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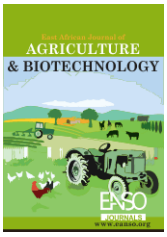

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Original Article

Adopter Category Characterizations and the Adoption of Mobile Phone Applications for Improved Small-scale Commercial Agriculture in Chitomborwizi-Makonde District, Zimbabwe

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Adopter Category Characterisations, Adoption, Mobile Phone Applications, Small-Scale Commercial Agriculture, Chitomborwizi-Makonde District Zimbabwe.

ABSTRACT

The aim of this study was to explore adopter category characterizations on the adoption of mobile phone applications for improved small-scale commercial agriculture in Makonde District, Zimbabwe. The study utilized Rogers' Diffusion of Innovations Theory's (DIT) adopter categories to proffer a comprehensive perspective for analysing small-scale commercial farmers' adoption characteristics in small-scale commercial agriculture. The study adopted a qualitative methodology, a case study research design, a sample of 12 research participants and in-depth key informant interviews. The study utilized purposive and snowball sampling techniques to gather primary data. The study employed thematic analysis to analyze primary data. The research results demonstrated that farmers' adopter characteristics (age, education, social status, financial support, digital literacy and technical proficiency, access to electricity and access to internet connectivity and network coverage) positively and negatively influenced the adoption of mobile applications. The results highlighted that innovator adopters, early adopters and early majority adopters were more likely to adopt mobile applications because these adopters showed more interest in mobile applications. In contrast, late majority adopters and laggards were less likely to adopt mobile applications because these adopters were less interested in the adoption of mobile applications. Further, innovator adopters, early adopters and early majority adopters' category characteristics enabled them to adopt mobile applications, while late majority adopters and laggards' adopters' category characterisations hindered the adoption of mobile applications. The study concluded that adopter category characterisations had differing impacts on small-scale commercial farmers' adoption of mobile applications. In addition, the study findings indicated that small-scale commercial farmers belong to different adopter categories and do not fit into the homogenous category of mobile application adopters. The study recommends the need to classify small-scale commercial farmers' adopter category characteristics to tailor strategies that promote the widespread adoption of mobile applications for improved small-scale commercial agriculture.

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INTRODUCTION

The adoption of mobile applications in agriculture is crucial for enhancing productivity, efficiency and sustainability. However, the adoption of mobile applications is influenced by a complex array of factors, including demographic, socio-economic and technological aspects, which play a vital role in shaping farmers' perceptions, attitudes and behaviours towards mobile applications. Among these characteristics are age, education level, social status, credit or financial support, digital literacy and technical proficiency, access to electricity, access to internet connectivity and network coverage. These factors can either facilitate or hinder the adoption of mobile applications in agriculture, ultimately affecting the livelihoods of farmers and the overall agricultural sector. Further, change agents consider all the adopters to be on the same adoption level and employ the same training strategies without recognising the different adopter category characteristics unique to each category (Nyarko et al., 2022; Molina-Maturano et al., 2021). Consequently, mobile phone applications introduced in agriculture face adoption difficulties because implementers do not understand the dynamism and complexities of potential adopters. Understanding the importance of these adopter category characteristics is essential for policymakers, extension agents, and technology developers seeking to promote the adoption of mobile applications in agriculture. By recognising the unique needs, challenges and opportunities associated with each adopter category characteristic, stakeholders can design and implement targeted strategies to support farmers in harnessing the potential of mobile applications, thereby contributing to a more productive, efficient and sustainable agricultural sector. Considering adopter category characterisations enhances resource optimisation, that is, resources can be allocated more efficiently to address the specific needs of farmer groups that inform the design of mobile applications, ensuring they meet the needs of and capabilities of farmers and offer tailored support services such as training and technical assistance based on farmers' needs and characteristics, thereby enhancing the adoption of mobile applications in agriculture. Further, by addressing the unique needs and challenges of different farmer groups, the likelihood of long-term adoption and sustained use of mobile applications

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increases leading to the development of scalable solutions that can be adapted to different contexts and farmers. Furthermore, recognising the diversity of adopter category characteristics promotes equity by ensuring that mobile applications are accessible and beneficial to all farmers regardless of their circumstances or background, thereby supporting inclusive development leading to positive social and economic impacts. In Zimbabwe, it appears there is a paucity of research on small-scale commercial farmers' adopter category characterisations. The current study focuses on filling this research gap in the context of small-scale commercial farmers in Chitomborwizi in Makonde District, Zimbabwe.

LITERATURE REVIEW

The adopter category characterisations were selected based on the adoption of agriculture technologies and related literature. These characteristics pointed to age, education level, social status, financial support, digital literacy and technical proficiency, access to electricity and access to internet connectivity and network coverage.

Age

Earlier research found that age is an important socio-demographic characteristic in the adoption of agricultural innovations. Studies conducted by Adams, & Jumpah (2021); Amoussohoui et al. (2023); Ayenew et al. (2020); Mutuma et al. (2023); Nyagango et al. (2022); Okonkwo et al. (2020); Steinke et al. (2020) and Zondo, & Ndoro (2022) established that age of farmers influenced the adoption of agricultural technology. Further, studies by Hoang, & Hoa (2023); Nguimkeu, & Okou (2024); Sapbamrer, & Thammachai (2021) found that younger farmers were in a better position to adopt digital technologies, than older farmers. In the same way, studies by Benard et al. (2020) and Nwali et al. (2022) emphasized that older farmers were constrained in their adoption of mobile applications. A study by Rogers (2003), in the innovation diffusion theory, categorised innovator adopters, early adopters and early majority as characteristically younger groups who show more interest in innovation adoption. A study by Rogers (2003) categorised late adopters and laggards as characteristically older groups who show less interest in innovation adoption. Further, a study by Staddon (2020) found no relationship between age and technology adoption behaviour. The research findings revealed mixed results.

