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RESILIENCE AND DIGITAL TRACEABILITY IN INFORMAL AGRICULTURAL SUPPLY CHAINS IN KENYA: LEVERAGING MOBILE TECHNOLOGIES POST-COVID-19

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Abstract

The performance of informal agricultural supply chains in Kenya remains a critical concern for food security, rural livelihoods, and market access, particularly in the wake of disruptions such as the COVID-19 pandemic. This study examined the influence of mobile-based digital traceability and supply chain resilience capabilities on the performance of informal agricultural supply chains in selected counties in Kenya. Guided by the Resource-Based View (RBV) and Technology Acceptance Model (TAM), the study adopted a cross-sectional explanatory research design and collected data from 317 respondents across Kisii, Meru, Nakuru, and Machakos counties. Structured questionnaires were used to capture perceptions related to traceability, resilience, and performance outcomes. Descriptive results revealed that respondents generally perceived mobile-based digital tools as useful for improving product verification and market information access, though satisfaction with existing platforms remained moderate. Similarly, actors demonstrated varying levels of resilience, particularly in their reliance on informal networks, flexible sourcing, and logistical adaptability. Pearson correlation analysis indicated positive and statistically significant relationships between all variables, with the strongest correlation observed between digital traceability and performance ($r = 0.617$, $p < 0.01$). Multiple regression analysis confirmed that both mobile-based digital traceability ($\beta = 0.444$, $p < 0.001$) and resilience capabilities ($\beta = 0.369$, $p < 0.001$) significantly influenced supply chain performance, with the model explaining 47.0% of the variation in performance outcomes ($R^2 = 0.470$). The findings underscore the dual importance of technological innovation and resilience strategies in enhancing the effectiveness, adaptability, and competitiveness of Kenya's informal agricultural supply systems. The study recommends scaling user-friendly traceability platforms, strengthening resilience through decentralized storage and transport networks, and promoting inclusive policy support for informal actors. These results provide actionable insights for policymakers, development partners, and agri-tech innovators aiming to modernize and stabilize informal food systems in Kenya and similar contexts.

Keywords: mobile-based digital traceability, supply chain resilience, informal agricultural markets, performance, Kenya

Background of the Study

The COVID-19 pandemic highlighted the fragility of informal agricultural supply chains in Sub-Saharan Africa, particularly in Kenya, where over 70% of agricultural trade flows through informal markets (Thorpe, Odame, & Kangai, 2023). Disruptions due to movement restrictions, market closures, and limited logistical infrastructure exposed the vulnerability of these systems to external shocks. As a response, various stakeholders—governmental, private, and donor agencies—began piloting digital traceability platforms and resilience-enhancing interventions to improve visibility and responsiveness across the supply chain (Ishengoma, 2020; Ngongolo & Gayo, 2020).

Mobile-based traceability technologies have emerged as critical enablers of transparency and accountability in informal agricultural markets. These include the use of mobile money (e.g., M-PESA), SMS-based data capture, and app-based commodity tracking systems. Such technologies not only support transaction monitoring but also play a role in reducing fraud, improving coordination, and facilitating financial inclusion for smallholders (Sokame, Wamalwa, & Tonnang, 2023). Despite their growing adoption, limited empirical studies have examined their impact on supply chain performance and resilience specifically within Kenya's informal settings.

Supply chain resilience—the capacity to absorb, adapt, and recover from disruptions—is particularly under-theorized in the African informal context (Klibi, Shawa, & Mkansi, 2022). Informal traders typically lack buffer inventories, redundant suppliers, or formal contracts, making them inherently vulnerable (Chanda et al., 2020). However, resilience can be cultivated through technological interventions that allow for flexible sourcing, early warning systems, and real-time communication—benefits increasingly associated with digital tools (Mensah et al., 2022; Gebremichael, Gebreslassie, & Mezgebe, 2023).

Kenya's government and NGOs have been experimenting with traceability systems in horticulture, dairy, and grains, but little is known about their effectiveness in enhancing both traceability and resilience in informal chains (Thorpe et al., 2023; Otundo, 2020). As the country strives toward achieving Sustainable Development Goals (particularly SDGs 2, 9, and 12), understanding how digital innovations can uplift informal actors and stabilize food systems is critical. Therefore, this study aims to assess the interplay between mobile-based digital traceability and supply chain resilience capabilities, and how these affect the performance of informal agricultural supply chains in Kenya post-COVID-19.

Statement of the Problem

Despite contributing over 33% of Kenya's GDP and employing more than 70% of the rural population, the agricultural sector continues to face persistent structural inefficiencies, especially in its informal supply chains (Sokame, Wamalwa, & Tonnang, 2023). The COVID-19 pandemic further exacerbated these inefficiencies by exposing the fragility of informal networks responsible for moving perishable goods like fruits, vegetables, and dairy products across counties. During the 2020–2021 lockdowns, more than 45% of smallholder farmers in Kenya reported market access disruption, and 36% of informal traders experienced total income loss due to logistical breakdowns and lack of visibility in supply operations (Thorpe, Odame, & Kangai, 2023).

