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Revolutionising the Public Extension System for Smallholder Livestock Farmers: User Experiences and the Prospects of Using Information and Communication Technologies in North West Province, South Africa

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ABSTRACT

The study aimed to determine farmers' and extension officers' experiences with public extension and the prospects of improving the public extension service through digital-based technology. Quantitative data were collected from 101 commercially oriented active beneficiaries of the Nguni cattle project in the North West Province, South Africa, using a structured questionnaire and analysed using descriptive statistics. Qualitative data were collected through focus group discussions (FGDs) and key informant interviews (KIIs) and analysed using thematic analysis. Ninety percent of the farmers regarded public extension as the key source of extension services received through farm visits (66%), telephone calls (65%), and visits to the extension offices (38%). Approximately 64% of respondents reported low visibility of extension officers in their farming areas. A very low extension officer-to-farmer ratio (typically 1:> 300) and a high demand for transport facilities were cited as constraints to service delivery by extension officers. The study showed that over three-quarters of the farmers had smartphones, with 89% having adequate smartphone operating skills. Approximately 80% had a strong positive perception of the usefulness of the proposed

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10.17159/2413-3221/2025/v53n1a18044

Livestock Management Database System (LMDS) in livestock production, while 84% were willing to pay to access the system. The results of the FGDs and KIIs also indicated high positive perceptions toward innovation. In conclusion, a digital-based platform was proposed to assist the public extension system in delivering well-coordinated extension and advisory services that would meet the needs of farmers cost-effectively.

Keywords: Public Extension System, Information and Communication Technologies, Smallholder Farmers, Willingness to Pay, Livestock Management Database System.

1. INTRODUCTION

Public extension significantly transforms the smallholder agricultural sector in South Africa (Trendov et al., 2019; Mapiye et al., 2021). Since the democratisation of South Africa in 1994, the country's agricultural extension system has attempted to move from a linear and top-down approach to a pluralistic and farmer-driven approach. The new orientation of extension service delivery became part of the envisioned transformation process for previously disadvantaged smallholder livestock farmers (Akpalu, 2013). The government took up a central role in driving the training and visit (T&V) approach toward smallholder farmers through its provincial departments of agriculture (Department of Agriculture, Land Reform and Rural Development [DALRRD], 2014; Koch & Terblanché, 2013). The T&V approach entails that the extension officers/advisors use a fixed schedule and travel to meet individuals or groups of farmers to share and disseminate agricultural technical information and technology (Mapiye et al., 2021).

The public extension system remains the largest and most common source of information for smallholder livestock farmers in South Africa (Ali, 2012; Mapiye et al., 2019). However, there is widespread concern that the public extension system is underperforming and has failed to effectively push the commercialisation agenda of the smallholder livestock sector (Food and Agriculture Organisation [FAO], 2017; Cook et al., 2021; Gwala et al., 2016). Most extension systems across Africa and Asia have attempted to move from supply-driven to demand-driven extension with little success (Davis & Terblanche, 2016; Duvel, 2000; Meena et al., 2013). This has prompted the need for new research and innovation strategies to revolutionise the extension approach.

A review of the literature suggests the potential of linking extension systems with information and communication technologies (ICT)-based strategies to promote and hasten farmer-farmer

10.17159/2413-3221/2025/v53n1a18044

interactions and the ability of farmers to effectively communicate with extension officers and researchers (feedbacking) (Costopoulou et al., 2016; Ogbeide & Ele, 2015; Marwa et al., 2020). According to many studies (Meena et al., 2013; Qiang et al., 2012; Trendov et al., 2019), the adoption and use of ICTs, such as web-based and mobile applications (mobile apps) present unprecedented opportunities for transforming smallholder farming through access to timely and relevant information and services. Therefore, the continued development and implementation of innovative strategies in revolutionising public extension services are essential (Wesley & Faminow, 2014). This study sought to provide evidence on the experiences and challenges of accessing extension services and the prospects of using ICTs to drive the revolution of extension service delivery. The reason for the interest in this topic is that an effective agricultural extension system is one aspect that brings long-term sustainability to the agricultural sector in general and the smallholder livestock sector in particular.

