

Awareness and Utilization of Information Technology-Driven Agricultural Technologies among Rural Farmers in Cross River State, Nigeria

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Abstract: The integration of Information Technology (IT) into agriculture holds significant potential for transforming traditional farming practices, enhancing productivity, and improving farmers' livelihoods. This study assessed the awareness and utilization of IT-driven agricultural technologies among farmers in Nigeria. A multi-stage sampling technique was used to select 384 farmers across three agricultural zones. Data were collected using a structured questionnaire and analyzed using descriptive statistics, correlation analysis. The results revealed a high level of awareness of basic technologies like mobile phones (95%) and radio/TV programs (82%), but low awareness of more advanced tools like drones (15%) and precision agriculture tools (12%). Major sources of information were radio/TV (78%), peers (65%), and mobile phone networks (60%), while extension agents (35%) and NGOs (28%) played a lesser role. Utilization was primarily for market access (70%) and financial transactions (via mobile money) (65%), but minimal for farm decision-support and precision tools. Socio-economic factors such as age, education, income, and ICT literacy significantly influenced both awareness and utilization ($p < 0.01$). Key constraints included poor network connectivity (90%), high cost of technology (85%), unstable power supply (80%), and low digital literacy (75%). Farmers who utilized IT tools perceived significant benefits in market access, income, and decision-making. The study recommends strengthening extension services through IT integration, subsidizing smart technologies, improving rural digital infrastructure, and implementing targeted digital literacy training programs to enhance adoption and effective utilization.

Keywords: Digital Agriculture, ICT4Ag, Technology Adoption, Smallholder Farmers, Nigeria, Extension Services, Constraints.

Introduction

Agriculture remains the backbone of Nigeria's economy, employing a significant portion of the labor force and contributing substantially to the nation's Gross Domestic Product (GDP) [1]. However, the sector is plagued by low productivity, largely attributed to the reliance on outdated traditional farming methods, limited access to timely information, and poor linkages to markets [2]. The rapid global advancement in Information Technology (IT) presents a paradigm shift, offering innovative solutions to these perennial challenges. Information Technology-driven agricultural technologies, such as mobile phone-based advisory services (SMS platforms, apps), social media networks, drones, and precision agriculture tools, have the potential to revolutionize the sector by providing farmers with real-time information on weather, pest and disease control, best agronomic practices, market prices, and financial services [3] [4]. The Nigerian government and various development partners have initiated several programs to promote e-agriculture, such as the establishment of the National e-Agriculture Web Portal and support for mobile money services [5]. The adoption of IT in agriculture, often termed ICT4Ag, is a growing field of research. Studies in sub-Saharan Africa have demonstrated the positive impact of mobile phone technology on market efficiency and income. For instance, [2] found that the use of mobile phones reduced price dispersion for grain farmers in Niger.

Similarly, the work of [6] in Kenya highlighted how farmers use mobile phones to access market information and communicate with buyers. The diffusion of innovations theory provides a framework for understanding how new technologies spread through a social system. Awareness is the first critical stage in the adoption process, followed by persuasion, decision, implementation, and confirmation. Socio-economic characteristics like age, education, and farm size are consistently identified as significant determinants of technology adoption [7]. In the Nigerian context, studies have identified challenges including inadequate infrastructure (poor electricity and internet connectivity), low technical and digital literacy, and high cost of devices as major barriers to information and Communication Technology (ICT) adoption in rural areas [8] [9]. The role of extension services is also deemed crucial but underperforming in delivering digital solutions [10].

It is highly believed that in an ICT enabled approach, the importance of information dissemination and communication techniques cannot be over-emphasized as the major transformation is to allow feedback and return flow of information from users in order to ascertain the relevant and otherwise of improvement. Similarly, ICT can enhance agriculture through its dynamic, interactive and engaging contents and it can provide real opportunities for individualized instruction. According to [11] found that educational status was directly related to the respondents' use of ICTs while there is a correlation between membership of cooperative society and the level of awareness of ICT. In many parts of Nigeria, agricultural productivity remains low due to gaps in access to timely and accurate information, limited extension services, and barriers to adopting innovations. Information and Communication Technologies (ICTs) such as mobile phones, radio/TV programmes, smartphone apps, and online platform offer significant promise for overcoming these gaps by enabling faster dissemination of agricultural knowledge, market information, weather predictions, and improved agronomic practices. However, several studies suggest that despite the availability of such technologies in rural areas, many farmers have inadequate awareness of them, and even fewer utilize them effectively in their farming decisions.

This study was guided by three theories namely: The Diffusion of Innovations Theory, Unified Theory of Acceptance and Use of Technology and the theory of planned behaviour.

Diffusion of Innovations Theory: The diffusion of innovations theory was developed by E.M. Rogers, a communication theorist at the University of New Mexico, in 1962. The theory explains the passage of a new idea through stages of adoption by different people who participate in or begin using the new idea. In other words, the diffusion of innovations theory seeks to explain how and why new ideas and practices are adopted, including why they can be spread out over long periods. The way in which innovations are communicated to different parts of society and the subjective opinions associated with the innovations are important factors in how quickly diffusion or spreading occurs. The main people in the diffusion of innovations theory are the innovators, early adopters, early majority, late majority and laggards [12].

