


Attitudes towards mobile digital recordkeeping among smallholder sheep farmers in the Nama-Karoo Biome, South Africa

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Abstract

Mobile digital technologies can be enablers of improved sustainability in smallholder livestock production systems, yet their use for farm recordkeeping in such systems remains under-examined. This study investigated the existing recordkeeping practices, and attitudes towards a proposed mobile digital recordkeeping application (app), among 53 smallholder sheep farmers in the Eden and Central Karoo Districts of South Africa's Nama-Karoo Biome. Data collected through a semi-structured questionnaire revealed that the farmers' recordkeeping relied mainly on memory (43%), loose paper notes (43%), and organised notebooks (25%). Only 8% used computer-based records. Nearly 90% of respondents expressed their willingness to adopt the proposed mobile recordkeeping app, and the vast majority agreed that the app could improve their recordkeeping (90% agreement) and decision-making (87% agreement). Opinions on the app's user-friendliness were more mixed, with 66% agreeing that it was user-friendly, 25% saying they were undecided, and 8% disagreeing. With respect to the potential limitations of the app, just over half (51%) of the farmers cited lack of digital skills and training as a limitation, with smaller percentages pointing to limitations posed by poor network connectivity (26%) and insufficient cashflow (23%) to buy mobile data. The findings thus point to the need for improved app user-friendliness, increased digital skills development, and, to a lesser extent, better network connectivity and more affordable data, if there is to be widespread adoption of the mobile digital recordkeeping app among the farmers who participated in the study.

Keywords

smallholder farming, sheep farming, recordkeeping, mobile digital application (app), technology adoption, digital skills, Nama-Karoo Biome, South Africa

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1. Introduction

In contemporary agriculture, the uptake of mobile digital technologies is increasingly framed as central to improving efficiency, resilience, and environmental sustainability (Csótó, 2017; Mkhize, 2024; Smidt & Jokonya, 2022). Digital tools can expand access to context-specific knowledge, support more systematic recordkeeping, and enhance productivity across livestock systems (Abdulai et al., 2023; Daum et al., 2022; Mapiye, 2022). These benefits are unevenly distributed because established commercial farmers tend to be early adopters, whereas smallholder farmers frequently remain on the margins of digital innovation (Makaula, 2021; Mkhize, 2024). Accordingly, in African smallholder farming contexts, agricultural digitisation is approached as part of a wider information and communication ecosystem shaped by power relations, institutional arrangements, and local capabilities, rather than as a purely technical process (Abdulai et al., 2023; Mkhize, 2024). For many African smallholder farmers, available information and communication technologies (ICTs) are still largely limited to radio, television, and (feature or smart) mobile telephony handsets (Abdulai et al., 2023; Makaula, 2021). At the same time, emerging evidence suggests that smartphone-based mobile applications (apps) can play transformative roles in farm management and decision-making (Ahikiriza et al., 2022; Csótó, 2017).

Resource-limited communities in emerging economies such as South Africa are becoming progressively more digitally connected. As of 2021, over 90% of mobile phones owned by South Africans were smartphones and the national smartphone adoption rate had reached about 80% (McCrocklin, 2021). Internet use in South Africa and across much of Africa is also rising, although persistent gaps remain in remote rural regions. Expansions in mobile network coverage and broadband infrastructure have enabled a proliferation of mobile services targeted at farming communities (Mapiye, 2022). For instance, in 2020, South Africa's two largest mobile network operators, Vodacom and MTN, launched extensive 5G networks, providing powerful mobile digital access services to many parts of the country (GSMA, 2020). Such developments create new technical possibilities for the digitalisation of smallholder agriculture—while at the same time foregrounding questions of access, affordability, and appropriate design (Mkhize, 2024).

Smallholder sheep farming is an important contributor to South Africa's agricultural economy and rural livelihoods (Molotsi, 2017). Sheep production is concentrated in pastoral areas where alternative land uses are limited, such as the Karoo region, which spans the dry western and central districts of South Africa's Western Cape Province, covering nearly half of the province's surface area. Sheep farming systems are typically low-input and rely heavily on natural veld grazing.