2. MATERIALS AND METHODS

2.1. Description of Study Area

The study was carried out in the four districts of the North West Province, South Africa (Table 1). The study sample constituted 101 commercially oriented smallholder cattle producers actively participating in the North West Industrial Development Corporation (IDC) Nguni cattle programme. Key informant interviews (KIIs) and focus group discussions (FGDs) were conducted to gain a deeper understanding of the study questions and to validate the quantitative results. The FGD participants were purposively selected from the survey sample with assistance from local extension advisors. They were based on gender, age, production level (herd size), and location to ensure diverse perspectives. The key informants were livestock extension officers working with the studied farmers across the province's four districts. They were identified with the assistance of district extension advisors. Table 1 shows the distribution of the respondents in the province. The study was guided by a pragmatic paradigm that accommodated positivist (quantitative) and social constructivist (qualitative) perspectives (Creswell, 2014). A partially mixed sequential design with the dominant quantitative method (survey) was adopted.

10.17159/2413-3221/2025/v53n1a18044

TABLE 1: The Distribution of Study Respondents across the Province

District Municipalities	No of FGDs	No of KIIs	Local Municipalities	No of Farmers
Dr Ruth Segomotsi Mombati			Greater Taung	1
			Kagisano-Molopo	22
	1	1	Naledi	2
Ngaka Modiri Molema	1	2	Ditsobotla	1
			Mahikeng	11
			Ramotshere Moiloa	3
			Ratlou	1
			Tswaing	5
Dr Kenneth Kaunda	1	2	Matlosana	7
			JB Marks	18
			Maquassi Hills	1
Bojanala Platinum	1	1	Kgetleng river	8
			Madibeng	8
			Moretele	2
			Moses Kotane	7
			Rustenburg	4

2.2. Quantitative Data Collection

A pretested structured questionnaire was administered to collect quantitative data through individual farmer interviews between November 2020 and February 2021. Five trained enumerators assisted in conducting the interviews using the local language (Setswana) to enable the farmers to understand correctly and respond comfortably. Data collected included the farmers' primary source of extension services, their experiences in receiving the services,

and the use of ICTs. The study gathered data on respondents' perceptions regarding the usefulness of the proposed LMDS and their willingness to pay (WTP) to access the system.

2.3. Qualitative Data Collection

Four FGDs were conducted with groups of 5-7 farmers at the DALRRD's district centres and lasted approximately one hour. The FGDs explored the farmers' experiences in receiving the extension services and using ICTs and their perceptions of the usefulness of the proposed LMDS technology. An FGD facilitator was hired to moderate the discussions, and an interview guide was developed to facilitate the discussions. The KIIs captured in-depth information and insights about agricultural extension delivery. A high-quality audio recorder was used to record the FGDs and KIIs, which were later transcribed verbatim by the researchers.

2.4. Statistical Analysis

Descriptive statistics were used to analyse the quantitative data using the PROC FREQ procedure of the Statistical Analytical System (SAS) (SAS Institute, 2012). A thematic analysis framework was computed to analyse qualitative data following the procedure set out in Braun and Clarke (2006) and Mauire and Delahunt (2017) using the Atlas-ti V8 software. Thus, a theory-driven (inductive) thematic analysis involving the use of the specific research question(s) in the interview guides (Neuman, 2007) and the analyst's focus was employed. The steps included familiarisation with the data sets through reading and rereading the transcripts and generating codes. The codes were collated into potential themes aligned with the study areas. Each theme's clear definitions and names were generated based on the available categories, followed by formulating how the themes could come together into a narrative. Lastly, interpretive analysis was conducted by formulating arguments from the qualitative results to support and validate findings from the quantitative study.

3. RESULTS AND DISCUSSION

3.1. Farmers' Demographic Characteristics

Table 2 profiles the farmers' demographic characteristics. Male farmers dominated the study sample. Generally, male farmers have better access to means of production and income than female farmers (Gosbert et al., 2019). Despite women performing significant roles within these systems (Usman et al., 2022), their limited participation and access to resources and incomes can significantly hinder the adoption of technologies among smallholders. Half of the

respondents were above 55 years old, with only 6% being less than 53. The demographic trend regarding age indicates low participation by youths in farming. This aligns with a study by Kimaro et al. (2015) that found low levels of engagement and a lack of interest in agriculture among young people. Poor participation by young people in farming could inhibit the introduction of modern farming technologies such as ICTs. Nearly 70% of the respondents had at least secondary education. Most respondents were full-time farmers, with average farming experience being 19 years. Invariably, better education and long tenure can enhance farmers' productivity and promote a more positive attitude toward and understanding new technologies. This finding aligns with previous studies (Kabir, 2015; Shemfe, 2018; Agholor & Ogujiuba, 2021) by suggesting that better education and more farming experience positively influence the adoption of ICTs.

