity prices in Northern Sierra Leone? How do digital transformation, shifting consumer preferences, and international market factors interact to influence local price dynamics and producer livelihoods? What supply chain constraints and collaborative arrangements characterise the current agricultural marketing environment, and how do these vary across occupational and demographic categories? Addressing these questions, this study contributes contextualised evidence to broader theoretical and policy debates concerning food systems transformation in fragile agrarian economies like Sierra Leone.

2. Literature Review

2.1. Market Dynamics and Price Formation in Developing Countries

Theoretical frameworks for understanding agricultural market dynamics in developing countries have evolved considerably from classical competitive equilibrium models toward more nuanced conceptualisations that account for market imperfections, institutional voids, and power asymmetries (Fafchamps & Gabre-Madhin, 2006; Barrett, 2021). In sub-Saharan Africa, agricultural markets are frequently characterised by high transaction costs, information asymmetries, limited contract enforcement, and concentration among a small number of traders and processors, all of which distort price signals and impede efficient resource allocation (Fafchamps & Gabre-Madhin, 2006). These structural features imply that smallholder producers often receive prices substantially below international or even national benchmarks, whilst consumers in remote rural areas face prices considerably above those observed in urban centres (Minot, 2014; Meyer & von Cramon-Taubadel, 2004).

Price transmission the process through which price changes in one market propagate to another has been extensively examined in the agricultural economics literature. Early contributions by Baffes and Gardner (2003) demonstrated that the transmission of world commodity prices to domestic markets in developing countries is often incomplete and asymmetric, with upward price adjustments transmitting more rapidly than downward adjustments. Meyer and von Cramon-Taubadel (2004) subsequently synthesised theoretical and empirical literature on asymmetric price transmission, identifying a range of market structure, policy, and behavioural factors that generate this phenomenon. In the West African context, Minot (2014) documented substantial food price volatility across sub-Saharan Africa, attributing this instability to a combination of weather shocks, policy interventions, thin markets, and weak integration with global trading systems. These findings underscore the importance of examining both external market linkages and internal supply chain constraints when analysing local price dynamics.

2.2. Global-Local Linkages and External Shocks

The increasing integration of local agricultural markets into global food systems has amplified the transmission of international price signals, trade policy changes, and macroeconomic fluctuations to rural communities in developing countries (Gilbert & Morgan, 2010; Headey & Fan, 2010). The 2007–2008 global food crisis demonstrated with stark clarity how confluences of biofuel demand expansion, energy price spikes, export restrictions, and speculative trading in commodity futures could generate severe price escalations with devastating consequences for food-importing developing nations (Headey & Fan, 2010; Barrett, 2021). More recently, the COVID-19 pandemic disrupted international food supply chains through labour shortages, logistics bottlenecks, and demand shocks, precipitating price volatility despite adequate aggregate global food supplies (Béné et al., 2021; Torero, 2020).

For Sierra Leone specifically, the World Bank (2023) documented deteriorating macroeconomic conditions characterised by currency depreciation, inflationary pressures, and declining foreign reserves, all of which affect agricultural input costs, producer incentives, and consumer purchasing power. International trade agreements, currency fluctuations, and foreign investment flows constitute critical external transmission mechanisms through which global market conditions impinge upon local agricultural price formation (Baffes & Gardner, 2003; Barrett, 2021). Climate-related events represent an additional vector of external shock transmission, with Lobell et al. (2011) demonstrating that observed climate trends have already begun to negatively impact global crop production, with disproportionate effects on tropical and subtropical regions where smallholder agriculture predominates.

2.3. Digital Transformation and E-Commerce in Agricultural Markets

The potential for ICT-based innovations to improve agricultural market performance has attracted substantial scholarly attention over the past two decades. Aker's (2010) seminal contribution demonstrated that mobile phone expansion in Niger significantly reduced price dispersion across grain markets, generating welfare benefits through improved arbitrage and market efficiency. Subsequent research has examined a diverse array of digital interventions, including short message service (SMS)-based price information systems, mobile money platforms for agricultural payments, and more recently, e-commerce marketplaces connecting producers directly with urban consumers (Ogutu et al., 2020; Reardon et al., 2019).

