

ASSESSING THE EFFECTIVENESS OF MOBILE APPS IN ENHANCING AGRICULTURAL EXTENSION SERVICES DELIVERY IN NIGERIA

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Abstract

This study assesses the effectiveness of mobile apps in enhancing agricultural extension services delivery in Nigeria. It also investigates the usage patterns, perceived usefulness, impact, and challenges of mobile app-based extension services in agricultural contexts. The study adopted a descriptive survey design. Through correlation analysis, data was gathered to assess the relationships between various factors related to the adoption and effectiveness of mobile technologies in agricultural extension. Findings reveal a strong positive correlation in the usage patterns of mobile apps among farmers and extension agents, indicating a convergence in adoption behaviors. Additionally, moderate to strong positive correlations were observed between perceived usefulness, ease of use, and satisfaction with mobile app-based extension services, highlighting the importance of user-centric design principles. Furthermore, moderate positive correlations were identified between mobile app usage and farmers' knowledge acquisition, adoption of improved agricultural practices, and agricultural productivity, suggesting a positive impact on these outcomes. However, challenges/barriers were found to have a strong positive correlation with the effectiveness of implementation/utilization of mobile app-based extension services, emphasizing the need for addressing obstacles to maximize impact. Recommendations include investing in user-centric design, providing training and capacity building, customizing content, fostering partnerships, strengthening monitoring and evaluation, advocating for supportive policies, and engaging communities. This research contributes to the understanding of mobile app-based extension services in agriculture and provides insights for stakeholders to enhance their effectiveness and adoption, ultimately empowering farmers and contributing to sustainable agricultural development.

Keywords: Mobile apps, Agricultural extension services, Usage patterns & Perceived usefulness

1. Introduction

Agriculture plays a pivotal role in Nigeria's economy, employing a significant portion of the population and contributing substantially to the nation's GDP. Similarly, agricultural extension services serve an essential role in guiding farmers to improve the efficiency and effectiveness of their production by transferring new technologies through training, visits, or farm school (Ayim et al., 2022). An effective agricultural extension service improves farmers' technical habits, such as fertilizer use, and leads to more efficient decision-making and better outcomes for farmers (profit, income, food security, etc.).

Despite its importance, the sector faces numerous challenges, including limited access to extension services, inadequate dissemination of agricultural information, and inefficient communication channels between farmers and extension agents. These challenges impede the adoption of modern farming techniques, hinder productivity, and ultimately inhibit rural development.

Historically, agricultural extension services in Nigeria have relied on conventional methods such as face-to-face interactions, workshops, and print media to disseminate information and knowledge to farmers. However, these approaches have been constrained by various factors, including limited resources, geographic barriers, and inefficiencies in reaching remote and marginalized communities (Amoussouhoui et al., 2022).

In recent years, the proliferation of mobile technology has presented new opportunities to revolutionize agricultural extension services delivery. Mobile apps offer a promising avenue for bridging the gap between extension agents and farmers, providing real-time access to relevant information, advisory services, market prices, weather forecasts, and best agricultural practices. Moreover, mobile apps have the potential to enhance the scalability, efficiency, and effectiveness of extension services by overcoming traditional barriers and reaching a wider audience (Craustes, 2023).

Despite the growing interest and investment in mobile app-based agricultural extension initiatives, there is a paucity of empirical evidence on their effectiveness in the Nigerian context. While anecdotal reports suggest positive outcomes, rigorous research is needed to assess the impact of mobile apps on enhancing agricultural extension services delivery, improving farmers' knowledge and practices, increasing productivity, and fostering rural development.

Therefore, this study seeks to fill this gap by systematically evaluating the effectiveness of mobile apps in enhancing agricultural extension services delivery in Nigeria. Specifically, the study aims to:

- i. Assess the usage patterns and adoption rates of mobile apps among farmers and extension agents.
- ii. Evaluate the perceived usefulness, ease of use, and satisfaction with mobile app-based extension services.
- iii. Measure the impact of mobile apps on farmers' knowledge acquisition, adoption of improved agricultural practices, and agricultural productivity.
- iv. Identify challenges and barriers to the effective implementation and utilization of mobile app-based extension services.

By providing empirical evidence and actionable insights, this study endeavors to inform policy formulation, program design, and investment decisions aimed at harnessing the

potential of mobile technology to transform agricultural extension services delivery and contribute to sustainable rural development in Nigeria.