Smallholder farmers face multiple structural and operational constraints that can undermine long-term sustainability (Daum et al., 2022; Myeni et al., 2019; Scholtz et al., 2008). One such constraint is the lack of systematic, detailed recordkeeping. Robust farm records are vital for, inter alia, selection of suitable genotypes (Molotsi, 2017), enablement of traceability, certification of organic production (DALRRD, 2023), and demonstration of compliance with hygiene and food-safety standards (Resti et al., 2024). Detailed recordkeeping thus provides a critical informational foundation for more farmers' participation in value chains that reward quality, provenance, and compliance. Despite its importance, recordkeeping among African smallholder farmers still often depends largely on paper-based methods, which are vulnerable to loss, damage, and fragmentation (Manteaw et al., 2021). Many farmers lack the skills and support required to develop systematic farm records, and the limited technology uptake can further constrain data collection and use (Gichohi, 2019; Kiptoo et al., 2021).

Although digital agriculture is expanding rapidly in African settings, empirical work on its use in the continent's smallholder poultry, sheep, goat, and pig systems remains limited (Daum et al., 2022; Kabir, 2015; Mkhize, 2024). Much of the existing literature focuses on large commercial enterprises, cattle systems, or broader agricultural sectors (Mapiye, 2022; Resti et al., 2024). Also, relatively little attention is paid to smallholders' needs, lived experiences, and perceptions with respect to digital tools (Ahikiriza et al., 2022; Caffaro et al., 2020; Musungwini, 2018). Nevertheless, available research points to the need to elicit targeted user requirements and perceptions before technology deployment—so as to identify design flaws, align innovations with farmers' priorities, and improve adoption prospects (Abdulai et al., 2023; Mapiye, 2022).

Against this backdrop, this study examined the potential for digitising farm recordkeeping among a cohort of South African smallholder sheep farmers. Specifically, the study documented the sheep production system in the study areas, documented existing recordkeeping practices, and explored the farmers' attitudes towards a proposed mobile recordkeeping app.

2. Literature review

Farm recordkeeping is fundamental to efficient and sustainable livestock production, including for smallholder sheep systems. Accurate records of animal health, reproduction, and performance underpin timely interventions, genetic improvement, and flock productivity (Arshad et al., 2024; Cloete et al., 2014). Systematic tracking of inputs and outputs enables economic analysis, cost control, and risk management, improving farm resilience in volatile markets (Basir et al., 2024). Records also support compliance with animal-welfare, food-safety, and environmental regulations, which increasingly require auditable evidence across value chains (DALRRD, 2023; van der Merwe et al., 2018). In premium and certification-based markets, robust record systems are central to traceability, allowing verification of origin, husbandry, and treatment histories, thereby securing access to higher-value outlets and reinforcing consumer trust (KDF, n.d.).

Conventional recordkeeping in smallholder systems is often based on paper notebooks, ad hoc forms, and reliance on farmers' memory, thus potentially generating weaknesses in quality, completeness, and usability of the data in the records. Paper records can easily be misplaced, damaged, or inconsistently updated, leading to gaps that can compromise management decisions and long-term planning (Basir et al., 2024). Manual transcription into secondary ledgers or paper spreadsheets can introduce further errors and generate labour and transaction costs that sometimes exceed those of digital approaches (Pavlović et al., 2009; Thriemer et al., 2012). Paper-based records systems used by smallholder farmers can also be hindered by low literacy and numeracy levels, and limited training in farm administration (Bontsa et al., 2023; Gichohi, 2019). Moreover, fragmented formats and non-standardised forms can impede aggregation, analysis, and interoperability with external databases, certification schemes, and advisory services, thus leaving the farmers poorly positioned for emerging data-driven governance and market requirements (Basir et al., 2024; Mkhize, 2024; Mwangi et al., 2020).

Digital tools increasingly offer structured responses to farmer recordkeeping limitations by transforming how data is captured, stored, and leveraged. Mobile and cloud-based digital record systems can reduce transcription steps and automate back-up, thus lowering the risk of data loss while improving accuracy and timeliness (Basir et al., 2024; Daum et al., 2021). Such platforms can integrate geo-referenced and time-stamped records with sensor data, enhancing the granularity and reliability of information used for economic analysis and decision support. Digital dashboards and analytics can enable farmers to visualise trends in health, fertility and productivity, identify outliers, and benchmark performance, thereby supporting proactive and evidence-based management (Javaid et al., 2022; Vlaicu et al., 2024).

For South African smallholder sheep farmers, digitised recordkeeping can strengthen traceability, certification compliance, and participation in high-value markets. Structured databases can make it easier to demonstrate adherence to welfare, health, and feeding protocols, a prerequisite for organic and geographic-indication labels such as Karoo Lamb (DALRRD, 2023; Javaid et al., 2022; van der Merwe et al., 2018). Digital traceability tools, often linked to mobile platforms, can support transparent value chains by connecting on-farm events with slaughter, processing, and retail information, improving consumer confidence and potentially capturing price premiums (Mwangi et al., 2020). Integration with digital extension and advisory services can allow record data to feed back into tailored recommendations on breeding, nutrition, and animal health, thus elevating flock performance and resilience (Daum et al., 2020).