Ogutu et al. (2020) synthesised evidence on ICT-based market information services across developing countries, finding generally positive but heterogeneous effects on producer prices, market participation, and welfare outcomes. The authors emphasised that the effectiveness of digital market interventions depends critically on complementary investments in human capital, physical infrastructure, and institutional frameworks. Reardon et al. (2019) examined the rapid transformation of food systems in developing regions, identifying the emergence of "supermarket revolutions," e-commerce platforms, and modernising wholesale markets as key structural drivers of change. However, these transformations have also raised concerns regarding the exclusion of small-scale producers who lack the scale, quality certification, and logistical capacity to meet the requirements of modernising value chains (Bellemare & Bloem, 2018; Reardon et al., 2019).

2.4. Consumer Behaviour Shifts and Demand-Side Dynamics

The demand side of agricultural markets has undergone substantial transformation across developing countries, driven by income growth, urbanisation, globalisation of food cultures, and evolving consumer preferences regarding health, sustainability, and convenience (Popkin & Ng, 2022; Tschirley et al., 2015). Popkin and Ng (2022) provided a comprehensive review of the nutrition transition, documenting shifts from traditional diets based on staple grains and pulses toward increased consumption of animal-source foods, processed products, and edible oils. These dietary changes create new market opportunities for agricultural producers whilst also posing significant public health challenges associated with rising rates of diet-related non-communicable diseases.

Countervailing to these trends, a growing body of research has documented the emergence of consumer preferences favouring locally sourced, organic, minimally processed, and sustainably produced foods, even in low-income country contexts (Tschirley et al., 2015; Popkin & Ng, 2022). Tschirley et al. (2015) examined the rise of a middle class in East and Southern Africa, finding that expanding urban consumer segments with discretionary income are increasingly willing to pay premiums for food quality attributes including safety, convenience, and provenance. These demand-side dynamics generate complex signalling environments for smallholder producers, who must balance production decisions against rapidly evolving and sometimes contradictory consumer preferences (Reardon et al., 2019).

2.5. Supply Chain Constraints and Collective Action

Rural agricultural supply chains in sub-Saharan Africa face a constellation of constraints encompassing inadequate transportation infrastructure, limited cold chain and storage facilities, poor market information systems, and weak producer organisations (Fafchamps & Gabre-Madhin, 2006; Markelova et al., 2009). Markelova et al. (2009) examined collective action for smallholder market access, finding that farmer groups, cooperatives, and other collaborative arrangements can substantially improve market participation, bargaining power, and price outcomes by reducing transaction costs, aggregating production volumes, and facilitating vertical coordination with buyers. However, the authors also noted that collective action initiatives frequently face challenges related to governance, member commitment, and external support sustainability.

Bellemare and Bloem (2018) investigated the welfare effects of contract farming arrangements, which represent an alternative institutional mechanism for linking smallholders with modernising value chains. Their findings indicated that contract farming generally improves producer welfare, though the magnitude and distribution of benefits depend on contract design, power dynamics between farmers and firms, and the availability of alternative marketing channels. In the Sierra Leonean context, where state capacity for agricultural extension and market development remains limited, strengthening collaborative mechanisms among producers and between producers and other value chain actors represents a critical priority for enhancing supply chain resilience and rural livelihoods (World Bank, 2023; Béné et al., 2021).

3. Methodology

3.1. Study Area and Research Context

This study was conducted in Yoni Chiefdom, Tonkolili District, Northern Province of Sierra Leone. Tonkolili District spans approximately 7,003 square kilometres with a population exceeding 530,000 according to the most recent national census. The district is predominantly rural, with agriculture serving as the primary economic activity for the majority of households. Yoni Chiefdom was purposively selected for this investigation due to its representative characteristics as a mixed farming and trading community with documented engagement in both subsistence and market-oriented agricultural production. The chiefdom encompasses a range of agro-ecological conditions suitable for rice, cassava, groundnuts, and various vegetable crops, and exhibits varying degrees of market access from relatively well-connected roadside settlements to more isolated hinterland villages.