2. Conceptual Review

Assess the usage patterns and adoption rates of mobile apps among farmers and extension agents

Usage patterns and adoption rates of mobile apps among farmers and extension agents have seen significant growth and have become an integral part of agricultural practices in recent years (Coggins et al., 2022). The advancements in mobile technology and the increasing availability of smartphones have facilitated the adoption of mobile apps as essential tools for farmers and extension agents worldwide. This conceptual review will assess the usage patterns and adoption rates of mobile apps in the agricultural sector, focusing on how they have transformed farming practices and improved agricultural productivity.

Adoption Rates

The adoption rates of mobile apps among farmers and extension agents have been steadily increasing due to several factors. Firstly, the decreasing cost and increasing accessibility of smartphones have made them more affordable and widely available, even in rural areas. As a result, farmers and extension agents can now access mobile apps that provide valuable agricultural information and services (Birner et al., 2021).

Secondly, the growing recognition of the benefits offered by mobile apps has contributed to their adoption. These apps provide farmers with real-time information on weather conditions, market prices, pest and disease management, agricultural best practices, and access to financial services. Extension agents, on the other hand, can leverage mobile apps to disseminate information and provide advisory services to farmers more efficiently.

Usage Patterns

Mobile apps for farmers and extension agents serve a wide range of purposes, catering to various aspects of agricultural activities. The following are some common usage patterns:

a. **Access to Information:** Mobile apps provide farmers and extension agents with easy access to a vast amount of agricultural information. This includes weather forecasts, crop-specific advice, market trends, government policies, and agricultural news. Such information enables farmers to make informed decisions regarding crop selection, planting timelines, irrigation, fertilization, and pest management (Balafoutis et al., 2017).

b. **Crop Management:** Mobile apps offer features that help farmers with crop management tasks. These include crop monitoring, disease diagnosis, soil testing, and yield prediction. By leveraging these apps, farmers can track the growth and health of their crops, identify potential issues, and take timely corrective actions (Barakabitze et al., 2015).

c. **Market Linkages:** Mobile apps facilitate direct access to market information and link farmers with potential buyers, eliminating intermediaries and improving price transparency. Farmers can check market prices, demand-supply trends, and connect with buyers or online marketplaces to sell their produce. This empowers farmers to negotiate better prices and make informed marketing decisions (Beza et al., 2018).

d. **Financial Services:** Mobile apps also provide financial services to farmers, including access to credit, insurance, and payment systems. These apps enable farmers to apply for loans, manage their finances, and receive payments digitally, reducing the risks associated with cash transactions and improving financial inclusion (Carrer et al., 2017).

e. **Advisory Services:** Extension agents leverage mobile apps to extend their reach and provide advisory services to farmers remotely. They can share crop-related information, answer queries, and provide personalized recommendations to farmers through chatbots, voice assistants, or online forums. This helps in scaling up advisory services and addressing the challenges of limited extension infrastructure (Chatterjee et al., 2020).

Benefits and Impact

The usage of mobile apps in agriculture has had several positive impacts on farmers and extension agents:

a. **Enhanced Productivity:** Mobile apps streamline agricultural processes, provide timely information, and improve decision-making, leading to increased productivity. Farmers can optimize resource utilization, adopt precision farming techniques, and mitigate risks effectively, resulting in higher yields and better crop quality (Khan et al., 2019).

b. **Improved Efficiency:** Mobile apps enable farmers to access information and services at their fingertips, eliminating the need for physical visits or relying solely on traditional knowledge sources. This saves time and effort, allowing farmers to allocate resources more efficiently and focus on other critical tasks (Grunert et al., 2018).

c. **Access to Market Opportunities:** Mobile apps bridge the information gap between farmers and markets, enabling them to explore diverse market opportunities. Farmers can identify high-demand crops, connect with potential buyers, negotiate better prices, and expand their customer base. This encourages market-driven agriculture and reduces market inefficiencies (Ellison et al., 2016).

d. **Empowerment and Knowledge Sharing:** Mobile apps empower farmers by providing them with up-to-date information, knowledge, and skills. They can access educational content, training modules, and expert advice, promoting continuous learning and capacity building. Additionally, farmers can share their experiences and best practices with each other, fostering knowledge exchange and community development (Cotter et al., 2020).

e. **Sustainability and Environmental Impact:** Mobile apps contribute to sustainable agricultural practices by promoting resource conservation, integrated pest management, and climate-smart techniques. They facilitate the adoption of eco-friendly farming methods, reducing the environmental impact of agricultural activities (Berkowsky et al., 2017).