TABLE 2: Characteristics of Commercially Oriented Smallholder Cattle Farmers in North West Province, South Africa

Variable	Category	%
Gender	Male	74
	Female	26
Marital status	Single	21
	Married	65
	Divorced/widowed	14
Household size	Below 3	15
	3-5	44
	6-8	34
	Above 8	7
Farmer's highest education level	No formal education	3
	Primary education	28
	Lower secondary education	8
	Higher secondary education	32
	Postsecondary/technical education	18
	Higher tertiary education	11
Farmer's age (years)	Below 35	6

	35-44	21
	45-54	23
	55-64	24
	Above 65	26
Farming engagement/employment	Full-time farmer	95
	Part-time farmer	5

3.2. Methods of Accessing Extension Services

The current study revealed that over 90% of the farmers relied on public extension services, while a few used private extension (7%) and full-time farm managers (3%). This finding corroborates Eicher (2007) and Raidimi and Kabiti (2019), who indicated that public extension was the largest and most common source of information for smallholder livestock farmers in developing countries. Ali and Haider (2012) and Mapiye et al. (2019) further asserted that public extension was a promoter of technology adoption by farmers and a potential bridge to the farmer-researcher linkage. South Africa's DALRRD, through its provincial departments, has a *de facto* monopoly over providing extension and advisory services (Akpalu, 2013; DALRRD, 2014; Koch & Terblanché, 2013). Due to the existing relationship between smallholder farmers and government extension officers, introducing new technologies requires active collaboration with extension officers to establish trust among the end users (Costopoulou et al., 2016; Karanja et al., 2020). Furthermore, the studied farmers indicated that they mainly received extension services through farm visits by extension officers (66%), telephone calls (65%), and visits to the extension offices of the DALRRD (38%). The following quote from the FGDs shows the primary source and channel used for receiving extension services by the farmers:

> "… our extension services come from the government. This is through the likes of Mr XXX and his colleagues. They sometimes visit my farm and advise on the areas I need help. It could be on management or production issues … we call to meet them, and we sometimes rely on WhatsApp to get updates from them."

The extension officers confirmed that their primary role was to provide farmers with information and technical advice on livestock production. They also highlighted some of the various channels that they used to deliver services, as evidenced by this quote:

> "… We provide technical advice to the farmers daily by visiting their farms. We also perform routine livestock husbandry procedures like ear tagging, branding, ear notching etc. Normally, we bring them together as a group of ten and demonstrate to them. We do farmers' days and information days where we link our farmers with external stakeholders or call specialists from organisations like North-West University, and Agricultural Research Council (ARC) so that they can demonstrate new ideas and programmes ..."

The current finding that extension officers provide technical advice to farmers through farm visits conforms with the literature (Duvel, 2000; Hanyani-Mlambo, 2002; Loki et al., 2020). Farmers may incur high costs due to driving to extension offices and making phone calls to find information and technology, which can result in less quality information available. Consequently, a lack of appropriate information makes it harder for the farmers to make sound and timely management decisions, especially in responding to risks and challenges and leveraging the available opportunities to grow their business (Mbanda-Obura et al., 2017; Myeni et al., 2019).

3.3. Challenges with the Public Extension Services: Farmers' and Extension Officers' Perspectives

Despite public extension being the primary source of agricultural services, there is a widespread concern that it has remained limited in transforming smallholder farmers into commercial farmers. In this study, farmers indicated the low visibility of extension officers (64% of respondents), with the average number of farm visits being four times a year. Moreover, farmers claimed a low response rate (66%) from extension officers, citing instances of the officers being unable to arrive on time due to other commitments. The limited access to extension services implies that farmers fail to receive timely and tailored assistance and cannot effectively provide feedback to the extension system (Van Schalkwyk et al., 2017).