3.2. Research Design and Sampling

The study employed a cross-sectional survey design, collecting primary data through structured questionnaires administered during June 2025. A multi-stage sampling approach was implemented. In the first stage, Yoni Chiefdom was purposively selected from among the chiefdoms in Tonkolili District based on criteria including agricultural production diversity, varying market access conditions, and logistical feasibility. In the second stage, communities within the chiefdom were stratified by proximity to market centres, and simple random sampling was used to select settlements for inclusion. In the final stage, respondents were recruited using systematic sampling procedures at community level, with every *n*th household approached for participation until the target sample size was achieved.

The final analytical sample comprised 202 respondents. This sample size provides adequate statistical power for detecting medium effect sizes in chi-square analyses with up to six response categories at the 0.05 significance level, whilst remaining logistically feasible within the resource constraints of a single-fieldwork-season study (Cohen, 1988). The achieved sample included respondents across diverse demographic and occupational categories, enhancing the generalisability of findings within the study area.

3.3. Data Collection Instrument

Data were collected using a structured questionnaire comprising six thematic sections: (1) respondent demographic and socioeconomic characteristics; (2) market trends impacting agricultural commodity prices; (3) consumer preference dynamics and emerging demand patterns; (4) e-commerce and digital marketplace impacts; (5) international market factor perceptions; and (6) supply chain constraints, collaborative arrangements, and coping strategies. The questionnaire was developed through an iterative process involving review of existing instruments from comparable studies, pilot testing with 15 respondents in a non-sampled community, and refinement based on feedback from field enumerators and pilot participants (Béné et al., 2021; Ogutu et al., 2020).

Multiple-select questions were used extensively for items assessing respondent perceptions of market trends, consumer preferences, international factors, and collaborative activities, reflecting the multidimensional nature of these constructs. Ordinal response scales were employed for items measuring e-commerce price effects, government subsidy evaluations, supply chain stabilisation income, and market access quality. All questionnaires were administered in Krio or English depending on respondent preference, with trained enumerators providing verbal translation where necessary.

3.4. Data Analysis

Survey data were coded, entered, and analysed using IBM SPSS Statistics Version 28. Descriptive statistics including frequencies, percentages, means, and standard deviations were computed for all demographic and substantive variables. Cross-tabulations with Pearson's chi-square tests of independence were conducted to examine associations between categorical variables, particularly the relationships between occupational categories and market-related outcomes. The chi-square statistic was selected as the appropriate non-parametric test for examining associations between nominal categorical variables given the cross-sectional design and the absence of assumptions regarding underlying distributional properties (Field, 2018). Statistical significance was assessed at the conventional $\alpha = 0.05$ level, with exact two-tailed p-values reported.

3.5. Ethical Considerations

The study protocol was reviewed and approved by the institutional research ethics committee prior to fieldwork commencement. Informed consent was obtained from all participants following verbal and written explanation of study purposes, voluntary participation, confidentiality protections, and data storage procedures. Respondents were assured of anonymity, with no personally identifiable information collected. All data were stored securely with access restricted to the research team. No financial compensation was provided for participation, though respondents were offered a summary of community-level findings upon study completion.

4. Results

4.1. Socio-Demographic Characteristics of Respondents

The demographic composition of the sample is presented in Table 1. Female respondents constituted the substantial majority at 73.3% ($n = 148$), reflecting the prominent role of women in agricultural production and marketing activities in Northern Sierra Leone. Male respondents accounted for 26.2% ($n = 53$), with a single respondent identifying as non-binary (0.5%). The age distribution revealed a concentration in the 31–45 years bracket (44.6%, $n = 90$), followed by the 18–30 years group (31.7%, $n = 64$), indicating that economically active adults in their prime productive years were well-represented.