Hence, the usage patterns and adoption rates of mobile apps among farmers and extension agents have witnessed substantial growth. Mobile apps have revolutionized farming practices by providing farmers with easy access to information, advisory services, market linkages, and financial support. The benefits of these apps include enhanced productivity, improved efficiency, access to market opportunities, empowerment, and sustainability. As technology continues to evolve, it is expected that mobile apps will play an increasingly vital role in transforming agriculture and contributing to global food security (Klerkx & Rose, 2020).

Evaluate the perceived usefulness, ease of use, and satisfaction with mobile app-based extension services

The evaluation of perceived usefulness, ease of use, and satisfaction with mobile app-based extension services is crucial in understanding the effectiveness and impact of these services on farmers and extension agents. By assessing these factors, the study can gain insights into the users' perspectives, identify areas of improvement, and ensure that mobile app-based

extension services meet their needs effectively. Hence, this study will evaluate the perceived usefulness, ease of use, and satisfaction with mobile app-based extension services, highlighting their significance and implications (Klerkx, 2022).

Perceived Usefulness

Perceived usefulness refers to the extent to which users believe that a mobile app-based extension service can enhance their job performance, provide valuable information, and address their specific needs. Several factors influence the perceived usefulness of these services:

a. **Access to Information:** Mobile app-based extension services offer users access to a wide range of agricultural information, including crop management practices, pest and disease control measures, weather forecasts, market prices, and government schemes. Farmers and extension agents perceive these services as valuable tools that provide them with timely and accurate information, enabling them to make informed decisions and improve their agricultural practices (Krah et al., 2019).

b. **Advisory Services:** Mobile apps often incorporate advisory services, where users can seek expert advice, ask questions, and receive personalized recommendations. The perceived usefulness of these services lies in the ability to obtain expert guidance remotely, overcoming the limitations of physical access to extension agents. Users value the convenience and efficiency of receiving prompt responses to their queries, which can assist them in resolving specific challenges and making informed decisions (Kieti et al., 2022).

c. **Market Linkages:** Mobile app-based extension services that facilitate market linkages are highly valued by farmers. These services provide information on market trends, prices, and potential buyers, enabling farmers to make informed marketing decisions and connect directly with buyers or online platforms. By eliminating intermediaries, users perceive these services as useful for improving their market access and negotiating better prices, ultimately enhancing their profitability (Leng et al., 2020).

d. **Financial Services:** Mobile apps that offer financial services, such as access to credit, insurance, and digital payment systems, are considered useful by farmers. These services address the financial challenges faced by farmers and provide them with convenient and secure options for managing their finances (Hoang, 2020). By streamlining financial transactions and reducing risks associated with cash-based transactions, these services contribute to the overall perceived usefulness of mobile app-based extension services.

Ease of Use

Ease of use refers to the degree to which users perceive mobile app-based extension services as user-friendly, intuitive, and easy to navigate. Factors that influence the ease of use include:

a. **User Interface:** A well-designed user interface that is visually appealing, intuitive, and easy to navigate significantly enhances the ease of use. Users appreciate mobile apps that have clear menu structures, simple icons, and logical workflows. A clutter-free and intuitive design ensures that users can quickly find the information or services they require without any confusion or frustration (Gichuki & Mulu-Mutuku, 2018).

b. **Language and Localization:** Mobile apps that are available in local languages and cater to specific regional needs are considered easier to use. When users can access information and services in their native language, it eliminates language barriers and enhances their understanding and engagement with the app. Additionally, localization of content, such as

region-specific crop recommendations or market information, adds to the ease of use and relevance of the app (Gow et al., 2020).

c. **Technical Requirements:** Mobile app-based extension services should be compatible with a wide range of devices and have low data and power consumption. Optimizing the app's performance and minimizing the data and battery usage make it easier for users, especially those in resource-constrained areas, to access and utilize the services without facing technical difficulties (Karpouzoglou et al., 2016).

d. **Training and Support:** Adequate training and support resources, such as user guides, tutorials, and helplines, contribute to the ease of use. Users appreciate having access to clear instructions and assistance when they encounter challenges or have questions about using the app. Providing ongoing technical support and addressing user feedback promptly can significantly improve the overall user experience and ease of use.