To validate this assertion, feedback from extension officers shows that one of the pervasive constraints to their service deliverables is the very high farmer-to-extension officer ratio (typically > 300:1). This work ratio practically prevents extension officers from visiting and supporting a sufficient number of farmers at a given time, hence the failure to meet the information and technological needs of the farmers. The extension system employs the T&V approach, which is when extension officers visit farms to provide services. This is proving very costly to the government as it requires much human capital and transport resources. For

10.17159/2413-3221/2025/v53n1a18044

instance, some extension officers reported sharing one car as a group of four, which often hindered their day-to-day planning and effectiveness in service delivery. These findings conform to those of many previous studies showing that public extension systems in developing countries are heavily under-resourced and overstretched, lack skilled human resources and infrastructural support, and face an overall decline in investment (Baig & Aldosari, 2013; Davis & Terblanche, 2016; Gwala et al., 2016; Cook et al., 2021). Additionally, the extension officers lack up-to-date data information on livestock numbers, farmer performance, and challenges faced by farmers, which affects their mechanisms and policy decisions, leading to the creation of solutions that fail to meet the needs of farmers on the ground.

3.4. Farmers' Experiences of Using Information and Communication Technologies

Over three-quarters of the interviewed farmers had smartphones, with 89% having medium to high smartphone operating skills (Table 3). Extension officers concurred that most farmers, especially emerging ones, had smartphones and laptops. Furthermore, when asked about the applications that they used with farmers, one extension officer responded as follows:

> "In terms of Apps, we mainly use WhatsApp to share and discuss things. For example, yesterday, there was a discussion on one of my groups with farmers. We were discussing how to handle broilers this coming winter with farmers advising one another on how to go about the process."

The findings on smartphone ownership and use by smallholder farmers are supported by many previous studies (Kabir, 2015; Kassem et al., 2021; Masuka et al., 2016; Shemfe, 2018), confirming the ICT revolution in Africa. Wyrzykowski (2020) notes that the increasing adoption of smartphones could be attributed to the increased availability of mobile phones and a decline in their prices in local markets. The proliferation of smartphones and the provision of mobile broadband are key factors driving internet use and, hence, access to digital-based technologies (Qiang et al., 2012). The study found that nearly two-thirds of farmers already used the Internet to search for agricultural-related management and marketing information and services. This conforms to the findings by Dehnen-Schmutz et al. (2016) and Khan et al. (2019), who argued that internet-connected smartphones allowed farmers to access large amounts of agricultural information, technologies, and services available on websites, in e-magazines, on internet portals, and social media platforms.

About 80% of the farmers strongly agreed that the LMDS would help them access agricultural information and manage livestock effectively. The findings of this study are supported by those of Kivunike et al. (2011) and Shemfe (2018), who asserted that farmers perceived ICTs as valuable tools for driving their farming and changing the quality of rural life. In addition to the positive assessment of the LMDS through farmers' perceptions, the results of the WTP study further revealed a very high level of users' appreciation of the innovation. Asked whether they would be willing to pay a full subscription fee, 84% of the farmers showed positive WTP (Table 3). A recent study by Hidrobo et al. (2020) also found that farmers had positive WTP for accessing digital-based agricultural and nutrition services. Moreover, the studied farmers were spending an average of R700 (USD39.32) on mobile subscriptions, which suggests the possibility of their paying a yearly subscription, ensuring the sustainability of the LMDS.

TABLE 3: Experiences with and WTP for ICT Innovation and the Perceived Constraints

Item	Percentage
Smartphone ownership among farmers	75
Smartphone operating skills (digital skills)	89
Perceived impact of LMDS innovation	80
Using internet to access agricultural information	67
WTP subscriptions for using LMDS	84

3.5. Perceived Constraints to the Use of Information and Communication Technologies

Figure 1 presents the perceived constraints to farmers' adoption of the proposed innovation. Over 40% of respondents reported poor availability of network connectivity. Improved mobile coverage complements the entire functioning of mobile phones, hence the adoption and operationalisation of ICTs for supporting smallholder farming systems (Trendov et al., 2019). The current finding on poor connectivity agrees with a previous report by the Global System for Mobile Communications Association (GSMA), formerly the Groupe Spéciale Mobile (2019), indicating that the African region still accounts for 40% of the world population not covered by the mobile broadband network. Kabir (2015) and Smidt (2021) also reported that farmers within rural areas had unstable network connectivity.

About 20% of farmers perceived a lack of digital skills as a constraint to adopting and using ICTs in agriculture. For example, when asked to comment on skills level during the FGDs, one of the farmers stated:

> "… I do not use technologically advanced phones because I do not have the skills. I use a simple phone that makes calls, that is all. However, I have a son who can assist me with other technical issues like mobile Apps, so there will not be a problem from my side."

