Technological Capabilities Toward Food Security Outcomes in Emerging Economies: A Comparative Analysis of Innovation and Resilience in Nigeria

Peace Aludogbu
New Mexico State University

Rebecca Scott
New Mexico State University

This study aims to examine the impact of digital technologies and innovation on resilience and food security in the Nigerian agri-food sector. By examining these relationships, the study aims to determine how technology and innovation inputs shape the ability to adapt and rebuild outcomes in an emerging economy. With the use of quantitative design, the study analyzed national-level data from 2015 to 2023, with key variables such as "Digital technology, Innovation, Resilience, and Food security" all measured with multiple indicators. Multiple and simple linear regression were employed to test the direct relationships between the variables. Results present a complex characteristic of organizational and technological movements in emerging economies. Indicating that while infrastructure and innovation measures are necessary, systematic outcomes such as food security and resilience may sometimes depend on governance policy and implementations. It also highlights how institutions, such as governments, systems, and organizations, can effectively utilize these tools.

Keywords: technology, innovation, resilience, food security, Nigeria

INTRODUCTION

Food security is an ongoing discussion among scholars and practitioners, especially for emerging economies that are heavily reliant on food exports for revenue. Recent statistics indicate that over 240 million sub-Saharan Africans, one in every four people, do not have sufficient food. This large number highlights how important food security is as a foundation for the well-being of the people, economic growth, and national growth (Ogundipe et al., 2020). Food security is described as ensuring food availability, access, and price reduction, and it also emphasizes the need to meet the required nutritional standard. Usually, this involves the intake of adequate calories of about 2,200 to 2,300 a day for adult women and 2,900 to 3,000 for adult men. Although many children require fewer calories to maintain healthy development and growth (Thomas et al., 2023). Despite these nutritional criteria, about 40% of the Nigerian population still suffers from food insecurity, highlighting a significant gap between the dietary needs and the actual access Nigerians have to adequate nourishment (Thomas et al., 2023).

This does not apply to Nigeria alone; food insecurity remains a constant problem across many developing countries (Enilolobo et al., 2022). Between 1996 and 2000, about 840 million people were ranked undernourished according to global food statistics. Out of these, there are 11 million living in developed countries, 30 million in emerging economies, and 799 million in developing countries, as surveyed by the FAO in 2002 (Enilolobo et al., 2022). Over time, the issue of widespread nutritional shortage has worsened in Nigeria, with the average daily calories per person intake decreasing from 140 in the 1990s to an average of 37 by 2013, improving to 42 in 2016, according to World Development Indicators (2019) and Enilolobo et al. (2022). The agri-food global systems mostly face global policy changes, supply chain disruptions, global trade dynamics, and decreased agri-food productivity (Pathak, 2023). As a result of these challenges, some research has shown that the application of digital technologies, which are agri-food inclusive, is vital in improving efficiency, agri-food productivity, precision farming, and decision-making (Barki et al., 2024). Moreover, agri-tech firms are progressively pushing for the transformation of food systems and resilience (Klerkx & Villalobos, 2024). (Prasad et al. 2023) highlighted how the private and government stakeholders are expanding R&D and extension services in the agri-food sector to improve and empower manufacturers to utilize sustainable and adaptive agri-food strategies. In Nigeria, these technological innovation capabilities are increasingly seen as methods for achieving long-term food system stability.

Despite the growing interest and technology initiatives, Nigerian food security remains a growing concern, which is primarily affected by environmental, economic, and policy challenges. Onwe (2024) detailed the issues with dependency on food imports in Nigeria. The author stated that the government should issue and promote policies that are friendly towards domestic food production and reduce the importation of food. Akinkuolie (2025) and Eneh & Eneh (2025) also highlighted some of the recurring issues in agri-food. One of the problems faced by the Nigerian agri-food sector is the rural areas that engage in seasonal agricultural activities, which often encounter disasters such as droughts that can be mitigated through measures like real-time monitoring or forecasts (Akinkuolie, 2025; Eneh & Eneh, 2025). This issue highlights how fragile the agri-food system is in Nigeria. This indicates how fragile the agri-food system is in Nigeria. Calling for the demand and need for resilient and adaptive implementations that exceed short-term alleviation. Food insecurity is likely to continue if there is no consistent implementation and effort to improve national resilience, which will further weaken economic and social stability.

Looking at the intensity of these issues, this paper offers a macro-level method that offers an in-depth knowledge of the structures that shape food security in Nigeria. Onwe (2024) utilized national datasets to indicate the food security patterns that most research does not discuss, specifically discussions on infrastructure development, global dynamic trade policies, and the government's capacity. Furthermore, some researchers, such as Dong et al. (2025), described how the improvement and investment in digital technologies boost and support the local agri-food sector, with a significant impact that strengthens the regional and national food system resilience. Chukwuma (2024) also presents a geospatial hybrid food security index for Nigerian regions, pinpointing the importance of national-scale analysis for regional differences. Drawing on these studies, this study applies national data from 2015 to 2024 to examine how technological and innovative capabilities, alongside resilience, impact food security outcomes in Nigeria. Considering these challenges and opportunities, we seek to answer the following research question.

RQ: *To what extent do digital technologies driven by resilience and innovation improve food security in Nigeria?*

Grounded in Organizational Processing Theory (OIPT) and the Dynamic Capabilities Theory (DCT) (Galbraith, 1974; Teece et al., 1997), this study emphasizes the need for digital innovation capabilities as important tools to address informational uncertainty and operational instability that set apart food systems in emerging economies. OIPT describes how uncertainty can be reduced and improved through the management and processing of information that will yield improved decision-making, especially where agri-food disruptions and insecurity are high (Premkumar et al., 2005; Galbraith, 1974; Joshi et al., 2024). On the other hand, the Dynamic Capabilities Theory states the importance of unique and external resources, such as innovation, as practical drivers that help agri-food supply chain stages, such as the micro or macro levels, to build and adapt to disruptions (Eisenhardt & Martin, 2017; Ciasullo et al., 2025). The OIPT and DCT frameworks offer a foundational insight to determine how technology advancements and organizational responsiveness can shape outcomes in food security. In the Nigerian context, food insecurity results from many factors, such as climate change, lack of awareness, infrastructural limitations, digital limitations, and many more. These theoretical frameworks thus support the examination of resilience as a mediating variable linking digital tools to innovation to more available, accessible food systems.

To empirically examine this relationship, this paper thus proposes a conceptual model that connects digital technology (internet access, ICT services, smart farming), innovation indicators (extension services, agri-food R&Ds), and food security outcomes (per capita food supply, price, widespread hunger) through the mediating role of resilience. National-level data from FAOSTAT (FAO), the International Telecommunication Union (ITU), and the World Bank, ranging from 2015 to 2024, will be employed to demonstrate system-level dynamics and macro trends. The detailed framework is presented in the next section. With the integration of technological and adaptive capabilities into one framework, this study aims to contribute to the ongoing discussion not only on theory on food security but also to provide real-world actionable insights for policymakers, governmental bodies, and stakeholders who aim to improve national agri-food systems in emerging economies.

The paper is organized as follows: Section 2 details the theoretical framework and conceptual model, Section 3 describes the methods, Section 4 details the analysis employed in the paper, Section 5 demonstrates a detailed discussion, and Section 6 provides the conclusion.

