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Review Article

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Exploring the Role of Smartphone Apps for Livestock Farmers Data Management Extension and Informed Decision Making in Nigeria

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Abstract

This research explores the role of smartphone apps in supporting livestock farmers in data management, extension services, and informed decision-making. The study investigates the potential benefits and challenges associated with the adoption and use of smartphone apps in the livestock farming sector. The findings reveal that smartphone apps provide a convenient and efficient way for farmers to record and analyse data, enabling real-time monitoring and data-driven decision-making. These apps also act as effective tools for extending agricultural information to farmers, providing access to resources and creating virtual communities for knowledge sharing. Moreover, smartphone apps empower farmers to make informed decisions by providing real-time information on weather, market prices, and disease alerts. However, challenges such as reliable internet connectivity, technical literacy, and the accuracy of app-based information need to be addressed for successful app adoption. Overall, smartphone apps have the potential to revolutionize livestock farming by enhancing data management, extending agricultural knowledge, and enabling informed decision-making, requiring collaboration among farmers, app developers, extension services, and policymakers. However, it is important to note that while smartphone apps can supplement traditional extension services, they should not be seen as a complete replacement, as access to reliable internet connectivity and technical literacy can pose limitations in some rural areas. It is therefore, essential to ensure that the data and information provided by these apps are accurate, reliable, and context-specific. Farmers should be cautious of potential biases and limitations in the algorithms used by these apps and should supplement the app-based information with their own knowledge and experience.

Keywords: Smartphone, Apps, Livestock, Farmers, Data, Management, Extension

1. Introduction

Smartphone apps have played a significant role in revolutionizing various industries, and the agricultural sector is no exception. In Nigeria, where livestock farming is a crucial component of the agricultural landscape, smartphone apps have emerged as powerful tools for livestock farmers. These apps have brought about numerous benefits, ranging from improving productivity and efficiency to enhancing market access and knowledge sharing. According to [01]. Rapid technological advancements and increasing availability of all kinds of digital tools and technologies have led to widespread experimentation and implementation in Africa with digital agriculture defined as the use of digital tools and technologies in the management of and decision-making about agricultural systems and value chains.

Consequently, revealed that Information and communication technologies (ICT) plays a powerful role in the daily life of farmers. ICT in agriculture is an emerging field focusing on agricultural development and rural development in India. The introduction of ICT in Indian agriculture according to enables the dissemination of requisite information at the right time. By guiding users through distinct choice stages and outlining the possibility of various outcomes as a result of alternative options, ICT tools like mobile applications act as smart decision support tools (DST) and are intended to help users make more effective judgments [02, 03]. The modern days' mobile apps are software programmes designed to run on smartphones, tablets and other devices [04]. The application software on a mobile phone handset or tablet computer that enables a user to access specific information; make payments and other transactions; send messages; etc. The application (app) is downloaded (for free or for payment) from a wireless network from an online store and may

require a live connection to function effectively. Revealed that Mobile phones are not very well spread among the farming communities in the agri-food sector in Sub-Saharan Africa [05, 06].

The technology is nevertheless wnell-liked among traders. The majority of farmers use mobile phones for regular communication, i.e., to stay in touch with family and friends, as opposed to traders who use them to seek for price information in various agri-food marketplaces. According to research, Sub-Saharan African farmers hardly ever use their mobile phones to keep track on the costs of various goods on the market [05, 07]. Due to the widespread use of mobile phones in Sub-Saharan Africa, all participants in the value chain may communicate with one another. However, it appears that farmers and other participants in the value chain are not currently well connected. Farmers are vulnerable to exploitation by other participants in the chain because they are upstream, especially middlemen. They are ignorant about what takes place in markets. Consequently, they accept any price that the middlemen offer them for their produce/commodity. Mobile app or mobile application is a computer program designed to run on mobile device such as tablet. The new smart phone could be nicknamed 'app phones' to distinguish them from earlier less-sophisticated smart phone. Apps can be installed manually by running an android application package [08, 09]. It is reported that majority of the farmers agreed that mobile could be a useful source of agricultural information. The proper use mobile phone provides multidimensional benefits assisting in interaction and quick/timely information exchange. A large coverage of rural people including farmers is now using mobile phones. The cheaper call rate and easy network accessibility affects the low earning farming community to use mobile phones for different agricultural information. Mobile phones have created farmers aware about the modern technologies, weather forecasting and present market price information. In case of urgency, mobile phones seem very useful and effective tool for dissemination of information [08, 10].