Educational attainment varied considerably, with secondary education being the most frequently reported level (31.2%, $n = 63$). Notably, 19.3% ($n = 39$) reported no formal education, whilst equivalent proportions had completed tertiary education (19.3%, $n = 39$) or postgraduate qualifications (16.8%, $n = 34$). A further 13.4% ($n = 27$) reported "Option 2" as their educational level, which in the Sierra Leonean context typically refers to vocational or technical training. Occupational diversity was observed, with business activities (37.1%, $n = 75$) and farming (33.2%, $n = 67$) constituting the primary livelihood strategies. Unemployed respondents accounted for 15.3% ($n = 31$), whilst those in formal employment represented 12.4% ($n = 25$). Housing tenure was predominantly owner-occupied (54.5%, $n = 110$), with 29.2% ($n = 59$) renting and 16.3% ($n = 33$) residing in family-owned dwellings.

Monthly income levels revealed significant economic constraints among the study population. The largest income bracket was SLL 500–1,000 (42.6%, $n = 86$), followed by less than SLL 500 (20.3%, $n = 41$), SLL 1,501–2,000 (18.8%, $n = 38$), and over SLL 2,000 (18.3%, $n = 37$). These income levels, when converted at prevailing exchange rates, indicate

that the majority of respondents subsist at or below internationally recognised poverty thresholds. The overwhelming predominance of rural residence (94.6%, $n = 191$) underscores the agrarian character of the study area, with only 5.4% ($n = 11$) residing in urban settings.

Table 1 Socio-Demographic Characteristics of Respondents (N = 202)

Characteristic	Category	Frequency	Percentage
Gender	Female	148	73.3%
Age group	18–30 years	64	31.7%
Education	Secondary	63	31.2%
Occupation	Business	75	37.1%
Housing	Owned	110	54.5%
Monthly income (SLL)	500–1,000	86	42.6%
Residence	Rural	191	94.6%

4.2. Market Trends Impacting Agricultural Commodity Prices

Respondents identified multiple trends perceived as influencing agricultural commodity prices in their local markets (Table 2; Figure 1). Digital marketplace expansion emerged as the most frequently cited trend, with 49 respondents (24.3%) selecting this option. This finding signals growing awareness among rural producers and traders of the transformative potential of digital platforms for agricultural commerce, consistent with broader patterns of digital diffusion documented across West Africa (Ogotu et al., 2020; Aker, 2010).

Changing consumer preferences and sustainability/environmental concerns were tied as the second most frequently identified trends, each cited by 45 respondents (22.3%). The co-equal salience of these two factors suggests that demand-side dynamics and environmental considerations are increasingly salient in respondent perceptions of market conditions. Global supply chain disruptions were identified by 32 respondents (15.8%), reflecting awareness of the lingering effects of pandemic-related disruptions and broader patterns of international supply chain fragility (Béné et al., 2021; Torero, 2020). Health and nutrition awareness (22 respondents, 10.9%) and food security policies (18 respondents, 8.9%) were cited less frequently but nonetheless represent non-trivial shares of respondent perceptions.

Table 2 Market Trends Impacting Agricultural Commodity Prices (N = 202, Multiple Select)

Market Trend	Frequency	Percentage
Digital marketplace expansion	49	24.3%
Changing consumer preferences	45	22.3%
Sustainability and environmental concerns	45	22.3%
Global supply chain disruptions	32	15.8%
Health and nutrition awareness	22	10.9%
Food security policies	18	8.9%

4.3. Consumer Preference Dynamics and Emerging Demand Patterns

Analysis of consumer preference changes (Table 3, Panel A) revealed local sourcing preferences as the most prominent demand-side trend, selected by 51 respondents (25.2%). Food safety concerns followed closely at 50 selections (24.8%), underscoring the salience of quality and safety attributes in consumer decision-making. Price sensitivity was identified by 35 respondents (17.3%), sustainability requirements by 32 (15.8%), organic or natural product demand by 31 (15.3%), and convenience factors by 15 (7.4%). The prominence of local sourcing and food safety preferences aligns with findings from Tschirley et al. (2015) regarding evolving middle-class consumption patterns in African cities, and with Popkin and Ng's (2022) documentation of the nutrition transition's complex demand-side manifestations.

Emerging consumer trends (Table 3, Panel B) exhibited a similar pattern, with the local food movement dominating at 70 selections (34.7%). Clean label and minimal processing preferences were cited by 36 respondents (17.8%), followed by health-conscious buying at 35 (17.3%), and plant-based diets and convenience foods tied at 27 selections each (13.4%). The substantially higher selection rate for the local food movement in Q35 compared to local sourcing preferences in Q27 likely reflects the more explicitly normative framing of the former question, which captured aspirational and identity-based consumption orientations alongside pragmatic sourcing considerations.