Kenya's informal supply chains are predominantly unstructured and lack reliable traceability systems, which limits the ability to track produce origin, transaction records, or distribution bottlenecks. This not only increases vulnerability to shocks such as pandemics and climate change but also limits access to higher-value formal markets, including export and institutional buyers who demand verifiable supply chain data (Ngongolo & Gayo, 2020). Additionally, informal traders and aggregators rarely possess redundant suppliers or digital tools for real-

time decision-making, resulting in slow recovery post-disruption and continued reliance on manual systems (Ishengoma, 2020).

While mobile-based digital traceability tools such as USSD applications, SMS platforms, and mobile money integration (e.g., M-PESA) are increasingly deployed in pilot projects, their adoption in informal chains remains low. A 2023 survey by Sokame et al. in Kenya and Rwanda found that only 27% of smallholders used mobile-based tools for recording transactions, and fewer than 15% had access to any form of digital traceability platform. Consequently, informal agricultural supply chains remain highly opaque, fragmented, and inefficient, despite their critical role in food distribution and urban food security.

In addition, supply chain resilience the capability to anticipate, absorb, and recover from shocks is underdeveloped among informal actors. These actors typically operate without contracts, inventory buffers, or formalized support networks. Klibi, Shawa, and Mkansi (2022) emphasized that resilience-building mechanisms in African informal systems are still at nascent stages, making them particularly susceptible to prolonged disruption, price shocks, and systemic failures. Given this context, there is a clear gap in both empirical data and policy-relevant research on how mobile-based digital traceability and resilience capabilities interact to influence the performance of informal agricultural supply chains in Kenya. Without targeted interventions and academic exploration, Kenya risks continued inefficiencies and vulnerability in a sector critical for national development and food security.

Objectives of the Study

General Objective

To examine the effect of mobile-based digital traceability and supply chain resilience capabilities on the performance of informal agricultural supply chains in Kenya in the post-COVID-19 context.

Specific Objectives

1. To examine the effect of mobile-based digital traceability on the performance of informal agricultural supply chains in Kenya.
2. To assess how supply chain resilience capabilities influence the performance of informal agricultural supply chains in Kenya.

Theoretical Review

Resource-Based View (RBV) Theory

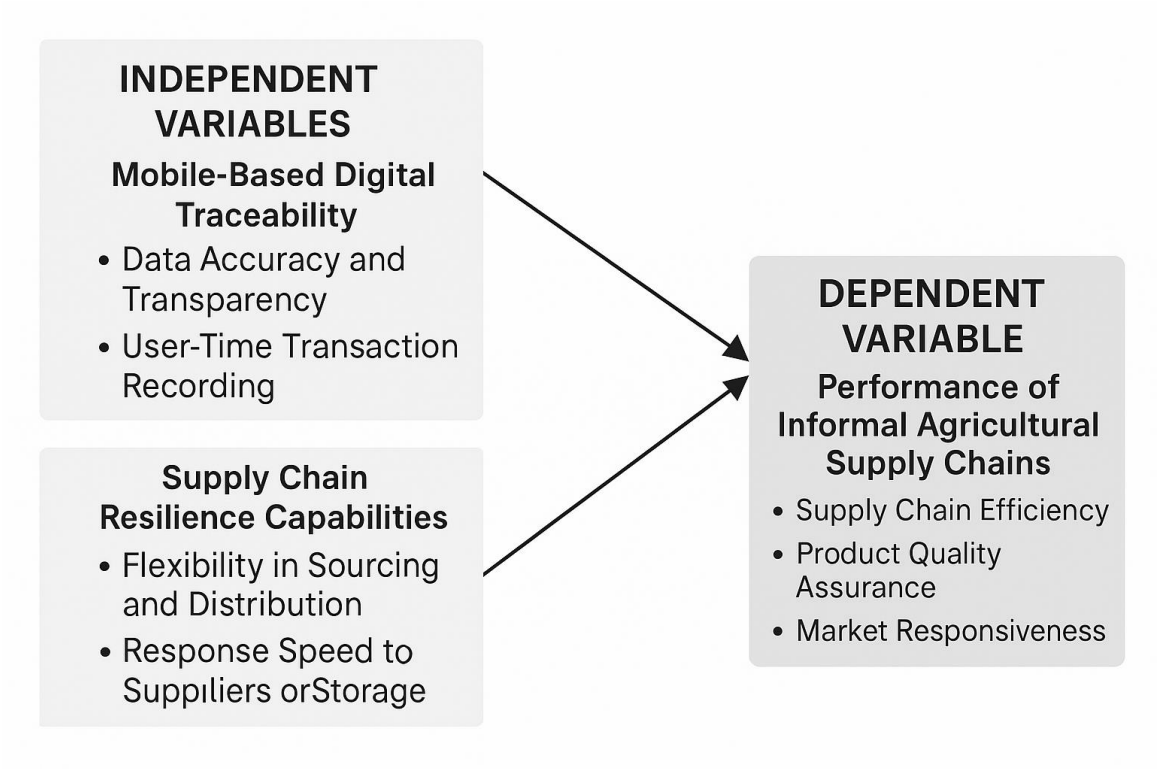
The Resource-Based View (RBV), proposed by Barney (1991), posits that organizations gain and sustain competitive advantage through the acquisition and effective utilization of valuable, rare, inimitable, and non-substitutable (VRIN) resources. In the context of informal agricultural supply chains, resilience capabilities—such as flexible sourcing, adaptive distribution networks, and redundancy planning—can be conceptualized as *strategic resources*. In Kenya's fragmented informal markets, resilience is not just about withstanding shocks but about transforming disruption into opportunity. For example, informal traders who developed relationships with multiple suppliers or adopted local warehousing strategies during the COVID-19 crisis demonstrated better performance and quicker recovery. This supports the RBV assumption that internal capabilities—rather than environmental positioning alone—determine long-term viability (Ngongolo & Gayo, 2020). Moreover, RBV theory helps explain performance variability between actors exposed to similar risks but possessing different levels of adaptive capacity. Actors who embed resilience through capabilities such as redundancy or