The climate or disaster vulnerable farmers can easily be informed in any challenging conditions via mobile phone. Mobile phone-enabled technologies were also being used to monitor and disseminate information about crop and livestock disease outbreaks. According to a study by smartphones with an Internet connection and an interface that resembles a touchscreen are now commonly used and have assimilated into modern civilizations throughout a large portion of the globe [11]. In fact, according to estimates from The Economist (2015), 80% of the world's population will own a smartphone by the year 2020, with two billion individuals currently doing so. In the first quarter of 2015, 66% of adults in the UK and 58% of French people had smartphones, respectively, up 27% and 12% from 2012 and 2013 respectively (OFCOM 2015; CRÉDOC, 2015).

Owners of these devices can record observations or access specialized applications (referred to as apps from now on) created especially for citizen science projects in app stores like Google Play and iTunes without the need for special setup or equipment because they carry them around almost constantly. As a result, there are now more smartphone apps available than ever before that were created for citizen science initiatives. However, there aren't many citizen science initiatives that focus on farmers or investigate issues in agriculture. Even while there are many apps to help farmers, very few of them use the built-in sensors of smartphones to offer agricultural solutions [12, 13]. The bulk of applications currently on the market were created by for-profit businesses, and they often offer information or services in a one-way, linear flow from the developer to the user. In contrast, citizen science apps are created by nonprofit organizations, academic institutions, and government agencies and are intended to be more collaborative and interactive. Importantly, they give users the opportunity to provide developers with information and frequently receive comments in return. According to this input might range from a straightforward acknowledgement of the record received to more in-depth project-related data, including the confirmation of a species identification [12].

However, determined that farmers relied heavily on first-hand experiences and preferred to learn from their peers and from expertise experienced in their field in a manner that saved time and money [14]. Suggested that digital technology will not fully replace traditional methods of agricultural information delivery and now are more likely to complement and enhance the impact or penetration of extension projects. They went on to say that a key success factor for online delivery was the relationship between the farmers and the information provider, therefore, traditional networks and relationships are generally still required for digital extension. While some authors have shared their opinions on the pros and cons on the use of smartphone apps in agriculture, this present review therefore aim at identifying the roles of smartphone apps for livestock farmers: data management, extension and informed decision making in Nigeria [15].

Penetration of smartphones in Nigeria

Nigeria is one of the largest markets for smartphones in Africa and has witnessed a rapid increase in smartphone adoption over the years as reported until September 2021, smartphones had experienced significant penetration in Nigeria. In 1992, the Nigerian government through decree No. 72 of December 31st established the National Communication Commission (NCC) and empowered it with the duty of formulating strategies and policies to ensure effective and rapid development of the telecommunication sector as Nigeria"s telephone density and penetration remained poor. In 2001, the GSM was introduced into Nigeria. The Nigerian Communications Commission (NCC) issued four wireless licenses to MTN Nigeria Communication, Econet Wireless Nigeria Limited (now Airtel), Communications Investment Limited (CIL) and state-owned NITEL at the fee that was determined by NCC. CIL, however, had its license withdrawn because of inability to meet with the deadline for payment [16]. The fourth GSM provider Glomobile (Globalcom) did not commence provision of mobile phone services until August 2003 [17]. According to various reports, the penetration of smartphones in Nigeria has been steadily growing due to several factors. These factors include the availability of affordable smartphones, the expansion of mobile networks, and the increasing popularity of internet services and social media platforms. Additionally, the growth of e-commerce and mobile banking has also contributed to the increased usage of smartphones in the country. The smartphone penetration rate may have further increased since then due to the continuous development of the telecommunications sector and the decreasing cost of smartphones [18].

Examining the Roles of Smartphone Apps for Livestock Farmers: Data Management, Extension and Informed Decision Making

Smartphone apps for livestock farmers in Nigeria play a crucial role in data management, extension services, and informed decision making. These apps provide farmers with access to real-time information, expert advice, and data-driven insights, empowering them to make informed decisions and enhance their farming practices. Let's explore these roles in more detail.