Digitisation can also confer broader sustainability and climate benefits on smallholder livestock systems. Digital farm-management tools can improve resource-use efficiency by linking records on feed, water, and grazing with environmental and climatic data, thereby optimising stocking rates and reducing degradation of rangelands (Nyamuryekung'e, 2023; Resti et al., 2024). In sheep farming systems, spatial data from GPS collars and remote-sensing platforms can be combined with digital grazing logs to refine rotational-grazing

strategies, protect vegetation, and align stocking with carrying capacity in semi-arid landscapes (Odintsov et al., 2021; ICARDA, 2024). Water-use records, integrated with sensor data and mobile alerts, can support early detection of leaks (from dams and reservoirs) and more precise allocation, helping to lower the water footprint of production in water-scarce regions (Tedeschi et al., 2021). More broadly, digital agriculture is recognised as a lever for reducing greenhouse-gas intensity and supporting climate-smart practices, including improved feeding strategies and reduced input wastage, thus aligning smallholder systems with wider climate and sustainability targets (Resti et al., 2024; Nyamuryekung'e, 2024).

Despite these advantages, the adoption of mobile digital recordkeeping among smallholder livestock farmers in African settings remains uneven and constrained by multiple, interacting barriers (Abdulai et al., 2023; Kabir, 2015). Limited digital literacy and low familiarity with, or access to, smartphones or specialised apps are major obstacles (Munthali et al., 2025). In addition, many African smallholder farmers lack the skills and/or confidence to navigate mobile digital interfaces and interpret outputs, especially where formal education levels are low (Abdulai et al., 2023; Bontsa et al., 2023; Liu et al., 2025). Further constraints are generated by poor mobile-network coverage and unreliable electricity, both of which can restrict the use of cloud-based services and real-time apps (GSMA, 2020; Mdoa & Mdiya, 2022; Wyrzykowski, 2020; Choruma et al., 2024). The affordability of hardware, of software subscriptions, and of mobile data bundles is also a constraint, and contributes to digital divides between wealthier and poorer producers (Chorume et al., 2024; Munthali et al., 2025; Musungwini, 2018; Shemfe, 2018).

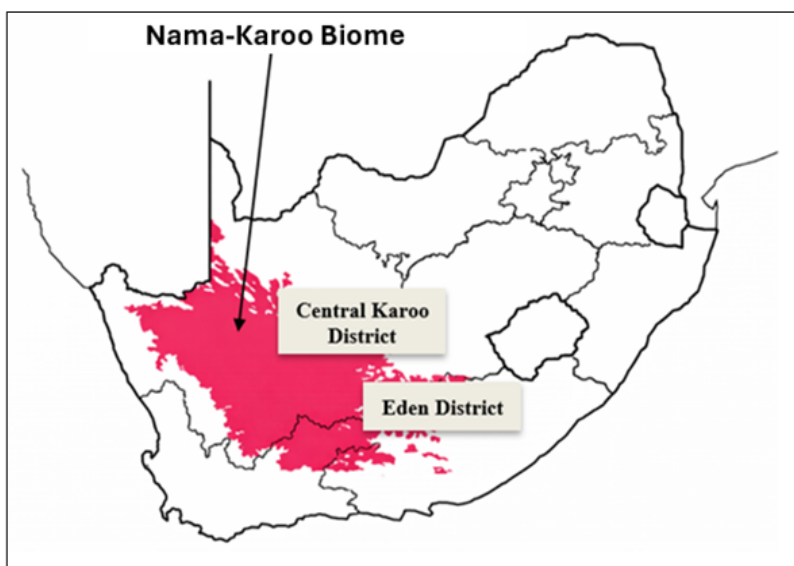
3. Research design

Guided by a pragmatic paradigm, this study employed a mixed-methods design that integrated quantitative and qualitative approaches. Combining these strands enabled the research to address both confirmatory and exploratory questions and to generate contextually grounded yet analytically robust insights (Creswell & Creswell, 2022).

Study sites

The study was conducted in the Eden and Central Karoo Districts of South Africa's Western Cape Province. Both districts lie within arid environments classified as part of the Nama-Karoo Biome (Figure 1), and both feature extensive sheep production systems (Acocks, 1975; Molotsi, 2017). The Nama-Karoo Biome is characterised by annual rainfall ranging from approximately 100 to 520 mm, which supports mainly grass-shrub vegetation. Across this predominantly pastoral region, mean maximum temperatures frequently exceed 30°C and mean minimum temperatures often drop below freezing (Mucina & Rutherford, 2006; SANBI, n.d.) Eden also forms part of the Cape Floristic Region, a highly biodiverse region noted for exceptional levels of plant and animal endemism (Robinson, 2017).