THEORETICAL BACKGROUND

Organizational Processing Information Theory

Organizational Processing Information Theory (OIPT) lays a foundational framework to understand how organizations can respond to uncertainty in dynamic situations. OIPT was extended by Galbraith (1974), stating that a task that involves high uncertainty will require decision-makers to process a high amount of information throughout the task execution. On the other hand, tasks that are clearly defined and understood ahead of time will not require ongoing adjustments. However, when there is information uncertainty, more knowledge is needed, leading to shifts in how resources are allocated, goals are prioritized, and schedules are met (Galbraith, 1974). That is to say, when there is high uncertainty within the external factors, such as agri-food systems that face continuous challenges, making the food system a complex chain (Vasanthraj et al., 2025). OIPT thus recommends that organizations align their goals, systems, and decision-making to match the intensity of problems faced (Galbraith, 1974). According to Smyth et al. (2025), the authors highlighted that OIPT is primarily concerned with how organizations can build and utilize strengths to attain the information processing requirements. Now, in the context of the Nigerian agri-food system, where multiple disruptions can easily arise, such as climate change, vulnerability of the farmers to policy changes, and technology requirements are frequent, OIPT offers a guideline to understand how digital capabilities, information, and resilient measures can improve the Nigerian agri-food system for better food security outcomes.

Dynamic Capabilities Framework

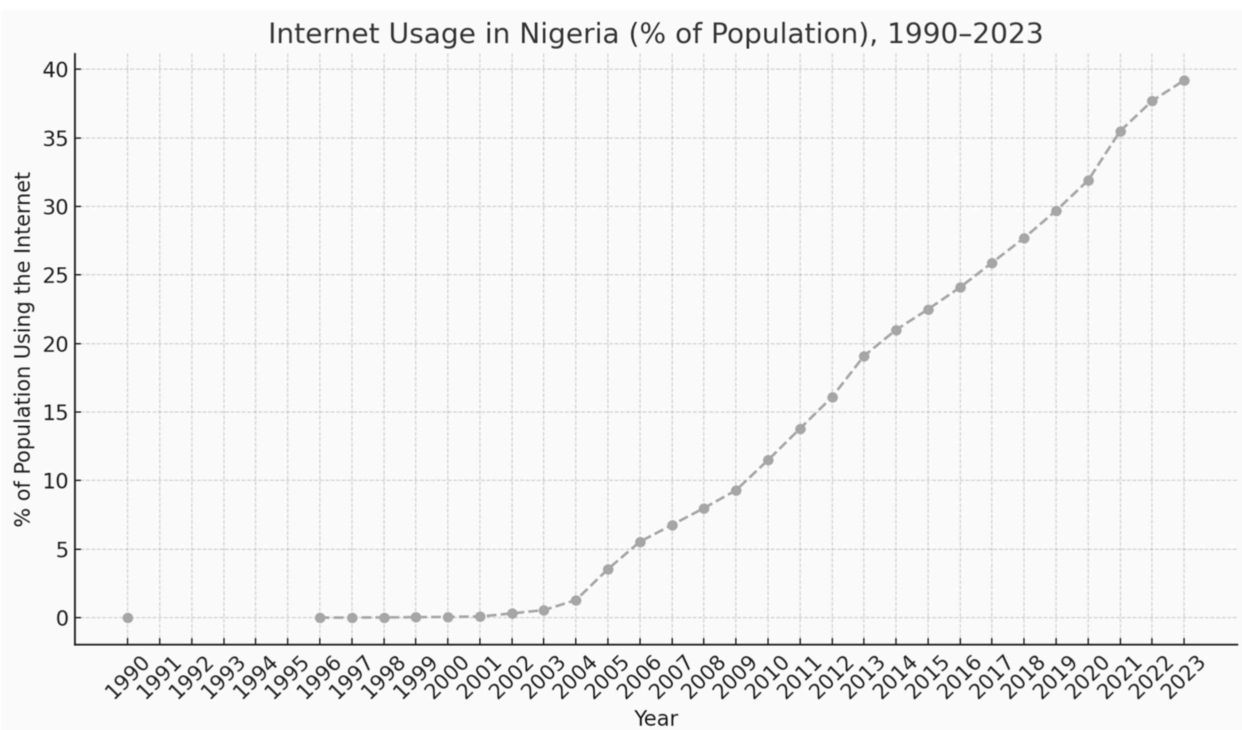
The Dynamic Capabilities framework is a distinct capability that firms possess that stands out and is hard for competitors to imitate, which helps Organizations respond to constantly changing customer needs and technological advancements (Teece, 2007). These distinct capabilities aid organizations in influencing the business environment, creating new services and products, and developing and implementing effective business models (Teece, 2007). Teece (2007) highlighted a model that assumes sensing, seizing, and transforming, applicable in the Nigerian agri-food system context, including climate impacts, innovation capabilities, digital infrastructure, policy dynamics, and more. Several recent studies have defined how these capabilities affect the Nigerian food system, Eneh & Eneh (2025), discussed how crop yield increases over time; however, food security suffers instability due to various factors such as unequal food allocation and land degradation, thus recommending that agri-food productivity is not enough to solve food security issues, highlighting how sensing and transformation practices can contribute to adaptation. Olaleye et al.

(2024) find that innovations are beneficial for improving business sustainability, further supporting the sizing and transformation aspects of the DCT model by Teece (2007).

Digital Technologies in Agri-Food Systems

Digital technologies are continually demonstrating how it can improve the AFSC. Panigrahi et al. (2025) described that recent technologies in the AFSC, such as AI, IOT, blockchain, big data analytics, cloud computing, and sensor technologies, are shaping the food systems by enhancing efficiency, traceability, and responsiveness. These technological advancements address continuous issues in the food systems, such as food safety, food security, and quality. Panigrahi et al. (2025) further listed technologies like deep learning and machine learning that support resource use, better crop selection, and yield forecasting, water and waste management. Together, the technologies improve the agri-food supply chain performance and sustainability. The agri-food systems are rapidly evolving with digitalization, integrating robots, intelligent systems, and sensors into farm operations (Konfo et al., 2023). As the AFSC grows dynamically, risks like food fraud, non-traceable processes, contamination, and inadequate information sharing threaten market stability and public safety. Therefore, applying Industry 4.0 digital tools reduces waste and improves logistics and traceability, which are necessary for high-quality and safe food (Plakantara & Karakitsiou, 2025). These technological advancements support sustainability goals by enabling adequate and optimum resource usage and advancing circular practices in the AFSC (Yu et al., 2025). These studies further strengthen the recommendation that digital technologies can enable dynamic resources and tools that reduce uncertainty. For Nigeria, measuring indicators such as internet usage and access, market data, and digital services might link digital adoption to food security outcomes.