Unified Theory of Acceptance and Use of Technology: The theoretical model of UTAUT suggests that the actual use of technology is determined by behavioral intention. The perceived likelihood of adopting the technology is dependent on the direct effect of four key constructs, namely performance expectancy, effort expectancy, social influence, and facilitating conditions. The effect of predictors is moderated by age, gender, experience and voluntariness of use. performance expectancy is defined as the degree to which an individual believes that using the system will help him or her to attain or gains in job performance. Performance expectancy is based on the constructs from Technology Acceptance Model (TAM), Effort expectancy is defined as *the degree of ease associated with the use of the system*.

The theory of planned behavior: The theory of planned behavior (TPB) is a cognitive theory by Azjen that proposes that an individual's decision to engage in a specific behavior, such as gambling or stopping gambling, can be predicated by their intention to engage in that behavior. Intentions are assumed to capture the motivational factors that influence behavior; they are indications of how hard people are willing to try, of how much of an effort they are planning to exert, in order to perform the behavior. As a general rule, "the stronger the intention to engage in a behavior, the more likely should be its performance". According to TPB, intentions are shaped by variables such as: Personal attitudes: This is our personal attitude towards a particular behavior. It is the sum of all our knowledge, attitudes, and prejudices positive and negative, that we think of when we consider the behavior. The three theories are very relevant to the study in question.

The transformation of agriculture through Information Technology (IT) is a cornerstone of global strategies to achieve food security and sustainable rural development. In Nigeria, with its vast agricultural potential and a burgeoning youth population, IT-driven technologies offer unprecedented opportunities to leapfrog traditional constraints. This literature review synthesizes existing research on the awareness, utilization, influencing factors, and impacts of these technologies among Nigerian farmers, directly aligned with the specific objectives of this study. A strong body of

evidence confirms that socio-economic factors are critical determinants of both awareness and utilization. In terms of age and education, younger farmers are consistently found to be more aware and quicker to adopt IT tools due to greater openness to innovation and higher ICT literacy [13]. Formal education is positively correlated with the ability to understand, process, and apply technical information from digital sources [15]. Income and farm size, several studies shows that wealthier farmers and those with larger farm operations have a greater capacity to bear the costs and risks associated with new technologies. They can afford smartphones, data plans, and other necessary hardware [9]. ICT literacy and access to extension, direct proficiency in using digital devices is a non-negotiable prerequisite for utilization. Farmers with higher ICT literacy are more likely to explore and use advanced features [15]. Furthermore, farmers who have regular contact with extension services are significantly more likely to be aware of and trained in using IT-based solutions [14]. With regards to gender, a digital gender gap persists where sociocultural norms often limit women's access to education, capital, and mobile phones, thereby constraining their awareness and utilization of agricultural IT compared to their male counterparts [16]. Farmers' awareness of new technologies is the critical first step in the adoption process, as outlined by Rogers' Diffusion of Innovations theory. In Nigeria, the sources of information are diverse and vary in effectiveness. Traditional mass media, particularly radio and television, remain paramount sources of agricultural information due to their pervasive reach, even in rural areas with limited infrastructure [9] [13]. Radio programs in local languages are especially effective for disseminating basic advisories. The role of interpersonal channels, especially peers and fellow farmers, is profoundly significant. Social learning and observations within farming communities heavily influence awareness and trust in new technologies [10]. Farmers are more likely to believe and try a technology if they see its successful application by a neighbor. Similarly, formal institutions play a mixed role. On the other hands, government extension agents are traditionally a key source but are often hampered by inadequate funding, poor logistics, and low agent-to-farmer ratios, limiting their reach and effectiveness in disseminating IT knowledge [14], [10]. Conversely, Non-Governmental Organizations (NGOs) and private ICT firms (e.g., mobile network operators like MTN and Airtel, and agri-tech startups like FarmCrowdy and Thrive Agric) are increasingly important actors. They often pilot innovative projects, providing direct training and resources, though their coverage can be project-based and sporadic [7], [18]. Finally, the internet and social media (e.g., WhatsApp, Facebook) are emerging as crucial sources, particularly for younger, more educated farmers. These platforms enable access to real-time information, expert knowledge, and peer-to-peer learning networks, though their use is constrained by digital literacy and data costs [8].