Figure 1: Map of South Africa featuring Nama-Karoo Biome and Central Karoo and Eden Districts



Source: Adapted from SANBI (n.d.)

Study population

Purposive sampling was employed to identify smallholder sheep farmers who were high-performing and already participating in government support programmes in the Eden and Central Karoo Districts. Recruitment of the 53 farmers who participated in the study was assisted by local extension officers.

Data collection

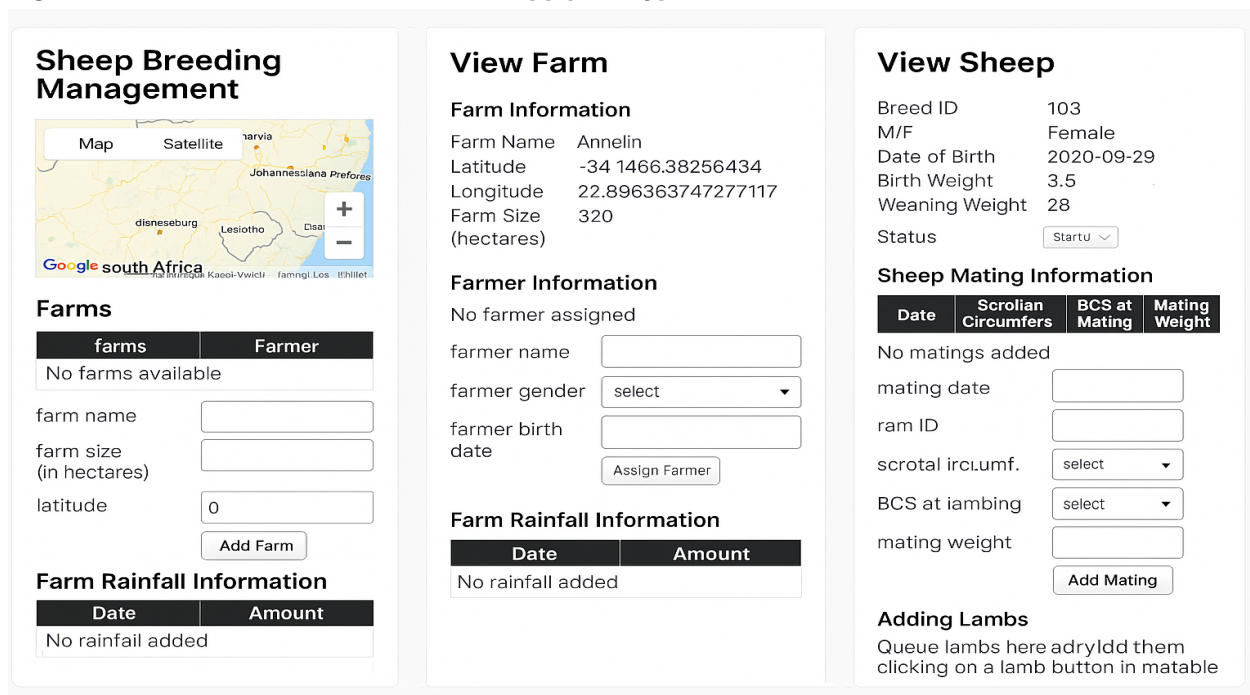
Data was collected through individual interviews using a semi-structured questionnaire. The instrument captured predominantly quantitative information via closed-ended questions on farmers' demographic characteristics (age, gender, education level), farm and flock characteristics (land size, production system), existing sheep production practices, current recordkeeping practices (type, format, frequency), and structured perceptions of the usefulness and ease of use of a mobile digital recordkeeping application. The closed-ended questions were complemented by open-ended questions that generated qualitative insights on the reasons for keeping or not keeping records, challenges associated with existing recordkeeping approaches, perceived benefits and concerns regarding digital recordkeeping, and suggestions for features of a mobile recordkeeping application. The data collection, which took place in 2021, was part of an ongoing Stellenbosch University research project and was approved by the university's Research Ethics Committee (ethical clearance certificate 9293).