Education

Prior studies show that education is an important socio-demographic characteristic that influences decision-making in the adoption of technology in the agricultural sector. Studies by Adams, & Jumpah (2021); Amoussohoui et al. (2023); Dube-Takaza et al. (2023); Mutuma et al. (2023); Nyagango et al, (2022); Ruzzante et al. (2021); Sapbamrer, & Thammchai (2021) and Zondo, & Ndoro (2022) found that educational levels influenced the adoption of agricultural technologies. Similarly, Hoang, & Hoa (2023); Massresha et al. (2021); Nguimkeu, & Okou (2024) found that the likelihood of adopting technology was greater for farmers with higher education levels. Likewise, a study by Rogers (2003) in the innovation diffusion theory categorised innovator adopters, early adopters and early majority adopters as characteristically educated who show more interest in innovation adoption. Conversely, Ullah et al. (2022) found that education negatively influenced farmers' innovation adoption decisions. Further, Rogers (2003) categorised the late majority and laggards as characteristically less educated and showing less interest in innovation adoption. The research findings revealed mixed results.

Social Status

Past studies revealed that farmers' social status positively influences the adoption of agricultural technologies. Studies by Adegbite (2020); Adegbite, & Ogunniyi (2020); Liu, & Wang (2020), Rao, & Gupta (2017); Sharma, & Sharma (2018); Singh (2019) and Singh, & Singh (2019) revealed

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that social status was a significant determinant of the adoption of mobile applications. In addition, a study by Rogers (2003) in the innovation diffusion theory categorised innovator adopters, early adopters and early majority adopters as characteristically belonging to a higher social status and showing more interest in innovation adoption. On the contrary, a study by Rogers (2003) found that a farmer's social status influenced the adoption of agricultural technologies. Further, Rogers (2003) categorised late majority adopters and laggards as characteristically belonging to a lower social status and showing less interest in innovation adoption. The research findings indicated mixed results.

Access to Financial Support

Preceding studies indicated that access to financial support positively influenced the adoption of agricultural technologies. Studies by Ayenew et al. (2020); Barrios et al. (2023); Deboche et al. (2020); Miine et al. (2023); Mutuma et al. (2023) and Ruzzante et al. (2021) revealed that access to financial support positively influenced the adoption of agricultural technologies. Further, a study by Nguimkeu, & Okou (2024) found that wealthier farmers were more likely to adopt digital technologies. Furthermore, studies by Dube-Takaza et al. (2023) and Hawas, & Degaga (2023) found that access to credit was more among adopters compared to non-adopters. A study by Rogers (2003) in the innovation diffusion theory categorised innovator adopters, early adopters and early majority adopters as characteristically financially lucid who show more interest in innovation adoption. In contrast, Achukwu et al. (2023) and Omar et al. (2020) found that the inability to acquire financial support was a barrier to the adoption of agricultural technology as they find it financially burdening to do so. A study by Rogers (2003) in the innovation diffusion theory categorised late majority adopters and laggards as characteristically less financially lucid and showing less interest in innovation adoption. The study findings show mixed conclusions.

Digital Literacy and Technical Proficiency

Previous studies found that digital literacy and technical proficiency influenced the adoption of agricultural technologies. Studies by Adegbite (2020); Adegbite, & Ogunniyi (2020); Liu, & Wang (2020), Rao, & Gupta (2019); Sharma, & Sharma (2018); Singh (2020) and Singh, & Singh (2020) revealed that digital literacy and technical proficiency positively influenced the adoption of agricultural technologies. In this study, innovator adopters, early adopters and early majority adopters were categorised as characteristically possessing digital literacy and technical proficiency and showing more interest in innovation adoption. On the contrary, Choruma et al. (2024); Erlangga et al. (2023) and Emeana et al. (2020) found that low digital literacy and technical proficiency hinder widespread digitalisation in agriculture and are highly likely to fail to achieve their intended purpose when implementers ignore literacy skills. In this study, late majority adopters and laggards were categorised as characteristically possessing low digital literacy and technical proficiency and showing less interest in adopting agricultural technologies. Research findings indicated mixed results.

Access to Electricity

Earlier studies found that access to electricity influenced the adoption of agricultural technology. Studies by Adegbite (2020); Adegbite, & Ogunniyi (2020); Liu, & Wang (2020), Rao, & Gupta (2019); Sharma, & Sharma (2018); Singh (2020) and Singh, & Singh (2020) found that access to reliable electricity promoted the use of digital technologies in agricultural activities. In this study, innovator adopters, early adopters and early majority adopters were categorised as characteristically having access to electricity and showing more interest in innovation adoption. In contrast, studies by Adegbite (2020); Adegbite, & Ogunniyi (2020); Liu, & Wang (2020), Rao, & Gupta (2019); Sharma, & Sharma (2018); Singh (2020) and Singh, & Singh (2020) further revealed that lack of electricity

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impeded the adoption of agricultural technologies. In this study, late majority adopters and laggards were categorised as characteristically having no access to electricity and showing less interest in innovation adoption. Research findings revealed mixed results.