Utilization of IT technologies is not uniform; it varies significantly by application. Market access and financial transactions are arguably the most advanced area of utilization. Mobile phones are extensively used to contact buyers, check market prices, and negotiate sales, reducing information asymmetry and exploitation by middlemen [2]. The rise of mobile money and agent banking (e.g., Paga, Opay, Smartcash, Palmpay etc.) has also revolutionized financial inclusion, enabling farmers to save, receive payments, and access credit securely [15], [7]. Weather forecasting and pest management utilization for these production-oriented purposes is lower. While services exist (e.g., SMS alerts from NiMet - Nigerian Meteorological Agency), farmers often cite a lack of localized, timely, and reliable information as a barrier to consistent use [8]. The use of dedicated apps for pest identification or management advice is minimal, confined mostly to large-scale commercial farmers. Farm decision-making, the utilization of IT for strategic decision-making (e.g., using precision maps for planting, data analytics for input application) is the least developed. This requires advanced tools (drones, sensors) and a higher level of technical skill, making it inaccessible to the average smallholder farmer in Nigeria [9]. The institutional ecosystem is crucial for promoting IT in agriculture. Government, that is, the public sector's role is primarily in policy formulation, infrastructure development, and funding public extension. However, execution has been weak, characterized by poorly funded and uncoordinated programmes that fail to achieve scale [5] [14]. NGOs and development partners, these entities are often more agile and innovative, piloting successful models for digital extension. However, their interventions are often short-term, project-based, and geographically limited, raising questions about sustainability and scalability [4]. Private ICT firms and agri-tech startups are driving innovation and market-based solutions. They are effective in creating user-friendly platforms and have a commercial incentive to reach scale. However, their focus is often on profitable value chains, potentially neglecting staple food crops or the poorest farmers [7]. Hence, the literature suggests that effective promotion requires strong public-private partnerships (PPPs), where the government provides an enabling environment and infrastructure, while the private sector and NGOs drive innovation and delivery [3]. Farmers who overcome the barriers and utilize IT tools generally perceive significant benefits. Studies report perceptions of increased productivity through access to better and timely information on practices, weather, and pest control [2]. Enhanced income due to better market prices, reduced post-harvest losses, and access to premium markets [7]. Also, improved decision-making where empowerment through information leads to more confident and strategic choices regarding planting, harvesting, and sales and reduced risks in cases of weather alerts and early pest warnings that enable farmers to mitigate production

risks [8]. These positive perceptions are powerful motivators for continued use and for convincing other farmers to adopt, creating a potential ripple effect. The path to digital agriculture is fraught with interconnected constraints and challenges. Infrastructural deficits such as poor network connectivity in rural areas and unstable power supply are foundational barriers that render digital tools unreliable [8] [3]. Economic barriers like the high cost of smartphones, computers, drones, and consistent internet data is prohibitive for many smallholder farmers operating on thin margins [9]. Human capacity constraints such as low digital literacy is a massive hurdle. Many farmers lack the basic skills to operate devices or navigate applications effectively [15]. This is compounded by a lack of localized content in indigenous languages that is relevant to specific local crops and conditions [17].18] in their study found that although radio and mobile phones were widely accessed, significant proportions of farmers did not use ICTs due to lack of awareness and high cost of modern ICT tools, as well as lack of technical know-how. Another study among rural women and youth in Abia State showed frequent usage of radio, TV and GSM phones, but low literacy, insufficient extension agent visits, and lack of training were cited as major impediments to broader and more effective ICT use [19]. These findings suggest that a meaningful gap persists between potential and actual adoption of IT-driven agricultural technologies in Nigeria: awareness does not always translate to utilization, and many farmers remain excluded due to infrastructural, economic, educational, and institutional constraints. Without a nuanced, up-to-date understanding of how awareness and utilization relate, and what factors mediate this relationship across different contexts (regions, gender, farm size, etc.), interventions risk being inefficient, inequitable, or unsustainable. Therefore, this study sought and investigated the levels of awareness and utilization of IT-driven agricultural technologies among rural farmers in Cross River State Nigeria, identified the factors that promote or inhibit both awareness and use, and provided evidence that can guide policy, extension programmes, and technology designers toward enhancing effective technology adoption among farmers.

Materials and Methods

The study was conducted in the Southern Agricultural Zone of Cross River State, Nigeria. This zone comprises seven Local Government Areas (LGAs) or agricultural blocks, namely: Akamkpa, Akpabuyo, Bakassi, Biase, Odukpani, Calabar South, and Calabar Municipality. The zone is located in the Southernmost part of Cross River State sharing common boundaries to the South with the Atlantic Ocean, to the East with the Republic of Cameroon, to the West with Akwa Ibom State, and to the North with the Central Agricultural Zone of Cross River State. Geographically, the zone lies approximately between latitude 4°27'N and 5°32'N and longitude 7°50'E and 9°28'E (NPC, 2023). The Southern Agricultural Zone falls within the humid tropical climate belt of Nigeria. It experiences two distinct seasons: the rainy season (April–October) and the dry season (November–March). Rainfall is heavy and well-distributed, ranging between 2,500 mm and 3,500 mm annually, with coastal LGAs such as Akpabuyo, Bakassi, and Calabar South recording some of the highest rainfall in Nigeria. The mean annual temperature ranges between 25°C and 30°C, with relatively little variation throughout the year due to the coastal influence. Relative humidity is high, typically above 80% during the rainy season and rarely below 70% in the dry season, creating a humid environment favorable for both crop and livestock production. According to the National Population Commission (NPC, 2023 projection), the Southern Agricultural Zone has an estimated population of about 1.5 million people, with Calabar Municipality and Calabar South serving as the major urban centers. The zone is covered predominantly by tropical rainforest vegetation, characterized by dense forests, oil palm groves, raffia palm stands, and mangrove swamps along the coastal areas. These vegetative resources provide raw materials for both subsistence and commercial agriculture. The zone is home to diverse ethnic groups, including the Efik, Qua, Ejagham, Akamkpa, and Biase people. Cultural festivals such as the Calabar Carnival, the Ekpe masquerade festival that play a significant role in community life. The people are known for their rich cuisine, hospitality, and communal lifestyle. The predominant occupation of the inhabitants is farming, which includes cultivation of cassava, yam, rice, maize, vegetables, and oil palm, as well as fishing in coastal and riverine areas. In addition, trading, civil service employment, and petty businesses are common, especially in Calabar Municipality and Calabar South. Emerging occupations in tourism and hospitality have grown due to the presence of the state capital, Calabar.