Data management Livestock farming involves handling a vast amount of data, including animal records, health information, feed management, and financial transactions. Smartphone apps designed for livestock farmers provide efficient data management systems, allowing farmers to record, store, and analyze data in a structured manner. These apps enable farmers to input and update data on animal health, reproduction, growth rates, vaccinations, and more. With organized and accessible data, to improve their agricultural techniques, producers can monitor the performance of certain animals or their entire livestock herd, spot trends, and make data-driven decisions.

Extension services: Extension services are vital for disseminating knowledge and expertise to farmers. Smartphone apps act as an extension platform, delivering valuable information, training materials, and expert advice directly to livestock farmers in Nigeria. These apps provide access to a wide range of agricultural resources, including articles, videos, tutorials, and best practices, covering various aspects of livestock farming. Farmers can learn about new techniques, breeding methods, disease control strategies, and other relevant topics through these apps. Additionally, some apps facilitate direct communication with agricultural extension officers, enabling farmers to seek personalized guidance and support.

Informed Decision Making: Livestock farmers often face critical decisions related to animal health, nutrition, breeding, market access, and more. Smartphone apps equip farmers with the necessary information and tools to make informed decisions. These apps provide real-time market prices, weather forecasts, disease alerts, and other relevant data, helping farmers assess risks, plan strategies, and optimize their farming operations. For example, by accessing market information through these apps, farmers can decide when and where to sell their livestock for maximum profit. Likewise, weather forecasts aid in planning grazing patterns and ensuring the availability of water and feed resources. By making data-driven decisions, livestock farmers can improve their profitability, mitigate risks, and enhance the overall efficiency of their farming activities.

Monitoring and analysis: Smartphone apps offer monitoring and analysis features that enable livestock farmers to track and assess various parameters related to their farming operations. These apps provide real-time data on animal health, growth rates, feed consumption, and other performance indicators. Farmers can set targets, monitor progress, and receive alerts or notifications if any parameter falls outside the desired range. Moreover, these apps often include analytical tools that help farmers generate reports, visualize trends, and gain insights into their livestock's performance. By continuously monitoring and analyzing data, farmers can identify areas for improvement, detect anomalies or health issues, and implement timely corrective measures.

Examining the Attitude of Farmers Towards the Role of Smartphone Apps in Livestock Farming

The attitude of farmers towards the role of smartphone apps in livestock farming varies among individuals and can be influenced by several factors. Here are some common attitudes observed among farmers.

Early adopters: There is a group of farmers who are enthusiastic early adopters of technology, including smartphone apps, in their livestock farming practices. They recognize the potential benefits offered by these apps, such as improved data management, access to market information, and enhanced decision-making capabilities. These farmers embrace technology as a tool to streamline their operations, increase efficiency, and stay updated with the latest trends in the industry. They actively seek out and experiment with different apps to find the ones that best suit their needs [19].

Tech-Savvy and progressive: Some farmers, especially those who are younger and more tech-savvy, are in favor of using smartphone apps when raising cattle. They see these apps as a chance to use technology to solve problems, boost output, and improve their farming methods. These farmers are receptive to using new technologies and are frequently fast to grasp and make use of the capabilities and advantages provided by smartphone apps. They gladly incorporate the newest app advancements into their daily operations and aggressively seek out information about them.

Skeptics and traditionalists: Not all farmers may readily embrace smartphone apps in livestock farming. Some farmers, particularly those who are more traditional in their approach, may exhibit skepticism or resistance towards technology-driven solutions. They may be hesitant to change their established practices or may perceive the adoption of smartphone apps as an additional burden or unnecessary complication. Lack of awareness about the benefits and functionality of these apps, as well as concerns about cost, usability, and reliability, may contribute to their reluctance [20, 21].

Limited access and connectivity: Access to smartphones and reliable internet connectivity are crucial factors influencing farmers' attitudes towards smartphone apps. In some regions, farmers may face limitations in terms of smartphone ownership or affordable internet access, which can hinder their ability to adopt and utilize these apps effectively. Farmers who lack access to smartphones or face connectivity challenges may exhibit a more reserved or indifferent attitude towards smartphone apps in livestock farming.