Owning a mobile device and having access to connectivity may not be sufficient to justify the productiveness of the devices among farmers. Instead, farmers' skills level in operating a smartphone and understanding its features is critical (Quandt et al., 2020). Many studies have shown that illiteracy and lack of digital skills among smallholder farmers and, in some cases, extension officers constrain the use of ICTs (for example, Messenger, 2018; Trendov et al., 2019). Most farmers in the current study had a relatively high level of education, which suggests better skills in using new technologies. Fostering better education and appropriate digital skills, especially among youths, women, and the elderly, will be essential in keeping pace with digital transformation and building digital societies (Steinfield & Wyche, 2013; Trendov et al., 2019). Additionally, factors such as low participation by youths and women in farming, as found in this study, could negatively impact the adoption and use of improved technologies (Wordofa et al., 2021).

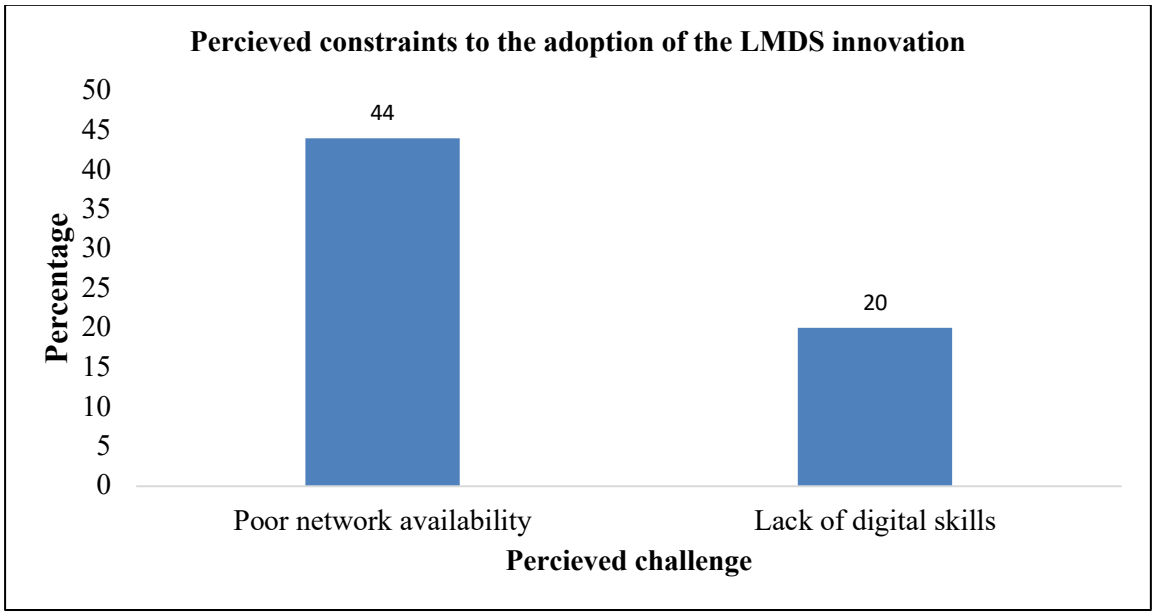

FIGURE 1: The Perceived Constraints to the Adoption of the LMDS by the Farmers

Vol. 53 No. 1, 2025: 120-138
10.17159/2413-3221/2025/v53n1a18044

3.6. Potential for the Application of Information and Communication Technologies in Revolutionising Agricultural Extension

The provision of extension services has continued to evolve, with efforts pointing to the application of ICTs (Marwa et al., 2020; Meena et al., 2013). The research discourse in this area already underscores the potential for ICTs in improving the provision of relevant information and agricultural services to smallholder farmers (Costopoulou et al., 2016; Marwa et al., 2020; Ogbeide & Ele, 2015). Thus, smallholder farmers can benefit from innovative and far-reaching digital measures to address the extension service challenges (Mapiye et al., 2021). The proposed LMDS is an example of such innovation. The LMDS is an innovation from a PhD research study performed in the Department of Animal Sciences at Stellenbosch University (SU) between 2018 and 2022. The study conceptualised a solution to assist emerging farmers in achieving sustainable growth into commercial farmers. Figure 2 presents the schematic representation of the tool and how it will connect farmers with extension and various agri-value chain players. It is a user-driven mobile phone application and web-based suite accessible through smartphones and computers. Its specific goals are to provide emerging livestock farmers with customised information and services tailored to their needs. Thus, the system allows the farmers to share challenges, experiences, data, information, technologies, and services with their colleagues and have timely access to actionable solutions without travelling or spending too much on airtime as they currently do. In addition, the LMDS will assist the government in the timely and cost-effective delivery of well-coordinated extension and advisory services that meet the farmers' needs and goals.

