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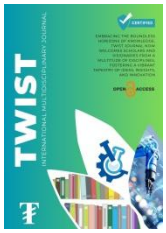

Exploring Agriculture Advisor's Perception Towards Adoption of Digital Farming Technologies to Transfer Knowledge to Small-Holder Farmer

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Abstract
The integration of digital farming technologies (ADTs), including mobile apps, GIS, IoT devices, AI systems, social media, online learning platforms, and drones, by agricultural advisors (extension service workers) aims to improve farmers' access to resources and Knowledge, especially during emergencies. However, understanding extension workers' perspectives on adopting these technologies remains critical, particularly in the post-COVID-19 era. Limited research explores how the pandemic shifted their beliefs and the reasons behind these changes. This study examines agricultural advisors' perceptions of ADT adoption to support emerging farmers. Grounded in the Technology Acceptance Model (TAM), the research was conducted at Moretele local municipality, Northwest Province, South Africa, with ten advisors sharing their beliefs through focus group discussions and semi-structured interviews. Data analyzed using the latest version of NVivo software revealed significant knowledge gaps about ADT applications. Participants expressed drastically changed perceptions post-COVID-19: while some initially viewed technology as ineffective in South Africa, they came to appreciate how even simple mobile technologies enabled them to access many farmers during the pandemic. Despite challenges such as limited technological Knowledge, inadequate infrastructure, and financial constraints, participants acknowledged the transformative potential of ADTs. The findings highlight the need for improved infrastructure, accessible training, and supportive government policies to foster sustainable and inclusive agricultural practices.

Keywords
Agriculture advisors, Agriculture Digital technologies, TAM, Perceptions

INTRODUCTION

Agriculture digital technologies (ADTs) have transformed numerous industries; however, many agricultural advisors or extension services still rely on conventional practices that often fail to meet the evolving needs of modern societies (Khan et al., 2021). Traditionally, agricultural advisors have served as a crucial link between research institutions and farmers. Yet, various challenges indicate that these knowledge transfer methods are insufficient, necessitating a more complex approach (Babu & Sah, 2019; Röling, 2019). Research suggests that conventional extension services have often overlooked smallholders and disadvantaged groups due to limited resources and varying information demands (Sahu et al., 2024). Moreover, sustainable agriculture development is a concerning factor globally, which can be achieved through quality access that relies on ADTs, which has the potential to attain sustainable development goals (SDGs), mainly 1, 2, 6, 8, 12, 14 and 15 (Walter et al., 2017). Agriculture plays a significant role in improving livelihoods, particularly in Africa sub-Saharan (SSA), which accounts for 54% of the working population (Biomlund et al., 2020) and contributes 15% to the Gross Domestic Product (GDP). The FAO (2020) highlighted that Sub-Saharan's agricultural sector has

increased by 2.6% annually due to local and international interest in the agriculture sector (Lajoie-O'Malleyb et al., 2020). Despite this increase, agriculture growth has not been ideal in production, job security, and sustainability (Collier et al., 2014), and one of the reasons is the lack of appropriate digital technologies (Fabregas et al., 2019).

ADTs have been identified as a vehicle to transform the agriculture sector, with improved access to 250 million smallholder farmers in the SSA region (Nguimkeu et al., 2021). In South Africa, agriculture contributes USD 21 billion, employing 5.3% of the population (Wang et al., 2023). Relative to the rest of SSA, South Africa is in the position of advanced ADTs used in agriculture, mainly focusing on precision farming, Agri-e-commerce, procurement, and digital advisory services (Stephenson et al., 2021). This has been supported by strong telecommunication and digital penetration in South Africa across all sectors of the economy. Due to various reasons, such as affordability, beliefs, Indigenous knowledge systems (IKS), the digital divide, and infrastructure, these digital tools were used little. Some constraints to utilizing digital technologies by agriculture advisors in South Africa have been due to the mixed perceptions towards digital technologies. However, acceptance and "intention of use" of these digital technologies are determined by the combination of perception and socio-economic characteristics (Bontsa et al., 2023). Mohr et al. (2021) identified that increased "intention to use" digital technologies relates to their usefulness and benefit and can potentially improve productivity, cost reduction, efficiency, and workload reduction. A negative perception of digital technology offers a barrier to its adoption. However, studies by Shaikh et al. (2022) and Javaid et al. (2022) emphasize that ADTs can significantly enhance agricultural knowledge dissemination coverage, reach, and quality through innovative delivery models. This technological shift is vital as global agriculture faces climate fluctuations, market risks, and changing consumer preferences (Klerkx & Rose, 2020). Early implementations of ADTs-driven platforms have shown that they can engage farmers three to five times more than traditional methods while reducing operational costs by 60% (Javaid et al., 2023; Singh et al., 2024).

Despite the affordability of digital use in the agriculture sector, there is still a limited understanding of whether agriculture advisors' perceptions changed in the post-COVID-19 era. While prior studies have explored various dimensions of digital agriculture before the COVID-19 pandemic eras, additionally there is a lack of comprehensive assessments focusing specifically on ADT's role in knowledge dissemination within the agricultural sector (Klerkx et al., 2019; Spanaki et al., 2020). Addressing this gap is crucial for enhancing knowledge transfer in agricultural development, particularly in achieving food security (Pawlak & Kołodziejczak, 2020). Therefore, this study aimed to identify the drivers of digital technology perception in a country such as South Africa, with various socio-economic and institutional factors affecting this perception. This study seeks to answer the question: What factors affect agriculture advisors' adoption of farming digital technologies (ADTs)?