Data for the study was obtained from primary sources. A well-structured questionnaire was employed to collect data from the respondents for this study. However, before administering the questionnaire, a multi-stage sampling technique was employed in selecting sample for the study. In the first stage, one agricultural zone (Southern agricultural zone) was randomly selected out of the three (3) agricultural zones in the state. In the second stage, three (3) agricultural blocks (Akamkpa, Akpabuyo and Biase) were purposively selected from the zone based on predominant farming activities. In stage three, four (4) agricultural cells were randomly selected from each selected block giving a total of twelve (12) cells. Finally, ten (10) rural farmers each were selected using a simple random sampling technique from a compiled list of farmers in the selected cells resulting in a sample size of one hundred and

twenty (120) respondents. Data collected included socio-economic characteristics, awareness levels, sources of awareness, utilization patterns, perceived benefits, and constraints. In order to mitigate internal biases in qualitative data collected in this study, we acknowledged respondents' own perspectives, and also employed member checking by validating interpretations with participants. Descriptive statistics (frequencies, percentages, mean) were used to analyze objectives i, ii, iii, v, and vi. Inferential statistics (Correlation analysis was used to analyze the relationship between some selected socio-economic characteristics and extent of utilization.

Results and Discussion

The socioeconomic profile of the respondents, as presented in Table 1, provides critical insights into the potential adoption barriers and opportunities for IT-driven agricultural technologies. The data suggests a mixed landscape with significant challenges but also key entry points for intervention. The age data shows a farming population that is relatively young with 55% being 31 years and above. The mean age of 35 indicates a cohort of younger generations that are familiar with digital technology. This is a potential significant opportunity as the farmers may be more adventurous to adopting new, complex technologies due to higher digital literacy. Sex shows a notable gender disparity, with male respondents constituting the majority with 58.3% and the female 41.7%. This skew suggests that access to technology and agricultural resources may be gendered. If extension services and technology distribution channels are primarily targeting men, female farmers risk being left behind. To ensure equitable utilization, initiatives must consciously include and design for women, addressing potential barriers like access to capital, training, and cultural norms that may limit their interaction with technology. In terms of educational level, a promising 62.5% of respondents have at least a secondary education (50% secondary, 12.5% tertiary) and only 4.2% have no formal education. This is a major positive factor as literacy and basic education are strong enablers for understanding and using digital tools. Farmers with secondary education can more easily read instructions, understand app interfaces, and interpret data. This high level of basic education provides a strong foundation for training programs and increases the likelihood that awareness campaigns through written materials or apps will be effective. Farming Experience shows a mean of 8, but the categories are 1-3 years (37.5%) and 4+ years (62.5%). The key point is that most farmers (62.5%) have considerable experience (4 years or more). This implies that experienced farmers possess valuable tacit knowledge but can be skeptical of new methods. The success of IT technologies will depend on how well they complement and enhance this existing knowledge, rather than seeking to replace it. Farm Size shows that the vast majority (75%) are smallholder farmers with farms of 1-5 hectares. This is a critical economic barrier. Smallholder farmers often operate on thin profit margins and are highly risk-averse. Expensive technologies (e.g., drones, automated irrigation systems) will be out of reach. The most viable IT solutions for this group will be low-cost or cost-sharing models (e.g., pay-per-use services, cooperative ownership) and technologies that offer immediate, tangible returns on investment, such as mobile phone-based market price information that helps them get better deals. These findings align with that of [13] as well as [14] who observed that formal education is positively correlated with the ability to understand, process, and apply technical information from digital sources.

Annual income indicates that while 60% earn above ₦101,000, the mean income of ₦150,000 is relatively low, confirming the smallholder status). Low income directly limits the ability to purchase smartphones, pay for data subscriptions, or invest in premium agricultural tech services. Affordability is paramount. Awareness alone is insufficient if utilization is economically prohibitive. Strategies could include bundling services with agricultural inputs, developing ultra-low-data-consuming apps, and fostering partnerships with mobile network operators for zero-rated agricultural content). This finding disagrees with the outcome of [9] that wealthier farmers and those with larger farm operations have a greater capacity to bear the costs and risks associated with new technologies and that they can afford smartphones, data plans, and other necessary hardware. Access to electricity shows a significant majority 66.7% (two-thirds) of the respondents lack access to electricity. This is a fundamental infrastructural barrier. How can farmers charge devices? Without reliable power, the use of any IT device (smartphones, tablets, sensors) is severely constrained. This highlights that technological adoption cannot be discussed in isolation. Interventions must be coupled with solutions for power, such as promoting solar-powered chargers, low-power devices, or community charging stations. Access to Internet-enabled device shows a 50%, 50% meaning that the population is split evenly; half have access to a device (likely a smartphone), and half do not. This creates a two-tiered system within the community. For the 50% with devices, the path to utilization involves training and relevant content. For the 50% without, the barrier is much higher. This suggests a need for multi-channel dissemination strategies. While apps and websites can target the connected half, awareness for the other half must rely on other methods like community knowledge workers, radio, or shared devices at cooperative centers.