Satisfaction

Satisfaction refers to users' overall contentment and fulfillment with mobile app-based extension services. It is influenced by several factors:

a. **Reliability and Accuracy:** Users expect mobile app-based extension services to be reliable, providing accurate and up-to-date information. Consistency in data accuracy, timely updates, and reliable functionality contribute to user satisfaction. Any technical glitches or inaccuracies can lead to frustration and reduced satisfaction levels (Arouna et al., 2017).

b. **Responsiveness and Timeliness:** Users appreciate mobile apps that are responsive and provide timely responses to their queries or requests for information. Prompt feedback and timely notifications enhance user engagement and satisfaction. Slow response times or delays in information delivery can lead to dissatisfaction and reduced trust in the app (Arouna et al., 2020).

c. **Customization and Personalization:** Mobile apps that allow users to customize their settings or receive personalized recommendations are often more satisfying. Users value the ability to tailor the app to their specific needs, preferences, and geographical context. Personalization features, such as saving favorite crops or markets, receiving targeted notifications, or setting reminders, enhance user satisfaction by providing a personalized and relevant experience (Aryal et al., 2020).

d. **Feedback Mechanisms:** Mobile app-based extension services often include feedback mechanisms that allow users to provide input, share their experiences, and suggest improvements. Users appreciate the opportunity to provide feedback and feel that their opinions are valued. When developers actively seek and respond to user feedback, it demonstrates a commitment to continuous improvement and enhances user satisfaction (Dawkins, 2016).

Implications

Evaluating the perceived usefulness, ease of use, and satisfaction with mobile app-based extension services has several implications:

a. **Service Improvement:** The assessment of these factors helps identify areas where improvements can be made to enhance the overall user experience. Feedback and user

insights can guide the development of new features, improvements in user interface design, and the addition of relevant content or services (Dollman et al., 2021).

b. **User Engagement and Adoption:** Positive evaluations of perceived usefulness, ease of use, and satisfaction contribute to increased user engagement and adoption rates. Satisfied users are more likely to continue using the app and recommend it to others, thereby expanding its user base (Fabregas et al., 2022).

c. **Tailored Services:** Understanding user perspectives helps developers tailor the services to better meet the specific needs of farmers and extension agents. This includes customizing content, language localization, and addressing regional or crop-specific requirements, thereby increasing the relevance and usefulness of the services (Ferrari et al., 2022).

d. **Trust and Credibility:** Positive evaluations of mobile app-based extension services contribute to building trust and credibility among users. Satisfied users are more likely to trust the information and recommendations provided by the app, leading to increased reliance on its services.

e. **Continuous Evaluation:** Perceived usefulness, ease of use, and satisfaction should be continuously monitored and evaluated to ensure that mobile app-based extension services remain effective and relevant. Regular user feedback, analytics, and performance metrics can provide valuable insights for ongoing improvements and updates (Hay & Pearce, 2014).

Hence, evaluating the perceived usefulness, ease of use, and satisfaction with mobile app-based extension services is essential to understand their effectiveness and impact. Positive evaluations contribute to increased user engagement, adoption rates, and trust in the services. By addressing user feedback and continuously improving the app's features, user interface, and content, developers can ensure that mobile app-based extension services meet the specific needs of farmers and extension agents, ultimately enhancing their agricultural practices and livelihoods.

Measure the impact of mobile apps on farmers' knowledge acquisition, adoption of improved agricultural practices, and agricultural productivity.

Mobile apps have the potential to revolutionize the way farmers access information, learn new practices, and enhance their productivity by providing real-time, tailored, and location-specific guidance. One of the primary benefits of mobile apps for farmers is their ability to deliver relevant and timely agricultural information directly to their smartphones or mobile devices. These apps can provide a wide range of knowledge, including weather updates, pest and disease management techniques, crop-specific recommendations, market prices, and best agricultural practices. By having access to such information at their fingertips, farmers can make informed decisions and take appropriate actions to optimize their farming operations.

Mobile apps also facilitate knowledge acquisition through interactive features such as tutorials, videos, and forums. These resources can help farmers understand complex agricultural concepts, learn about innovative techniques, and share experiences with other farmers. The interactive nature of these apps encourages active learning, engagement, and knowledge exchange among farmers, empowering them with the latest insights and best practices in agriculture.

The adoption of improved agricultural practices is another area where mobile apps have shown significant impact. By providing step-by-step guidance and personalized

recommendations, these apps can help farmers implement sustainable farming techniques, efficient irrigation methods, integrated pest management strategies, and precision agriculture approaches. The accessibility and convenience of mobile apps enable farmers to overcome barriers to adopting new practices, thereby enhancing their productivity, reducing input costs, and minimizing environmental impacts.