THEORETICAL FRAME

The Technology Acceptance Model (TAM), a well-established theory in information systems literature, offers a sound theoretical framework to analyse the determinants of individuals' technology adoption and usage (Al-Nuaimi & Al-Emran, 2021). TAM posits that two primary constructs directly influence users' intentions to adopt technology: that it has been tested, and there are four constructs, which are perceived usefulness and perceived ease of use, attitude toward use, and behavioural intention to use (He et al., 2018). These constructs allow the study to investigate agriculture advisors' adoption, which is driven by behaviour and is a construct of attitude toward using technology in any field. Whereby attitude directly reflects the user's perception and beliefs based on the usefulness and perceived ease of use of digital technologies.

TAM is a theoretical framework that seeks to understand information-based choice models, which shows that users of digital technologies go through a series of steps in making a choice and decision (Ran,2020). Initially, users form perceptions based on their evaluation of how the technology aligns with their needs and whether it is easy to use and affordable. These evaluations influence their overall perceptions and beliefs towards technology, shaping positive and negative attitudes about its utility and usefulness to integrate into their tasks and context. This outlook directly impacts their willingness to engage with the technology, making them consciously adopt and utilize it. TAM emphasizes addressing user perceptions and attitudes to drive effective technology adoption and sustained usage. However, (Bantsa et al., 2023) advocate for highly customised value-adding services of these digital technologies with integration and utilization of multi-lingual and Indigenous knowledge systems (IKS) to enhance agriculture advisors' adoption of digital technologies in South Africa.

The current study focused on the agricultural advisors' beliefs and perceptions regarding digital technologies, thereby focusing on two constructs (perceived usefulness and perceived ease of use) of TAM, which are the initial part of the theory. Perceived usefulness seeks to demonstrate the extent to which users (agriculture advisors) believe digital technologies will improve their performance, production, and life in general (Shang, 2021). It emphasises perceived effectiveness and wide range of opportunities that certain digital technologies could afford. At the same time, Perceived ease of use refers to the extent to which a user (agriculture advisor) interacts with a specific digital technology without experiencing any difficulty (Fabregas et al., 2019). It emphasizes how users perceive the complexity and simplicity of the technology.

TAM posits that perceived usefulness and ease of use affect users' intentions of a particular technology and, consequently, affect the actual use of the technology (Tahar et al., 2020). This implies that to enhance the use of

technologies in organizations, the technologies should be perceived as valuable and relatively easy to use see Figure 1 below.

Researchers can identify critical factors, develop effective interventions, and predict user behavior by understanding agriculture advisors' factors that influence technology acceptance. TAM provides valuable insights into user-centered design, training and support, persuasive communication, and technology implementation strategies. Focusing on user perceptions and beliefs, TAM provides a useful framework for understanding the dynamics of technology acceptance and informing the development of practical technology implementation strategies.

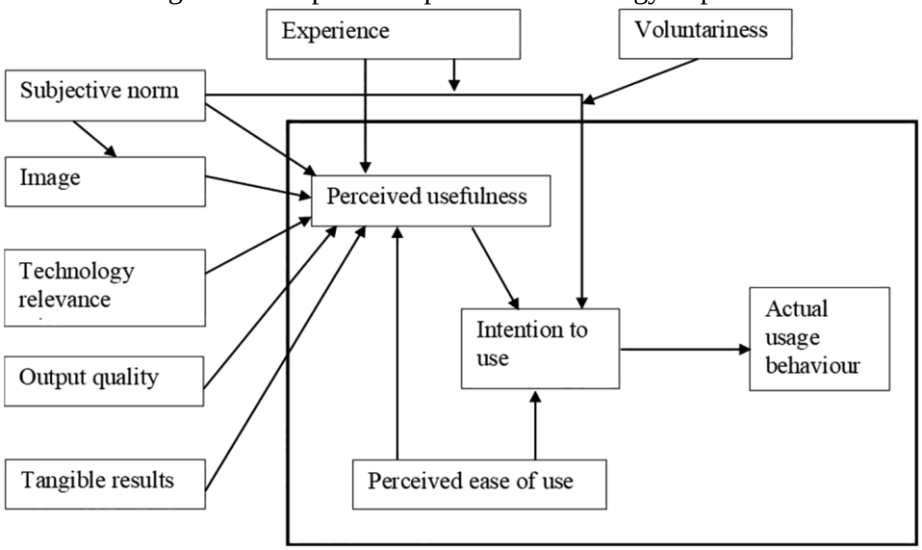

Fig. 1 Extended technology acceptance model (***Source***: Castiblanco Jimene et al., 2021)

MATERIALS AND METHODS

Description of Study Area

Moretele municipality is part of the Bojanala District in the eastern region of the Northwest Province (NWP), South Africa (DAFF NWP 2018). It is located approximately 60 km North of Pretoria, bordering the Limpopo and Gauteng Provinces, and comprises 66 villages and 10 farms. The five villages were selected from the municipality (Municipality, 2018). The area is located at the following coordinates: latitudes 25.142°S to 25.285°S and longitudes 27.970°E to 28.253°E above sea level. It covers an area of about 1 369km2 km^2 of land—annual average rainfall of 565 mm, with rain falling in the summer months between October and March. The maximum monthly average temperatures in summer range from 27 to 34 °C and 20 to 23 °C in winter, and the respective minimum temperatures range from 15 to 16 °C in summer and 3 to 6 °C in winter (Bodiba et al., 2024).