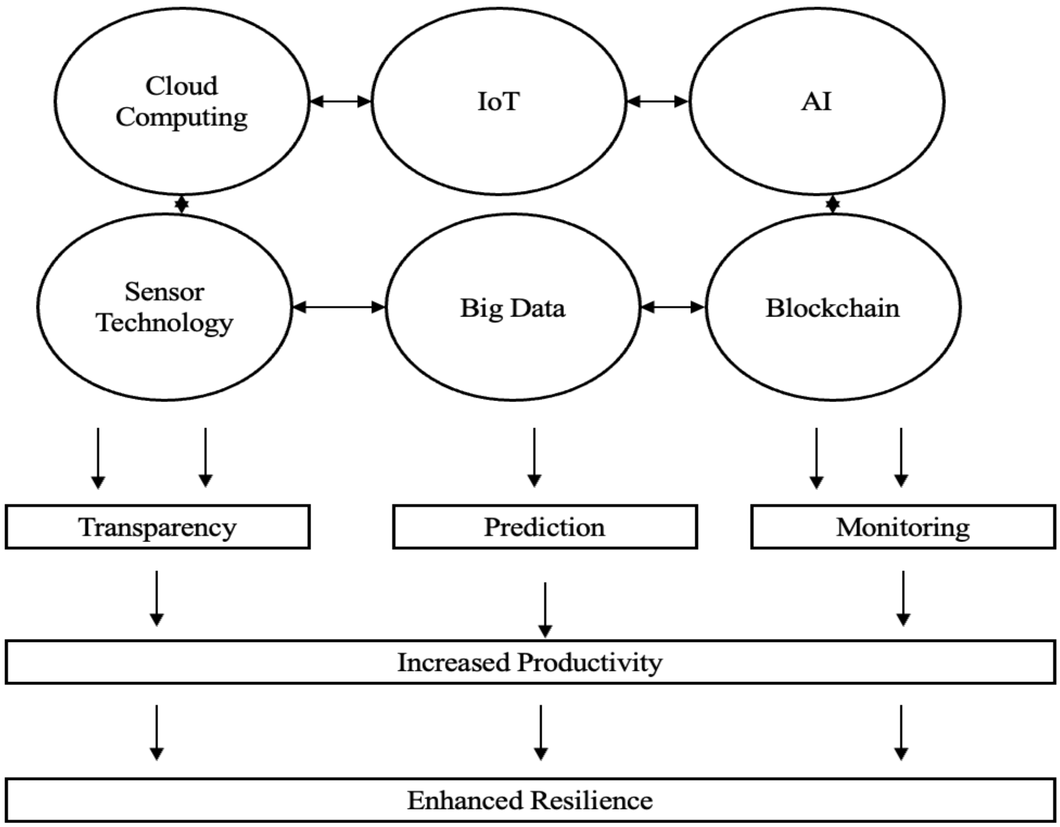
FIGURE 1
USAGE IN NIGERIA (1990-2023)



Source: World Bank (2023), based on data from the International Telecommunication Union (ITU), *World Telecommunication/ICT Indicators Database*.

The usage and adoption of digital technologies in Nigeria have improved over the past two decades. As shown in Figure 1, internet access and use grew from 0% in the 2000s to over 38% access and use in 2023 (World Bank, 2023). This shows that Nigerians are ready to adopt and use digital technologies, a strong indicator to implement and expand digital technology in the Nigerian agri-food system. Figure 2 summarizes some of the digital technologies explored in the AFSC.

FIGURE 2
DIGITAL TECHNOLOGIES IN AGRI-FOOD SUPPLY CHAIN



Source: Authors own work

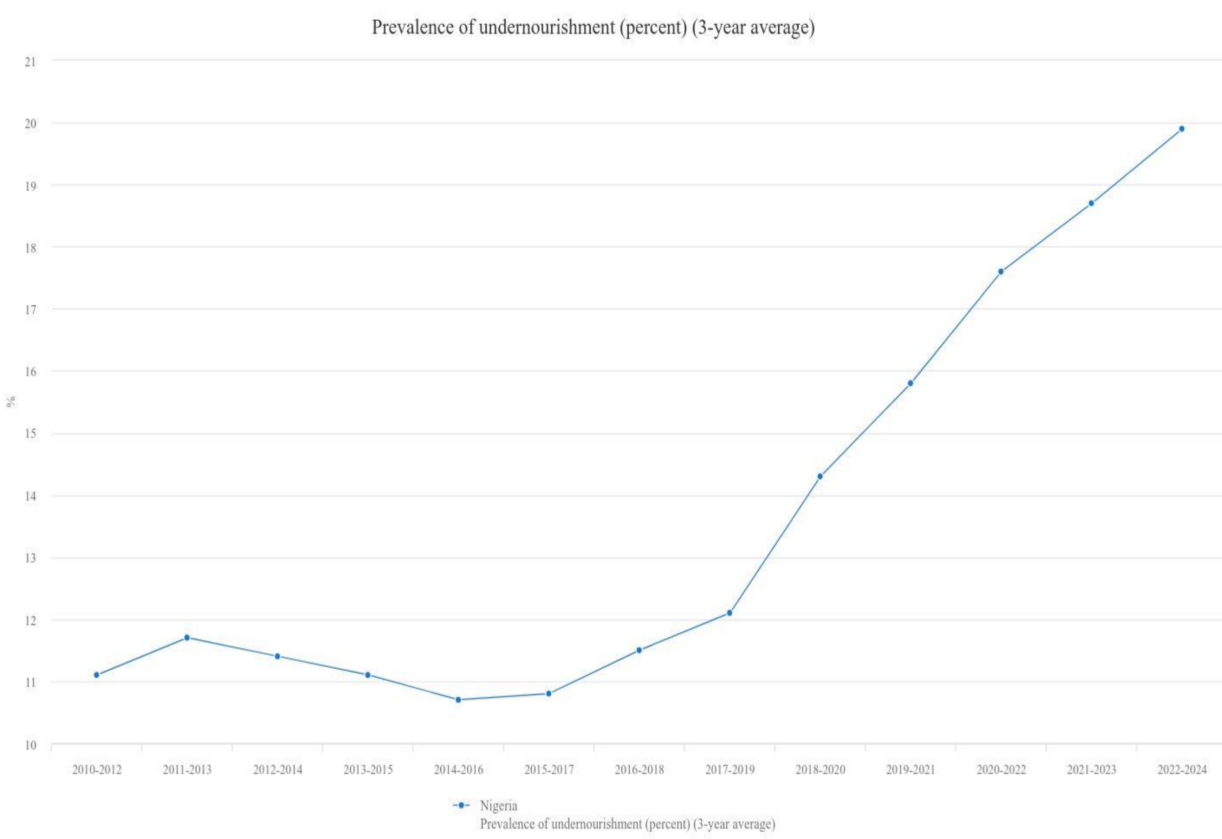
Innovation and Food Systems Transformation

Innovation is important in any organization or system, especially in dynamic environments. Innovation can be defined in multiple ways; however, innovation in the agri-food system can not be defined solely by novelty, but by how stakeholders or producers perceive the newness of the outcome, where an idea or process may be seen as standard by some and transformative by others (Charatsari et al., 2022). As noted in the 5th SCAR report, innovation has the potential to ensure sustainable and healthy food, advancing circular and resilient agri-food systems (Charatsari et al., 2022). An important aspect of digital innovation is improving the connection between consumers and producers through advanced and innovative applications, personalized food products, and transparent feedback information. This will create an avenue for requirements, preferences, and facilitating both farm-to-fork and fork-to-fram flows, the traditional flow of the AFSC, and the reverse flow of information (Vahdanjoo et al., 2025). Many innovative digital technologies, such as AI, IoT, Digital Twins, and precision agriculture, transform traditional agri-food practices by improving productivity, minimizing environmental footprints, and enabling informed data usage and sharing with better data-driven decisions across the food systems (Finger, 2023). Innovation is not just about advancing knowledge and change, but a strategic move for transforming the agri-food systems, especially in emerging economies.