Furthermore, mobile apps can contribute to agricultural productivity by improving resource management and decision-making. Apps that integrate data analytics, remote sensing, and machine learning algorithms can assist farmers in optimizing fertilizer and pesticide applications, irrigation scheduling, and crop rotation strategies. By leveraging real-time data and advanced analytics, farmers can make data-driven decisions and respond promptly to changing conditions, leading to improved yield, resource efficiency, and overall productivity.

However, it is essential to consider certain challenges and limitations associated with mobile apps in the agricultural context. Access to smartphones and reliable internet connectivity can be barriers for farmers in some regions, particularly in rural areas. Language barriers, illiteracy, and limited digital literacy skills may also impede the effective use of mobile apps. Therefore, addressing these challenges by ensuring wider access to affordable smartphones, expanding internet infrastructure, providing user-friendly interfaces, and offering support and training programs is crucial to maximize the potential impact of mobile apps on farmers' knowledge acquisition and productivity.

To measure the impact of mobile apps on farmers' knowledge acquisition, adoption of improved agricultural practices, and agricultural productivity, comprehensive research studies can be conducted. These studies can employ a combination of qualitative and quantitative methods to assess various indicators, including changes in farmers' knowledge levels, adoption rates of recommended practices, yield improvements, input cost reductions, and overall farm profitability. Surveys, interviews, focus group discussions, and on-field observations can be utilized to gather data and insights from farmers who have used mobile apps.

Additionally, monitoring and evaluation frameworks can be employed to track the outcomes and impact of mobile app interventions over time. Key performance indicators such as the number of downloads and active users, user engagement metrics, user satisfaction levels, and feedback from farmers can provide valuable insights into the effectiveness and usability of mobile apps. Longitudinal studies and comparative analyses can also be conducted to measure the sustained impact of mobile apps on farmers' knowledge, practices, and productivity.

Hence, mobile apps have the potential to significantly impact farmers' knowledge acquisition, adoption of improved agricultural practices, and agricultural productivity. By providing accessible information, interactive learning experiences, personalized recommendations, and data-driven decision support, mobile apps empower farmers with the necessary knowledge and tools to enhance their farming practices. However, addressing challenges related to access and digital literacy is crucial to ensure equitable benefits for all farmers. Through rigorous research and monitoring, we can gain a deeper understanding of the impact of mobile apps and work towards harnessing their full potential to transform agriculture and improve the livelihoods of farmers worldwide.

Identify challenges and barriers to the effective implementation and utilization of mobile app-based extension services.

The implementation and utilization of mobile app-based extension services in agriculture face several challenges and barriers that need to be addressed for their effective adoption and impact. These challenges can be categorized into technical, infrastructural, socio-economic, and capacity-related factors. Understanding and overcoming these barriers are crucial to maximize the benefits of mobile app-based extension services for farmers.

Technical Challenges

- a. **Device Compatibility:** Ensuring that mobile apps are compatible with a wide range of devices and operating systems can be a challenge. Farmers may have different smartphone models or use older devices that may not support the latest app versions.
- b. **Connectivity Issues:** Limited or unreliable internet connectivity in rural areas can hinder the seamless use of mobile apps. Slow internet speeds or complete lack of network coverage can prevent farmers from accessing app features and timely information.
- c. **App Design and Usability:** Mobile apps should be designed with user-friendly interfaces, intuitive navigation, and clear instructions. Complex or confusing app layouts may deter farmers from effectively utilizing the extension services.

Infrastructural Challenges

- a. **Limited Internet Infrastructure:** Inadequate internet infrastructure, especially in rural areas, can restrict the availability and accessibility of mobile app-based extension services. Insufficient coverage and bandwidth can hinder the smooth functioning and data transfer required for the apps to operate effectively (Faustin et al., 2010).
- b. **Power Supply:** Frequent power outages or lack of access to electricity can pose challenges for farmers in charging their mobile devices. This can limit their ability to use mobile apps consistently and benefit from extension services.

Socio-economic Challenges

- a. **Digital Divide:** The "digital divide" refers to the gap in access to and usage of digital technologies between different socio-economic groups. Farmers from marginalized communities or low-income backgrounds may have limited access to smartphones, internet connectivity, or the necessary digital skills to effectively use mobile app-based extension services.
- b. **Language and Literacy:** Mobile apps should be available in local languages and designed with consideration for varying literacy levels. Language barriers and low literacy rates can hinder farmers' understanding and utilization of app content, limiting the impact of extension services.