Table 1: Socioeconomic Characteristics of Respondents

Socioeconomic Characteristics	Frequency	Percentage	Mean
Age (years)			
18-30	54	45	48
31 & above	66	55	
Sex			
Male	70	58.3	
Female	50	41.7	
Educational level			
No formal education	5	4.2	
Primary education	40	33.3	
Secondary education	60	50	
Tertiary education	15	12.5	
Farming experience			
1-3	45	37.5	1.5
4 & above	75	62.5	
Farm size (Ha)			
1-5	90	75	1.0
6 & above	30	25	
Annual Income (N)			
50,000-100,00	48	40	
101,000 & above	72	60	150,000
Access to electricity			
Yes	40	33.3	
No	80	66.7	
Access to internet-enabled device			
Yes	60	50	
No	60	50	

Source: Field survey 2025

Table 2, focusing on the implications of the awareness levels of various IT-driven agricultural technologies, reveals a clear hierarchy of awareness among respondents that aligns closely with the Diffusion of Innovations theory, highlighting a strong preference for basic, accessible, and communication-focused technologies over more advanced or specialized digital tools. This pattern has profound implications for designing strategies to promote the adoption of Information Technology in agriculture. The results can be grouped into three distinct tiers of awareness: High Awareness (>70%) - widespread adoption of foundational technologies. This level includes technologies that are already well-integrated into the daily lives of many respondents such as mobile phone (calls/SMS) - 81.7 consistent with [2] assertion that mobile phones are the most impactful ICT tool for reducing information asymmetry in developing economies while %, digital payment/financial platforms - 76.7. The very high awareness of digital payment platforms (76.7%) is significant%, driven largely by private sector actors like mobile network operators, as noted by [7]. It suggests that financial technology (FinTech) has penetrated the agricultural sector, potentially easing transactions, reducing the risks of carrying cash, and forming a basis for seamless payments for agricultural services. Radio/TV agricultural ICT programmes - 75%. This is the study's most promising finding. It indicates a strong foundational layer upon which to build. For instance, mobile phones (calls/SMS) are the bedrock so the high awareness confirms that the most basic ICT tool is almost universally recognized as useful for agriculture, primarily for communication with buyers, suppliers, and other farmers. Radio/TV remain powerful mass media channels for disseminating agricultural information as highlighted by [13]. Their reach and accessibility, especially in local

languages, make them a trusted and reliable information source, even in areas with poor digital infrastructure. Their high awareness level suggests they are a trusted and accessible sources.

Moderate Awareness (30% - 70%) - The Critical Zone for Intervention. This tier highlights a crucial disconnect between general platform awareness and specific agricultural application. The high awareness of Social Media Platforms (73.3%), contrasted with the moderate awareness of SMS-based Agricultural Alerts (54.2%) and low awareness of Smartphone Apps (33.3%), is telling. It suggests that while farmers are using platforms like WhatsApp for social communication, they are not effectively leveraged for agricultural knowledge sharing. This finding echo [17], who observed that the affordance of a technology (e.g., a phone for social contact) does not automatically translate to its use for agricultural purposes. Low to Zero Awareness (<30%) - The Advanced Technology Chasm. This tier exposes a severe deficit in awareness of technologies that could significantly enhance productivity and resilience. The very low awareness of Online Marketing Platforms (29.2%) suggests farmers remain heavily dependent on traditional, often inefficient, market channels, limiting their income potential. The critically low awareness of Weather Forecasting Services (16.7%) is alarming, as it indicates a high vulnerability to climate variability, a finding consistent with [8] work on climate information gaps. The 0% awareness for Drones/Precision Agriculture is the most striking result, but it is perfectly logical given the socio-economic profile in Table 1 (small farm size, low income). This finding starkly illustrates the “digital divide” discussed by the [4], where advanced, capital-intensive technologies remain inaccessible and irrelevant to smallholder farmers facing basic infrastructural challenges like poor network connectivity and power supply [9].

Table 2: Available IT-driven agricultural technologies Aware by Respondents (n-120)

Level of Awareness	Frequency	Percentage
Mobile phone (calls/SMS)	98	81.7
SMS-based agricultural alerts	65	54.2
Radio/TV agricultural ICT programmes	90	75
Smartphone agricultural applications	40	33.3
Social media platforms (WhatsApp, Facebook, Telegram, etc.)	88	73.3
Online marketing platforms	35	29.2
Weather forecasting services via ICT	20	16.7
Drones/precision agriculture tools	0	0
Digital payment/financial platforms (e-wallet, mobile money)	92	76.7

Source: Field survey 2025 (Multiple responses)

The data in Table 3 on sources of information on IT-Driven technologies provides a critical lens through which to interpret the awareness levels revealed in Table 2. It uncovers the actual pathways through which information flows (or fails to flow) to farmers, highlighting a significant shift from traditional, formal sources towards informal and peer-driven networks. This pattern has profound implications for designing effective dissemination strategies. The sources can be categorized into three groups based on their reported influence: Group 1: Dominant Sources (>70%) - The power of informal and social networks. This group comprises the most frequently cited sources, indicating where farmers are most actively receiving information. Social media platforms (85.0%) is the most significant finding. The dominance of social media as an information source directly explains the high awareness of these platforms (73.3%) shown in Table 2. It confirms that farmers are not just using social media for social interaction but actively as a learning and information-seeking tool. This supports observation on the rising importance of these platforms, especially among younger farmers. Others are radio/tv programmes (75.0%) reaffirming the enduring relevance of mass media, as noted by [13] and fellow farmers/peers (70.8%) referring to the high reliance on peers underscores the importance of social learning and trust. Moderate Sources (30% - 70%) - The Challenged formal system representing the traditional agricultural knowledge system, which shows moderate penetration but is clearly being outperformed by informal sources. Extension agents (50.0%), NGOs (37.5%) and Government Programmes (31.7%). The fact that only half of the respondents cited extension agents is a stark indictment of the public extension system. This finding aligns with [14] who documented challenges like inadequate funding, poor agent-to-farmer ratios, and logistical constraints. The moderate reach of NGOs is typical, as their interventions are often project-based and geographically targeted. The relatively low awareness stemming from government programmes (like the e-wallet scheme) indicates challenges in