Resilience in Food Systems

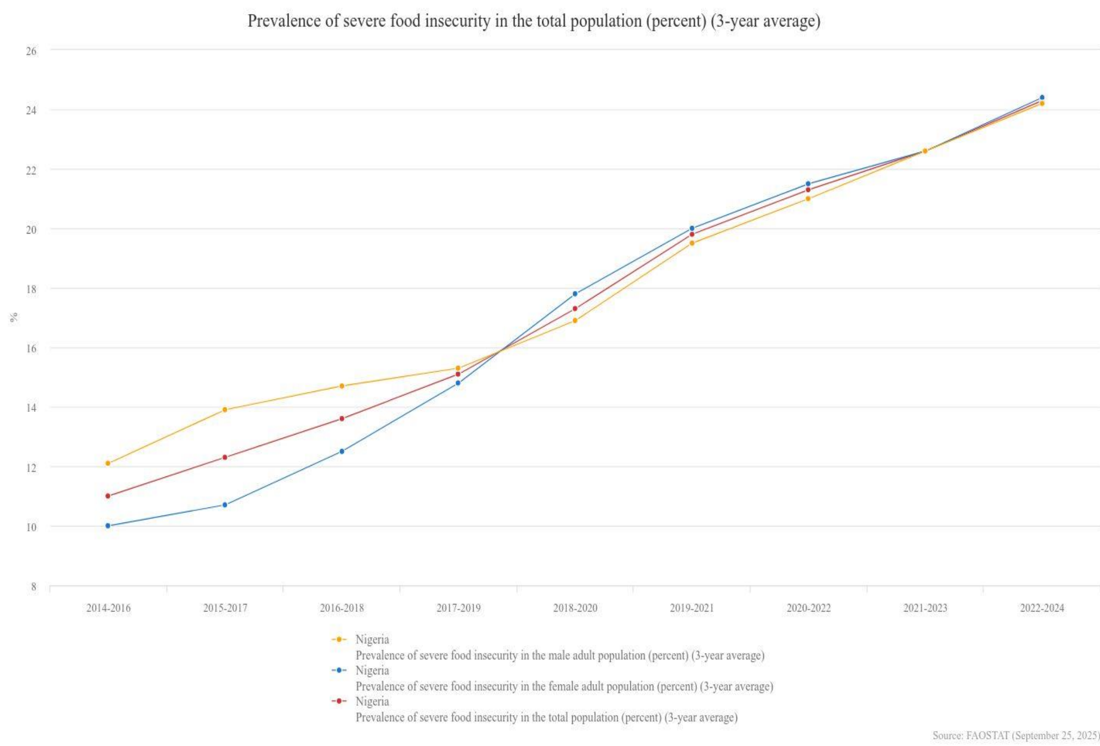
Supply chain resilience was derived from social psychology theory, which refers to a supply chain's ability to recover, bounce, and adapt to future disruptions (Ghobakhloo et al., 2023). GAIN (2025) describes resilience in food systems as the ability of the agri-food system to combat, transform, and adapt in response to dynamic shocks while ensuring the stability of important functions and sustaining food security. As global economic policies and climate change increase (Huang et al., 2025), the Nigerian food system needs tougher, resilient measures. The FAOSTAT figures highlight food insecurity trends, such as the undernourishment rate, which went from 11% in the 2010s to approximately 20% between 2022 and 2024, as seen in Figure 3. While 24% of the Nigerian population suffers from severe food insecurity, detailed in Figure 4, and 75% are affected with moderate food insecurity. Severe food insecurity is highlighted in Figure 5. These data show the food system is highly affected by repeated supply chain disruptions, climate shocks and impacts, and structural inadequacies. In the context of Nigeria, adaptive capacities are constrained by a lack of proper policy, limited infrastructure and access to finance, and insufficient awareness and education of the population (Akinkuolie et al., 2024). To enhance and rebuild resilience, strategies must be implemented to integrate social protection, smart farming, precision agriculture, real-time monitoring, and governance that can quickly bounce back from shocks (Knorr & Augustin, 2025; Huang et al., 2025).