agility—though operating in informal, low-infrastructure settings—can achieve significant supply chain performance improvements.

Technology Acceptance Model (TAM)

The Technology Acceptance Model (TAM), developed by Davis (1989), theorizes that the acceptance and usage of new technologies are influenced by two main factors: perceived usefulness and perceived ease of use**.** This theory is especially applicable in understanding how and why informal agricultural supply chain actors in Kenya adopt (or reject) mobile-based digital traceability tools. In rural Kenyan contexts, where literacy levels, smartphone penetration, and digital literacy vary widely, users' perception of the *reliability* and *efficiency* of digital traceability platforms (e.g., SMS, USSD, mobile apps) significantly affects uptake. If traders and farmers find the tools too complex or irrelevant to their needs, they are unlikely to integrate them into daily operations—regardless of how effective the tools may be in theory (Sokame et al., 2023). Furthermore, the behavioral intention to use traceability tools is shaped by trust in the technology, alignment with existing practices, and the level of external support (e.g., training or incentives). TAM offers a structured way to evaluate these determinants and understand the barriers to digital transformation in informal supply chains.

Conceptual Framework



Mobile-Based Digital Traceability

Mobile-based digital traceability is increasingly recognized as a transformative solution for enhancing transparency and coordination in agricultural supply chains, particularly in low- and middle-income countries. In the context of Kenya, informal agricultural markets are largely unregulated and undocumented, which hinders visibility and accountability among value chain actors. Digital traceability—enabled through mobile phones, USSD codes, and app-based platforms—has emerged as a low-cost and scalable mechanism for improving trust and efficiency in these systems (Sokame, Wamalwa, & Tonnang, 2023). These tools allow for the recording of transactions, tracking of produce from origin to market, and real-time sharing of pricing and logistics data, which is particularly crucial for perishable commodities.

However, empirical evidence suggests that despite its potential, uptake of digital traceability in Kenya remains modest. A study by Sokame et al. (2023) in Kenya and Rwanda reported that only 27% of surveyed smallholders used mobile tools for transaction documentation, and fewer than 15% had any exposure to formal traceability systems. Thorpe, Odame, and Kangai (2023) found that among informal horticultural traders in Kenya, adoption was heavily influenced by digital literacy and perceived value, with many viewing mobile traceability tools as too complex or unreliable for daily use. These findings align with the Technology Acceptance Model (Davis, 1989), which postulates that technology adoption is driven by perceived usefulness and ease of use. In informal Kenyan markets, perceived usefulness is often hampered by low awareness of traceability benefits and inconsistent platform design tailored to local users. Moreover, limited access to smartphones, poor connectivity in rural areas, and a lack of training further constrain adoption.

Nevertheless, when implemented effectively, digital traceability can generate substantial benefits for informal supply chain actors. It enables better quality control, reduces disputes over pricing and quantity, and facilitates access to higher-value markets that require traceable produce. Klibi, Shawa, and Mkansi (2022) argue that traceability is becoming a prerequisite for integration into regional and global value chains, particularly in food systems undergoing digital transition. Therefore, understanding the extent to which mobile-based traceability affects the performance of informal agricultural supply chains in Kenya is both a timely and policy-relevant inquiry.