Table 3 Consumer Preference Dynamics and Emerging Trends (N = 202, Multiple Select)

Consumer Trend	Frequency	Percentage
Panel A: Consumer Preference Changes (Q27)		
Local sourcing preferences	51	25.2%
Food safety concerns	50	24.8%
Price sensitivity	35	17.3%
Sustainability requirements	32	15.8%
Organic/natural product demand	31	15.3%
Convenience factors	15	7.4%
Panel B: Emerging Consumer Trends (Q35)		
Local food movement	70	34.7%
Clean label/minimal processing	36	17.8%
Health-conscious buying	35	17.3%
Plant-based diet	27	13.4%
Convenience foods	27	13.4%

4.4. E-Commerce and Digital Transformation

Perceptions regarding the effect of e-commerce on agricultural commodity pricing were assessed through a single-select ordinal item (Figure 2). A clear directional pattern emerged, with the majority of respondents (62.9%) reporting that e-commerce has increased prices comprising 33.2% ($n = 67$) who perceived a moderate increase and 29.7% ($n = 60$) who reported a very significant increase. This finding is consistent with the argument that digital marketplace integration in contexts with limited competition and high transaction costs may generate price increases rather than reductions, as platform fees, delivery charges, and intermediary markups are passed through to final consumers (Reardon et al., 2019; Ogotu et al., 2020).

A smaller but non-trivial proportion of respondents (17.8%, $n = 36$) perceived that e-commerce has moderately decreased prices, likely reflecting experiences with platforms that reduced search costs or enabled direct producer-consumer linkages that eliminated intermediary margins. Only 4.5% ($n = 9$) reported a very significant decrease, whilst 14.9% ($n = 30$) observed no noticeable change. The predominance of price-increasing perceptions suggests that, in the current Sierra Leonean context, the costs of digital market integration may outweigh the efficiency benefits for rural consumers and producers.

Technology adoption patterns among respondents further illuminated the digital transformation landscape. Mobile price information services were the most frequently cited adopted technology (25.2%), followed by storage and preservation technologies (22.8%), digital trading platforms (20.8%), and transport improvements (17.8%). These findings indicate that digital information access is currently more prevalent than digital market participation, consistent with the staged model of technology adoption documented in the ICT for agriculture literature (Aker, 2010; Ogotu et al., 2020).

Table 4 Perceived Effect of E-Commerce on Agricultural Commodity Pricing (N = 202, Single Select)

Perceived Effect	Frequency	Percentage
Very significant increase	60	29.7%
Moderate increase in prices	67	33.2%
No noticeable change	30	14.9%
Moderate decrease	36	17.8%
Very significant decrease	9	4.5%

4.5. International Market Factors

Respondent perceptions of international market factors affecting local agricultural commodity prices are summarised in Table 5 and Figure 4. International trade agreements were identified by 49 respondents (24.3%) as the most salient external factor, followed by currency fluctuations at 44 selections (21.8%). The prominence of these macroeconomic and policy-level factors reflects the growing integration of Sierra Leone's agricultural sector into regional and international trading systems, as well as the vulnerability of import-dependent economies to exchange rate movements (Baffes & Gardner, 2003; World Bank, 2023).

Foreign investment was cited by 40 respondents (19.8%), global supply disruptions by 35 (17.3%), and changing global consumer preferences by 31 (15.3%). Climate-related events, despite their documented impacts on agricultural production in West Africa (Lobell et al., 2011), were identified by only 18 respondents (8.9%) as a factor affecting local market prices. This relatively low salience may reflect the temporal framing of the question, which focused on market price effects rather than production impacts, or may indicate limited awareness among rural respondents of the market transmission pathways through which climate shocks affect commodity prices.