Sheep Breeding Management (SBM) app

The prototype of a mobile recordkeeping app, called Sheep Breeding Management (SBM), was used to facilitate data collection in the study. The app prototype was developed as part of a research project undertaken in the Department of Animal Sciences (Sustainable Agriculture programme) at Stellenbosch University, which is focused on designing a farmer management database system. The conceptualisation, system requirements, and functional specifications of the app were developed by that project's academic research team, while the software development was outsourced to a private company.

The app prototype was demonstrated to participating farmers. The app, which enables users to capture and retrieve data on breeding histories, health interventions, and growth performance for individual animals, is intended to enhance decision-making, improve breeding outcomes, and optimise flock productivity and income (Figure 2). It seeks to standardise, preserve, and mobilise farm-level data within a wider agricultural information system, thus serving as a foundational information infrastructure that can mediate relationships between farmers, extension services, certification bodies, and markets.

Figure 2: User-interface features of SBM app prototype



Data analysis

The quantitative data was analysed using frequency counts, percentages, and cross-tabulations. Qualitative data was analysed through thematic analysis, with inductive open coding applied to identify key insights. Related codes were grouped into categories and refined into themes through comparison and analytical note-taking.

4. Results and discussion

Farmer demographics

As seen in Table 1, the vast majority (96%) of the participating sheep farmers were male. The largest age cohort (28%) comprised farmers aged 56 to 65, followed by 25% aged 46 to 55, and 23% aged 66 or older. This age profile confirms that sheep farming in the study areas is dominated by middle-aged and older farmers, mirroring evidence in other studies of limited youth involvement in agriculture (Myeni et al., 2019; Omotesho et al., 2022). Technology adoption in agriculture tends to be enhanced by young people's participation, as younger farmers tend to be more willing to experiment with digital tools (Omotesho et al., 2022).

In terms of educational achievement, the largest cohort (30%) of the farmers who participated in the study had a lower-secondary level of education, followed by 17% with an upper-secondary level, 13% with a post-secondary technical education, and 13% with a tertiary college/university education. These relatively high levels of educational attainment suggested a favourable foundation for the adoption and effective use of ICTs and the proposed SBM recordkeeping application.

With respect to years of farming experience, 26% of respondents had 11 to 20 years of experience, 27% had 21 to 30 years of experience, and 15% had 31 or more years of experience. Put another way, 68% of the farmers had 11 or more years of experience. It can be assumed that these farmers' high levels of experience enhanced their ability to evaluate the practicality and benefits of new technologies (Gichohi, 2019). Consistent with Mapiye (2022), who found that experience was positively associated with perceived usefulness of digital tools, this combination of extensive farming knowledge and openness to innovation suggests considerable potential for uptake of the SBM application among the sampled farmers.

Table 1: Farmer demographics

		<i>n</i>	%
Gender	Male	51	96%
	Female	2	4%
Age	35 or younger	3	6%
	36–45	10	19%
	46–55	13	25%
	56–65	15	28%
	66 or older	12	23%
Level of educational attainment	No formal education	2	4%
	Primary	12	23%
	Lower secondary	16	30%
	Upper secondary	9	17%
	Post-secondary technical	7	13%
	Tertiary college/university	7	13%

		<i>n</i>	%
Years of farming experience	10 or fewer	17	32%
	11-20	14	26%
	21-30	14	26%
	31 or more	8	15%

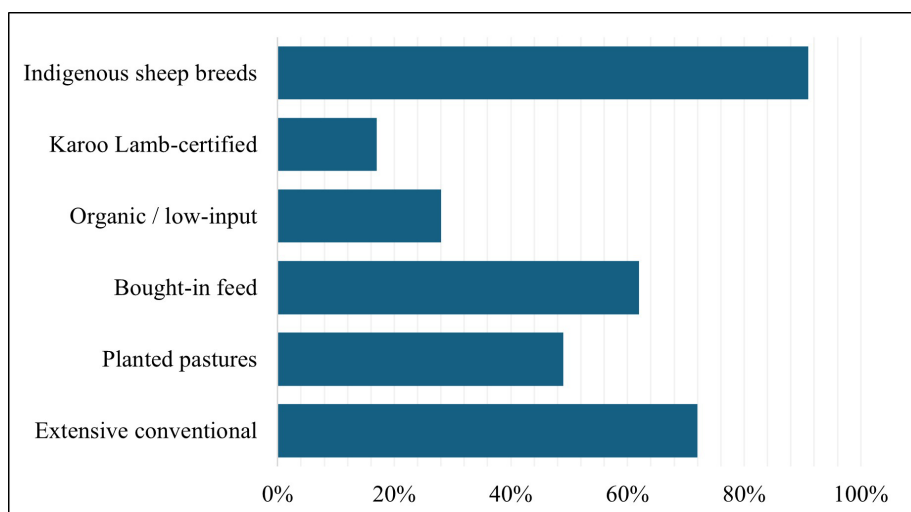
Sheep farming practices and production system characteristics