Supply Chain Resilience Capabilities

Supply chain resilience refers to the capacity of a system to anticipate, absorb, adapt to, and recover from disruptions while sustaining core functions. In Kenya's informal agricultural economy, this concept is particularly important given the sector's exposure to systemic risks such as climate change, market volatility, infrastructure gaps, and pandemics like COVID-19. Unlike formal supply chains that may rely on insurance or inventory buffers, informal chains must build resilience through flexible sourcing, redundancy, improvisation, and social capital (Ngongolo & Gayo, 2020). These adaptive capabilities are often informal and community-driven, yet they serve as critical pillars of continuity for millions of producers and traders.

Empirical studies have shown that actors in informal agricultural chains with greater flexibility and redundancy mechanisms were better able to withstand the economic shocks of the pandemic. For example, Ngongolo and Gayo (2020) observed that in Tanzanian and Kenyan border counties, small traders who maintained relationships with multiple suppliers or diversified their logistics options resumed operations faster than those dependent on single sources. Similarly, Gebremichael, Gebreslassie, and Mezgebe (2023) found that the ability to reconfigure routes and access alternative distribution networks contributed significantly to the resilience of supply chains in fragile contexts. These findings affirm the relevance of the Resource-Based View (RBV) theory, which posits that organizations derive sustainable advantage from rare and inimitable internal capabilities (Barney, 1991).

In the context of Kenya, resilience manifests not just as the ability to return to normal operations but also as the agility to exploit new opportunities during or after a disruption. For instance, some informal aggregators leveraged mobile platforms to pivot to direct-to-consumer sales during the pandemic, bypassing traditional wholesale channels that were temporarily blocked (Ishengoma, 2020). These shifts underscore that resilience is a dynamic attribute rooted in learning, adaptability, and resourcefulness. Despite its significance, the resilience of informal supply chains in Sub-Saharan Africa remains under-theorized and under-measured in empirical literature, warranting further research to quantify its role in shaping supply chain performance.

Performance of Informal Agricultural Supply Chains

Performance in informal agricultural supply chains is a multidimensional construct that encompasses not only economic outcomes such as profitability but also operational metrics such as delivery reliability, responsiveness to shocks, and access to markets. In Kenya, informal supply chains dominate the domestic food distribution system, especially for perishables like fruits, vegetables, and dairy. These chains are characterized by their speed, flexibility, and localized networks, but they are also prone to inefficiencies, lack of traceability, and high post-harvest losses (Thorpe et al., 2023).

Studies have shown that performance in informal supply chains is closely linked to the presence of digital tools and resilience mechanisms. Sokame et al. (2023) found that smallholder networks using mobile-based tracking systems were more likely to maintain or grow their transaction volumes during the pandemic, as they were better able to communicate with buyers, manage logistics, and reduce spoilage. On the other hand, chains that lacked redundancy or flexibility experienced prolonged downtimes and revenue losses. These outcomes demonstrate that performance is not determined solely by market demand or pricing, but by the interplay of digital capabilities and adaptive systems.

Furthermore, Gebremichael et al. (2023) emphasize that informal supply chain performance should be evaluated through metrics that reflect the realities of informal actors, such as stability of income, frequency of trading activity, and customer satisfaction. These outcomes reflect the resilience and traceability structures in place, suggesting that interventions targeting performance improvement must simultaneously enhance both digital and adaptive capacities. In a policy context, strengthening the performance of informal agricultural supply chains is vital for ensuring national food security, supporting livelihoods, and promoting equitable rural development.

Research Methodology

Research Design

This study employed a cross-sectional explanatory research design to examine the influence of mobile-based digital traceability and supply chain resilience capabilities on the performance of informal agricultural supply chains in Kenya. As noted by Saunders, Lewis, and Thornhill (2019), explanatory designs are appropriate for establishing cause-and-effect relationships between variables. The cross-sectional approach allowed data to be collected from a diverse set of supply chain actors at a single point in time, which was both time-efficient and suitable for a context where longitudinal tracking was impractical.

Study Area and Target Population

The research was carried out in four Kenyan counties: Kisii, Meru, Nakuru, and Machakos. These counties were purposively selected based on their active engagement in informal agricultural markets and their exposure to digital interventions post-COVID-19. The target population included smallholder farmers, informal traders and aggregators, transporters, and market vendors operating within agricultural supply chains. This population was selected due to its central role in Kenya's domestic food system, particularly in the distribution of horticultural, dairy, and cereal produce. Thorpe, Odame, and Kangai (2023) highlighted that these actors are often overlooked in formal agricultural policy yet are vital to urban food security and rural incomes.