Table 5 International Market Factors Affecting Local Agricultural Prices (N = 202, Multiple Select)

International Factor	Frequency	Percentage
International trade agreements	49	24.3%
Currency fluctuations	44	21.8%
Foreign investment	40	19.8%
Global supply disruptions	35	17.3%
Changing global consumer preferences	31	15.3%
Climate-related events	18	8.9%

4.6. Supply Chain Constraints, Collaborative Arrangements, and Market Access

The final set of results addresses supply chain functioning, collaborative practices, market access quality, and the experience of marketing challenges (Table 6). Income stabilisation effects from supply chain activities were predominantly modest: 53.0% ($n = 107$) reported that supply chain engagement contributed "a little" to income stability, 29.7% ($n = 60$) reported "not at all," 9.9% ($n = 20$) reported "somewhat," and only 7.4% ($n = 15$) reported "very much." These findings indicate that for the majority of respondents, agricultural supply chain participation provides limited and unstable income benefits, consistent with the characterisation of smallholder agriculture as a poverty trap in contexts with weak value chain integration (Fafchamps & Gabre-Madhin, 2006; Markelova et al., 2009).

Collaborative arrangements among agricultural stakeholders were reported by 58.9% ($n = 119$) of respondents, with 41.1% ($n = 83$) indicating no collaborative engagement. Among those who did collaborate, knowledge sharing was the most common form (37.0%), followed by shared transportation (34.5%) and joint marketing (28.6%). These patterns align with Markelova et al.'s (2009) findings regarding the prevalence of informal, horizontally oriented collective action among African smallholders, in contrast to the more structured vertical coordination mechanisms observed in commercial agricultural systems.

Market access quality was assessed through a five-point ordinal scale. "Good" market access was reported by 40.1% ($n = 81$), "fair" by 19.3% ($n = 39$), "poor" by 17.3% ($n = 35$), "very poor" by 12.9% ($n = 26$), and "very good" by 10.4% ($n = 21$). The combined "poor" and "very poor" categories encompass 30.2% of respondents, indicating substantial market access deficits for a significant minority of the study population.

The experience of marketing challenges was widespread, with 75.2% ($n = 152$) of respondents reporting that they had faced challenges in accessing or selling in agricultural markets. Among these, lack of transport (40.6%), distance to markets (38.1%), and limited market information (25.7%) were the most frequently cited specific constraints. These findings resonate with established literature documenting the centrality of physical infrastructure and information gaps as binding constraints on smallholder market participation in sub-Saharan Africa (Fafchamps & Gabre-Madhin, 2006; Minot, 2014).

Sales frequency patterns indicated that 35.6% ($n = 72$) sold agricultural products frequently, 30.7% ($n = 62$) occasionally, 22.3% ($n = 45$) rarely, and 11.4% ($n = 23$) very frequently. The combined "rarely" and "occasionally" categories encompass 53.0% of respondents, suggesting that irregular and infrequent market participation is normative in this context.

Table 6 Supply Chain Constraints, Collaborative Arrangements, and Market Access (N = 202)

Variable	Category	Frequency	Percentage
Supply chain stabilisation income	A little	107	53.0%
Collaboration with other stakeholders	Yes	119	58.9%
Collaboration type (among collaborators)	Knowledge sharing	44	37.0%
Market access quality	Good	81	40.1%
Faced market challenges	Yes	152	75.2%
Specific challenges (among those facing challenges)	Lack of transport	62	40.6%
Sales frequency	Frequently	72	35.6%

4.7. Chi-Square Analyses

Two chi-square tests of independence were conducted to examine associations between occupational categories and key market-related outcomes (Table 7). The first analysis examined the relationship between occupation and the experience of market challenges. The results indicated a statistically significant association ($\chi^2 = 13.990$, $df = 4$, $p = 0.007$). Examination of the cross-tabulation revealed that business owners reported the highest absolute number of affirmative responses ($n = 61$), though this partly reflects their larger representation in the sample. Farming respondents also exhibited high rates of market challenge exposure ($n = 56$), whilst employed and unemployed respondents showed more variable patterns. The Cramér's V effect size for this association was 0.263, indicating a small-to-medium strength of association.