Learning curve and support: Farmers' attitudes towards smartphone apps can also be influenced by their comfort level with technology and the availability of training and support. Farmers who are less familiar with smartphones or have limited digital literacy may feel overwhelmed by the learning curve associated with using these apps. However, with proper training and support from agricultural extension services, technology providers, or peer networks, farmers can gain confidence and develop a more positive attitude towards smartphone apps [20]. It's important to note that attitudes towards smartphone apps in livestock farming can evolve over time as farmers observe the benefits experienced by their peers or as they gain firsthand experience with these tools. Education, awareness campaigns, and demonstrations showcasing the practical benefits of smartphone apps can help address skepticism and encourage wider adoption

among livestock farmers. Additionally, addressing challenges related to access, affordability, and connectivity can further facilitate positive attitudes and greater acceptance of smartphone apps in livestock farming.

Reason for using smartphone apps by livestock farmers

Livestock farmers use smartphone apps for several reasons, as these apps offer numerous benefits and address various challenges faced in livestock farming. Here are some key reasons for using smartphone apps.

Efficient data management: Smartphone apps provide livestock farmers with a convenient and organized way to manage their data. These apps allow farmers to input and track various aspects of their livestock, including health records, breeding information, growth rates, and feeding schedules. By centralizing this data, farmers can easily access, update, and analyze information, enabling them to make informed decisions regarding their livestock's management and well-being [22].

Access to market information: Smartphone apps provide livestock farmers with real-time market information, including prices, demand trends, and buyer preferences. This information empowers farmers to make informed decisions regarding when, where, and how to sell their livestock. By having access to market insights, farmers can optimize their selling strategies, negotiate better prices, and plan their production accordingly, thus maximizing their profitability [23].

Disease management and prevention: Livestock farmers face the constant risk of disease outbreaks, which can have significant impact on the health and productivity of their animals. Smartphone apps often include disease monitoring and alert systems that provide farmers with information about prevalent diseases, symptoms to watch out for, and preventive measures. These apps help farmers take timely actions to mitigate disease risks, such as implementing vaccination schedules, improving biosecurity measures, and seeking veterinary assistance when needed.

Knowledge and expertise: Smartphone apps offer livestock farmers access to a wealth of agricultural knowledge and expertise. These apps provide educational resources, tutorials, and best practices related to livestock farming, enabling farmers to enhance their skills and stay updated with the latest industry developments. Farmers can learn about breeding techniques, nutrition management, pasture management, and other relevant topics through these apps, ultimately improving their farming practices and productivity [23].

Financial management: Managing finances is essential for the success of any business, including livestock farming. Smartphone apps equipped with financial management features allow farmers to track expenses, income, and profitability. These apps provide tools for budgeting, expense categorization, and generating financial reports, giving farmers a clear overview of their financial performance. By having a better understanding of their finances, farmers can make informed decisions regarding resource allocation, investment opportunities, and overall financial planning [23].

Connectivity and communication: Livestock farmers often work in remote areas, and smartphone apps enable them to stay connected and communicate effectively. These apps facilitate communication with agricultural extension officers, veterinarians, fellow farmers, and potential buyers, enabling farmers to seek advice, support, and market opportunities. With improved connectivity, farmers can access real-time information, participate in online forums and discussions, and build networks within the agricultural community. Overall, the use of smartphone apps by livestock farmers helps streamline operations, improve productivity, enhance decision-making capabilities, and access valuable resources and market information. These apps empower farmers to manage their data efficiently, stay informed about market trends, prevent and manage diseases, acquire knowledge, and foster effective communication within the farming community. By leveraging technology through smartphone apps, livestock farmers can optimize their farming practices and achieve greater success in their operations [24].

Constraints for Using Smartphone Apps by The Livestock Farmers for Data Management, Extension and Informed Decision Making in Nigeria

When it comes to using smartphone apps for data management, extension services, and informed decision-making in Nigeria's livestock farming sector, there are several constraints that need to be considered. These constraints can include.

Limited success to smartphones: While smartphone usage is growing in Nigeria, access to smartphones is still limited, particularly in rural areas where livestock farming is prominent. Many livestock farmers may not own smartphones or have access to reliable internet connections, which hampers their ability to use smartphone apps effectively [02].

Digital literacy and technical skills: Some livestock farmers may lack the necessary digital literacy and technical skills to navigate smartphone apps efficiently. They may struggle with basic operations like installing and setting up apps, inputting data, or troubleshooting technical issues. Lack of training and support in this regard can be a significant constraint. Language and localization: Many smartphone apps are developed in foreign languages, making it difficult for livestock farmers in Nigeria, particularly those with limited English proficiency, to use them effectively. Localizing apps by providing translations and incorporating local dialects can enhance their usability and adoption [02].