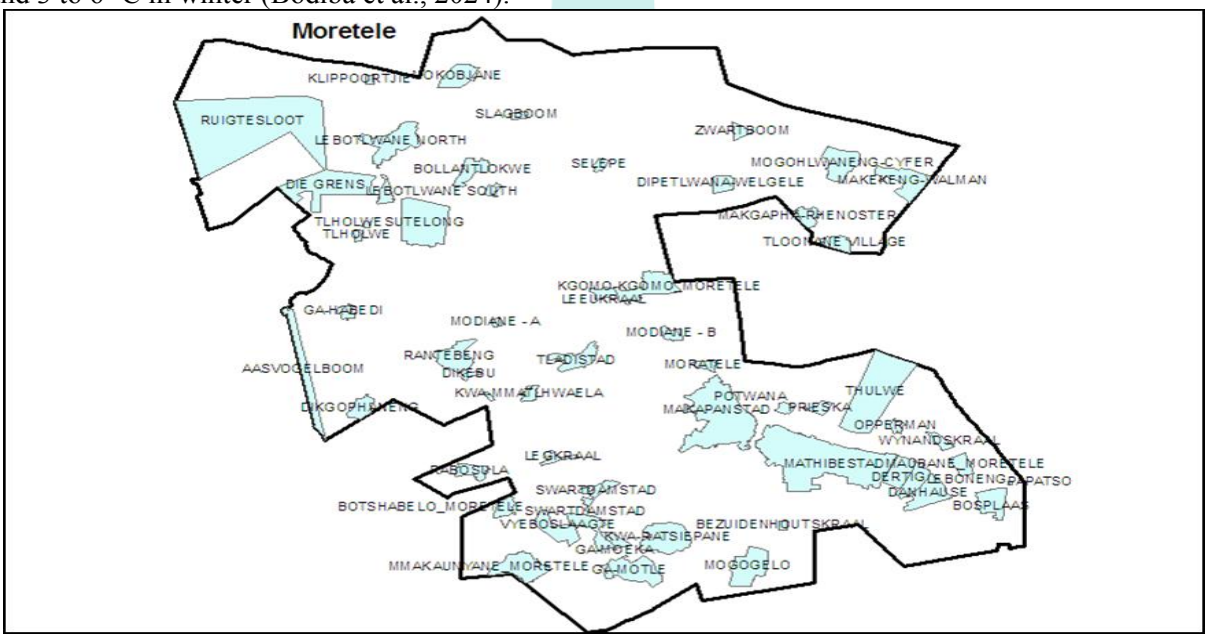

Fig. 2 Map of the study area

Sampling

For this study, we purposively recruited 10 agriculture advisors in Moretele municipality. The targeted participants are the individuals exposed to the use of the various digital tools and gender diversity, ensuring that the data gathered was enough to saturate the study and embrace the beliefs related to agricultural digital technologies (ADT) used in the farming sector.

Data Collection
The study employed a qualitative approach to ensure comprehensive data gathering (Mack,2005). In-depth semi-structured interviews lasting 45 minutes explored personal experiences with farming digital technologies, knowledge acquisition processes, perceived benefits, challenges, and adaptation strategies. Focus Group Discussions (FGDs) complemented individual interviews, with four sessions involving 10 participants, generating collective insights and exploring shared experiences (Boateng. 2012). Participant observation was conducted in natural settings to document user interactions with agriculture digital technologies (ADT) learning behaviors and contextual influences.

Data Analysis
The analysis follows a systematic approach, carefully preparing all collected data, including interview transcription, organization of field notes, and document compilation (Bachio et al., 2004). Thematic analysis will be conducted using NVivo software, progressing through initial coding, pattern identification, and theme development (Woolf et al., 2017). The interpretation phase will consider contextual factors, theoretical alignment, and pattern synthesis, with findings validated through member checking and peer review.

RESULTS

Awareness and Understanding of Agriculture Digital Technologies
Participants exhibited varying awareness and understanding of Agriculture digital technologies (ADT). Many agriculture advisors articulated a solid familiarity with applications such as mobile apps, which are essential online platforms, but limited Knowledge of advanced technologies such as crop monitoring, predictive analysis tools, precision farming, and crop monitoring. However, some agriculture advisors reported that this limitation emanates from a lack of professional development to upskill some agriculture advisors with access and use to advance these technologies. **Participant 3:** *"I never considered using mobile apps to service my farmers. I usually visit farmers in face-to-face mode."*

Participant 2: "*I think, in my case, I believe smartphones were beneficial during COVID-19. I created a WhatsApp group to assist and advise my farmers. My main challenge was that farmers often gave inaccurate information.*"

Participant 4: "*That was great, sir! However, we needed more technology support to monitor farmers' performance, especially during the COVID-19 pandemic, which was frustrating.*"

The above extraction from participants demonstrates agriculture advisors' mixed perceptions and beliefs in digital tools, as one participant believes in the traditional advisory method (face-to-face mode). In contrast, others strongly believe that this digital tool helped during COVID-19 to communicate with farmers and provide immediate support. For example, tools like WhatsApp were highlighted as instrumental in maintaining advisory services during COVID-19, showcasing their practicality in overcoming logistical barriers. This is consistent with Javaid et al., (2023) and Singh et al., (2024) that correctly implementing digital technologies shows they can engage farmers three to five times more than traditional. However, ease of use emerges as a nuanced issue. While essential tools such as smartphones and apps are accessible and familiar to many advisors, limitations arise when these tools lack the sophistication needed for more complex tasks, such as monitoring farmer performance with specific agriculture digital technologies such as drones, tracking devices for animals, predictive analyst, and crop management. This highlighted a gap in perceived ease of use, not in understanding basic technology but in applying it effectively to meet all professional needs.