FIGURE 3
TRENDS IN UNDERNOURISHMENT IN NIGERIA



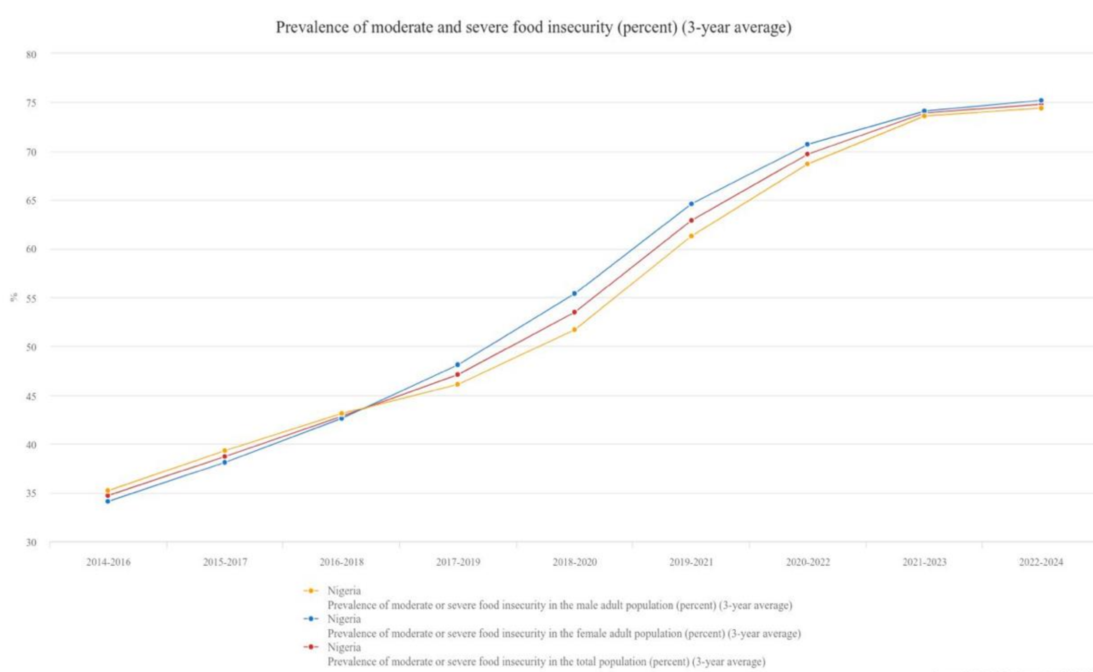
Source: FOASTAT

FIGURE 4
SEVERE FOOD INSECURITY IN NIGERIA



Source: FAOSTAT

FIGURE 5
MODERATE AND SEVERE FOOD INSECURITY IN NIGERIA

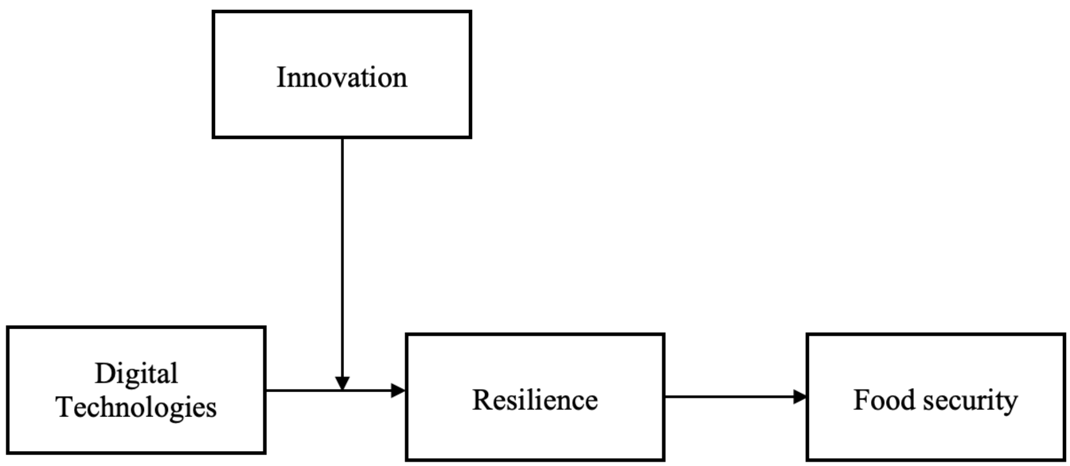


Source: FAOSTAT

Linking Technological Capabilities to Food Security Outcomes

Given the continuous need for improvement and checks in the food system, more research is going into how digital technologies, combined with innovation, are an important factor in enhancing food security through better, more resilient food systems. Despite the digital and innovative potential, such as drones, smart farming tools, and mobile agr-food strategies, it remains limited in Sub-Saharan Africa (Mekonnen et al., 2024). Innovations at the farm level, like precision agriculture, smart sensors, and digital tools, improve food transparency and traceability, logistics, and information sharing (Wolfert et al., 2023). A strategic focus is on food waste reduction, improved and trackable packaging, and agricultural R&D that can further strengthen food systems (Von Braun et al., 2023). These challenges are also mostly linked, requiring a coordinated response to drive meaningful change (Vignola & Oosterveer, 2025). The advancement of technological implementation in the agri-food system is important for improving employment, productivity, and long-term food security (Kapari et al., 2023). These studies further support the conceptual model, as illustrated in Figure 6, which links digital technologies and innovation to resilience, thereby advancing food security outcomes.

FIGURE 6
CONCEPTUAL MODEL



Source: Authors own work

METHODOLOGY

Research Design

This study employs a macro-level comparative quantitative research design to examine how digital technological capabilities and innovation impact food security outcomes, with the mediating role of resilience, in Nigeria. National-level data are used to describe relationships and systematic trends spanning from 2015 to 2024.

Variables and Data Sources

Data are sourced from national open databases, including the World Bank, the Food and Agriculture Organization (FAOSTAT), Agricultural Science and Technology Indicators (ASTI), the Global Innovation Index (GII), and the International Telecommunication Union (ITU). The data will be collected according to four important variables:

Digital Technology: This key variable is measured by two indicators, which are the average internet usage and ICT services. These indicators will be collected from the World Bank and ITU (World Bank, 2023; International Telecommunication Union, 2024).

Innovation: The variable "innovation" will be measured using Agriculture Research & Development (R&D) expenditure (% of GDP), extension services such as training, sustainability measures, market and supply chain support, as well as the number of agri-tech startups (patent applications) in Nigeria. These data collections will be sourced from the following sources: FAO (2023), World Intellectual Property Organization (2024), and National Bureau of Statistics (2022).

Resilience: The implementation of food system indicators such as frequency of production shocks, cereal import dependency ratio, and cereal yield (kg/ha). Sourced from FAOSTAT (FAO, 2023).

Food Security: Food security in Nigeria is evaluated through food supply per capita, food price inflation, and prevalence of undernourishment, sourced from (FAOSTAT, World Bank) (FAO, 2023; World Bank, 2023).

Sampling and Data Analysis Technique

This paper adopts a robust empirical approach, utilizing SPSS Version 31, which is selected for its ability to perform diagnostics for statistical assumptions and conduct multivariable regression analysis (Field, 2022). We first employed descriptive statistics (Mean, Median, Standard Deviation, and Range) to summarize variability and trends in the data, followed by a Pearson correlation analysis to determine the bivariate relationships between the key variables. Finally, a linear regression analysis is used to indicate the predictive relationships between the variables "digital technology, innovation, resilience, and food security outcomes." This analysis is conducted using data that spans from 2015 to 2024, providing a robust timeframe for evaluating long-term trends. The unit of analysis is the country-level performance of the Nigerian agri-food system. The use of linear regression, performed using the software SPSS, was selected for its capability in testing a statistically significant association between continuous, interval-scaled variables. Regression examines the estimation of how independent variables in this paper (Digital technology, Innovation) contribute to the dependent variable (Food security), both directly and through the mediating pathway (Resilience) (Hair et al., 2021; Pallant, 2020). That is how or why digital technology and innovation affect an outcome (Food security).

ANALYSIS AND RESULTS

This section presents the structure and results of the empirical analysis conducted using SPSS version 31.1. The analysis includes descriptive statistics, Pearson correlation, and linear regression to evaluate and determine the relationships between digital technology, innovation, resilience, and food security in Nigeria using national-level data from 2015 to 2024.

Descriptive Statistics

Table 1 presents the descriptive statistics for the study variables from 2015 to 2023 (N = 9). Each variable had multiple indicators, which we used to analyze the national-level data. For Digital technology, the average internet usage is 30.47%, with a range of 16.71 and a Standard deviation of 6.01, suggesting moderate variation over the years. The mean value for ICT services is 4.27% of total services. For Innovation, agri R&D expenditure turned out low with a mean value of 0.09% and a high number of frequency zero values, indicating a lack of expenditure on agricultural research and development, while patents, which are used as a proxy for the number of agri-tech startups, had a mean of 157.33%, standard deviation 194.03, and a range of 439. For Resilience-related indicators, cereal yield had a mean of 1584.4kg/ha (Kilograms/Hectare), with a stable range of 153.60.

In contrast, the mean of production shocks showed a mean of 107.49, indicating moderate fluctuations. In contrast, the cereal import dependency had an average of 7.59% and zero dependency in more than half of the observations. The food security variable, with three indicators, shows that food price inflation averaged 15.38%, and the per capita food supply averaged 17.33kg/capita/day, with a range of 36, showing the changes in food availability over the years. The prevalence of undernourishment, with a mean of 12% indicates that about 12% of the Nigerian population was undernourished across the observed years. The prevalence of undernourishment indicator also had a standard deviation of 5.26 and a range of 18, indicating that some years experienced worse hunger levels, while others were slightly better. This variation could be attributed to policy changes, climate effects, conflict, and economic shocks, providing the gap for further analysis.

TABLE 1
SUMMARY OF DESCRIPTIVE STATISTICS (2015-2023)

Key Variables	Indicators	Mean	Median	Std. Dev	Range	Min	Max	Years Observed
Digital Technolgy	Internet Usage	30.47	29.70	6.01	16.71	22.50	39.21	2015-2023
Digital Technology	Ict Services	4.27	4.28	1.03	3.32	2.44	5.77	2015-2023
Innovation	Agricultural R&D (%)	0.10	0.00	0.20	0.55	0.00	0.55	2015-2023
Innovation	Patents Applications	157.33	85.00	194.03	439.00	0.00	439.00	2015-2023
Resilience	Cereal Yield (Kg/ha)	1584.40	1596.90	53.05	153.60	1506.10	1659.70	2015-2023
Resilience	Cereal Import Dependency	7.59	0.00	9.01	17.60	0.00	17.60	2015-2023
Resilience	Production Shocks	107.49	107.56	2.80	7.89	103.45	111.34	2015-2023
Food Security	Food Price Inflation	15.38	15.70	4.66	15.65	9.01	24.66	2015-2023
Food Security	Prevalence of Undernourishment	12.00	11.80	5.26	18.00	0.00	18.00	2015-2023
Food Security	Per Capita Food Supply	17.33	12.00	15.48	36.00	0.00	36.00	2015-2023

Pearson Correlation

Table 2 presents the Pearson correlation coefficients for the key variables of the study, which include digital technology, innovation, resilience, and food security, with indicators from 2015 to 2023. The bivariate correlations provide preliminary insights into the direction and strength of the linear relationship between the variables, using a significance threshold of $p < .05$. Significant relationships were observed among specific variable indicators. Internet usage showed a positive correlation with production shocks ($r = .93$, $p < .01$), indicating that increased internet connectivity is associated with a higher number of reported production shocks. This suggests that good internet connectivity facilitates the detection and reporting of more information about challenges in food production systems. Contrarily, internet usage was negatively correlated with cereal import dependency ($r = -0.85$, $p < .01$) and per capita food supply, indicating a negative relationship.