Capacity-related Challenges

- a. **Technical Literacy:** Farmers may lack the necessary technical skills to operate mobile apps, navigate settings, or troubleshoot issues. Training and capacity-building initiatives are essential to equip farmers with the knowledge and skills to effectively utilize app-based extension services.
- b. **Awareness and Adoption:** Limited awareness among farmers about the existence and benefits of mobile app-based extension services can hinder their adoption. Engaging in

targeted awareness campaigns and demonstrating the value of these services can increase farmer participation and usage (Isgin et al., 2008).

By addressing these challenges, stakeholders can create an enabling environment for the effective implementation and utilization of mobile app-based extension services in agriculture. This, in turn, can empower farmers with valuable knowledge, enhance their decision-making capabilities, and contribute to improved agricultural practices and productivity (Leeuwis & Aarts, 2011).

Theoretical Framework

This study is theoretically underpinned on Technology Acceptance Model (TAM).

The Technology Acceptance Model (TAM), initially proposed by Davis in 1989 and further developed by Venkatesh and Davis in 2000, is a widely recognized theory that explains individuals' acceptance and use of technology. The TAM posits that the intention to use a technology is influenced by two primary factors: perceived usefulness and perceived ease of use. Perceived usefulness refers to the extent to which individuals believe that using a particular technology will enhance their performance or productivity. Perceived ease of use refers to the perception of how easy it is to understand, learn, and use the technology.

Applying the TAM to the study of mobile app-based extension services in agriculture, perceived usefulness would relate to farmers' beliefs about the benefits and value they can derive from using these services. For example, farmers may perceive that mobile apps can provide them with real-time information on weather patterns, crop diseases, market prices, and improved agricultural practices, leading to increased productivity, reduced costs, and better decision-making. Farmers who perceive mobile apps as useful are more likely to adopt and utilize them for extension services.

Perceived ease of use is also relevant as it influences farmers' attitudes towards using mobile apps. If farmers perceive the apps as user-friendly, intuitive, and compatible with their existing knowledge and skills, they are more likely to adopt and utilize them. On the other hand, if farmers perceive the apps as complex, difficult to navigate, or requiring extensive technical expertise, they may be hesitant to adopt them.

The TAM provides a theoretical framework to understand the factors that influence farmers' acceptance and utilization of mobile app-based extension services. By examining farmers' perceptions of usefulness and ease of use, the study can gain insights into the determinants of adoption and identify potential barriers or challenges that may hinder effective implementation and utilization.

Moreover, the TAM can aid in the design and development of mobile app-based extension services that align with farmers' needs, preferences, and usability expectations. By incorporating features that enhance perceived usefulness and ease of use, such as personalized recommendations, interactive tutorials, intuitive interfaces, and multilingual support, app developers can increase farmers' acceptance and engagement with the services.

In summary, the Technology Acceptance Model (TAM) is relevant to the study as it provides a theoretical foundation for understanding farmers' acceptance and utilization of mobile app-based extension services. By considering the factors of perceived usefulness and perceived ease of use, the study can explore the determinants of adoption and identify strategies to overcome barriers and enhance the effectiveness of these services in the agricultural context.

3. Methodology

The methodology employed for evaluating the effectiveness of mobile apps in enhancing agricultural extension services delivery in Nigeria involves a mixed-methods approach. Data collection primarily relies on a descriptive survey design. This entails administering questionnaires to participants representing various stakeholders, including farmers, extension agents, and agricultural cooperatives across different regions of Nigeria. To ensure a comprehensive understanding, both quantitative and qualitative data are gathered. Quantitative data, obtained through the surveys, focus on capturing metrics related to mobile app usage, perceptions, and their impact on agricultural practices. Meanwhile, qualitative insights are derived from in-depth interviews conducted with key informants, such as agricultural experts, extension service providers, and app developers.

The study adopted a simple descriptive statistical tools such as frequency distribution scale and simple percentage for data analysis while correlation analysis was conducted to provide nuanced insights into the effectiveness of mobile apps in improving agricultural extension services delivery in Nigeria.

4. Results

Table 1: Descriptive Statistics on assessing the usage patterns and adoption rates of mobile apps among farmers and extension agents.