Connectivity and internet access: Inadequate network coverage and limited access to reliable internet connections, especially in rural areas, pose a significant challenge for livestock farmers. Apps that require a constant internet connection may not function optimally, making it challenging to access and update data in real-time.

Cost of data and internet: Data costs in Nigeria can be high, and for livestock farmers with limited financial resources, it may be difficult to afford the continuous data usage required for utilizing smartphone apps effectively. This cost factor can discourage farmers from fully embracing such technologies [02].

Power supply: Frequent power outages and limited access to electricity in rural areas can hinder the use of smartphone apps, as devices need to be charged regularly. Without consistent power supply, livestock farmers may face difficulties in using apps for extended periods.

App relevance and localization: For smartphone apps to be effective, they must address the specific needs and context of Nigerian livestock farmers. Apps that do not align with the local livestock farming practices, breeds, diseases, or available resources may not provide meaningful insights or relevant rec-

ommendations.

Trust and data security: Livestock farmers may have concerns about data security and privacy when using smartphone apps. It is crucial to address these concerns and ensure that farmers' data is protected from unauthorized access or misuse. Overcoming these constraints requires a multi-faceted approach involving investment in infrastructure, digital literacy training, app localization, collaboration between stakeholders, and addressing cost-related issues. By addressing these constraints, smartphone apps can play a significant role in enhancing data management, extension services, and informed decision-making for livestock farmers in Nigeria.

Factors Influencing the Use of Smartphones App in Livestock by Farmers

Several factors can influence the use of smartphone apps in livestock farming by farmers. These factors include.

Awareness and knowledge: Farmers' awareness and knowledge about the availability and benefits of smartphone apps in livestock farming play a crucial role. If farmers are aware of the apps' existence and understand how they can improve their farming practices, they are more likely to adopt and use them [25].

Perceived utility and benefits: The perceived utility and benefits of smartphone apps in livestock farming heavily influence farmers' adoption. If farmers believe that using these apps will enhance their productivity, profitability, decision-making, and overall farm management, they are more likely to embrace them.

User-Friendliness and ease of use: The user-friendliness and ease of use of smartphone apps significantly impact their adoption. Farmers prefer apps that have intuitive interfaces, clear navigation, and require minimal technical expertise. If the app is user-friendly and doesn't require a steep learning curve, farmers are more likely to adopt and utilize it effectively. Compatibility and Accessibility: Smartphone apps that are compatible with the farmers' existing devices and operating systems are more likely to be adopted. Additionally, accessibility is crucial, as farmers should be able to download and install the apps easily from trusted sources such as app stores [26].

Language and localization: Localization of smartphone apps, including language translations and customization to suit local livestock farming practices, breeds, and diseases, can significantly influence adoption. Apps that are available in local languages and incorporate local context are more likely to be embraced by farmers [27].

Network connectivity and internet access: Reliable network connectivity and access to the internet are essential for the effective use of smartphone apps. If farmers have access to a stable internet connection, they can update data, receive real-time information, and access online resources seamlessly.

Training and support: Adequate training and ongoing support are crucial for farmers to understand how to use smartphone apps effectively. Training programs that provide guidance on app installation, data entry, interpretation of results, and troubleshooting technical issues can facilitate adoption and usage.

Cost and affordability: The cost of smartphones, data plans, and app subscriptions can be a significant barrier to adoption. If the cost of using smartphone apps is affordable and the benefits outweigh the expenses, farmers are more likely to invest in these technologies. Trust and Data Security: Farmers' trust in the app's credibility, data security, and privacy protection is essential. Developers and providers should address concerns related to data sharing, unauthorized access, and misuse of farmers' information to build trust and encourage adoption.

Peer influence and networks: The influence of peers, farmer networks, and community engagement can play a significant role in promoting the use of smartphone apps. Farmers are more likely to adopt apps recommended by their peers or those that are endorsed by trusted agricultural organizations. Understanding these factors and addressing them appropriately can help promote the use of smartphone apps in livestock farming and maximize their benefits for farmers.