Access to Internet Connectivity and Network Coverage

Prior studies highlighted that access to internet connectivity and network coverage influenced the adoption of agricultural technologies. Studies by Adegbite (2020); Adegbite, & Ogunniyi (2020); Liu, & Wang (2020), Rao, & Gupta (2019); Sharma, & Sharma (2018); Singh (2020) and Singh, & Singh (2020) found that the availability of mobile networks and reliable broadband in rural areas are key for development and successful scaling up of digital agriculture solutions. In this study, innovator adopters, early adopters and early majority adopters were categorised as characteristically having access to internet connectivity and network coverage and showing more interest in innovation adoption. Conversely, studies by Choruma et al. (2024); Erlangga et al. (2023) and Omar et al. (2020) found that lack of internet network coverage combined with affordability concerns in rural areas lack access to meaningful connectivity to have access to vital information and services. In this study, late majority adopters and laggards were categorised as characteristically having no access to electricity and showing less interest in innovation adoption. Research findings revealed mixed results.

THEORETICAL FRAMEWORK

Adopter Category Classifications

Technology adoption theoretical frameworks established in previous studies are critical for understanding the adoption of agricultural technologies. The diffusion of innovations theory (DIT), as articulated by Rogers (1995), offers a comprehensive perspective for analysing technology adoption. Rogers (1962) first introduced the concept of adopter categories in his seminal work, “Diffusion of Innovations”. This framework has been widely applied in various fields including agriculture to understand the adoption and diffusion of new technologies. Rogers posited that individuals can be categorised into five distinct adopter categories based on their propensity to adopt new technologies. These categories include innovator adopters, early adopters, early majority adopters, late majority adopters and laggards. Further, the DIT acknowledges that individuals and groups assimilate new technologies at varying rates. The innovation adoption curve, as conceptualised by Rogers (2003), depicts the adopter categories based on their readiness to embrace new technologies or concepts. The theory highlights the diversity in adoption behaviours in embracing innovations. As noted by Rogers (2003) the process of adopting innovations is not instantaneous but occurs over time in which an individual adopts innovations earlier within a social system, with variations among adopter categories being associated with differing levels of innovativeness (Rogers, 2003). Thus, farmers’ innovativeness depended on the degree to which they were relatively early in adopting mobile phone applications in agriculture. In this study, adopter categories enabled the identification and understanding of the characteristics, behaviours and motivations of farmers who adopt new technologies at different stages and provided a framework for tracking and assessing the adoption of mobile applications over time. Figure 1 represents a bell-shaped curve and effectively divides adopters into distinct adopter groups, as outlined below:

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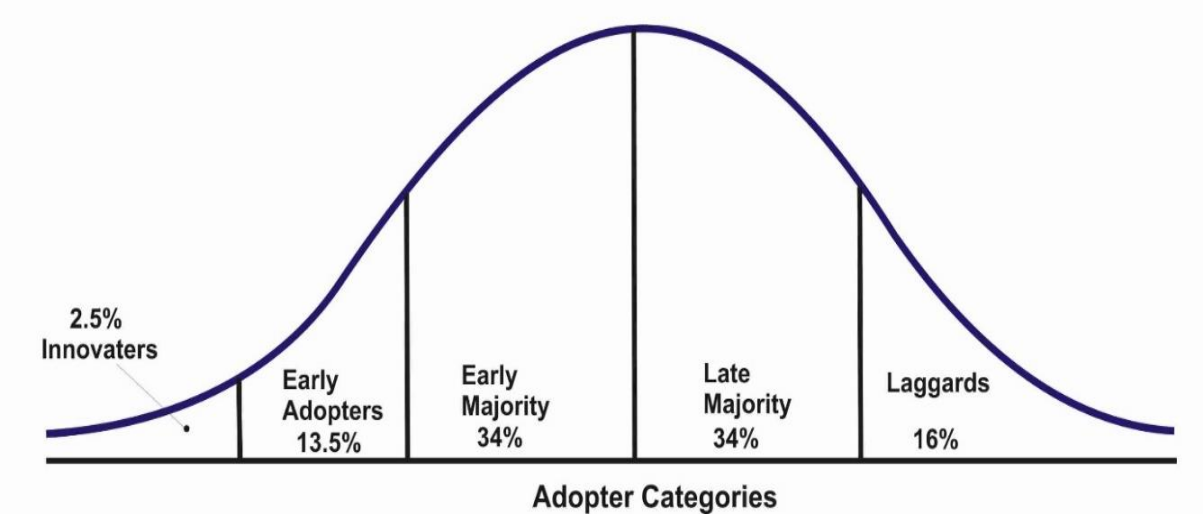
Figure 1: Adopter Categories



Source*: Rogers (2003)*

Innovator Adopters

Innovators constitute the initial segment of adopter categories (Rogers, 2003). They are the pioneers in embracing new technologies. They comprise approximately 2.5% of the overall potential adopter population in the social system. They are typically younger and belong to a higher social class, possess significant financial resources and have the capability to comprehend and utilise complex technical information. Further, innovators are characterised by their propensity for risk-taking and enthusiasm for novel technologies. Furthermore, innovators tend to expand their social networks beyond local circles, engaging in more diverse and cosmopolitan relationships. Thus, innovators are resilient in the face of occasional failures associated with new ideas (Rogers, 2003).