Per capita food supply refers to the average amount of food available for each person in a given population over a specific period (kg/capita/year), and was negatively correlated with production shocks ($r = -.90$, $p < .01$) and cereal import dependency ($r = -.96$, $p < .001$), this suggests that food availability tends to be linked with reduced import dependency and little to no production disruptions. Internet usage and food price inflation showed a moderate positive correlation ($r = .74$, $p < .05$), suggesting a possible connection between digital access and food price dynamics. Innovation indicators, specifically agricultural R&D, were negatively correlated with ICT services ($r = -0.73$, $p < .05$), whereas patent applications did not show a statistically significant relationship. The prevalence of undernourishment did not show a significant correlation with any of the key variable indicators, which suggests that this indicator may be influenced by other factors not fully captured in the model.

TABLE 2
CORRELATION MATRIX AMONG KEY VARIABLE INDICATORS

Variable Indicators	1	2	3	4	5	6	7	8	9	10
Internet Usage (%)	–	.56	.34	.21	.47	.74*	–.85**	.93**	–.85**	.14
ICT Services (% exports)		–	.45	–.73*	.33	.25	.16	.35	.28	.18
Patent Applications			–	.51	.44	.41	.12	.46	.23	.27
Agri. R&D (% of GDP)				–	.31	.08	.25	.32	.18	.33
Extension Services					–	.29	.17	.21	.22	.11
Food Price Inflation (%)						–	–.64	.60	–.57	.04
Cereal Import Dependency (%)							–	–.88**	–.96***	.05
Production Shocks (count)								–	–.90**	.03
Per Capita Food Supply (kg/day)									–	.02
Prevalence of Undernourishment (%)										–

*Note. *p < .05; **p < .01; ***p < .001. Values represent Pearson correlation coefficients between the indicators of digital technology, innovation, resilience, and food security.*

Linear Regression

In Model 1, resilience was predicted from innovative digital technology using multiple linear regression to examine whether innovation and digital technology predict resilience. The model was not statistically significant. $F(2, 6) = 0.914$, $p = .450$, indicating that even with the combination of digital technology and innovation variables, there was no significant variance in resilience. The model accounted for 23.4% of the variance in resilience ($R^2 = .234$); however, the adjusted R^2 turned out to be negative (-.022), suggesting that there is limited explanatory power due to the sample size. Digital technology ($\beta = .457$, $p = .253$) and Innovation ($\beta = .246$, $p = .522$) did not emerge as significant predictors of resilience. While digital technology and innovation had positive beta weights, it were not statistically significant, likely due to overlapping variance or a small sample size. A simple linear regression was performed in model 2 to determine if resilience significantly predicts food security. However, the results showed that the model was not statistically significant. $F(1,7) = 1.200$, $p = .310$. The model accounted for 146% of the variance in food security ($R^2 = .146$), with an adjusted R^2 of .024. The coefficient for resilience was not significant ($\beta = -.383$, $p = .310$), indicating that resilience does not predict food security in Model 2. Although model 2 is not statistically significant, the negative β coefficient suggests an inverse relationship between resilience and food security, meaning that when resilience increases, food security decreases, and vice versa.

TABLE 3
SUMMARY OF REGRESSION RESULTS

	Predictors	B	SE	β	t	p
Model 1: Predicting Resilience						
	Digital Technology (DigitalTeach_Mean)	3.370	2.668	.457	1.263	.253
	Innovation (Innovation_Mean)	0.061	0.090	.246	0.680	.522
	R^2					.234
	Adjusted R^2					-.022
	F(2, 6)					0.914 (p = .450)
Model 2: Predicting Food Security						
	Resilience (Resilience_Mean)	-0.112	0.102	-.383	-1.095	.310
	R^2					.146
	Adjusted R^2					.024
	F(1, 7)					1.200 (p = .310)

*Note. B = Unstandardized Coefficients; SE = Standard Error; β = Standardized Coefficients. Model 1 predicts Resilience using Digital Technology and Innovation. Model 2 predicts Food Security using Resilience. Significance levels: *p < .05, **p < .01, ***p < .001.*

DISCUSSION

In this study, we examined how digital technology and innovation influence resilience, and how resilience affects food security outcomes in the Nigerian agri-food system. The descriptive statistics results showed a general positive trend across digital access (internet usage) and food per capita supply, whereas the regression analysis revealed a different pattern. In Model 1, we found that digital technology and innovation were positively predicted by resilience; however, the relationship was not statistically significant, suggesting that while digital technology and innovation may theoretically improve a system's ability to overcome shocks, some contextual factors may influence how resilience is applied in practice.

It is interesting to note that the beta weights still align with the expectations from the OIPT and Dynamic Capabilities framework. Model 2 revealed a negative but nonsignificant relationship between resilience and food security. This inverse relationship invites further examination of how resilience is operationalized and whether current resilience strategies are sufficient for stability, availability, and food access. These findings present a complex characteristic of organizational and technological movements in emerging economies. Indicating that while infrastructure and innovation measures are necessary, systematic outcomes such as food security and resilience may sometimes depend on governance policy and implementations, socio-environmental conditions, and institutional capacity.

Theoretical Implications

The study's findings contribute to the theory by extending the OIPT and the Dynamic Capabilities framework into the agri-food context of emerging economies. The OIPT provides a guideline for understanding that access to timely and relevant information helps reduce uncertainty and enables effective responses and adaptation to disruptions in organizations (Daft & Lengel, 1986; Galbraith, 1973). We found that although internet usage did not significantly predict resilience, the positive coefficients align with the OIPT standpoint, which is that good connectivity supports better information flows and decision-making in the AFSC. It is therefore noteworthy to understand that the results that are not significant indicate that connectivity alone cannot foster resilience, except when accompanied by enabling drivers or structures, such as institutional support or organizational strategies and implementations (Tushman & Nadler, 1978). The study also contributes to the relevance of Dynamic Capabilities Theory, which states that the utilization of internal and external resources enables adaptation to dynamic changes (Teece, 2007). The results showed that innovation, measured through agricultural R&D and patents indicators, had no significant effect on resilience or food security. This suggests a gap in understanding how innovation contributes to functional dynamic capabilities, due to limited capacity or weak institutional infrastructure (Eisenhardt & Martin, 2000; Zollo & Winter, 2017). The inverse relationships between resilience and food security provide new insight into the notion that resilience constantly improves security.