Perceived Benefits of Farming Digital Farming digital technologies
The perceived benefits of Farming digital technologies emerged as a prominent theme among participants. Many highlighted increased efficiencies as a significant advantage, noting how agriculture digital technologies streamline farming operations, leading to better resource management and time savings. Improved decision-making was another key benefit; participants reported that digital technologies provide driven insight that this tool can enhance their advisory services related to crop management and pest control. **Participant 5:** *"AI tools for soil analysis have made it much easier for me to advise farmers. I can now give them quicker feedback and help them better understand their land, especially this season."*

Participant 7: *"Wow, that's such a great idea! This is something all of us should adopt because we already have access to smartphones with Meta-AI."*

Participant 3: *"Even though we don't have access to drones, animal tracking devices, or apps for soil analysis, those advanced agriculture-specific technologies Meta-AI on my WhatsApp has been a big help. It gives me useful information that I can share with farmers."*

The participant's comments reflect a growing enthusiasm for AI-based tools in agriculture, particularly in enabling more efficient and informed advisory practices. The participants highlighted the direct impact of AI on improving advisory efficiency and land management. This demonstrates the usefulness and ease of use in streamlining agriculture processes

and practices. Participants alluded to the broader adoption of AI tools due to their accessibility to smartphones they use daily. This demonstrates the importance of perceived ease of use, as participants value tools that integrate seamlessly into existing devices and workflows. While other participants (Participant 3), however, draw attention to the broader challenge of limited access to advanced agricultural technologies, such as drones and tracking devices. Despite these barriers, Meta-AI, integrated with WhatsApp, provides a practical workaround that enables advisors to deliver meaningful support to farmers to improve quality production. This highlights the adaptability of digital tools in resource-limited contexts and their role in reducing technological gaps.

An intriguing aspect that emerged from the study was integrating traditional agricultural Knowledge with digital agriculture technologies. Participants emphasized that while AI technologies offer advanced capabilities, they should not replace the invaluable insights gained from years of experience in local farming practices. Many farmers wanted to blend their traditional Knowledge with AI-driven data to create more effective farming strategies. One farmer explained, **Participant 2:** *"I know my land and its cycles better than any machine. If I can use AI to enhance what I already know, that's where the real power lies".* This perspective highlights the importance of respecting and incorporating indigenous knowledge systems in adopting new technologies.

Challenges in Implementing Agriculture Digital Technologies

Despite the numerous benefits of digital technologies, participants highlighted several challenges that hindered their implementation. A significant barrier was the lack of infrastructure; many areas struggled with unreliable internet connectivity and electricity, which impeded the effective use of digital tools. Participants also emphasized the need for training in using digital agriculture technologies effectively. **Participant 3:** *"Ongoing education is crucial to adopt these tools successfully. I want to use them, but it's difficult without proper training or reliable internet access."*

Participant 5: *"That's true, sir. On top of that, the cost of agriculture-specific digital technologies is prohibitive."*

Participant 6: *"For me, besides the cost, I want to see how these technologies can integrate with the way our farmers work, especially those who still use indigenous farming systems."*

The participants emphasize the barriers that hinder the adoption of digital tools in agriculture, including inadequate training and limited internet access. Participants highlighted the importance of ongoing education and capacity-building initiatives, suggesting that perceived ease of use is directly tied to access to training and infrastructure. Without these, even willing adopters struggle to utilize the tools fully. The participants identified the financial burden of specialized agricultural technologies. This was consistent with Munthali et al. (2018), who alluded that an economic barrier that influences the perceived usefulness of digital tools is that if they are too costly, their potential benefits remain out of reach for many advisors and farmers.

A critical perspective on cultural integration, stressing the need to align digital technologies with indigenous farming practices. This reflects a desire for tools that are not only functional but also contextually relevant. Technologies must demonstrate their usefulness in ways that complement traditional systems rather than displacing them. The participants' insights point to a multi-faceted challenge: successfully adopting digital tools requires affordable technologies, adequate training, reliable infrastructure, and cultural alignment. These factors collectively influence perceived ease of use and usefulness, central to the adoption process. These challenges illustrate the complexities of integrating advanced technology into traditional farming practices.

Prospects Regarding Digital Technologies Adoption

An agricultural extension advisor reflected on post-COVID-19 changes, stating, we've seen success when agricultural advisors work together; they help each other learn how to use digital technologies effectively. For instance, after attending a course post-COVID-19.

Participant 7: *"I was impressed by how drones could improve the rate at which we assess farms, especially since we're each allocated so many smallholder farmers." He enthusiastically continued, and* **Participant 5:** *said, "Maybe I should bring one from my dep*artment to demonstrate how it works because seeing it in action could change perceptions."

Other participants echoed this growing optimism. One added **Participant 10:** *"I don't believe much in these technologies yet, but learning how they work might change my mind. These tools sound promising."* Another participant chimed in, **Participant 3:** *"This is wonderful! Despite their limitations, digital technologies are the future of farming. I've seen farmers combine these tools with indigenous systems, and it improves production."*

The discussions reflected a shift in perceptions toward technology adoption in crop and livestock farming. A participant highlighted the transformative role of blending traditional and modern methods: "If we get better internet access and training, we can transform how farmers farm. Farmers using drones for crop health assessments and apps for weather or pest control advice are already seeing improvements. With its AI-supported tools, even WhatsApp helps us share quick,

real-time advice with farmers. These tools allow us to improve advisory services, whether crop management or livestock feeding systems.

Another advisor shared an example of digital tools improving livestock production, saying, **Participant 2:** *"One of my farmers adjusted their cattle feeding system after using AI recommendations. This season, their animals were healthier and saw better growth rates. It's changing how we provide advice because we now rely on real data."* Another participant pointed to soil analysis tools as critical. **Participant 6**: *"I've seen farmers use soil sensors and AI apps to determine exactly what their land needs, whether nutrients, irrigation adjustments, or pest control, and their yields have improved."*

Participants emphasized that access to community learning opportunities was key to this transformation. At community workshops, when farmers see others using digital tools like drones, soil testing devices, or livestock monitoring systems successfully, it inspires them to try it, too. It's easier to trust technology when you see tangible results from your neighbour's farm, one said. Another reflected on the bigger picture, noting that these technologies are expensive, but we can bring more farmers on board with government subsidies or support. The tools are AI for advice, precision irrigation systems, and drones for monitoring crops, and they're already changing farming for those who use them.