Early Adopters

Early adopters follow closely behind innovators in the adoption process. They account for about 13.5% of the total potential adopter population in social system (Rogers, 2003). Early adopters are influential figures within their social systems, frequently serving as thought leaders for potential adopters. Their endorsement of a new technology can significantly contribute to wider acceptance by the adopting population. Similarly, they are typically young, highly educated, and financially astute, enjoy a higher social status and exhibit a balanced approach to risk. Likewise, early adopters are more socially engaged and tend to be more selective in their adoption decisions, preferring not to be the last to discover a new technology (Rogers, 2003).

Early Majority Adopters

The early majority category represents the third segment within the adopter categories. They account for 34% of the potential adopter population in a social system (Rogers, 2003). They are often characterised by their relatively lower affluence and distinct social behaviours, exhibit a careful consideration of new technologies and embrace novel technologies only when they are assured of their potential benefits. Characterised by their risk-averse nature, they prioritise the judicious allocation of their limited resources towards technologies that are deemed valuable, and frequently seek insights from thought leaders and rely on endorsements from acquaintances who have previously utilised the innovations. Additionally, they engage with reviews, articles and promotional materials to assess the practicality of new technologies. Thus, they typically represent the initial substantial influx of innovations (Rogers, 2003).

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Late Majority Adopters

Late majority adopters are the fourth group in the adopter categories. They comprise 34% of the potential adopters of the population in the social system (Rogers, 2003). They tend to be old, less affluent, and less educated and often exhibit a more conservative approach to innovation. Their scepticism towards new technologies leads them to adopt innovations only after a substantial portion of the population has already adopted them. They are primarily influenced by social pressure, conduct extensive research on new technologies and prefer to review visual evidence, such as images or videos prior to adopting a decision. Thus, late majority adopters generally favour established solutions and are hesitant to take risks (Rogers, 2003).

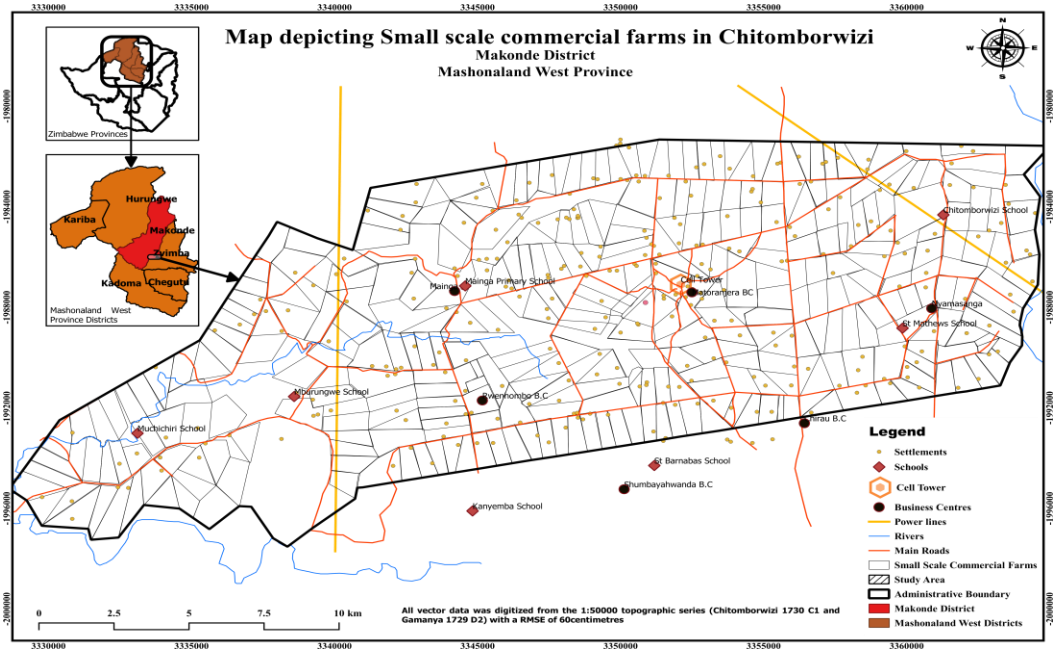
Laggards

Lastly, laggards represent the final segment of the adoption categories, accounting for 16% of the potential adopters of the population in the social system. Laggards are particularly resistant to change, holding a strong preference for traditional practices. Their reluctance to embrace new technologies often results in their adoption occurring only after the innovations have become outdated. Further, laggards are typically older, possess the lowest social status and have limited financial resources, showing minimal engagement in opinion leadership. Furthermore, their social interactions are largely confined to family and close friends and their acceptance of new technologies often signals a decline in the technology's relevance. They are unaffected by social influence and are considered to be too traditionalist.

METHODOLOGY

The study was conducted in Chitomborwizi-Makonde District, Mashonaland West Province, Zimbabwe. The study covered the Chitomborwizi small-scale commercial farming area. Figure 2 shows the study area. The study employed a qualitative approach and utilized in-depth key informant interviews. Non-probability purposive and snowball-sampling techniques were utilized to come up with the study area and 12 research participants. The study adopted thematic analysis to analyze data.

Figure 2: Map of Makonde-Chitomborwizi Small-scale Commercial Farming Area



Source: *Author (2024)*

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RESULTS AND DISCUSSIONS OF RESEARCH FINDINGS

Adopter Category Characterizations

The analysis demonstrated that adopter categories were evaluated in terms of age, education, digital literacy, technical expertise; social status, access to financial support, access to internet connectivity and electricity supply.