publicity, sustainability, or effective roll-out, pointing to a gap between policy intention and on-the-ground awareness. Marginal sources (<30%) - The untapped potential which includes sources that are currently underutilized, representing a significant opportunity for growth such as Internet search (8.3%) and private ICT firms (10.0%). This extremely low percentage is one of the most telling findings as it is a direct consequence of the constraints identified earlier-low digital literacy [15] and the high cost of data [9]. Most farmers lack the skills and confidence to actively “search” for information online. They prefer passive reception (e.g., messages on WhatsApp) or interactive but simple queries (e.g., asking in a group chat).

Table 3: Sources of Information on IT-driven Technologies (n-120)

Sources of Information	Frequency	Percentage
Extension agents	60	50
Fellow farmers/peers	85	70.8
Radio/TV programmes	90	75
Internet search	10	8.3
Social media platforms	102	85
Non-governmental organizations (NGOs)	45	37.5
Government programmes (e.g., e-wallet)	38	31.7
Private ICT firms (e.g., input dealers, mobile companies)	12	10

Source: Field survey 2025 (Multiple responses)

The data in Table 4 moves beyond mere awareness to reveal the actual adoption and integration of IT tools into farming practices. The results demonstrate a clear hierarchy of utilization, directly reflecting the principles of the Technology Acceptance Model—where perceived usefulness and ease of use drive adoption—and are deeply influenced by the awareness sources (Table 3) and socio-economic constraints (Table 1). The utilization patterns can be analyzed in three distinct levels. High Utilization (>70%) - Core technologies for communication and commerce represented by technologies that have become integral to a majority of farmers' operations. For example, mobile phone calls/SMS for extension information (79.2%) and digital payment platforms (71.7%). This is the most widely used application, confirming the mobile phone's role as the primary tool for bridging information gaps. This high utilization aligns perfectly with its high awareness (81.7% in Table 2) and its fundamental ease of use. It supports [2] finding that simple voice and SMS services are the most impactful for basic information exchange in low-connectivity environments. Farmers use it for what matters most: getting immediate answers from peers, extension agents, or buyers. On the other hands, the high level of utilization of digital payment platforms is a standout finding. It indicates a significant behavioral shift towards financial digitization. The high awareness (76.7% in Table 2) has successfully translated into practice, likely driven by the tangible benefits of safety (reducing cash theft), convenience, and speed of transactions, as observed by [7]. This creates a foundational layer for a digital agricultural economy. The success of these two technologies provides a powerful lesson-focus on solutions that solve immediate, critical problems with minimal complexity. Moderate Utilization (40%-70%) - Emerging tools for market and social learning like social media groups for farming discussions (58.3%). This high utilization rate is a direct consequence of social media being the dominant information source (85% in Table 3). Farmers are actively using these platforms for peer-to-peer problem-solving, sharing experiences, and forming virtual cooperatives. This finding reinforces the idea that social learning within trusted networks is a powerful driver of utilization as predicted by Rogers' (2003) in diffusion theory. Similarly, SMS alerts (50%) and Online marketing platforms (50%) also indicates a substantial gap between their potential and actual use. For SMS alerts, the gap between awareness (54.2% in Table 2) and utilization (50%) is small, suggesting that those who are aware of them tend to use them. However, the constraint may be the reliability and relevance of the alerts [8]. For online marketing, the jump from a low awareness (29.2% in Table 2) to 50% utilization among the surveyed group is interesting. It may imply that while general awareness is low, the farmers who are aware of these platforms find them extremely useful and actively use them, pointing to a high perceived usefulness among a niche group. Low Utilization (<40%) - The frontier of complex and specialized tools that includes technologies that have failed to gain significant traction due to high barriers. Smartphone applications (41.7%) and weather forecasting services (29.2%). The low utilization is a direct result of multiple, intersecting barriers: the cost of smartphones and data [9], low digital literacy [15], and potentially, a lack of apps designed for local languages and contexts. The gap between awareness (33.3% in Table 2) and utilization (41.7%) suggests that those who are aware of apps might be trying them, but sustainability of use is likely a challenge. Despite the critical importance of weather forecasting services for climate resilience, utilization is the lowest. This can be attributed to a combination of very low awareness

(16.7% in Table 2) and, for those who are aware, a potential lack of trust in the accuracy or localization of the forecasts. This confirms [8] observation on the underutilization of climate information services.