A significant majority (71%; $n = 38$) of the participating sheep farmers practised extensive conventional farming. Approximately half ($n = 26$) of the farmers used planted pastures and 62% ($n = 33$) relied on bought-in feeds for supplementation. In the words of one participant: "I have limited pasture, so I slaughter my flock to reduce numbers on the farm. Our sheep have exceeded the grazing capacity over the years." This narrative aligns with studies in South Africa and Southern Africa that have identified recurrent feed shortages due to drought conditions and overgrazing, particularly among farmers with limited capital to purchase supplementary feed (Lamega et al., 2021; Scholtz et al., 2008).

Nearly a third (30%; $n = 16$) of the respondents reported producing sheep using organic or low-input practices, while 17% ($n = 9$) were certified Karoo Lamb producers (Figure 3). Organic or low-input production refers to farm-level management practices characterised by minimal use of synthetic inputs, whereas Karoo Lamb certification denotes compliance with a formally regulated geographical-indication scheme that requires adherence to specific production rules and independent verification under the Agricultural Products Standards Act (DALRRD, 2023; van der Merwe et al., 2018). This geographical-indication registration requires farmers whose products are certified as Karoo Lamb to adhere to specific practices and rules and to provide verifiable evidence that shows that their lambs and lamb meat are authentically produced under Karoo conditions (Kirsten et al., 2008). Discussions with farmers indicated that some were unaware that their current practices might qualify for such certification.

Almost all (91%; $n = 48$) of the interviewed farmers primarily used local Indigenous sheep breeds at their farms. Indigenous breeds are recognised for their robustness and adaptability, tolerance to heat and drought, efficient foraging, favourable meat quality, and strong reproductive performance when provided with extensive grazing (Molotsi, 2017).

Figure 3: Farming practices and production systems

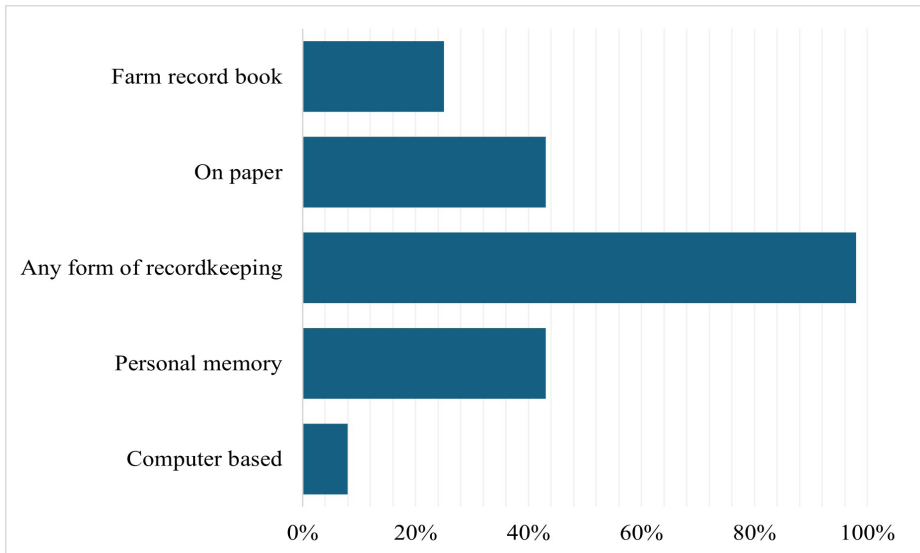


Recordkeeping practices

All but one of the respondents (98%; $n = 52$) reported keeping some form of farm records, indicating widespread recognition of their importance (Figure 4). However, the majority relied on traditional methods such as personal memory (43%; $n = 23$) or loose pieces of paper (43%; $n = 23$), with only a minority using more structured systems. About one-quarter of respondents kept their records using a dedicated farm

record book (25%; $n = 13$). This practice indicated a shift towards more organised documentation, even though the system remained manual. Only 8% ($n = 4$) of the farmers reported using computer-based digital systems to keep farm records. They relied on basic tools such as Microsoft Excel spreadsheets and typed records in Microsoft Word. Importantly, none of the respondents reported using a purpose-built mobile or digital farm management application comparable to the proposed SBM app. These findings suggested that, while some farmers had begun experimenting with computer-based tools, penetration of mobile digital recordkeeping solutions had not occurred.