Age

Younger farmers are more likely to adopt mobile applications. Research participants reported that young farmers,

> *"Are familiar with smartphones and mobile applications, making it easier for them to adopt and use agricultural mobile applications" (Agricultural Extension Officer, 1).*
>
> *"Are more willing to take risks and try new technologies" (Lead Farmer, 2).*
>
> *"Are more open to new ideas and innovations" (Agricultural Researcher, 1).*

On the contrary, research participants noted that older farmers,

> *"Have limited experience with digital technologies, making it difficult for them to navigate and use mobile applications" (Lead Farmer, 1).*
>
> *"Show age-related cognitive decline affects older farmers' ability to learn and use new technologies" (Agricultural Researcher, 2).*
>
> *"Have physical limitations, such as vision and hearing loss that make it difficult for them to use mobile applications" (Community Leader, 1).*
>
> *"Are resistant to change and less likely to adopt mobile applications" (Agricultural Extension Officer, 2).*
>
> *"Have limited access to training and support, making it difficult for them to learn and use mobile applications" (Opinion Leader, 2).*

The research findings found that the age of farmers positively influenced the adoption of mobile applications because they are young, more familiar with smartphones and mobile applications, are more willing to take risks and try new technologies and are more open to new ideas and innovations. These results are consistent with findings conducted by Adams, & Jumpah (2021); Amoussohoui et al. (2023); Ayenew et al. (2020); Hoang, & Hoa (2023); Mutuma et al. (2023); Nyagango et al. (2022); Nguimkeu, & Okou (2024); Okonkwo et al. (2020); Sapbamrer, & Thammchai (2021); Steinke et al., (2020) and Zondo, & Ndoro (2022). These studies argued that younger farmers are more likely to adopt mobile applications. On the contrary, the results of the current study indicated that age did not affect the adoption of mobile applications. This finding is consistent with the findings by Staddon (2020). This study argued that age is not a determinant of technology adoption. The results of this study found that young farmers were classified as innovator adopters, early adopters and early majority. This is consistent with research findings conducted by Rogers (2003). The finding highlights that these adopters showed more interest in innovation adoption. Further, the study found that old farmers were less likely to adopt mobile applications due to limited digital experience; age-related cognitive decline, limited vision and hearing, resistance to change and limited digital training and support. This research finding concurs with the research findings conducted by Benard et al. (2020) and Nwali et al. (2022). These studies emphasized that older farmers were constrained in their adoption of mobile applications. Further, the results of this study found that old farmers were classified as late majority adopters and laggards. This is consistent with research findings by Rogers (2003). This argued that these adopters show less interest in innovation adoption.

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Education

Educated farmers are more likely to adopt mobile applications. Research participants reported that educated farmers,

> *"Have better literacy skills, making it easier for farmers to understand and navigate mobile applications" (Agricultural Extension Officer, 1).*
>
> *"Have data analysis and interpretation technical skills needed to use effectively mobile applications" (Mobile Applications Developer, 1).*
>
> *"Have critical thinking skills, enabling them to evaluate the effectiveness of mobile applications and make informed decisions" (Lead Farmer, 1).*
>
> *"Have problem-solving skills, which allow them to troubleshoot issues in mobile applications" (Agricultural Researcher, 2).*
>
> *"Are aware of the potential benefits of mobile applications in agriculture" (Opinion Leader).*
>
> *"Attitudes towards technology make them more receptive to adoption" (Mobile Applications Developer, 2).*
>
> *"Have boosted confidence in their ability to use mobile applications, which lead to increased adoption" (Agricultural Researcher, 2).*
>
> *"Can make informed decisions about mobile phone applications adoption, based on their understanding of the technology and its potential benefits" (Lead Farmer, 2).*

Contrariwise, research participants indicated that less educated farmers,

> *"Have limited experiences with digital technologies, which makes it difficult for them to navigate and use mobile applications" (Agricultural Extension Officer, 2).*
>
> *"Struggle to understand technical terms and concepts related to mobile applications, which makes it difficult for them to use mobile applications effectively, a characteristic associated with baby boomers" (Mobile Applications Developer, 2).*
>
> *"Have limited ability to evaluate the credibility and reliability of information provided by mobile applications, a characteristic of late majority and laggards" (Mobile Applications Developer, 1).*
>
> *"Are more resistant to change and less likely to adopt mobile applications" (Community Leader, 1).*
>
> *"Have limited access to training and support, which makes it harder for them to learn and use mobile applications" (Agricultural Extension Officer, 1).*

The results of the current study found that educated farmers were more likely to adopt mobile applications. This finding is consistent with findings conducted by Adams, & Jumpah (2021); Amoussohoui et al. (2023); Dube-Takaza et al. (2023); Mutumwa et al., (2023); Nyagango et al (2022); Ruzzante et al. (2021); Zondo, & Ndoro (2022); Hoang, & Hoa (2023); Massresha et al. (2021) and Nguimkeu, & Okou (2024). These studies highlighted that the adoption of technology was greater for farmers with higher education levels. The research findings of this study found that innovator adopters, early adopters and early majority adopters were educated. This finding is consistent with findings by Rogers (2003). This study highlighted that these adopter category groups show more interest in innovation adoption. In contrast, the current study revealed that less educated farmers were less likely to adopt mobile applications due to limited digital experience, struggle to understand technical concepts and terms, and limited ability to evaluate the credibility of information provided by mobile applications. This finding aligns with the findings of Ullah et al.