Sampling Technique and Sample Size

A multistage sampling approach was adopted. Initially, purposive sampling was used to select the counties. Within each county, stratified sampling was used to group respondents by their role in the supply chain. Systematic random sampling was then applied within each stratum to select individual participants. This approach ensured representativeness across different supply chain functions. The sample size was determined using Yamane's (1967) formula for a known population. With an estimated population of 2,000 informal actors and a 5% margin of error, the required sample size was calculated to be 333. The study successfully surveyed 340 respondents, exceeding the minimum requirement and enhancing statistical power.

Data Collection Methods

Data collection was conducted using a structured questionnaire administered through face-to-face interviews. The questionnaire included closed-ended items and Likert-scale statements designed to measure the key variables. These items were developed based on existing instruments and adapted to reflect the local context. The questionnaire was pre-tested in a pilot study in Kiambu County, leading to minor adjustments for clarity and reliability. Interviews were conducted in either English, Kiswahili, or local languages, depending on participant preference, and were carried out with the assistance of trained enumerators. To supplement the survey data, semi-structured interviews were conducted with five key informants, including county agricultural officers and representatives from NGOs and digital traceability platforms.

Measurement of Variables

The independent variable, mobile-based digital traceability, was measured through indicators including the frequency of use of mobile tools, the ability to verify produce origin, and perceived usefulness of the traceability platform. These measures were adapted from studies such as Klibi, Shawa, and Mkansi (2022), who emphasized traceability as a critical enabler of supply chain visibility in African contexts. Supply chain resilience capabilities were measured through items assessing sourcing flexibility, response time to disruptions, and access to backup suppliers. This operationalization followed resilience frameworks developed by Gebremichael, Gebreslassie, and Mezgebe (2023). The dependent variable, performance of informal agricultural supply chains, was evaluated through delivery reliability, transaction stability, and market access—drawing on the work of Thorpe et al. (2023), who explored performance outcomes in Kenya's horticultural sector during the pandemic.

Data Analysis Techniques

Data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 26. Descriptive statistics were first computed to summarize the demographic and background characteristics of the respondents. This included frequencies, means, and standard deviations. Bivariate correlation analysis was then performed to assess associations among variables. Multiple linear regression analysis was used to test the hypothesized effects of mobile-based traceability and resilience capabilities on supply chain performance. According to Field (2018), regression analysis is appropriate for exploring causal effects and estimating the strength of predictive relationships. Internal consistency of scale items was assessed using Cronbach's Alpha, with all constructs achieving reliability coefficients above the accepted threshold of 0.70. Qualitative data from key informants were transcribed and analyzed thematically to provide explanatory insights and contextual validation for the quantitative findings.

Research Findings and Discussion

This section presents the findings of the study based on both descriptive and inferential statistical analyses. Descriptive statistics were used to summarize the demographic characteristics of the respondents and to explore patterns in responses related to mobile-based digital traceability, supply chain resilience capabilities, and supply chain performance. Inferential analyses, including Pearson correlation and multiple linear regression, were conducted to determine the nature and strength of relationships among the variables and to test the study hypotheses. Out of the 340 questionnaires distributed across the four counties—Kisii, Meru, Nakuru, and Machakos—a total of 317 were successfully completed and returned, yielding a response rate of 93.2%. This high response rate enhanced the reliability of the data and minimized the risk of non-response bias, consistent with standards for field-based studies in development contexts (Saunders, Lewis, & Thornhill, 2019).

Descriptive Analysis

Mobile-Based Digital Traceability

Descriptive statistics were used to examine respondents' perceptions of mobile-based digital traceability. The results, presented in Table 1, show that participants generally agreed with statements suggesting the value of digital traceability in improving transparency, coordination, and market access within informal agricultural supply chains. The mean scores ranged from 3.507 to 4.113, indicating moderate to high levels of agreement, while standard deviations ranged from 0.679 to 0.982, reflecting moderate response variation.

The highest-rated statement was, *"Mobile traceability improves my ability to verify product origin"* (Mean = 4.113, SD = 0.679), suggesting that traceability is seen as critical for transparency and trust. This aligns with findings by Sokame, Wamalwa, and Tonnang (2023), who observed that mobile verification tools enhance credibility in informal market transactions. The statement, *"Mobile systems help me access more reliable market information,"* also received strong support (Mean = 3.928, SD = 0.792), highlighting the role of traceability in reducing information asymmetry, a known barrier in informal economies (Klibi, Shawa, & Mkansi, 2022).

Conversely, the lowest-rated item was, *"I am satisfied with the digital traceability tools currently available to me"* (Mean = 3.507, SD = 0.982). This may reflect user frustrations with tool usability, limited coverage, or lack of technical support, which Thorpe, Odame, and Kangai (2023) identified as challenges in pilot traceability systems in Kenya. The relatively high standard deviation for this item also indicates divergent experiences among respondents, suggesting a need for more inclusive, user-centered technology design.

Overall, the data show that respondents generally perceive mobile traceability tools positively, especially in their capacity to enhance product verification and information access, but also express reservations about satisfaction and ease of use. These results underscore the importance of both technological availability and contextual usability in the success of digital interventions in informal supply chains.