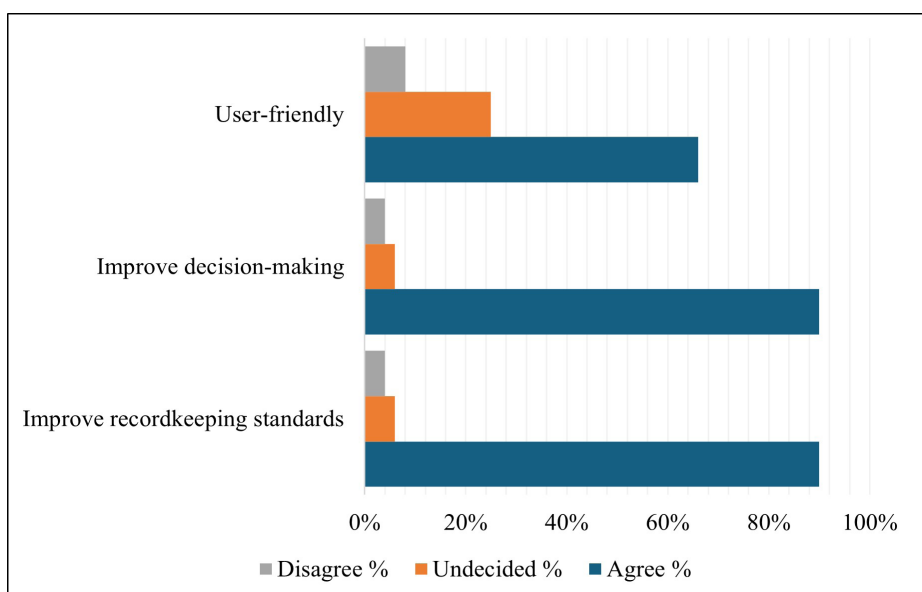
Figure 4: Recordkeeping practices



Farmers’ perceptions of potential strengths of SBM recordkeeping app

A generally positive attitude was found among the participating sheep farmers towards the SBM app, with 91% ($n = 48$) expressing willingness to use the proposed tool (Figure 5). The same large majority (91%; $n = 48$) of respondents agreed that the SBM application would strengthen their decision-making. On the question of the app’s user-friendliness, while most (66%; $n = 35$) of the interviewed farmers agreed that the proposed tool was user-friendly, a considerable proportion (25%; $n = 13$) were undecided and 8% ($n = 4$) disagreed.

Figure 5: Views on app’s potential strengths



These findings show that, although most of the participating farmers had not previously engaged with digital record-keeping, the vast majority recognised its potential value. Similar findings emerged from the studies cited above by Kabir (2015) and Kiptoo et al. (2021). Such divergence between high willingness to adopt and limited prior use of digital recordkeeping constitutes a structural adoption paradox: willingness signals aspiration and perceived relevance, but adoption can be constrained by numerous factors, including limited institutional support, high learning costs, uncertainty over sustained value capture, limited access to training, limited and/or costly internet connectivity, and the broader economic vulnerabilities of smallholders (McCrocklin, 2021; Mkhize, 2024; Munthali et al., 2025). Addressing these barriers through affordable, user-centred technologies, improved rural connectivity, and sustained digital-literacy programmes has been found to be critical if expressed willingness is to translate into effective and sustained use of digital recordkeeping tools (Abdulai et al., 2023; Musungwini, 2018).

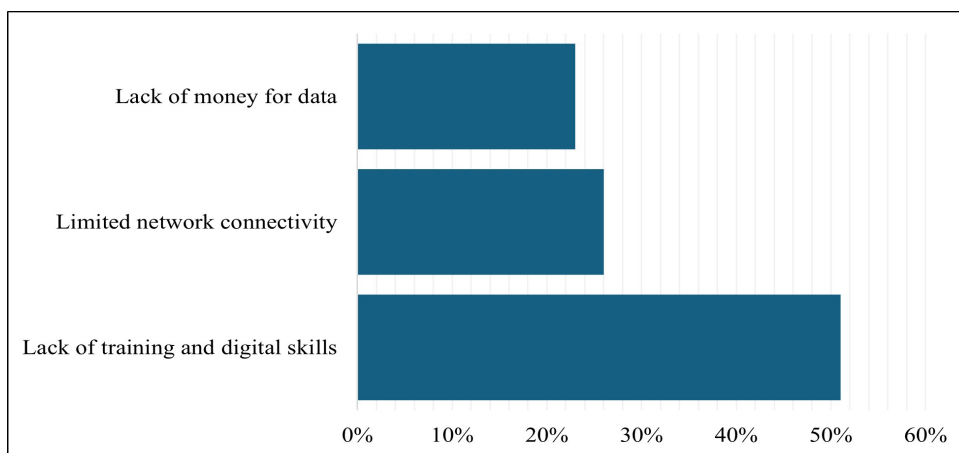
The findings indicate that most of the farmers believed the app, if adopted, could empower them to make better decisions regarding farm management practices. This perception aligns with evidence from Daum et al.'s (2022) study in Kenya and India, where digital tools such as the Farmtree app were found to support more informed selection and culling decisions, resulting in cost reductions and improved herd performance.