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(2022). This study argued that lack of education impedes the adoption of agricultural technology. Further, the current study found that less educated farmers belonged to late majority adopters and laggards. This finding is consistent with research findings by Rogers (2003). This study highlighted that these adopter groups show less interest in innovation adoption.

Digital Literacy and Technical Proficiency

Digitally literate and technically proficient farmers are more likely to adopt mobile applications. Research participants reported that digital literacy and technical expertise,

> *"Allows farmers to easily navigate mobile applications due to better understanding of the features and functionality of mobile applications" (Lead Farmer, 1).*
>
> *"Allows effective management and analysis of data" (Agricultural Extension Officer, 1).*
>
> *"Enhances troubleshooting of issues within mobile applications" (Mobile Applications Developer, 2).*
>
> *"Allows farmers to customise mobile applications to suit their specific needs, integration of mobile applications with other tools and systems" (Mobile Applications Developer, 1).*
>
> *"Enable farmers to modify mobile applications to address specific challenges experienced in agricultural activities and operations" (Lead Farmer, 2).*
>
> *"Enhances confidence in using mobile applications, improves user experience, increases efficiency that helps farmers streamline their operations and activities, thereby reducing time and effort" (Opinion Leader, 2).*
>
> *"Facilitate scaling up of mobile applications adoption among farmers" (Agricultural Extension Officer, 2).*

Contrariwise, research participants indicated that farmers with limited digital literacy and low technical proficiency,

> "*Struggle to navigate mobile applications, which lead to frustration and abandonment" (Lead Farmer, 2).*
>
> *"May not understand basic digital concepts, such as passwords, usernames and data storage" (Mobile Applications Developer, 1).*
>
> *"May not be able to troubleshoot issues with mobile applications, which lead to downtime and reduced productivity" (Mobile Applications Developer, 2).*
>
> *"May not be more likely to fear technology and be hesitant to adopt mobile applications" (Agricultural Researcher, 1).*
>
> *"May not be able to evaluate the effectiveness and reliability of mobile applications, leading to poor decision making" (Agricultural Extension Officer, 2).*

The research findings found that digital literacy and technical proficiency allowed farmers to navigate mobile applications easily, effectively manage and analyse data, troubleshoot issues within mobile applications and farmers to customise mobile applications to suit their specific needs. Further, digital literacy and technical proficiency enabled farmers to modify mobile applications to address specific challenges experienced in agricultural activities and operations, enhanced confidence in using mobile applications and facilitated scaling up of mobile applications adoption among farmers. This finding is consistent with research findings conducted by Adegbite (2020); Adegbite, & Ogunniyi (2020); Liu, & Wang (2020), Rao, & Gupta (2019); Sharma, & Sharma (2018); Singh (2020) and Singh, & Singh (2020). These studies

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revealed that digital literacy and technical proficiency are critical for the adoption of mobile applications. This study found that innovator adopters, early adopters and early majority adopters characteristically possessed digital literacy and technical proficiency. The study argued that these adopters were familiar with mobile applications and showed more interest in innovation adoption. On the contrary, this study found that farmers with low digital literacy and technical proficiency struggle to navigate mobile applications, have a low understanding of digital concepts and terms, are unable to troubleshoot issues with mobile applications, fear technology and are unable to evaluate the effectiveness and reliability of mobile applications. This finding aligns with the findings of Choruma et al. (2024); Emeana et al. (2020) and Erlangga et al. (2023).

These studies argued that low digital literacy and technical proficiency deter farmers from adopting mobile applications. This study found that the late majority adopters and laggards characteristically possessed low digital literacy and technical proficiency. The study argued that these adopters show less interest in adopting agricultural technologies.

Social Status

Farmers with high social status are more likely to adopt mobile applications. Research participants reported that a higher social status,

> *"Increases their access to resources such as mobile devices, internet connectivity, and opportunities for training and capacity building" (Agricultural Extension Officer, 2).*
>
> *"Enable diverse social networks that provide access to valuable information and expertise" (Agricultural Researcher, 1).*
>
> *"Allows more autonomy in decision-making" (Lead Farmer, 2).*
>
> *"Help mitigate risks and improve productivity" (Agriculture Researcher, 2).*

Contrariwise, research participants indicated that lower social status,

> *"Limits access to resources, such as smartphones, internet connectivity, network coverage, training and support, which are necessary for mobile applications adoption" (Opinion Leader, 2).*
>
> *"Limits digital literacy, which makes it difficult for them to navigate and use mobile applications" (Mobile Applications Developer, 2).*
>
> *"Lead farmers to perceive mobile applications as not relevant to their needs and circumstances, which reduce their motivation to adopt these digital tools" (Community Leader, 1).*
>
> *"Instils in farmers the fear of technology, which makes farmers hesitant to adopt mobile applications" (Lead Farmer, 1).*

The research findings found that high social-status farmers positively influenced the adoption of mobile applications by increasing farmers' access to resources such as mobile devices, internet connectivity, and opportunities for training and capacity building; enabling diverse social networks that provide access to valuable information and expertise; allows more autonomy in decision-making and help mitigate risks and improve productivity. This finding concurs with past studies by Adegbite (2020); Adegbite, & Ogunniyi (2020); Liu, & Wang (2020), Rao, & Gupta (2017); Sharma, & Sharma (2018); Singh (2019) and Singh, & Singh (2019). These studies argued that social status was a significant determinant of the adoption of mobile applications. The study found that innovator adopters, early adopters and early majority adopters characteristically belonged to a higher social status. This is consistent with a study by Rogers (2003). This study argued that these adopters show more

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interest in adopting mobile applications. On the contrary, this study found that the low social status of farmers limits access to resources, which makes it difficult for them to navigate and use mobile applications, farmers perceive mobile applications as irrelevant to their needs and circumstances and instil in farmers the fear of technology. This aligns with the finding by Rogers (2003). This study argued that a farmer's social status negatively influences the adoption of mobile applications. Furthermore, this study found that late majority adopters and laggards characteristically belonged to a lower social status. This finding is consistent with research findings by Rogers (2003). This study argued that these adopters show less interest in innovation adoption.