Practical Implications

This study provides guidelines for policymakers, agri-food stakeholders, development agencies, and government agencies working to strengthen and improve food systems in resource-constrained situations, such as Nigeria. The variables that were not significant between digital technology, as measured by internet usage, and resilience suggest that expanding digital infrastructure may not be enough to improve adaptive capacity. This highlights the importance of physical access and the functional integration of digital tools in coordinating, making decisions, and communicating within the Agri-food supply chain. Global reports have shown that digital transformation in the AFSC requires investments in digital literacy, training, creating awareness, and a service delivery mechanism (FAO, 2023; Cruz, 2024). For example, ICT services should have broader systems that offer real-time weather forecasts, agri-food support, and market price dynamics reports to enable the generation of solid resilience at the farm and local cooperative levels. Furthermore, innovation measured by agricultural R&D and agri-tech activity (patents) is most times promoted as an enabler of transformation, but it is not statistically significant in predicting resilience or food security, which indicates a gap between the impact of field-level impacts and innovation inputs. Development strategies and implementations should represent decentralized innovation models and boost agricultural extension services, which are known to transform research into real-life usable practices for smallholders (Aker et al., 2016). In conclusion, the findings encourage a more balanced approach that combines inclusive innovation, digital tools, and localized resilience-building into a unified method for food systems.

CONCLUSION

This paper examined the relationship between digital technology, innovation, and food security, with resilience as a mediating factor in the Nigerian agri-food system. We used a decade of national-level data spanning from 2015 to 2023, and the analysis presented different dynamics. While some variables using certain indicators were not statistically significant, this raises important theoretical and situational considerations within the agri-food research stream. Given that Nigeria is a developing country, one would expect certain developments in specific sectors; however, the opposite is the case. Digital technology and innovation alone may not be enough to foster meaningful growth in the food systems, especially in a resource-constrained environment. These insights emphasize the need for a better understanding of context and a holistic approach to the adoption of technology and food system development in emerging economies, taking into consideration the level of knowledge the population has in specific domains.

LIMITATIONS

This paper acknowledges several limitations. First, the study relies on national-level secondary data, which might mask the differences that exist within a single country, in this case, Nigeria. for example, differences between the north, south, east, and west regions, as well as between urban and rural areas, in terms of access to digital tools, innovation implementation, availability, and access to food. This limits the generalizability of the findings to local contexts, where the impacts of resilience and technology use and adoption may differ significantly. Second, the indicators used to measure innovation and resilience were limited due to data availability. For Innovation, we were limited to Agricultural R&D up to 2016, with no specific agri-tech startups; thus, we replaced it with patents filed up to the year 2020. For resilience, indicators of cereal yield were aggregated across cereals, with no specific crop performance data, and production shocks had no direct measure of shocks (e.g., floods, droughts), causing a lag in real-time disruptions. Digital technology, with indicators of internet usage, may not have captured speed, quality, or access equity (urban vs. rural), while ICT services measure trade output, not household penetration or infrastructure. Third, the study employed a linear regression, which does not account for non-linear effects, which are common in complex systems such as food security and the agri-food supply chain. That is to say, the agri-food supply chain does not always behave in a linear manner; a small change in rainfall may have a significant impact in one region but no impact at all in another region. Using this method may have contributed to why some of the results were not significant.

FUTURE RESEARCH

To generalize this study and obtain different results, future research should consider a mult-level and mixed-methods approach to better capture the evolving nature of agri-food systems. Household-level surveys or Sub-national studies may offer more insights and details on how resilience and innovation differ in diverse regions. The use of other mediating or moderating variables, such as social capital, government aid, literacy, and access to extension services, might shape the link between innovation and food systems outcomes. Furthermore, future research could integrate system dynamics models, such as using simulations, to examine how things change and how feedback loops work in different regions and contexts. Additionally, the use of qualitative case studies, such as interviews and observations, to better understand outcomes that are not solely caused by one factor but by a combination of multiple influencing factors, as well as community-specific solutions. Comparative study across countries with similar development contexts or better situational factors. Lastly, actively involving local communities and farmers in the design, planning, and execution of research, not solely as subjects, but as collaborators in the research and development process. This will ensure that any technology or process aligns with reality and addresses the actual problems being faced.

REFERENCES

Aker, J.C., Ghosh, I., & Burrell, J. (2016). The promise (and pitfalls) of ICT for agriculture initiatives. *Agricultural Economics*, *47*(S1), 35–48.

Akinkuolie, T.A., Ogunbode, T.O., & Adekiya, A.O. (2025). Resilience to climate-induced food insecurity in Nigeria: A systematic review of the role of adaptation strategies in flood and drought mitigation. *Frontiers in Sustainable Food Systems*, *8*, 1490133.

Alam, G.M., Khatun, M.N., Sarker, M.N.I., Joshi, N.P., & Bhandari, H. (2023). Promoting agri-food systems resilience through ICT in developing countries amid COVID-19. *Frontiers in Sustainable Food Systems*, *6*, 972667.

ASTI. (2023). *Agricultural R&D indicators: Nigeria*. Agricultural Science and Technology Indicators (ASTI), International Food Policy Research Institute (IFPRI). Retrieved from https://www.asti.cgiar.org

Barki, K., & Rachmah, M.A. (2024). Systematic literature review: Agricultural digitalization, technological transformation towards efficient and sustainable agriculture. *Journal of Agriculture Faculty of Ege University, 61*(2), 259–271.

Benfica, R., Chambers, J., Koo, J., Nin-Pratt, A., Falck-Zepeda, J., Stads, G.J., & Arndt, C. (2023). Food system innovations and digital technologies to foster productivity growth and rural transformation. *Science and Innovations for Food Systems Transformation*, 421.

Charatsari, C., Lioutas, E.D., De Rosa, M., & Vecchio, Y. (2022). Technological innovation and agrifood systems resilience: The potential and perils of three different strategies. *Frontiers in Sustainable Food Systems, 6*, 872706.

Chukwuma, E.C., Afolabi, O.O.D., Okonkwo, C.C., Olamigoke, O.O., & Okonkwo, C.E. (2024). Application of geospatial technology and decision model in the development of improved food security index. *Scientific Reports, 14*(1), 30204.