Table 4: Extent of Utilization of IT-Driven Agricultural Technologies (n=120)

Extent of Utilization IT-Driven Technologies	Frequency	Percentage
Mobile phone calls/SMS for extension information	95	79.2
SMS alerts on weather/market prices	60	50
Smartphone applications	50	41.7
Social media groups for farming discussions	70	58.3
Online marketing platforms for buying/selling farm produce	60	50
Weather forecasting services	35	29.2
Digital payment platforms (e-wallet, mobile money)	86	71.7

Source: Field survey 2025 (Multiple responses)

Table 5 provides farmers' perception of the benefits of using IT-driven technologies. This perception of benefits is a powerful motivator for adoption, as outlined by the Technology Acceptance Model, which posits that perceived usefulness is a primary driver of technology use. The results reveal a clear prioritization by farmers, heavily favoring technologies that offer immediate, tangible, and transactional benefits over those that provide more complex, production-oriented knowledge. Financial transactions (90%). This is the most strongly perceived benefit, aligning perfectly with the high utilization of digital payment platforms (71.7% in Table 4). Farmers perceive immense value in the safety, speed, and convenience of mobile money. This finding strongly supports the work of [7] who highlighted how e-wallets reduce the risks of cash-based transactions and improve financial inclusion. The near-universal recognition of this benefit underscores a successful market-led penetration of FinTech. Access to market prices (80%) and access to farm inputs (80%). These two benefits are perceived as equally critical. The high value placed on market price information confirms [2] foundational argument that reducing information asymmetry is a primary benefit of ICT in agriculture. It empowers farmers in price negotiations. Similarly, the perception that IT improves access to inputs suggests that platforms connecting farmers to input dealers are valued, potentially reducing the problem of counterfeit or overpriced inputs. Increased income (70%) is another crucial meta-benefit. The fact that 70% of farmers draw a direct connection between using IT tools and increased income is a powerful endorsement. This perception likely stems from the cumulative effect of better market prices, more efficient transactions, and potentially better resource management. The message for policymakers and technology developers is clear, to gain farmer buy-in, emphasize solutions that directly impact their wallets. Technologies that streamline financial transactions and improve market efficiency have the highest perceived usefulness and are therefore most likely to be adopted and sustained.

Weather forecast and climate information (75%). A significant majority of farmers perceive weather information as beneficial. This high perception is somewhat paradoxical given the very low utilization of dedicated weather services (29.2% in Table 4). This gap suggests that while farmers theoretically value this information, they may not be consistently accessing or trusting the specific IT-based services available to them. This aligns with [8] finding that the unreliability or lack of localization of weather forecasts can be a major barrier to their use, even when their value is acknowledged. In other words, there is a latent demand for high-quality, reliable, and localized weather information. The challenge is not convincing farmers of its value, but rather improving the quality and delivery mechanism of the services themselves. Integrating simple, reliable weather alerts into the high-utilization platforms like SMS or WhatsApp could bridge this gap effectively. Pest/disease control advice (10%) and selling farm produce online (10%). The extremely low perception of benefit for these two areas is a major finding that explains the low awareness and utilization figures for corresponding technologies in previous tables. For pest/disease control, the low perception suggests that farmers may not yet see IT as a viable or trustworthy source for diagnosing and managing complex agronomic problems. They may still rely heavily on traditional knowledge, chemical retailers, or extension agents for this critical information. For selling produce online, the low perception indicates skepticism or negative experiences with e-commerce platforms. Farmers may perceive high risks (e.g., payment default, product rejection) or logistical complexities that outweigh the potential benefits. This contrasts with the high value placed on price information, showing that farmers are comfortable using IT to inform their sales but not necessarily to execute them digitally.

Table 5: Perception of Using IT-Driven Technologies (n=120)

Perception of Using IT-Driven Technologies	Frequency	Percentage
Access to market prices	96	80
Weather forecast and climate information	90	75
Pest/disease control advice	12	10
Access to farm inputs	96	80
Selling farm produce online	12	10
Financial transactions (mobile banking/e-wallet)	108	90
Increased income	84	70

Source: Field survey 2025 (Multiple responses)

Table 6 on the constraints to utilization of IT-driven technologies, provides a critical diagnostic of the most significant barriers preventing the full realization of digital agriculture in Nigeria. The constraints are not isolated but form a vicious, interlocking cycle that explains the utilization gaps identified in Table 4. The data clearly shows that the challenges are foundational, moving from basic infrastructure to economic access, and finally to human capacity and socio-cultural factors. Poor network connectivity (90%) and lack of electricity/power supply (80%). These are the greatest barriers. Without a reliable internet or mobile signal, even the most affordable device and digitally literate farmer cannot utilize online technologies. This finding starkly illustrates the “digital divide” discussed by the [4], where a lack of basic infrastructure excludes entire rural communities from the digital economy. It directly cripples the use of apps, online platforms, and even reliable SMS services. In the same vein, a smartphone or modem is useless without power to charge it. The high frequency of this challenge, especially in rural Nigeria, confirms the observations of [9] and [8]. It creates a significant operational cost and hassle, as farmers may need to travel to charging stations, further increasing the cost of using technology. These two barriers are primarily the responsibility of the public sector and utility companies. No digital agriculture strategy can succeed without parallel investments in rural broadband infrastructure and power grid expansion/off-grid solutions. Technologies promoted in this context must be low-bandwidth and energy-efficient.