Table 1: Descriptive Statistics for Mobile-Based Digital Traceability (n = 317)

Statement	Mean	Standard Deviation
I frequently use mobile tools to track produce movement in real-time.	3.764	0.812
Mobile traceability improves my ability to verify product origin.	4.113	0.679
I find mobile-based platforms easy to use for recording transactions.	3.589	0.954
Using mobile tools reduces disputes in pricing and quantity.	3.743	0.836
Mobile systems help me access more reliable market information.	3.928	0.792
I am satisfied with the digital traceability tools currently available.	3.507	0.982

Supply Chain Resilience Capabilities

To assess supply chain resilience capabilities, respondents were asked to rate six statements capturing various dimensions of resilience such as flexibility, adaptability, and redundancy. The results, shown in Table 2, indicate that participants generally reported moderate to high agreement with statements reflecting their ability to respond to and recover from supply disruptions. The mean scores ranged from 3.562 to 3.935, and the standard deviations varied between 0.688 and 0.922, suggesting relatively consistent responses across the sample.

The most strongly agreed-upon statement was *"I rely on networks or partnerships that support business continuity"* with a mean score of 3.935 and a standard deviation of 0.688. This emphasizes the importance of informal relationships and social capital in sustaining operations during shocks, a finding consistent with prior studies that highlight resilience as being deeply embedded in informal cooperation and community ties (Gebremichael, Gebreslassie, & Mezgebe, 2023).

Another highly rated item was *"I can easily switch suppliers when my main source is unavailable"* (Mean = 3.846), indicating that flexibility in sourcing is a commonly employed resilience mechanism among informal traders. Similarly, *"I am able to adjust product sourcing routes during disruptions"* (Mean = 3.803) reflects strategic adaptability—an attribute emphasized by Ngongolo and Gayo (2020) as key to resilience in volatile environments.

On the lower end, the statement *"I maintain informal inventory or storage buffers for emergencies"* had the lowest mean of 3.562 and the highest variability (SD = 0.922), suggesting that while some actors implement redundancy through storage, others lack the resources to do so. This variability may reflect disparities in capital, access to space, or perishability of produce, all of which influence the ability to maintain buffer stocks (Klibi, Shawa, & Mkansi, 2022).

Overall, these findings indicate that supply chain resilience among informal agricultural actors in Kenya is predominantly shaped by network reliance, adaptive sourcing, and distribution flexibility, though challenges remain in maintaining physical redundancies.

Table 2: Descriptive Statistics for Supply Chain Resilience Capabilities (n = 317)

Statement	Mean	Standard Deviation
I can easily switch suppliers when my main source is unavailable.	3.846	0.734
My business quickly recovers after a supply chain disruption.	3.679	0.851
I have access to alternative transportation or distribution channels.	3.718	0.765
I maintain informal inventory or storage buffers for emergencies.	3.562	0.922
I am able to adjust product sourcing routes during disruptions.	3.803	0.799
I rely on networks or partnerships that support business continuity.	3.935	0.688

Performance of Informal Agricultural Supply Chains

To evaluate the performance of informal agricultural supply chains, respondents rated six statements reflecting operational effectiveness, market access, customer satisfaction, and income stability. The findings presented in Table 3 indicate a moderate to high level of agreement across the items, with mean scores ranging from 3.618 to 3.856 and standard deviations between 0.725 and 0.882, suggesting a relatively consistent experience among respondents.

The highest-rated statement was *"My customers are satisfied with the quality and reliability of supply"* (Mean = 3.856, SD = 0.725). This suggests that despite operating in informal systems, many supply chain actors have succeeded in maintaining a dependable level of service. This finding aligns with Thorpe, Odame, and Kangai (2023), who noted that informal traders in Kenya have developed strong interpersonal relationships with buyers, compensating for the lack of formal contracts through consistent delivery and product quality.

Close behind was the statement *"My supply operations are consistently timely, even during disruptions"* (Mean = 3.794), indicating a degree of logistical reliability even under uncertain conditions. Such performance reflects the adaptive behaviors and informal resilience strategies identified in recent empirical studies (Gebremichael, Gebreslassie, & Mezgebe, 2023). Similarly, respondents expressed moderate agreement with *"My income from supply chain activities has remained stable or improved"* (Mean = 3.743), reflecting partial economic recovery in the post-COVID period.

The lowest-rated statement was *"I have experienced fewer post-harvest losses over the last year"* (Mean = 3.618, SD = 0.851), indicating that challenges in storage, preservation, and timely delivery persist. This mirrors concerns raised by Sokame, Wamalwa, and Tonnang (2023), who found that inadequate infrastructure and weak cold chain systems contribute to high food wastage rates in informal Kenyan markets.