Ciasullo, M.V., Ferrara, M., & Lim, W.M. (2025). Dynamic capabilities and data-driven culture for digital transformation: Evidence from agri-food SMEs. *British Food Journal*.
Cruz, M. (2024). *Digital opportunities in African businesses*. World Bank Publications.
Daft, R.L., & Lengel, R.H. (1986). Organizational information requirements, media richness and structural design. *Management Science, 32*(5), 554–571.
Dong, Y., Qi, C., Gui, C., & Yang, Y. (2025). Spatial spillover effects of digital infrastructure on food system resilience: An analysis incorporating threshold effects and spatial decay boundaries. *Foods, 14*(9), 1484.
Eisenhardt, K.M., & Martin, J.A. (2017). Dynamic capabilities: What are they? In *The SMS Blackwell handbook of organizational capabilities* (pp. 341–363).
Eneh, C.A., & Eneh, O.C. (2025). A system dynamics analysis of agricultural practices and food security in Nigeria. *Journal of Health, Population and Nutrition, 44*(1), 285.
Enilolobo, O.S., Nnoli, T.I., Olowo, S.O., Aderemi, T.A., Adewole, A.O., Olapade, V.O., & Esedeke, J.F. (2022). Determinants of food security in Nigeria. *Acta Universitatis Danubius. Oeconomica, 18*(3).
FAO. (2023). *The state of food and agriculture 2023: Revealing the true cost of food to transform agrifood systems*. Rome: FAO.
Field, A. (2024). *Discovering statistics using IBM SPSS statistics*. Sage.
Finger, R. (2023). Digital innovations for sustainable and resilient agricultural systems. *European Review of Agricultural Economics, 50*(4), 1277–1309.
Food and Agriculture Organization of the United Nations. (n.d.). *FAOSTAT food security/nutrition: Visualize data*. Retrieved from https://www.fao.org/faostat/en/#data/FS/visualize
Galbraith, J.R. (1974). Organization design: An information processing view. *Interfaces, 4*(3), 28–36.
Global Alliance for Improved Nutrition. (2025). *Food system resilience*. Retrieved from https://www.gainhealth.org/impact/cross-cutting-themes/food-system-resilience
Ghobakhloo, M., Iranmanesh, M., Foroughi, B., Tseng, M.L., Nikbin, D., & Khanfar, A.A. (2023). Industry 4.0 digital transformation and opportunities for supply chain resilience: A comprehensive review and a strategic roadmap. *Production Planning & Control*, 1–31.
Hair, J.F. (2009). *Multivariate data analysis*.
Huang, I.Y., Forero, O.A., Wagner-Medina, E.V., Diaz, H.F., Tremma, O., Fargetton, X., & Lowenberg-DeBoer, J. (2025). Resilience of food supply systems to sudden shocks: A global review and narrative synthesis. *Global Food Security, 44*, 100842.
International Telecommunication Union. (2024). *Measuring digital development: Facts and figures 2024*. Retrieved from https://www.itu.int/pub/D-IND-ICT_MDD-2024-4
Joshi, S., Sharma, M., Luthra, S., Agarwal, R., & Rathi, R. (2024). Role of industry 4.0 in augmenting endurability of agri-food supply chains amidst pandemic: Organisation flexibility as a moderator. *Operations Management Research*, 1–15.
Kapari, M., Hlophe-Ginindza, S., Nhamo, L., & Mpandeli, S. (2023). Contribution of smallholder farmers to food security and opportunities for resilient farming systems. *Frontiers in Sustainable Food Systems, 7*, 1149854.
Klerkx, L., & Villalobos, P. (2024). Are AgriFoodTech start-ups the new drivers of food systems transformation? An overview of the state of the art and a research agenda. *Global Food Security, 40*, 100726.
Knorr, D., & Augustin, M.A. (2025). Towards resilient food systems: Interactions with indigenous knowledge. *Trends in Food Science & Technology*, 104875.
Konfo, T.R.C., Djouhou, F.M.C., Hounhouigan, M.H., Dahouenon-Ahoussi, E., Avlessi, F., & Sohounhloue, C.K.D. (2023). Recent advances in the use of digital technologies in agri-food processing: A short review. *Applied Food Research, 3*(2), 100329.
Mekonnen, S.A., Jalata, D.D., & Onyeaka, H. (2024). Building resilience in Sub-Saharan Africa's food systems: Diversification, traceability, capacity building and technology for overcoming challenges. *Food and Energy Security, 13*(4), e563.

National Bureau of Statistics. (2022). *National agricultural sample census (NASC) community tables*. Abuja, Nigeria: NBS. Retrieved from https://nasc.nbs.gov.ng/
Olaleye, B.R., Lekunze, J.N., Sekhampu, T.J., Khumalo, N., & Ayeni, A.A.W. (2024). Leveraging innovation capability and organizational resilience for business sustainability among small and medium enterprises: A PLS-SEM approach. *Sustainability, 16*(21), 9201.
Ogundipe, A.A., Obi, S., & Ogundipe, O.M. (2020). Environmental degradation and food security in Nigeria. *International Journal of Energy Economics and Policy, 10*(1), 316–324.
Onwe, J.C., Ojide, M.G., Subhan, M., & Forgenie, D. (2024). Food security in Nigeria amidst globalization, economic expansion, and population growth: A wavelet coherence and QARDL analysis. *Journal of Agriculture and Food Research, 18*, 101413.
Pallant, J. (2020). *SPSS survival manual: A step-by-step guide to data analysis using IBM SPSS*. McGraw-Hill Education.
Panigrahi, R.R., Singh, N., & Muduli, K. (2025). Digital technologies and food supply chain: A scoping view from 2010 to 2024. *International Journal of Industrial Engineering and Operations Management, 7*(2), 150–174.
Pathak, H. (2023). Transforming the agri-food sector in India for achieving the sustainable development goals. *Anthropocene Science, 2*(1), 1–4.
Plakantara, S.P., & Karakitsiou, A. (2025). Transforming agrifood supply chains with digital technologies: A systematic review of safety and quality risk management. *Operations Research Forum, 6*(3), 113.
Prasad, P.V., Bhatnagar, N., Bhandari, V., Jacob, G., Narayan, K., Echeverría, R., ... & Compton, J. (2023). Patterns of investment in agricultural research and innovation for the Global South, with a focus on sustainable agricultural intensification. *Frontiers in Sustainable Food Systems, 7*, 1108949.
Premkumar, G., Ramamurthy, K., & Saunders, C.S. (2005). Information processing view of organizations: An exploratory examination of fit in the context of interorganizational relationships. *Journal of Management Information Systems, 22*(1), 257–294.
Smyth, C., Scott, M., Fosso Wamba, S., & Dennehy, D. (2025). Creating agri-food supply chain resilience using AI-enabled information processing: Identifying the mediating role of organisational mindfulness and flexibility. *Enterprise Information Systems*, 2534401.
Teece, D.J. (2007). Explicating dynamic capabilities: The nature and microfoundations of (sustainable) enterprise performance. *Strategic Management Journal, 28*(13), 1319–1350.
Teece, D.J., Pisano, G., & Shuen, A. (1997). Dynamic capabilities and strategic management. *Strategic Management Journal, 18*(7), 509–533.
Thomas, A., Thomas, M.A.H., Turk, M.R.A., & Turk, R. (2023). *Food insecurity in Nigeria: Food supply matters*. International Monetary Fund.
Tushman, M.L., & Nadler, D.A. (1978). Information processing as an integrating concept in organizational design. *Academy of Management Review, 3*(3), 613–624.
Vahdanjoo, M., Sørensen, C.G., & Nørremark, M. (2025). Digital transformation of the agri-food system. *Current Opinion in Food Science*, 101287.
Vasanthraj, V., Potdar, V., Agrawal, H., & Kaur, A. (2025). Transforming milk supply chains with blockchain: Enhancing visibility and cost reduction. *Benchmarking: An International Journal, 32*(5), 1686–1719.
Vignola, R., & Oosterveer, P. (2025). Conceptualizing the governance challenges for food system transformation. *Frontiers in Sustainable Food Systems, 9*, 1397574.
Von Braun, J., Afsana, K., Fresco, L.O., & Hassan, M.H.A. (2023). Food systems: Seven priorities to end hunger and protect the planet. *Science and Innovations for Food Systems Transformation*, 3–9.
Wolfert, S., Verdouw, C., van Wassenaer, L., Dolfsma, W., & Klerkx, L. (2023). Digital innovation ecosystems in agri-food: Design principles and organizational framework. *Agricultural Systems, 204*, 103558.

World Bank. (2023). *Individuals using the Internet (% of population) – Nigeria*. World Telecommunication/ICT Indicators Database (ITU). Retrieved from https://data.worldbank.org/indicator/IT.NET.USER.ZS?locations=NG

World Intellectual Property Organization. (2024). *Global innovation index 2024: Unlocking the promise of social entrepreneurship*. Retrieved from https://www.wipo.int/web-publications/global-innovation-index-2024/en/

Yu, P., Hamid, R.A., Osman, L.H., & Liao, J. (2025). Bridging the digital gap: Empirical insights into agri-food supply chain transformation. *Sustainable Futures*, 100810.

Zollo, M., & Winter, S.G. (2002). Deliberate learning and the evolution of dynamic capabilities. *Organization Science, 13*(3), 339–351.