Perceived usefulness, productivity gains, reduced workload, and cost savings are well-established drivers of technology acceptance in agriculture (Caffaro et al., 2020; Javaid et al., 2022). Strong positive perceptions can also be driven by recognition of the inefficiencies and risks associated with paper-based recordkeeping, such as data loss and difficulties in retrieving information (Mwanga et al., 2020). However, contrasting evidence has also been identified. For instance, the study by Bontsa et al. (2023) with farmers in South Africa's Eastern Cape Province found that some farmers viewed digital tools for small-stock production as overly complex, expensive, and poorly aligned with existing practices. Thus, positive attitudes towards technology adoption are by no means guaranteed in African smallholder farming settings. New digital tools must be simple, affordable, and clearly responsive to farmers' information needs if they are to be readily and successfully adopted.

Farmers' perceptions of potential limitations of SBM recordkeeping app

Just over half (51%; $n = 27$) of the participating farmers identified lack of training and digital skills as the most significant limitation, while 26% ($n = 14$) cited limited network connectivity and 23% ($n = 12$) cited lack of money for data (Figure 6).

Figure 6: Views on app's most significant potential limitation



The identification, by 51% of the farmers, of lack of training and digital skills as the app's most significant potential limitation corresponds with the findings of other studies that have pointed to the importance of strengthening digital skills among targeted users when seeking successful implementation of digital innovations (Csótó, 2017; Daum et al., 2022; Mapiye, 2022). The farmers' identification of this potential limitation also echoes the findings by Mkhize (2024) of literacy and capacity gaps undermining information systems in smallholder agriculture and underscores the importance of embedding capacity-building and

on-farm support into digital innovation initiatives. According to Liu et al. (2025), improvements in digital literacy not only increase adoption rates but also enhance the depth and quality of technology use among farm households.

The finding that roughly a quarter (26%) of the participating farmers saw limited network connectivity as a potential limiting factor for use of the app aligns with the realities of infrastructure deficits in sub-Saharan African rural areas, where investment in telecommunications is often limited, despite policy commitments to digital inclusion (McCrocklin, 2021; Wyrzykowski, 2020). The finding that 23% of the participating farmers saw a lack of money for mobile data as a potential limitation on use of the app aligns with findings in South African studies such as the study by Shemfe (2018), which found high data costs to be a significant financial burden for 40% of the small-scale farmers surveyed in the Mahikeng Local Municipality of North-West Province.

5. Conclusion

The findings from this study highlight both the transformative potential of mobile digital tools such as the SBM recordkeeping app and the substantial constraints that must be addressed for this potential to be realised. The findings suggest that only with digital skills training, improved app user-friendliness, enhanced mobile network coverage and lower-cost data could the app be fully and successfully be integrated into the practices of the sheep farmers who participated in the study.

More broadly, this study has demonstrated that smallholder farmer recordkeeping needs to be understood as an information capability embedded within numerous dynamics, and that purely adoption-centric explanations of technology uptake are insufficient. If the SBM recordkeeping app, or similar, is eventually adopted by the farmers who participated in the study, future research should assess how routine digital recordkeeping affects farmer performance over time, and should also seek to identify pathways for co-design and scaling of similar digital tools for recordkeeping in different production systems and different kinds of agro-ecological regions.

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Data availability statement

The data that support the findings of this study are available from author Obvious Mapiye, upon reasonable written request, at omapiye@sun.ac.za.

AI declaration

AI was used to improve language and grammar during the writing of this article.

Competing interests declaration

The authors have no competing interests to declare.

Authors' contributions declaration

V.M.: Conceptualisation; methodology; investigation; formal analysis; data curation; writing – review and editing.

O.M.: Formal analysis; writing – original draft; writing – review and editing.

A.M.: Project administration; funding acquisition; supervision, writing – review and editing.

J.K.: Supervision; writing – review and editing.

All authors read and approved the final manuscript.

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