Overall, the descriptive results suggest that while many actors in Kenya's informal agricultural supply chains are performing relatively well in terms of customer service and market engagement, significant barriers—especially around post-harvest management and income volatility—still constrain consistent performance.

Table 3: Descriptive Statistics for Performance of Informal Agricultural Supply Chains

Statement	Mean	Standard Deviation
My supply operations are consistently timely, even during disruptions.	3.794	0.813
I have maintained or increased trading volumes despite external shocks.	3.669	0.882
My customers are satisfied with the quality and reliability of supply.	3.856	0.725
I can reliably access urban markets with my produce.	3.721	0.797
I have experienced fewer post-harvest losses over the last year.	3.618	0.851
My income from supply chain activities has remained stable or improved.	3.743	0.778

Correlation Analysis

To assess the strength and direction of relationships among the three core variables—Mobile-Based Digital Traceability, Supply Chain Resilience Capabilities, and Performance of Informal Agricultural Supply Chains—a Pearson correlation analysis was conducted. The results are presented in Table 4.

The findings indicate that Mobile-Based Digital Traceability showed a strong positive correlation with Performance of Informal Agricultural Supply Chains ($r = .617$). This suggests that actors who adopt mobile traceability tools tend to perform better in terms of delivery reliability, transaction volume, and income stability. This result aligns with the work of Thorpe, Odame, and Kangai (2023), who found that informal horticulture traders using mobile platforms during the pandemic recovered faster and expanded market access more effectively than those using manual systems.

Similarly, a moderate and positive correlation was found between Supply Chain Resilience Capabilities and Performance ($r = .582$). This indicates that respondents with more robust resilience strategies—such as supplier redundancy, rapid response, and informal support networks—were more likely to report stable operations and customer satisfaction. The result supports the findings of Gebremichael, Gebreslassie, and Mezgebe (2023), who emphasized that resilience mechanisms are central to sustaining performance in volatile environments, especially within informal economies that lack formal safety nets.

All the observed correlations were statistically significant ($p < .01$), suggesting strong empirical support for the theoretical propositions linking digital tools and resilience capabilities to supply chain outcomes.

Table 4: Pearson Correlation Matrix

Variable 1	Mobile-Based Digital Traceability (r)	Supply Chain Resilience Capabilities (r)	Performance of Informal Agricultural SCs (r)
Mobile-Based Digital Traceability	1.000		
Supply Chain Resilience Capabilities	0.524 P=0.000	1.000	
Performance of Informal Agricultural SCs	0.617 P=0.000	0.582 P=0.000	1.000

The correlation findings confirm the interdependence between digital transformation, adaptive resilience, and performance in Kenya's informal agricultural supply chains. These relationships

provide a strong basis for further regression analysis to determine the predictive power of the independent variables.

Regression Analysis

Multivariate regression analysis was used to assess the relationship between the independent variables (*mobile-based digital traceability* and *supply chain resilience capabilities*) and the dependent variable (*performance of informal agricultural supply chains in Kenya*).

Table 5: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.686	.470	.467	.2920

The model summary was used to explain the proportion of variation in the dependent variable that could be accounted for by the independent variables. The R-squared value for the relationship between mobile-based digital traceability and supply chain resilience capabilities and the performance of informal agricultural supply chains was 0.470. This implies that 47.0% of the variation in performance could be explained by the two independent variables. The remaining 53.0% of the variation is attributed to other variables not included in this model.

Table 6: Analysis of Variance (ANOVA)

Model	Sum of Squares	df	Mean Square	F	Sig.
1	Regression	23.728	2	11.864	139.400
	Residual	26.716	314	0.085	
	Total	50.444	316		

a. Dependent Variable: Performance of informal agricultural supply chains in Kenya
b. Predictors: (Constant), Mobile-Based Digital Traceability, Supply Chain Resilience Capabilities

The ANOVA results were used to test whether the model was a good fit for the data. The calculated F-value was 139.400 and the p-value was 0.000. Since the F-calculated was greater than the critical F-value (not shown here) and the p-value was less than the significance level of 0.05, the model was considered a good fit for the data. Therefore, the model can be used to predict the influence of mobile-based digital traceability and supply chain resilience capabilities on the performance of informal agricultural supply chains in Kenya.

Table 7: Regression Coefficients

	Unstandardized Coefficients	**Standardized Coefficients**	**t**	**Sig.**
	B	Std. Error	Beta	
(Constant)	–0.223	0.184	–1.212	0.045
Mobile-Based Digital Traceability	0.444	0.034	13.044	0.000
Supply Chain Resilience Capabilities	0.369	0.034	11.016	0.000

The regression model was as follows:

$$\mathbf{Y = -0.223 + 0.444X_1 + 0.369X_2 + \varepsilon}$$

Where: Y = Performance of informal agricultural supply chains
X_1 = Mobile-Based Digital Traceability
X_2 = Supply Chain Resilience Capabilities
ε = Error term

According to the results, mobile-based digital traceability had a statistically significant effect on the performance of informal agricultural supply chains in Kenya ($\beta = 0.444$, $p = 0.000$). The relationship was considered significant since the p-value was less than the conventional alpha level of 0.05. These results support findings by Thorpe, Odame, and Kangai (2023), who found that mobile tools improve supply reliability and efficiency in Kenya's horticulture sector.