Financial Resources

Farmers with financial resources were more likely to adopt mobile applications. Research participants reported that access to financial resources,

> *"Enables farmers to purchase smartphone devices, which are essential for mobile application adoption" (Agricultural Extension Officer, 1).*
>
> *"Enables farmers to purchase data plans and internet services, which are necessary for mobile applications usage" (Community Leader, 2).*
>
> *"Enhance payments of subscription fees for some mobile applications" (Mobile Applications Developer, 1).*
>
> *"Is critical in accessing training and support services, which help farmers to effectively use mobile applications" (Agricultural Researcher, 2).*

Contrariwise, research participants indicated that lack of financial resources,

> *"Inhibits affordability of smartphones that are necessary for mobile applications adoption" (Lead Farmer, 2).*
>
> *"Impedes affordability of data plans and internet services that are necessary for mobile applications usage" (Mobile Applications Developer, 2).*
>
> *"Obstructs adoption of mobile applications which require subscription fees" (Agricultural Extension Officer, 1).*
>
> *"Hampers training and support services that are necessary for farmers to effectively use mobile applications" (Opinion Leader, 2).*

This study found that farmers with access to financial resources positively influenced the adoption of mobile applications by enabling them to purchase smartphone devices, data plans and internet services, enhanced payments of subscription fees and access training and support services. This finding is consistent with research findings by Ayenew et al. (2020); Barrios et al. (2023); Deboche et al. (2020); Miine et al. (2023); Mutuma et al. (2023); Ruzzante et al. (2021). These studies argued that access to financial support is key to the adoption of agricultural technologies. This study found that wealthier farmers adopted mobile applications. This finding is consistent with research findings by Nguimkeu, & Okou (2024). This study argued that rich farmers were in a better position to adopt mobile applications. This study found that access to credit was higher among adopters compared to non-adopters. This research finding concurs with research results by Dube-Takaza et al. (2023) and Hawas, & Degaga (2023). These studies argued that innovators, early adopters and early majority adopters had more access to credit than late majority adopters and laggards. Further, this study found that early adopters and early majority adopters as characteristically financially lucid.

This finding concurs with research findings by Rogers (2003). This study argued that these adopters show more interest in innovation adoption. In contrast, the research results indicated that lack of financial support impeded the adoption of mobile

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applications by inhibiting the affordability of smartphones, data plans and internet services and hampered training and support services. This finding is consistent with the findings by Achukwu et al. (2023) and Omar et al. (2020). Those studies argued that the inability to acquire financial support was a barrier to the adoption of agricultural technology. The study results indicated that late majority adopters and laggards were characteristically less financially lucid. This is consistent with the study findings by Rogers (2003). This study argued that these adopters show less interest in innovation adoption.

Access to Electricity

Farmers with access to electricity were more likely to adopt mobile applications. Research participants reported that access to electricity,

> *"Enables farmers to charge their mobile devices, which allow for increased usage and adoption of mobile applications" (Agricultural Extension Officer, 2).*
>
> *"Enables farmers to use the internet-enabled devices, which provide farmers with access to online information, services, and mobile applications" (Lead Farmer, 1).*
>
> *"Facilitates digital literacy training, which enables farmers to effectively use mobile applications and other digital tools" (Community Leader, 1).*
>
> *"Help farmers to optimise their operations, leading to productivity and efficiency" (Agricultural Extension Officer, 1).*

Contrariwise, research participants indicated that lack of electricity,

> *"Obstructs access to power for farmers to charge their mobile devices, which makes it difficult to use mobile applications" (Agricultural Researcher, 1).*
>
> *"Makes it difficult for farmers to use mobile devices for extended periods, which limits their ability to access and use mobile applications" (Community Leader, 2).*
>
> *"Limits farmers' access to the internet, which makes it difficult to access online information and services" (Opinion Leader, 2).*
>
> *"Leads to difficulties in transmitting data on weather forecasts, market prices, good agricultural practices, due to limited electricity and internet connectivity" (Mobile Applications Developer, 1).*
>
> *"Result in farmers incurring additional costs which they may not have to buy generators or travelling to charging stations to access electricity" (Lead Farmer, 2).*

The results of this study showed that access to electricity positively influenced the adoption of mobile applications by enabling farmers to charge their mobile devices, to use internet-enabled devices, facilitated digital literacy training and helped farmers to optimise their operations. This is consistent with the findings by Adegbite (2020); Adegbite, & Ogunniyi (2020); Liu, & Wang (2020), Rao, & Gupta (2019); Sharma, & Sharma (2018); Singh (2020) and Singh, & Singh (2020). These studies argued that access to reliable electricity promoted the use of digital technologies in agricultural activities. Further, this study underscored that innovator adopters, early adopters and early majority adopters characteristically had access to electricity. This finding showed that these adopters showed more interest in innovation adoption. On the contrary, this study revealed that lack of electricity impeded the adoption of agricultural technologies by obstructing access to power for farmers to charge their mobile devices, limited farmers' access to the internet, leading to difficulties in transmitting data on weather forecasts, market prices, good agricultural practices and resulted in farmers incurring additional costs. This finding is consistent with research findings by

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Adegbite (2020); Adegbite, & Ogunniyi (2020); Liu, & Wang (2020), Rao, & Gupta (2019); Sharma, & Sharma (2018); Singh (2020) and Singh, & Singh (2020). These studies argued that lack of access to electricity was a deterrent to the adoption of mobile applications. Further, this study's results revealed that the late majority of adopters and laggards characteristically had no access to electricity. This finding indicated that these adopters show less interest in innovation adoption.

