INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY FUTURISTIC DEVELOPMENT

Digital Tools, Women, and Micro-Livestock Farming: Enhancing Productivity and Resilience in Smallholder Animal Agriculture in Sub-Saharan Africa

Never Assan [1*], Hilary Marufu [2]
[1] Zimbabwe Open University, Faculty of Agriculture, Department of Agriculture Management, Bulawayo Regional Campus, Bulawayo, Zimbabwe
[2] Zimbabwe Open University, Faculty of Technology, Department of Information Technology, National Centre, Harare, Zimbabwe

* Corresponding Author: **Never Assan**

Article Info

P-ISSN: 3051-3618
E-ISSN: 3051-3626
Impact Factor (RSIF): 8.31
Volume: 07
Issue: 01
Received: 09-01-2026
Accepted: 07-02-2026
Published: 06-03-2026
Page No: 49-60

Abstract
The integration of digital technology, women's empowerment, and micro-livestock farming presents a transformative strategy for enhancing smallholder productivity, increasing household income, and improving food and nutritional security in Sub-Saharan Africa. By granting women farmers access to real-time data on animal health, climate risks, market opportunities, and financial services, digital tools facilitate improved decision-making, reduce production losses, and enhance market engagement. When women, who predominantly manage poultry, goats, sheep, and other micro-livestock, effectively utilize these technologies, the resultant improvements in livestock productivity and income generation directly contribute to enhanced household welfare, increased resilience to climate and economic shocks, and more inclusive rural development. Women constitute a significant proportion of this workforce and are especially engaged in micro-livestock production (e.g., poultry and small ruminants) because of low entry barriers and high nutritional value. Despite this central role, women frequently face structural barriers, including limited access to digital tools, financial exclusion, and lower mobility, all of which limit their adaptation capacity and productivity. Concurrently, digital agricultural technologies—from mobile advisory services to digital marketplaces—are emerging as transformative tools for enhancing smallholder resilience, information access, value chain participation, and climate adaptation. This review synthesizes evidence on digital technologies in SSA's agricultural context, examines gendered access and use of digital tools, evaluates the role of micro-livestock in rural livelihoods, and highlights how digital innovations can foster women's empowerment and climate-resilient micro-livestock systems. Current barriers, such as infrastructural constraints, limited internet connectivity, and the gender digital divide, are also discussed. The review concludes with a conceptual framework linking digital inclusion, gender empowerment, and micro-livestock productivity and offers policy and research recommendations to support equitable digital transformation in SSA.

DOI: https://doi.org/10.54660/IJMFD.2026.7.1.49-60

Keywords: Digital Tools, Women, Micro-Livestock, Smallholder Animal Agriculture, Sub-Saharan Africa

1. Introduction

In Sub-Saharan Africa (SSA), agriculture is predominantly characterized by smallholder farming, which employs a significant portion of the rural population and is crucial for food security, nutrition, and rural livelihoods. Women play a pivotal role in this sector, comprising over half of the agricultural labour force and contributing an estimated 60–70% of the region's food production (FAO, 2021). This underscores their vital role in enhancing household welfare and supporting national food systems. Women are actively engaged in labour-intensive agricultural tasks such as planting, weeding, harvesting, and post-harvest processing (Assan, 2014) [1]. Additionally, they manage micro-livestock enterprises, including poultry, goats, and sheep. These livestock

species are particularly advantageous for smallholder households because of their low capital investment requirements, minimal land needs, and modest feed resources, making them accessible livelihood assets for resource-constrained farmers, especially women (Palacios-Lopez et al., 2023; Gwaka & Dubihlela, 2020) [11, 15].

Micro-livestock production systems are extensively distributed across Sub-Saharan Africa (SSA) and play a vital role in enhancing household nutrition, generating income, and bolstering resilience against economic and climatic adversities (Assan, 2021) [3]. The region is home to approximately two billion poultry and hundreds of millions of goats and sheep, highlighting the scale and significance of these systems in rural livelihoods. These species are well adapted to diverse and often challenging agro-ecological conditions, and are commonly managed by resource-poor households, particularly women. In countries such as Nigeria, Kenya, and Ethiopia, women frequently lead small-scale poultry and goat enterprises, providing eggs, meat, and a steady cash income while reinforcing household food security (Assan et al 2026) [2]. Through these enterprises, women often retain a degree of decision-making authority over livestock assets, which can enhance household welfare and promote greater gender equity in rural agricultural systems (Heifer International, 2025; Assan, 2014) [1, 12].