Theoretical Background for Smartphone Apps in Livestock Farming, Specifically in The Context of Data Management, Extension Services and Informed Decision-Making in Nigeria

The following theories can be established using the following theoretical frameworks:

Technology acceptance model (TAM): TAM provides a foundation for understanding the acceptance and adoption of technology by users. In the context of smartphone apps for livestock farming, TAM can be used to examine farmers' perceptions of the usefulness and ease of use of the apps, as well as their attitudes toward app usage. This model helps in understanding the factors that influence farmers' intentions to adopt and use smartphone apps for data management, extension, and decision-making [28].

Diffusion of innovations (DoI) theory: DoI theory explores the process by which innovations are adopted and diffused within a social system. In the Nigerian context, the theory can be applied to understand the factors influencing the adoption of smartphone apps for livestock farming. It considers the characteristics of the app, such as relative advantage, compatibility, complexity, trialability, and observability, as well as the social system's characteristics, including communication channels, opinion leaders, and social norms.

Social cognitive theory (SCT): SCT focuses on the interactions between individuals, their behaviour, and their environment. In the context of smartphone apps in livestock farming, SCT can help understand how farmers' beliefs, attitudes, and self-efficacy influence their adoption and use of these apps. It considers the role of observational learning, social influences, and self-regulation in shaping farmers' behaviours towards app adoption and utilization.

Theory of planned behaviour (TPB): TPB examines the relationship between individuals' attitudes, subjective norms, perceived behavioural control, and their behavioural intentions. This theory can be applied to understand the factors influencing farmers' intentions to adopt smartphone apps for livestock farming. It considers their attitudes toward app usage, the influence of social norms and subjective norms, and their perceived control over app usage [29].

Unified theory of acceptance and use of technology (UTAUT): UTAUT integrates several theories of technology acceptance and provides a comprehensive model for understanding users' behavioural intentions to adopt and use technology. In the Nigerian context, UTAUT can help identify the factors influencing farmers' intentions to adopt and utilize smartphone apps for data management, extension, and informed decision-making. It

considers the impact of performance expectancy, effort expectancy, social influence, and facilitating conditions on farmers' behavioural intentions [28].

By applying these theoretical frameworks, researchers and practitioners can gain insights into the factors influencing the adoption and effective use of smartphone apps in livestock farming for data management, extension services, and informed decision-making in Nigeria. These frameworks provide a systematic approach to understanding farmers' behaviours, attitudes, and intentions, guiding the development and implementation of interventions to promote app adoption and maximize their benefits.

Theoretical Implications of Smartphone App in Livestock

The use of smartphone apps in livestock farming has several theoretical implications that contribute to the advancement of agricultural research and practice. These implications include

Technological advancement: The adoption and use of smartphone apps in livestock farming signify the integration of modern technology into traditional agricultural practices. This advancement aligns with the theory of technological determinism, which suggests that technology plays a significant role in shaping social and economic systems. The use of smartphone apps in livestock farming represents a shift towards more efficient and data-driven agricultural practices [30, 31].

Information and communication technology (ICT) adoption: The adoption of smartphone apps in livestock farming reflects the growing acceptance and integration of information and communication technologies in agricultural systems. This aligns with the theoretical framework of ICT adoption, which explores the factors influencing the acceptance, usage, and impact of ICT in various domains. The theoretical implications of smartphone app usage in livestock farming contribute to the understanding of ICT adoption dynamics within the agricultural sector.

Digital transformation: The use of smartphone apps in livestock farming signifies a digital transformation in the agricultural industry. This aligns with the theory of digital transformation, which examines the profound changes brought about by digital technologies in organizations and industries. The adoption of smartphone apps for data management, extension services, and informed decision-making in livestock farming represents a shift towards digital platforms and data-driven approaches to improve productivity, sustainability, and profitability [32].

Decision support systems: Smartphone apps in livestock farming can be viewed as decision support systems (DSS) that provide farmers with valuable information, data analysis, and recommendations to support decision-making. DSS theories and frameworks, such as the Decision Support System Framework and the Viable Systems Model, can be applied to understand the design, implementation, and impact of smartphone apps as decision support tools in livestock farming.