Internet Connectivity and Network Coverage

Farmers with internet connectivity and network coverage were more likely to adopt mobile applications. Research participants reported that access to internet connectivity and network coverage,

"Enables farmers to access real-time information on weather, markets and best agricultural practices" (Agricultural Extension Officer, 1).

"Is necessary for mobile applications to function" (Lead Farmer, 1).

"Enables farmers to transmit and analyse data from their farms, which allows for more informed decision-making" (Mobile Applications Developer, 2).

"Facilitates communication and collaboration among farmers, farmers and extension agents, farmers and markets, farmers and other agricultural stakeholders, promoting knowledge sharing and innovation" (Agricultural Researcher, 2).

Contrariwise, research participants indicated that lack of internet connectivity and network coverage,

"Hinder access to online information, such as weather forecasts, market prices, and best agricultural practices, which are essential for informed decision-making" (Lead Farmer, 1).

"Constrain access to critical mobile applications features and services" (Opinion Leader, 2).

"Deter transmission of data on diseases and pests and crop yields to agricultural extension agents or buyers and best agricultural practices to farmers from agricultural extension agents" (Mobile Applications Developer, 2).

"Inhibits access to online marketplaces and agricultural extension services, which can provide critical support, services and resources" (Community Leader, 2).

"May farmers incur additional costs of travelling to areas with internet connectivity or purchasing expensive data plans to access the internet" (Agricultural Researcher, 2).

The results of the study highlighted that lack of internet connectivity and network coverage facilitated the adoption of mobile applications by enabling farmers to access real-time information on weather, markets and best agricultural practices, transmit and analyse data from their farms and facilitate communication and collaboration among agricultural stakeholders. This finding is consistent with research findings by Adegbite (2020); Adegbite, & Ogunniyi (2020); Liu, & Wang (2020), Rao, & Gupta (2019); Sharma, & Sharma (2018); Singh (2020) and Singh, & Singh (2020). These studies argued that the availability of mobile networks and reliable broadband in rural areas are key for the development and successful scaling up of digital agriculture solutions. Further, this study's results underlined that innovator adopters, early adopters and early majority adopters characteristically had access to internet connectivity and network coverage. This study revealed that these adopters had more interest in innovation adoption. Conversely, the study results indicated that lack of internet connectivity and network coverage hampered access to online information; constrained access to critical mobile applications features and services; and deterred data

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transmission on diseases, pests and crop yields to agricultural extension agents or buyers. Further, lack of internet connectivity and network coverage inhibited access to online marketplaces and negatively facilitated additional costs of travelling to areas with internet connectivity or purchasing expensive data plans to access the internet. This finding is consistent with research results conducted by Choruma et al. (2024); Erlangga et al. (2023) and Omar et al. (2020). These studies argued that lack of internet network coverage combined with affordability concerns in rural areas lack access to meaningful connectivity to have access to vital information and services. Further, this study found that the late majority adopters and laggards characteristically had no access to electricity. The study results highlighted that these adopters showed less interest in innovation adoption.

LIMITATIONS OF THE STUDY

The research was limited to a small group of research participants, raising concerns about the relevance of the findings to other regions and contexts. As a result, the generalisability of findings is constrained. The sampling methods used led to a relatively homogenous group of research participants, potentially resulting in limited variation in the data gathered. Further studies could enhance understanding of the characteristics of adopter categories by expanding the number of research participants including other farmers within the agriculture sector. Furthermore, utilising quantitative methods could produce results that are more widely generalizable due to a larger sample size.

CONCLUSION

The research demonstrated that farmers' adopter characteristics positively and negatively influenced farmers' decisions to adopt mobile applications for improved small-scale commercial agriculture. The research revealed that innovator adopters, early adopters and early majority adopters were more interested in adopting mobile applications. In contrast, late majority adopters and laggards were less interested in adopting mobile applications. The results highlighted that innovator adopters, early adopters and early majority adopters were more likely to adopt mobile applications because these adopters showed more interest in mobile applications. In contrast, late majority adopters and laggards were less likely to adopt mobile applications because these adopters were less interested in the adoption of mobile applications. Innovator adopters, early adopters and early majority adopters' category characteristics enabled them to adopt mobile applications. In contrast, late majority adopters and laggards' adopters' category characterisations hindered the adoption of mobile applications. Further, the research identified that small-scale commercial farmers do not adopt mobile phone applications simultaneously. Furthermore, the study findings indicated that small-scale commercial farmers belong to different adopter categories and do not fit into the homogenous category of mobile application adopters. The study recommends the need for policies that account for different adopter category groups of small-scale commercial farmers to tailor strategies that encourage widespread adoption of mobile applications.

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