In recent years, digital agricultural technologies have begun to transform agricultural systems in SSA by improving the flow of information, market connectivity, and climate risk management (Tech Herfrica, 2021) [17]. Technologies such as mobile advisory platforms, digital financial services, and online marketplaces provide farmers with real-time information on livestock health, disease outbreaks, feed management, weather conditions, and market prices. These tools can enhance decision-making, improve livestock productivity, and expand market opportunities for smallholder producers (Heifer International, 2025) [12]. For example, mobile-based poultry advisory services in Kenya and Nigeria have helped farmers improve flock management and reduce disease-related losses, while digital marketplaces enable producers to connect with buyers beyond local communities (World Economic Forum, 2022) [19]. Despite these opportunities, gender-based barriers to digital access and use—including limited digital literacy, affordability constraints, and social norms influencing technology ownership—often prevent women from fully benefiting from these innovations (FAO, 2021).

The ongoing digital gender gap continues to limit women's involvement in digital agricultural innovation throughout SSA (FAO, 2021). Despite the rapid increase in mobile phone usage in rural regions, women are much less likely than men to own mobile phones or access mobile Internet services. This disparity hinders their ability to use digital advisory platforms, financial services, market information, and climate-related data. It is estimated that women's mobile phone ownership in SSA trails behind men's by approximately 10–15 percentage points, and differences in Internet usage and digital skills further limit their interaction with advanced digital platforms. By 2022, approximately 220 million women in SSA had mobile phones; however, many remained either unconnected or inadequately connected due to cost barriers, limited digital literacy, and restrictive social norms (Heifer International, 2025) [12]. These inequalities diminish women's ability to harness digital technologies for livestock management, marketing, and climate adaptation, potentially exacerbating existing gaps in productivity, income, and resilience, especially in micro-livestock systems where women are the primary managers (GSMA, 2024) [10].

Implementing gender-responsive digital strategies is not just important; it is imperative to effectively tackle these challenges. By prioritizing women's access to mobile technologies, enhancing rural connectivity, and offering digital literacy programs tailored for smallholder livestock producers, we can drive transformative change. These strategies are essential to empower women, bridge the digital divide, and unlock the full potential of rural communities (Commonwealth, 2024) [5]. By promoting inclusive training initiatives that bolster digital infrastructure and developing user-friendly platforms for livestock management, women's interactions with digital agricultural services can be significantly enhanced. Empowering women to fully leverage digital technologies enhances their capacity to manage livestock enterprises, engage in markets, and mitigate climate-related risks, thereby contributing to greater household resilience, food security, and rural economic development (Majezwa & Jiba, 2026) [13]. This review synthesizes evidence to examine the application of digital technologies in smallholder agricultural systems in sub-Saharan Africa, with particular emphasis on micro-livestock production, gender disparities in digital access, and pathways for inclusive climate resilience. By highlighting the intersections between gender, livestock production, and digital innovation, this paper seeks to inform policy frameworks, development investments, and research priorities aimed at strengthening equitable and climate-resilient smallholder agriculture across the region.

2. Methodology

This review utilizes a systematic literature scanning methodology to synthesize existing knowledge on the intersection of digital technologies, gender, and micro-livestock systems in Sub-Saharan Africa (SSA). It encompasses studies published between 2020 and 2026, with a focus on peer-reviewed journal articles, reports from international agencies, and significant development and policy studies. The aim is to capture both empirical evidence and policy-relevant insights into women's involvement in micro-livestock production, digital adoption, and resilience in the face of climate variability. A structured search was conducted across multiple academic databases, including Scopus, Web of Science, PubMed, ScienceDirect, and Google Scholar, as well as institutional and policy archives such as those of the FAO, IFAD, Heifer International, and the Commonwealth Secretariat. The search strategy employed combinations of keywords and Boolean operators to ensure comprehensive coverage, including: "digital agriculture" AND "women" AND "smallholder" AND "livestock," "micro-livestock" AND "gender" AND "SSA," "mobile advisory services" AND "poultry" OR "goats" AND "Africa," and "climate-smart agriculture" AND "gender" AND "technology adoption."