In these reflections, a clear picture emerges digital technologies, from drones to AI-powered advisory tools, have the potential to revolutionize agricultural practices. Janssen et al. (2015) alluded to improving decision-making, enhancing livestock health, optimizing irrigation, and enabling precision crop management, which are tools beginning to bridge the gap between traditional farming methods and modern innovations. Participants expressed that adopting these technologies would accelerate with better infrastructure, affordable solutions, and tailored training. This forward-looking perspective reveals a growing readiness among advisors and farmers to embrace digital tools as essential components of a sustainable and efficient agricultural future (Bracken, 2022).

DISCUSSION

The results showed that participants have mixed perceptions and beliefs regarding adopting those digital tools to improve their advisory practice. The findings were extracted from people who had lived experiences with the research problem and were interviewed through focus group discussion, which took about 4 to 6 weeks. The study ensured that free, participatory, and democratic were set to create a conducive environment for all. The study revealed that agriculture digital technologies were considered the expensive cause of the digital divide. However, they can potentially improve their advisory practice, professionalism, and farmers' production. Vincent et al. (2020) concurred that accessing agriculture digital advisory (ADT) is expensive and requires specific skills. In developing countries like South Africa, with areas with an internet connection, these agricultural digital technologies (ADT) are challenging to learn about and unreachable to some agriculture advisors (Burra et al., 2021). Moreover, in Sharan Africa (SSA), only 20% of the population can access quality internet (Pigato, 2001). The lack of internet access has been compounded by the private sector, which has offered services to these digital technologies through profit-driven institutions. However, this can work against agriculture advisors in an area where the network is changing, and that might affect smallholder farmers allocated to them. In addition, the difficulty that agriculture advisors face in rural areas or remote areas are exacerbated by ancillary inputs such as electricity services and data which are commonly found lacking where agriculture advisors should offer help to smallholders (Sherrif, 2007).

However, (Kalkanci et al., 2019) indicated that unprivileged areas lacking access to basic needs are due to a neglected bottom-up approach and building of social and economic inclusive communities to curb the injustices of the digital divide. Van Dijk (2020) indicated that the digital divide shapes users' beliefs towards adopting digital technologies. Benyam et al. (2021) emphasize that they are bound to adopt low digital technologies when the digital divide is rive. Hackfort (2021) suggested in their intellectual piece that to maximize the adoption of digital technologies in agriculture and human development, and they must consider three levels: competencies, capacities, and inequalities in access and according to Cullen (2001) referred to the digital divide because of a lack of willingness to cater to equal access and skills for all. This digital divide is deepened by digitalization between formal organizational structures in South Africa, such as the Department of Agriculture Rural Development, and willingness to digitalize the agriculture advisory services. The need to digitize the agriculture advisory service as a practice to assist farmers demonstrates inclusivity that can potentially reduce the digital divide. However, according to Simelton et al., (2021), the capability and professional development approach as prescribed by Alkire et al., (2009) can inform human dignity, accessibility, injustices, and rights. In the current study, what appears as a digital divide might be informed by opportunities available for the agriculture advisor to value their way of doing things.

Cindi (2021) highlighted in the African context that an explicit integration of Indigenous Knowledge (IK) in digital technologies is not just for recognizing the African way of doing things but for continuing to protect and embrace injustices, human dignity, and rights. This lack of IK in digitalizing advisory services in agriculture is one of the drawbacks, with Islam, (2015) and Zhai et al., (2020) highlighting that instead of seeing Indigenous Knowledge, digital technologies in parrel can be used in conjunction. Indigenous Knowledge System (IKS), with the use of digital technology to advance agriculture advisory practice, is in its developmental stages in Africa with multilingualism, and the cost of implementation is deterred (Mulaudzi, 2022). In South Africa, the Indigenous Knowledge System (IKS) has been one of the elements addressing food security that should be preserved, used, and disseminated (Balogun et al., 2021).

Vilakazi, et al., (2022) highlighted the use of IKS in South Africa and the need to demonstrate good IK practices in areas where they are highly needed for survival. This can be achieved through digital technologies. Agriculture advisor themselves can adapt existing technologies to suit their contextual needs. This improves the appropriateness of technologies. The results showed that agriculture advisors managed to assist many farmers with huge farm sizes in a very short period when they were using technology as compared to traditional practice for listening, the use of drones managed to give them accurate data on the soil faster and quicker than they can do traditionally. This was contrary to Klerkx et al., (2019), who found that adopting digital technology has a significant role in the economy.

According to Nyariki (2011), various farm sizes require different technologies for efficiency and productivity. Khanna et al. (2019) indicated that digital technologies have brought new solutions to agriculture, which seemed challenging to resolve decades ago. This trend changed how agriculture advisor offers their services to farmers. Agriculture advisors could exchange information with farmers, which has improved access through multiple means of approach and engagement, such as TikTok, YouTube, Facebook Messenger, and WhatsApp. As evident from other studies, most of the farmers who adopted the app owned a smartphone had an internet connection, and could read, type, and navigate through the app. They used it to get information about the farmers in planning and managing their farming activities, enhancing their negotiation power with the traders according to the daily market price available in the app, and facilitating farmers to exchange their farm queries with the experts having to travel. However, limitations of the app included inappropriate weather information or the name of the pesticide, which would further infer that service providers and policy makers should emphasize customized training programs with refresher training and follow-up training to ensure that farmers understand the process and can use such innovations. Agriculture advisors had positive perceptions post-COVID-19 showed the most significant appreciation towards adopting digital technologies. According to Fabregas et al., (2019) as well as Aker, (2011) and Cole et al., (2021), digital technologies are helpful when as got to help agriculture advisors show farmers how to take advantage of market prices to increase bargaining power. This positive perception regarding the adoption of digital technologies was not appreciated only by agriculture advisors but also by farmers in the process.