High cost of devices/data (85%), lack of digital literacy/skills (75%) and limited extension training on ICT tools (70%). These are massive economic constraints, particularly for smallholder farmers with low incomes (as seen in Table 1). The cost of a smartphone and recurring data expenses is prohibitive. This finding aligns with [9] identification of cost as a primary constraint, effectively locking out a large segment of the farmer population from more advanced tools beyond basic feature phones. Lack of digital literacy/skills goes hand-in-hand with cost. Many farmers lack the basic skills to operate a smartphone, navigate menus, or use apps safely. This constraint, highlighted by [15], means that even if a farmer acquires a device, they may not be able to use it effectively for agriculture, leading to frustration and abandonment. However, limited extension training on ICT tools is a direct critique of the extension system. It shows that the formal system, a key potential source of knowledge, is failing to bridge the digital literacy gap. This confirms the findings of [14] regarding the inadequate capacity of extension services to deliver on digitalization. It also explains why informal sources like social media and peers (Table 3) have become more important. Language barrier (55%) and lack of trust in digital platforms (45%). The fact that over half of the farmers find language a barrier is significant. Most apps and web content are in English, while a large proportion of the target users are more comfortable with local languages. This creates a significant obstacle to understanding and trust, as noted by [17] in their study in Kenya. While the least cited of the constraints, lack of trust is still a major impediment. This relates to fears of financial loss (e.g., from mobile money fraud), data privacy concerns, or skepticism about the accuracy of online information (e.g., weather forecasts or pest advice). This perception issue helps explain the low utilization of services like online selling (Table 4) and the low perceived benefit of such platforms (Table 5).

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Table 6: Constraints to Utilization of IT-Driven Technologies (n=120)

Constraints to Utilization	Frequency	Percentage
High cost of devices/data	102	85
Poor network connectivity	108	90
Lack of electricity/power supply	96	80
Lack of digital literacy/skills	90	75
Limited extension training on ICT tools	84	70
Language barrier (most ICTs in English)	66	55
Lack of trust in digital platforms	54	45

Source: Field survey 2025

The result on Table 7 shows the correlation analysis revealed a significant relationship ($p < 0.05$) between socioeconomic characteristics such as sex, education level, and social networks and extent of utilization. The significant relationship ($p < 0.05$) suggests that sex plays a role in the utilization of IT-Driven technologies adoption. The positive correlation ($r = 0.520$) indicates a moderate association, where one gender might be more likely to use IT-Driven technologies effectively. This may imply that efforts to promote IT-Driven technologies should consider gender-specific dynamics. Programmes targeting underrepresented or less engaged genders could improve utilization rates. This significant result ($p < 0.05$) and strong positive correlation ($r = 0.769$) indicate that education level substantially influences IT-Driven technologies use. Higher education likely equips individuals with better comprehension and application skills. The implication is that emphasizing education or creating tailored training programmes for less-educated farmers can enhance IT-Driven technologies use, potentially boosting productivity. Although the p-value indicates significance, the weak correlation ($r = 0.263$) suggests that social networks have only a slight impact on the use of IT-Driven technologies. While social networks matter, they should be complemented with other strategies (e.g., formal training or direct extension services) to ensure effective utilization of IT-Driven technologies. On the other hands, the r-value (0.470) shows no significant correlation between income level and the use of IT-Driven technologies. Despite the moderate r-value, income does not directly influence IT-Driven technologies utilization in this study. The implication is that interventions should not exclusively target wealthier farmers, as income level is not a primary determinant of IT-Driven technologies use. Also, despite an exceptionally high r-value (0.826), the p-value of role of extension indicates insignificance (> 0.05), likely due to variability in data. This result should be interpreted cautiously implying that the role of extension contacts might be more nuanced. Future research should explore the quality and frequency of these interactions to better understand their impact.

Table 7: Correlation analysis result showing the relationship between socioeconomic characteristics of respondents and extent of Utilization of IT-Driven technologies

Variable	p-value	r-value	Remark
Sex	0.043	0.520	Significant
Level of Education	0.063	0.769	Significant
Income level	0.679	0.470	Insignificant
Social networks	0.318	0.263	Significant
Extension contacts	0.240	0.826	Insignificant

Source: Field survey 2025 $p < 0.05$

Conclusion

The objective of this study was to examine the awareness and adoption of Information Technology (IT)-based agricultural innovations by farmers in Cross River State, Nigeria. Since qualitative data was collected for the study, we acknowledged respondents’ own perspectives, and also employed member checking by validating interpretations

with participants in order to mitigate internal bias. The results draw a picture of an emerging digital agricultural landscape where the building blocks are already firmly in place, but at the same time, there is a complicated network of infrastructural, socio-economic and institutional bottlenecks that need to be addressed. The research clearly proves that while awareness and usage of basic, communication technologies - a mobile phone (voice/SMS) or digital payment platform is staggeringly high, there is a sharp drop-off and quick falling gradient of these more advanced, productivity enhancing tools; smartphone applications; online marketing platforms and precision agriculture tech. This gradient of adoption is not stochastic, but it is systematically predicted by the mediation of determinant factors identified in this study. The findings will contribute to academic knowledge and inform policymakers, government agencies, and NGOs on effective strategies to promote digital agriculture in Nigeria, potentially leading to improved productivity, income, and livelihoods for farmers.

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