In 2020, the LMDS intervention was disclosed to SU's Innovus and was accepted for commercialisation. Innovus is the technology transfer office of SU, which is responsible for commercialising innovative ideas resulting from research and development at the University.

10.17159/2413-3221/2025/v53n1a18044

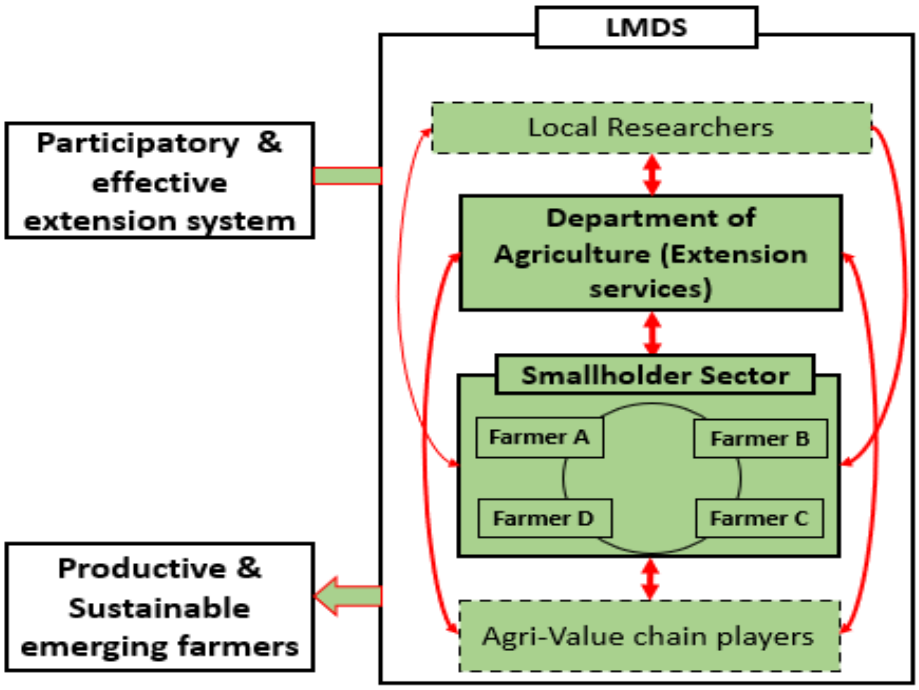

FIGURE 2: A Schematic Representation of the LMDS

The LMDS was developed by understanding the specific needs and preferences of the targeted users, namely farmers, and by gaining opinions from agricultural extension officers. This makes it an immersive and user-centric intervention that meets the targeted users' expectations (Asare-Kyei, 2013). It is important to involve end-users directly in developing new agricultural innovations since this increases trust among them, making the innovation less reliant on donor funding (Van Zyl et al., 2014).

4. CONCLUSIONS

The study results show that public extension is the primary source of extension services for farmers, who can access the services through farm visits and telephone calls. However, farmers and extension officers have reported that the public extension service has remained limited in providing services to help smallholders improve their productivity. The extension officers can only provide services to a few farmers because of the high farmer-to-extension officer ratio. Furthermore, since the government relies on the T&V approach, extension officers cannot visit some farmers due to limited support resources. Lack of direct and two-way communication between farmers and other experts, such as researchers, worsens this situation. The study findings illustrate that all farmers had mobile phones, with most having smartphones and the skills to operate the gadgets. Farmers had experience using ICTs and positive perceptions of

the proposed LMDS, suggesting the likelihood of farmers adopting mobile-based technologies. However, limited network connectivity and digital skills have implications for farmers' adoption and usability of the technology, and therefore, these issues should be addressed. In conclusion, the study results provide key insights that will help researchers, development agents, and policymakers develop digital-based intervention strategies to revolutionise public extension systems in South Africa and developing countries.

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