CONCLUSIONS

This study sought to determine the factors that influence the perceptions of agriculture advisors towards the adoption of agriculture digital technologies adoption—the theoretical framework Technology Acceptance Model (TAM). The focus group and semi-structured interview were used to gain insight from agriculture advisors regarding agriculture digital technologies (ADT). The study showed strong perceptions towards post-COVID-19, even among agriculture advisors who strongly believed in conventional practices such as IKS when advising farmers. Agriculture advisors were able to access more farmers through digital technologies, advising them with accurate information picked up from technologies such as drones, sensor soil testing, mobile applications, and social media. Furthermore, not just agriculture advisors exhibited a positive perception towards digital technologies but also farmers assisting to attain high production and get their provide in market at relatively low cost. This was informed and reinforced using low-tech digital technologies. This study concludes that socio-economic factors affect agriculture advisors' beliefs about digital technologies. All combined, these have influenced and created alternatives for agriculture advisors to focus overly on low-tech digital technologies in Moretele municipalities.

RECOMMENDATIONS

This study suggests several recommendations to address the challenges faced by agricultural advisors in the Moretele municipalities, particularly in the aftermath of COVID-19, which significantly impacted their roles. One key recommendation is to make affordable high-tech digital technologies available to these advisors. The central government could play a crucial role by subsidizing these technologies within the agricultural sector to enhance advisory services. Additionally, engaging suppliers to provide low-cost digital solutions could help make these technologies more accessible. This approach could include offering ancillary and complementary services, such as data access, internet connectivity, and after-sales support, to facilitate the further adoption of digital tools. Integrating existing low-tech solutions with advanced digital technologies is another viable strategy, allowing for cost-effective options that balance affordability and functionality. Promoting affordable digital technologies could help reduce disparities in access and bridge the digital divide, particularly for advisors working with economically disadvantaged smallholder farmers. Given their deep-rooted presence in communities and familiarity with vulnerable farmers, extension officers could play a pivotal role in supporting this transition. Collaborations with traditional and community leaders could further encourage technology developers to align innovations with agricultural advisors' needs and small-scale farmers relying on indigenous knowledge, cultural practices, and traditions.

Government funding is vital to developing and disseminating these tailored digital tools. Furthermore, promotional efforts, whether through print, electronic, or social media, should prioritize historically underserved areas to improve accessibility and productivity for farmers in remote regions. This strategy could foster widespread adoption of digital technologies by agricultural advisors, irrespective of their backgrounds or beliefs. Finally, future research could explore the determinants influencing technology adoption, including perceived usefulness, ease of use, and intention to adopt, as outlined in the Technology Acceptance Model (TAM). These insights could refine strategies to support digital transformation in agricultural advisory services.

LIMITATIONS OF STUDY

The study encountered both conceptual and methodological limitations. The perceptions could have been organized based on the TAM framework, specifically focusing on factors such as interest, perceived usefulness, ease of use, and intention to adopt the technology. Additionally, the study's external validity was constrained by the purposive sampling design, which was limited in terms of both geographic scope and timing. As a result, the findings may not be readily generalizable to other settings or contexts.

REFERENCES

1. Adnan, N., Nordin, S. M., Bahruddin, M. A., & Tareq, A. H. (2019). A state-of-the-art review on facilitating sustainable agriculture through green fertilizer technology adoption: Assessing farmers behavior. Trends in Food Science & Technology, 86, 439-452. https://doi.org/10.1016/j.tifs.2019.02.040.
2. Aker, J. C. (2011). Dial "A" for agriculture: a review of information and communication technologies for agricultural extension in developing countries. Agricultural economics, 42(6), 631-647. https://doi.org/10.1111/j.1574-0862.2011.00545.x.
3. Alkire, S., & Deneulin, S. (2009). The human development and capability approach. In An introduction to the human development and capability approach (pp. 22-48). Routledge.Simelton, E., & McCampbell, M. (2021). Do digital climate services for farmers encourage resilient farming practices? Pinpointing gaps through the responsible research and innovation framework. Agriculture, 11(10), 953. https://doi.org/10.3390/agriculture11100953.
4. Al-nuaimi, M,N and al-emran, M., 2021. Learning management systems and technology acceptance models: A systematic review. Education and Information Technologies, 26(5), pp.5499-5533.
5. Babu, S.C. AND Sah, R.P., 2019. Agricultural research and extension system in Nepal: An organizational review (pp. 291-319). Springer Singapore.
6. Bachiochi, P. D., & Weiner, S. P. (2004). Qualitative data collection and analysis. Handbook of research methods in industrial and organizational psychology, 161-183.
7. Balogun, T., & Kalusopa, T. (2021). A framework for digital preservation of Indigenous knowledge system (IKS) in repositories in South Africa. Records Management Journal, 31(2), 176-196. https://doi.org/10.1108/RMJ-12-2020-0042.
8. Barrett, C. B., Moser, C. M., McHugh, O. V., & Barison, J. (2004). Better technology, better plots, or better farmers? Identifying changes in productivity and risk among Malagasy rice farmers. American Journal of Agricultural Economics, 86(4), 869-888.
9. Benyam, A. A., Soma, T., & Fraser, E. (2021). Digital agricultural technologies for food loss and waste prevention and reduction: Global trends, adoption opportunities and barriers. Journal of Cleaner Production, 323, 129099. https://doi.org/10.1016/j.jclepro.2021.129099.
10. Bjornlund, V., Bjornlund, H., & Van Rooyen, A. F. (2020). Why agricultural production in sub-Saharan Africa remains low compared to the rest of the world–a historical perspective. International Journal of Water Resources Development, 36(sup1), S20-S53. https://doi.org/10.1080/07900627.2020.1739512.
11. Boateng, W. (2012). Evaluating the efficacy of focus group discussion (FGD) in qualitative social research. International Journal of Business and Social Science, 3(7).
12. Bontsa, N. V., Mushunje, A., & Ngarava, S. (2023). Factors influencing the perceptions of smallholder farmers towards adoption of digital technologies in Eastern Cape Province, South Africa. Agriculture, 13(8), 1471. https://doi.org/10.3390/agriculture13081471.
13. Bracken, J. (2022). Application of digital advisory tools and services within a farm advisory service context (Doctoral dissertation, University College Dublin. School of Agriculture and Food Science).
14. Castiblanco Jimenez, I. A., Cepeda García, L. C., Marcolin, F., Violante, M. G., & Vezzetti, E. (2021). Validation of a TAM Extension in Agriculture: Exploring the Determinants of Acceptance of an e-Learning Platform. Applied Sciences, 11(10), 4672. https://doi.org/10.3390/app11104672.
15. Cindi, L. (2021). Incorporating African Indigenous Knowledge Systems into the Basic Education curriculum: Experiences from two schools in the Gauteng and KwaZulu-Natal Provinces, South Africa. http://hdl.handle.net/11660/11720.
16. Cole, S. A., & Fernando, A. N. (2021). 'Mobile'izing agricultural advice technology adoption diffusion and sustainability. The Economic Journal, 131(633), 192-219. https://doi.org/10.1093/ej/ueaa084.
17. Collier, P., & Dercon, S. (2014). African agriculture in 50 years: smallholders in a rapidly changing world?. World development, 63, 92-101. https://doi.org/10.1016/j.worlddev.2013.10.001.
18. Cullen, R. (2001). Addressing the digital divide. Online information review, 25(5), 311-320.https://doi.org/10.1108/14684520110410517.
19. Fabregas, R., Kremer, M., & Schilbach, F. (2019). Realizing the potential of digital development: The case of agricultural advice. Science, 366(6471), eaay3038. DOI: 10.1126/science.aay3038.
20. Hackfort, S. (2021). Patterns of inequalities in digital agriculture: A systematic literature review. Sustainability, 13(22), 12345. https://doi.org/10.3390/su132212345.