Metric	Mean	Median	Std. Deviation	Min	Max
Frequency of app usage (per week)	4.2	4	1.3	1	7
Adoption rate (%)	78	80	15	50	95

Source: Field Survey, 2024

Table 1 illustrates that farmers and extension agents use mobile apps regularly, with a mean frequency of 4.2 times per week. The usage is consistent, with a median of 4 times per week and a low standard deviation, indicating relatively stable usage patterns.

The adoption rate of mobile apps among farmers and extension agents is high, with an average adoption rate of 78%. The median adoption rate is 80%, indicating a majority of participants have adopted mobile apps. The standard deviation suggests some variability in adoption rates among participants.

Table 2: Descriptive Statistics evaluating the perceived usefulness, ease of use, and satisfaction with mobile app-based extension services.

Metric	Mean	Median	Std. Deviation	Min	Max
Perceived usefulness (1-5)	4.3	4	0.8	3	5
Ease of use (1-5)	4.1	4	0.9	2	5
Satisfaction (1-5)	4.5	4	0.7	3	5

Source: Field Survey, 2024

Table 2 depicts that the participants perceive mobile app-based extension services as highly useful, with an average rating of 4.3 out of 5. The median and low standard deviation indicate a consistent perception of usefulness among participants.

The ease of use of mobile app-based extension services is rated positively, with an average score of 4.1 out of 5. Participants find the apps relatively easy to use, as indicated by the median score of 4 and low standard deviation.

Participants express high satisfaction with mobile app-based extension services, with an average rating of 4.5 out of 5. The median score of 4 and low standard deviation suggest consistent satisfaction levels among participants.

Table 3: Descriptive Statistics measuring the impact of mobile apps on farmers' knowledge acquisition, adoption of improved agricultural practices, and agricultural productivity.

Metric	Mean	Median	Std. Deviation	Min	Max
Knowledge acquisition (1-10)	8.2	8	1.2	5	10
Adoption of agricultural practices (%)	85	85	10	60	95
Agricultural productivity (%)	20% increase	-	-	-	-

Source: Field Survey, 2024

Table 3 shows that mobile apps contribute significantly to farmers' knowledge acquisition, with an average score of 8.2 out of 10. The median and low standard deviation indicate consistent improvement in knowledge among participants.

The adoption of improved agricultural practices is high among participants using mobile apps, with an average adoption rate of 85%. The median adoption rate of 85% suggests consistent adoption across participants. The standard deviation indicates some variability in adoption rates.

Participants report a significant increase in agricultural productivity, with an average improvement of 20%. While a median value isn't applicable in this context, the absence of standard deviation suggests consistent reports of productivity improvement.

Table 4: Descriptive Statistics identifying challenges and barriers to the effective implementation and utilization of mobile app-based extension services.

Metric	Frequency	Most Common Challenges and Barriers
Technical issues	25%	Connectivity problems, app crashes, compatibility issues
Lack of awareness /training	20%	Insufficient training on app usage, unawareness of app functionalities
Language barriers	15%	Limited language support, language complexity of app content
Access to smartphones	10%	Affordability issues, limited availability of smartphones in rural areas
Resistance to change	30%	Resistance from older farmers, skepticism towards technology adoption

Source: Field Survey, 2024

Table 4 shows the frequency and most common challenges and barriers reported by participants. Technical issues such as connectivity problems and app crashes are the most prevalent, followed by lack of awareness/training on app usage. Language barriers and access to smartphones also pose significant challenges, albeit to a lesser extent. Resistance to change, particularly from older farmers, is also a notable barrier to effective implementation and utilization of mobile app-based extension services.

Test of Hypotheses

H0₁: There is no significant difference in the usage patterns of mobile apps between farmers and extension agents.

Table 5: Correlation Analysis

	Farmers' Usage Patterns	Extension Agents' Usage Patterns
Farmers	1	0.85
Extension Agents	0.85	1

Source: SPSS Output from field survey, 2024

The correlation value of 0.85 suggests a strong positive correlation between the usage patterns of mobile apps among farmers and extension agents, indicating similar usage patterns. This supports the null hypothesis that there is no significant difference in usage patterns between farmers and extension agents.

H0₂: There is no significant relationship between the perceived usefulness, ease of use, and satisfaction with mobile app-based extension services.

Table 6: Correlation Analysis

	Perceived Usefulness	Ease of Use	Satisfaction
Perceived Usefulness	1	0.75	0.80
Ease of Use	0.75	1	0.70
Satisfaction	0.80	0.70	1

Source: SPSS Output from field survey, 2024

The correlation values indicate moderate to strong positive correlations between perceived usefulness, ease of use, and satisfaction with mobile app-based extension services. This suggests that users who perceive the app as useful also find it easy to use and are satisfied with it, supporting the null hypothesis.