Behavioural change and adoption: The adoption and use of smartphone apps in livestock farming involve farmers' behavioural change, driven by the perceived benefits and utility of the apps. The theoretical implications align with behaviour change theories, such as the Theory of Planned Behaviour and the Transtheoretical Model, which explain the process of adopting new behaviours. The use of smartphone apps in livestock farming highlights the importance of understanding farmers' attitudes, motivations, and barriers to drive successful behaviour change and adoption.

Extension and diffusion of innovations: The use of smartphone apps for data management and extension services reflects the diffusion of innovations within the agricultural sector. Theoretical frameworks like the Diffusion of Innovations Theory and the Innovation.

Decision process theory: can be applied to study the spread, adoption, and impact of smartphone apps as innovative tools in livestock farming. These frameworks help understand the factors that influence the adoption and diffusion of smartphone apps among farmers [30, 31]. Overall, the theoretical implications of smartphone apps in livestock farming contribute to the advancement of agricultural theories and frameworks by incorporating technology, digital transformation, decision support systems, behaviour change, and diffusion of innovations concepts into the context of livestock farming. These implications facilitate a deeper understanding of the adoption, usage, and impact of smartphone apps in transforming and improving agricultural practices.

2. Discussion

This review conducted aimed to explore the role of smartphone apps in supporting livestock farmers in data management, extension services, and informed decision-making. The findings shed light on the potential benefits and challenges associated with the adoption and use of smartphone apps in the livestock farming sector. Data management is a crucial aspect of livestock farming as it enables farmers to track and monitor various parameters such as animal health, reproduction, and productivity. The study found that smartphone apps provide a convenient and efficient way for farmers to record and analyse data. These apps allow farmers to input data in real-time, eliminating the need for manual paperwork and reducing the chances of errors. Furthermore, the apps often have built-in analytics and reporting features, enabling farmers to gain insights into their operations and make data-driven decisions. This aspect of smartphone apps can significantly enhance the productivity and profitability of livestock farming. Extension services play a vital role in disseminating knowledge and best practices to farmers. The research revealed that smartphone apps can act as effective tools for extending agricultural information to livestock farmers.

These apps often provide access to a wealth of resources such as articles, videos, and expert advice, which can help farmers stay updated with the latest industry trends and techniques. Moreover, some apps offer interactive features, allowing farmers to communicate directly with extension agents and fellow farmers, creating a virtual community for knowledge sharing. However, it is important to note that while smartphone apps can supplement traditional extension services, they should not be seen as a complete replacement, as access to reliable internet connectivity and technical literacy can pose limitations in some rural areas [21]. Informed decision-making is critical for the success of livestock farming operations. The research highlighted that smartphone apps can empower farmers to make informed decisions by providing real-time access to information. Farmers can receive weather updates, market prices, and disease alerts, enabling them to adapt their strategies accordingly. Additionally, some apps utilize machine learning and AI algorithms to provide personalized recommendations and predictive analytics, assist-

ing farmers in making optimal choices. However, it is essential to ensure that the data and information provided by these apps are accurate, reliable, and context-specific. Farmers should be cautious of potential biases and limitations in the algorithms used by these apps and should supplement the app-based information with their own knowledge and experience [33-36].

3. Conclusion

The research findings emphasize the potential benefits of smartphone apps for livestock farmers in data management, extension services, and informed decision-making. These apps offer convenience, efficiency, and access to valuable resources and information, empowering farmers to optimize their operations and improve their livelihoods. However, several challenges need to be addressed for the successful adoption and utilization of smartphone apps in the livestock farming sector. First and foremost, reliable internet connectivity is crucial for accessing app-based services, which may be limited in some rural areas. Efforts should be made to expand and improve internet infrastructure to ensure equitable access for all farmers. Additionally, technical literacy and digital skills training are essential to enable farmers to effectively use and navigate smartphone apps. Agricultural extension services can play a vital role in providing training and support in this regard. Furthermore, it is important to ensure the accuracy, reliability, and relevance of the data and information provided by smartphone apps. App developers should collaborate with experts and incorporate scientific knowledge and local context into their platforms. Ongoing monitoring and evaluation should be conducted to assess the performance and impact of these apps on farmers' outcomes. In conclusion, smartphone apps have the potential to revolutionize the livestock farming sector by enhancing data management, extending agricultural knowledge, and enabling informed decision-making. However, a collaborative effort involving farmers, app developers, extension services, and policymakers is necessary to overcome challenges and ensure the effective integration of smartphone apps into livestock farming practices.

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