The second analysis examined the relationship between occupation and reported changes in farming practices. This analysis also yielded a statistically significant result ($\chi^2 = 13.438$, $df = 4$, $p = 0.009$), suggesting that occupational status is systematically associated with adaptive behaviour in agricultural production. These findings are broadly consistent with Béné et al.'s (2021) observations regarding the differential vulnerability and adaptive capacity of livelihood groups in the context of food system shocks.

Table 7 Chi-Square Test Results: Occupation by Market-Related Outcomes

Analysis	χ^2 Value	df	p-Value	Significance
Occupation $\times$ Faced market challenges	13.990	4	0.007	
Occupation $\times$ Changed farming practices	13.438	4	0.009	

Table 8 Cross-Tabulation: Occupation by Faced Market Challenges (N = 202)

Occupation	Yes	No	Row Total
Business	61	14	75
Farming	56	11	67
Employed	16	9	25
Unemployed	17	14	31
Others	2	2	4
Column total	152	50	202

Government subsidy perceptions were also assessed, with 38.1% evaluating subsidies as "somewhat positive," 25.7% as "highly positive," 14.9% as "somewhat negative," 12.9% as "neutral," and 8.4% as "highly negative." The combined positive evaluations (63.8%) substantially outweighed negative evaluations (23.3%), suggesting that existing subsidy programmes are perceived as beneficial, albeit with room for improvement in design, targeting, and implementation.

5. Discussion

The findings of this study illuminate the complex interplay of global market forces, digital transformation, consumer behaviour shifts, and supply chain constraints in shaping agricultural commodity price dynamics in Northern Sierra Leone. Several themes merit extended discussion in relation to the extant literature and policy implications.

The predominance of digital marketplace expansion as the most frequently cited market trend (24.3%) resonates with broader documentation of rapid digital diffusion across African agricultural systems (Ogututu et al., 2020; Aker, 2010). However, the finding that e-commerce is predominantly perceived as increasing rather than decreasing prices introduces an important nuance to prevailing narratives of digital transformation as unambiguously welfare-enhancing. This pattern is consistent with Reardon et al.'s (2019) observation that the benefits of digital market integration are contingent on competitive conditions, regulatory frameworks, and the distribution of bargaining power among value chain actors. In contexts characterised by limited platform competition, inadequate consumer protection, and high logistics costs, digital intermediation may add layers of cost rather than eliminate inefficiencies. This interpretation aligns with Ogutu et al.'s (2020) finding that the welfare effects of ICT-based market information services are highly heterogeneous and depend critically on complementary institutional investments.

The strong salience of local sourcing preferences (25.2%) and the local food movement (34.7%) in respondent perceptions of consumer trends reflects the emergence of what Tschirley et al. (2015) have termed "consumption stratification" in African food systems, wherein growing segments of urban consumers are willing to pay premiums for provenance, quality, and safety attributes. Popkin and Ng (2022) have similarly documented the complex, multidimensional character of the nutrition transition, which encompasses both increased demand for processed convenience foods and countervailing preferences for traditional, locally sourced, and minimally processed products. For smallholder producers in Northern Sierra Leone, these evolving demand patterns create both opportunities and challenges: opportunities for product differentiation and value-added production, but challenges in meeting the quality, consistency, and certification requirements of emerging market segments.

The statistically significant associations between occupation and both market challenge exposure ($\chi^2 = 13.990$, $p = 0.007$) and farming practice adaptation ($\chi^2 = 13.438$, $p = 0.009$) underscore the structural heterogeneity of rural livelihoods and the differential vulnerability of occupational groups to market disruptions. Business-oriented respondents, despite their higher rates of market challenge exposure, may possess greater adaptive capacity through income diversification and social capital accumulation, whilst farming-dependent households may face more constrained adaptation options (Bellemare & Bloem, 2018; Béné et al., 2021). These findings support Barrett's (2021) argument for disaggregated, livelihood-sensitive approaches to food systems research and policy.