The inclusion criteria were delineated as follows:

1. Studies conducted within Sub-Saharan Africa or those with findings explicitly pertinent to this region.
2. Research focusing on micro-livestock systems, including poultry, goats, sheep, pigs, or small ruminants, and/or the participation of women in agricultural activities.
3. Evidence pertaining to the adoption of digital technologies, encompassing mobile advisory platforms, e-finance, digital

marketplaces, and information and communication technology (ICT)-based extension services.

4. Publications from the period 2014 to 2026, with a preference for systematic reviews, meta-analyses, and high-quality empirical studies.

The exclusion criteria were as follows:

Studies conducted outside Sub-Saharan Africa (SSA), unless they provide relevant transferable insights. Publications not available in the English language. Articles lacking empirical or evidence-based analysis, such as opinion pieces devoid of data. All identified sources underwent thorough evaluation for relevance, quality, and methodological soundness. Peer-reviewed articles were prioritized, while reports from international organizations and NGOs were incorporated to enrich the academic literature with insights from policy and practice. The data extracted from the selected studies provided quantitative estimates of livestock populations, women's participation rates, technology adoption, and socioeconomic impacts, enabling a comprehensive synthesis of evidence on the intersection of digital technology, gender, and micro-livestock systems.

The review adhered to PRISMA-style principles for systematic evidence collection and reporting, ensuring transparency in the search strategy, study selection, and data extraction processes. The findings were synthesized narratively and, where applicable, supplemented with tables and figures to depict regional and country-level patterns, gender disparities, and technology adoption trends. This methodology offers an integrated understanding of how digital innovations affect micro-livestock management, women's empowerment, and climate resilience in Sub-Saharan Africa.

3. Results And Discussion

3.1. Conceptual Framework: Digital Inclusion for Climate-Resilient Micro-Livestock Systems

The conceptual framework depicted in Figure 1 outlines the interconnected pathways that link climate change stressors, digital technologies, gender empowerment, and the resilience of micro-livestock systems in Sub-Saharan Africa (SSA). It highlights how incorporating digital tools into smallholder livestock systems can enhance women's ability to manage micro-livestock enterprises, leading to increased productivity, income, and resilience against climate-related challenges. Smallholder livestock systems in SSA are increasingly vulnerable to climate change stressors, such as rising temperatures, frequent droughts, new disease outbreaks, and limited feed and water resources.

The challenges discussed exert a direct influence on the health and productivity of livestock, thereby posing a substantial threat to the livelihoods and food security of rural households that are heavily reliant on small-scale animal production. Micro-livestock systems, particularly those involving poultry, goats, and sheep, are essential to rural livelihoods. These livestock species are primarily managed by women and are vital sources of household nutrition, consistent income, and financial stability, especially in resource-limited households. While these systems are vulnerable to climate variability, they demonstrate a significant capacity for adaptation and can greatly benefit from improved management practices, enhanced market access, and timely information on disease and climate risks. The framework emphasizes the pivotal role of digital agriculture tools in reinforcing these systems.