21. He, Y., Chen, Q. and Kitkuakul, S., 2018. Regulatory focus and technology acceptance: Perceived ease of use and usefulness as efficacy. Cogent Business & Management, 5(1), p.1459006.
22. Islam, F. (2015). Institutionalization of agricultural knowledge management system for digital marginalized brural farming community. ISDA 2010. https://hal.archives-ouvertes.fr/hal-00516458.
23. Janssen, S., Porter, C. H., Moore, A. D., Athanasiadis, I. N., Foster, I., Jones, J. W., & Antle, J. M. (2015). Towards a new generation of agricultural system models, data, and knowledge products: building an open web-based approach to agricultural data, system modeling and decision support. AgMIP. Towards a New Generation of Agricultural System Models, Data, and Knowledge Products, 91.
24. Javaid, M., Haleem, A., Khan, I.H. AND Suman, R., 2023. Understanding the potential applications of Artificial Intelligence in Agriculture Sector. Advanced Agrochem, 2(1), pp.15-30.
25. Javaid, M., Haleem, A., Singh, R.P. and Suman, R., 2022. Enhancing smart farming through the applications of Agriculture 4.0 technologies. International Journal of Intelligent Networks, 3, pp.150-164.
26. Kalkanci, B., Rahmani, M., & Toktay, L. B. (2019). The role of inclusive innovation in promoting social sustainability. Production and Operations Management, 28(12), 2960-2982. https://doi.org/10.1111/poms.13112.
27. Kamunyu, E.N., 2022. Factors Influencing Adoption Of Mobile Banking Services In Informal Settlements Of Mavoko Sub-county In Machakos County, Kenya (Doctoral dissertation, KCA University).
28. Khan, N., Ray, R.L., Sargani, G.R., Ihtisham, M., Khayyam, M. AND Ismail, S., 2021. Current progress and future prospects of agriculture technology: Gateway to sustainable agriculture. Sustainability, 13(9), p.4883.
29. Khanna, A., & Kaur, S. (2019). Evolution of Internet of Things (IoT) and its significant impact in the field of Precision Agriculture. Computers and electronics in agriculture, 157, 218-231. https://doi.org/10.1016/j.compag.2018.12.039.
30. Klerkx, L. and Rose, D., 2020. Dealing with the game-changing technologies of Agriculture 4.0: How do we manage diversity and responsibility in food system transition pathways?. Global Food Security, 24, p.100347.
31. Klerkx, L., Jakku, E., & Labarthe, P. (2019). A review of social science on digital agriculture, smart farming and agriculture 4.0: New contributions and a future research agenda. NJAS-Wageningen journal of life sciences, 90, 100315. https://doi.org/10.1016/j.njas.2019.100315.
32. Lajoie-O'Malley, A., Bronson, K., van der Burg, S., & Klerkx, L. (2020). The future (s) of digital agriculture and sustainable food systems: An analysis of high-level policy documents. Ecosystem Services, 45, 101183. https://doi.org/10.1016/j.ecoser.2020.101183.
33. Mack, N. (2005). Qualitative research methods: A data collector's field guide.
34. Marikyan, M. and Papagiannidis, P., 2021. Unified theory of acceptance and use of technology. TheoryHub book.
35. Mashi, S.A., InkanI, A.I. AND Oghenejabor, O.D., 2022. Determinants of awareness levels of climate smart agricultural technologies and practices of urban farmers in Kuje, Abuja, Nigeria. Technology in Society, 70, p.102030.
36. Mohr, S., & Kühl, R. (2021). Acceptance of artificial intelligence in German agriculture: an application of the technology acceptance model and the theory of planned behavior. Precision Agriculture, 22(6), 1816-1844. Precision Agriculture (2021) 22:1816–1844. https://doi.org/10.1007/s11119-021-09814-x.
37. Mulaudzi, F. M., & Lebese, R. (2022). Working with indigenous knowledge.
38. Municipality, V. D. (2018). Limpopo Province. South Africa.
39. Munthali, N., Leeuwis, C., van Paassen, A., Lie, R., Asare, R., van Lammeren, R., & Schut, M. (2018). Innovation intermediation in a digital age: Comparing public and private new-ICT platforms for agricultural extension in Ghana. NJAS-Wageningen Journal of Life Sciences, 86, 64-76.
40. Nguimkeu, P., & Okou, C. (2021). Leveraging digital technologies to boost productivity in the informal sector in Sub-Saharan Africa. Review of Policy Research, 38(6), 707-731. https://doi.org/10.1111/ropr.12441.
41. Nyariki, D. M. (2011). Farm size, modern technology adoption, and efficiency of small holdings in developing countries: evidence from Kenya. The Journal of Developing Areas, 35-52. https://www.jstor.org/stable/23215262.
42. Pigato, M. (2001). Information and communication technology, poverty, and development in sub-Saharan Africa and South Asia. Washington, DC: World Bank.
43. Ramadania, S. and Braridwan, Z., 2019. The influence of perceived usefulness, ease of use, attitude, self-efficacy, and subjective norms toward intention to use online shopping.
44. Ran, L. (2020). An empirical study of influencing factors on mobile food delivery app consumers' continuous use intention with the perspective of herd behavior--integrated model based on TAM, ISSM, and ECM. DOI:10.14457/NIDA.the.2020.114.
45. Röling, N., 2019. The agricultural research-technology transfer interface: a knowledge systems perspective. In Making the link (pp. 1-42). CRC Press.
46. Sahu, S., Bishnoi, S., Sharma, P.R., Satyapriya, Mahra, G.S., Burman, R.R., Barua, S., Misha Madhavan, M., Sangeetha, V., Sinha, S.K. AND Singh, R., 2024. Exploring popular information sources and determinants of farmers' access to agricultural extension services in the Indo-Gangetic plains. Frontiers in Sustainable Food Systems, 8, p.1339243.
47. Sekabira, H., Bonabana, J., & Asingwire, N. (2012). Determinants for adoption of information and communications technology (ICT)-based market information services by smallholder farmers and traders in