Similarly, supply chain resilience capabilities also had a statistically significant effect on performance ($\beta = 0.369$, $p = 0.000$). The relationship was significant at the 5% level, indicating that adaptive sourcing, redundancy, and network strength contribute to consistent operations. These findings align with Gebremichael, Gebreslassie, and Mezgebe (2023), who emphasized resilience as a core factor in sustaining performance in African agricultural systems.

Conclusion

This study examined the influence of two key factors mobile-based digital traceability and supply chain resilience capabilities on the performance of informal agricultural supply chains in Kenya. Drawing on data from 317 respondents across Kisii, Meru, Nakuru, and Machakos counties, the study employed descriptive, correlation, and regression analyses to assess the magnitude and direction of these relationships.

The findings revealed that mobile-based digital traceability significantly contributes to improved supply chain performance. Respondents who frequently used digital tools such as USSD codes, mobile apps, and SMS systems to record transactions and track produce origin demonstrated better outcomes in delivery timeliness, customer satisfaction, and income stability. The positive and statistically significant regression coefficient ($\beta = 0.444$, $p < 0.001$) affirmed that traceability enables actors to reduce information asymmetry, resolve disputes, and improve market access, particularly in environments lacking formal contracts or infrastructure.

Equally, the study found that supply chain resilience capabilities have a substantial effect on performance outcomes. Participants who reported flexible sourcing arrangements, rapid response mechanisms, and strong informal networks were more likely to sustain operations and retain customers during periods of disruption. The regression results ($\beta = 0.369$, $p < 0.001$) confirmed that resilience mechanisms—though often informal—are vital in enabling continuity and recovery, particularly in the face of challenges such as post-COVID economic shocks, market closures, or climate-induced disruptions.

Together, the two variables explained 47% of the variation in supply chain performance, underscoring their combined importance. The study concludes that enhancing performance in Kenya's informal agricultural sector requires a dual approach: integrating digital traceability tools to strengthen data visibility and accountability, while simultaneously building resilience capabilities to support flexibility, redundancy, and adaptation under stress. Both strategies are essential for enabling informal actors to transition toward more stable, efficient, and competitive supply chain systems.

Recommendations

Based on the empirical evidence drawn from this study, the following recommendations are made, aligned with the two independent variables: With respect to mobile-based digital traceability, it is recommended that the government and private sector invest in expanding access to low-cost, mobile-friendly traceability platforms designed for informal actors. Such systems should include multilingual interfaces, offline functionality, and integration with mobile payment solutions like M-PESA. Training and sensitization programs should also be deployed through farmer groups, cooperatives, and local market associations to enhance uptake and digital literacy.

Moreover, policymakers should support the scaling of digital traceability pilots into permanent national infrastructure, particularly for commodities with short supply cycles such as vegetables and dairy. Partnerships between agri-tech startups, local governments, and NGOs should be encouraged to ensure that traceability systems are context-specific and inclusive of marginalized rural traders and women-led businesses.

Regarding supply chain resilience capabilities, the study recommends that informal actors be supported through resilience-focused programs that promote supply diversification, logistical flexibility, and informal warehousing. Investments in communal storage, rural aggregation points, and flexible transport models such as motorcycle-based cold chains can strengthen actors' ability to maintain operations during supply disruptions.

In addition, local governments and development partners should promote the formation of community-based contingency networks including peer-to-peer trader alliances and micro-cooperatives that can share risks and pool resources during crises. Access to informal credit, digital forecasting tools, and alternative supplier databases can further enhance resilience.

Finally, future research should explore how the interaction between digital traceability and resilience evolves over time, particularly under recurring shocks such as floods, droughts, or global supply fluctuations. Longitudinal studies will offer deeper insights into how informal systems can transition into more formalized, adaptive networks that sustain performance in a dynamic and uncertain environment.

Suggestions for Further Studies

Future studies should consider adopting a longitudinal approach to assess the long-term impact of mobile-based digital traceability and resilience capabilities on supply chain performance. Researchers could also explore additional variables such as digital literacy, access to finance, or gender as mediators or moderators of these relationships. Expanding the study to other counties or countries and conducting commodity-specific analyses (e.g., dairy vs. horticulture) would offer more context-specific insights. Finally, using objective system data alongside self-reports and examining policy and institutional influences could strengthen future research outcomes.

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