International market factors, particularly trade agreements (24.3%) and currency fluctuations (21.8%), were widely perceived as influencing local price dynamics, reflecting the growing openness of Sierra Leone's economy to external market forces (World Bank, 2023; Baffes & Gardner, 2003). The relatively low salience of climate-related events (8.9%) may warrant further investigation, as it appears inconsistent with both the empirical literature on climate impacts in West Africa (Lobell et al., 2011) and the study population's high agricultural dependence. This discrepancy may reflect

limited awareness of climate-price transmission mechanisms, temporal framing effects in the survey instrument, or genuine contextual variation in the relative importance of climatic versus market-mediated shocks.

The supply chain analysis reveals a concerning picture of limited income stabilisation, constrained collaboration, and widespread market access challenges. That 53.0% of respondents reported only "a little" income stabilisation from supply chain activities, and 29.7% reported "not at all," indicates that current agricultural marketing arrangements provide inadequate livelihood security for the majority of rural households. The finding that 58.9% engage in some form of collaboration, primarily through informal knowledge sharing and shared transportation, suggests latent potential for strengthening collective action institutions, consistent with Markelova et al.'s (2009) findings regarding the benefits of horizontal coordination for smallholder market access. However, the predominance of informal, non-contractual arrangements also implies vulnerability to free-riding, coordination failures, and limited scalability.

The government's role in agricultural market development, as reflected in subsidy perceptions, appears broadly positive but insufficiently transformative. The combined 63.8% positive evaluation suggests that subsidy programmes are reaching intended beneficiaries and generating perceived welfare improvements. Nevertheless, the persistence of severe market access constraints, limited supply chain income stabilisation, and high rates of market challenge exposure indicate that existing policy interventions have not yet achieved systemic improvements in rural agricultural marketing conditions.

6. Conclusion

This study has provided empirical evidence from Northern Sierra Leone regarding the multifaceted forces shaping agricultural commodity markets in a fragile, post-conflict agrarian economy. The findings demonstrate that global market integration, digital transformation, and evolving consumer preferences are actively reshaping local price dynamics, whilst supply chain constraints and weak collaborative institutions limit the capacity of smallholder producers to capture value from these structural transformations. Three policy implications merit emphasis.

Digital marketplace development requires regulatory attention to ensure competitive, inclusive, and pro-poor outcomes. The predominant perception that e-commerce increases prices suggests that current platform business models may be extracting excessive rents or passing through inefficiencies in logistics and payment systems. Policymakers should consider measures to promote platform competition, subsidise rural connectivity infrastructure, and establish consumer protection frameworks appropriate to the digital agricultural economy.

The strong consumer demand for local, safe, and sustainably produced foods identified in this study represents a significant market opportunity for organised smallholder producers. Investing in quality certification systems, producer organisation capacity, and shortened value chains connecting rural producers with urban consumers could enable smallholders to capture premiums from emerging demand segments whilst simultaneously advancing food safety and environmental sustainability objectives.

Strengthening rural supply chain infrastructure, particularly transportation, storage, and market information systems remains an urgent priority. The high prevalence of transport and distance constraints (40.6% and 38.1%, respectively) as barriers to market access underscores the centrality of physical infrastructure in enabling agricultural commercialisation. Targeted investments in rural roads, consolidated market facilities, and ICT-based information services could yield substantial returns in terms of reduced post-harvest losses, improved price discovery, and enhanced smallholder welfare.

Research should employ longitudinal designs to track the evolution of digital market integration, consumer behaviour, and supply chain functioning over time. Mixed-methods approaches combining quantitative surveys with qualitative case studies would enhance understanding of the causal mechanisms underlying the correlational patterns identified in this study. Comparative research across multiple chiefdoms and districts in Sierra Leone would illuminate the extent to which the present findings generalise to other agro-ecological and market access contexts.

Compliance with ethical standards

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Disclosure of conflict of interest

No conflict of interest to be disclosed.

Statement of ethical approval

This study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. The research protocol was reviewed and approved by the Review Board, School of Agriculture and Food Sciences, Njala University, prior to the commencement of fieldwork. All procedures involving human participants were performed in compliance with institutional and national ethical standards.

Statement of informed consent

Informed consent was obtained from all individual participants included in this study. Participants were provided with verbal and written explanations of the study objectives, procedures, potential risks and benefits, and their right to withdraw at any time without penalty. All participants provided written informed consent prior to data collection.

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