Mayuge District. Journal of Development and Agricultural Economics, 4(14), 404-415. DOI: 10.5897/JDAE12.081.
48. Shaikh, T.A., Rasool, T. AND Lone, F.R., 2022. Towards leveraging the role of machine learning and artificial intelligence in precision agriculture and smart farming. Computers and Electronics in Agriculture, 198, p.107119.
49. Shang, L., Heckelei, T., Gerullis, M. K., Börner, J., & Rasch, S. (2021). Adoption and diffusion of digital farming technologies-integrating farm-level evidence and system interaction. Agricultural systems, 190, 103074. https://doi.org/10.1016/j.agsy.2021.103074.
50. Sheriff, S. (2007). Rural access: options and challenges for connectivity and energy in Tanzania. International Institute for Communication and Development, Hague.
51. Soma, T., & Nuckchady, B. (2021). Communicating the benefits and risks of digital agriculture technologies: Perspectives on the future of digital agricultural education and training. Frontiers in Communication, 6, 762201. https://doi.org/10.3389/fcomm.2021.762201.
52. Spanaki, K., Sivarajah, U., Fakhimi, M., Despoudi, S. and Irani, Z., 2022. Disruptive technologies in agricultural operations: A systematic review of AI-driven AgriTech Stephenson, J., Chellew, T., von Köckritz, L., Rose, A., & Dinesh, D. (2021). Digital agriculture to enable adaptation: A supplement to the UNFCCC NAP Technical Guidelines. CCAFS Working Paper.research. Annals of Operations Research, 308(1), pp.491-524.
53. Van Dijk, J. (2020). The digital divide. John Wiley & Sons.
54. Vilakazi, B. S., Zengeni, R., & Mafongoya, P. (2022). Integrating Indigenous Knowledge Systems (IKS) with Science-Based Strategies into Climate Variability Mitigation and Adaptation of Farming Communities in Semi-Arid Southern Africa. Indilinga African Journal of Indigenous Knowledge Systems, 21(1), 119-140. https://hdl.handle.net/10520/ejc-linga_v21_n1_a11.
55. Vincent, A., & Saravanan, R. (2020). Agricultural extension and advisory Systems in Tamil Nadu. *National Institute of agricultural extension management (MANAGE)*.
56. Walter, A., Finger, R., Huber, R., & Buchmann, N. (2017). Smart farming is key to developing sustainable agriculture. Proceedings of the National Academy of Sciences, 114(24), 6148-6150. https://doi.org/10.1073/pnas.1707462114.
57. Wang, G., LU, Q. and Capareda, S.C., 2020. Social network and extension service in farmers' agricultural technology adoption efficiency. Plos one, 15(7), p.e0235927.
58. Wang, J., Lin, Q., & Zhang, X. (2023). How does digital economy promote agricultural development? Evidence from Sub-Saharan Africa. Agriculture, 14(1), 63. https://doi.org/10.3390/agriculture14010063.
59. Woolf, N. H., & Silver, C. (2017). Qualitative analysis using NVivo: The five-level QDA® method. Routledge.
60. Zhai, Z., Martínez, J. F., Beltran, V., & Martínez, N. L. (2020). Decision support systems for agriculture 4.0: Survey and challenges. Computers and Electronics in Agriculture, 170, 105256. https://doi.org/10.1016/j.compag.2020.105256.
61. Zielonka, J.T. and Rothlauf, F., 2021. Techno-eustress: the impact of perceived usefulness and perceived ease of use on the perception of work-related stressor.