H0₃: Mobile apps have no significant impact on farmers' knowledge acquisition, adoption of improved agricultural practices, or agricultural productivity.

Table 7: Correlation Analysis

	Knowledge Acquisition	Adoption of Practices	Agricultural Productivity
Mobile App Usage	0.60	0.55	0.50

Source: SPSS Output from field survey, 2024

The correlation values in table 7 above indicate moderate positive correlations between mobile app usage and farmers' knowledge acquisition, adoption of improved agricultural practices, and agricultural productivity. This suggests that there is a relationship between using mobile apps and these outcomes, challenging the null hypothesis.

H0₄: There are no significant challenges or barriers affecting the effective implementation and utilization of mobile app-based extension services.

Table 8: Correlation Analysis

	Challenges/Barriers	Implementation/Utilization Effectiveness
Challenges/Barriers	1	0.80
Implementation/Utilization Effectiveness	0.80	1

Source: SPSS Output from field survey, 2024

Table 8 shows the correlation value of 0.80 which suggests a strong positive correlation between identified challenges/barriers and the effectiveness of implementation/utilization of mobile app-based extension services. This indicates that the presence of challenges/barriers is associated with reduced effectiveness, challenging the null hypothesis.

5. Summary of Findings

The findings revealed several key insights:

The findings suggest that there are similarities in the usage patterns of mobile apps among farmers and extension agents, indicating no significant difference between these two groups. Additionally, there is a positive relationship between perceived usefulness, ease of use, and satisfaction with mobile app-based extension services, indicating that users who find the app useful also perceive it as easy to use and are satisfied with it. The study also indicates that mobile app usage is associated with improvements in farmers' knowledge acquisition, adoption of improved agricultural practices, and agricultural productivity. This challenges the notion that mobile apps have no significant impact on farmers' outcomes. Furthermore, the presence of challenges and barriers is correlated with reduced effectiveness in the implementation and utilization of mobile app-based extension services, contradicting the idea that there are no significant challenges or barriers among farmers and extension agents.

Conclusion

The correlation analysis conducted in this research provides valuable insights into the dynamics of mobile app-based extension services in agriculture. The findings underscore the significance of mobile technologies in agricultural extension, revealing patterns of usage, perceived usefulness, impact on farmers' outcomes, and challenges faced in implementation.

The strong positive correlation between the usage patterns of mobile apps among farmers and extension agents indicates a convergence in their adoption behaviors. This suggests a promising trend towards the widespread adoption of mobile technologies for accessing agricultural extension services.

Moreover, the moderate to strong positive correlations between perceived usefulness, ease of use, and satisfaction with mobile app-based extension services highlight the importance of user-centric design principles in enhancing user experience and satisfaction. This emphasizes the need for continued efforts in developing intuitive and valuable mobile applications tailored to the needs of farmers and extension agents.

Furthermore, the moderate positive correlations observed between mobile app usage and farmers' knowledge acquisition, adoption of improved agricultural practices, and agricultural productivity suggest a positive impact of mobile technologies on these outcomes. This

underscores the potential of mobile app-based extension services to contribute to agricultural development and sustainability.

However, the strong positive correlation between identified challenges/barriers and the effectiveness of implementation/utilization of mobile app-based extension services indicates the presence of significant hurdles that need to be addressed. Overcoming these obstacles will be crucial for maximizing the effectiveness and reach of mobile app-based extension services.

Hence, while mobile app-based extension services hold promise for enhancing agricultural practices and productivity, addressing challenges and ensuring user satisfaction are paramount for their successful implementation and widespread adoption.

Recommendations

Based on the findings of the study, the following recommendations are proposed to enhance the effectiveness and adoption of mobile app-based extension services in agriculture:

- i. Invest in user-centric design principles to ensure that mobile applications are intuitive, user-friendly, and valuable to farmers and extension agents.
- ii. Provide comprehensive training and capacity building programs to farmers and extension agents to enhance their digital literacy and proficiency in using mobile apps for accessing extension services.
- iii. Tailor the content and features of mobile apps to the specific needs and contexts of different user groups, such as smallholder farmers, large-scale producers, and extension workers.
- iv. Foster partnerships and collaboration between government agencies, NGOs, research institutions, private sector companies, and other stakeholders involved in agricultural extension.

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