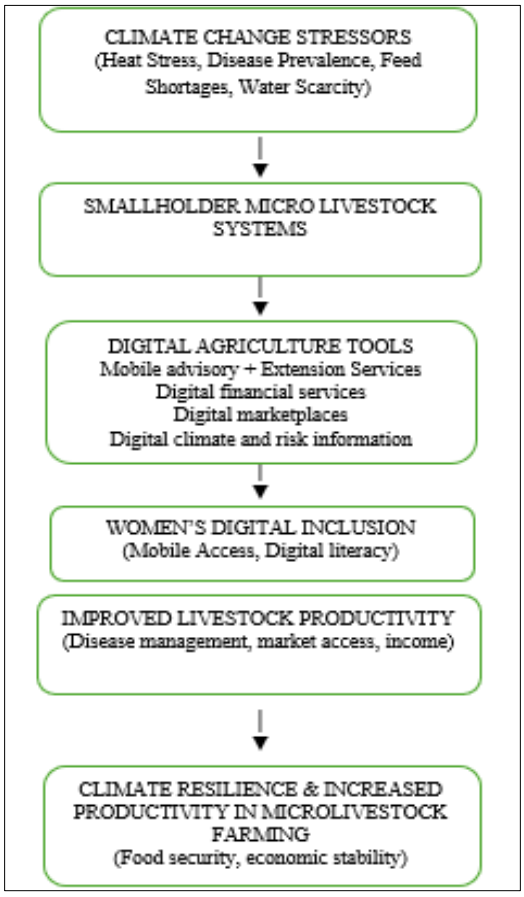

Fig 1: Conceptual framework linking digital technologies, gender empowerment, and climate-resilient micro-livestock systems in SSA

Technologies, such as mobile advisory services, digital financial platforms, digital marketplaces, and climate information applications, equip farmers with immediate access to critical information regarding animal health, feeding strategies, breeding management, disease outbreaks, market prices, and weather forecasts. These tools significantly enhance farmers' decision-making abilities and improve their efficiency in livestock management, while also reducing losses due to climate-related shocks and market uncertainties.

It is important to include women in digital technology. Women need fair access to mobile phones, the Internet, and digital skills training. This helps them use digital tools in farming. We must remove barriers, such as lack of access to technology, cultural restrictions, and financial problems. This will help women fully participate and benefit from new digital farming technologies. When women have access to and effectively utilize digital technologies, substantial enhancements in livestock productivity and enterprise performance can be realized.

Improved disease monitoring, optimized feeding practices, enhanced breeding management, and increased market participation can lead to greater production efficiency and higher income generation for women-managed micro-livestock enterprises. Ultimately, these advancements contribute to broader climate resilience, as increased productivity, income stability, and adaptive capacity bolster household food security and mitigate vulnerability to climate shocks. Through these interconnected pathways, digital inclusion has emerged as a pivotal driver of sustainable and resilient micro-livestock systems in sub-Saharan Africa.

The conceptual framework highlights several key insights regarding the role of digital technologies in strengthening micro-livestock systems in Sub-Saharan Africa. First, the framework underscores women-centred digital inclusion as a critical pathway for enhancing micro-livestock productivity and strengthening the adaptive capacity of smallholder farming systems under increasing climate stress. Ensuring that women have equitable access to mobile devices, digital platforms, and the skills required to use them effectively enables them to make informed decisions in livestock management and respond more efficiently to climate-related risks.

Second, the framework emphasizes that the integration of multiple digital services, including mobile advisory platforms, digital financial services, online marketplaces, and climate information systems, can significantly improve decision-making, production efficiency, and market access for smallholder livestock producers. These integrated services allow farmers to access timely information, financial resources, and marketing opportunities that collectively enhance the performance and sustainability of micro-livestock enterprises.

Finally, the framework highlights that focusing on micro-livestock systems managed by women provides a strategic entry point for pro-poor and gender-responsive agricultural interventions. Because these systems are widely accessible to resource-constrained households and are often controlled by women, strengthening them through digital innovation can simultaneously promote climate-smart agriculture, rural livelihoods, and gender equity across smallholder farming communities in SSA.

3.3. Livestock Populations and Micro-Livestock Importance

In Sub-Saharan Africa (SSA), micro-livestock species, such as poultry, goats, sheep, and pigs, are prevalent and serve as the foundation of smallholder farming systems. By 2018, the region was home to approximately 2 billion poultry, 438 million goats, and 384 million sheep, highlighting their extensive presence and vital role in rural livelihoods (Gwaka & Dubihlela, 2020) [11]. Although larger animals, such as cattle and camels, hold economic importance, micro-livestock species play a more significant role in providing household nutrition, cash income, and empowering women with control over productive resources. Their short production cycles, ability to thrive in less favourable environments, and minimal resource needs make them particularly resilient against climate change, droughts, and other challenges (FAO, 2021; Majezwa & Jiba, 2026) [13].

Country-specific examples further emphasize the importance of micro-livestock systems for rural livelihoods and women's economic involvement across SSA. In Nigeria, women predominantly engage in small-scale poultry and goat farming, especially in the semi-arid northern areas, where these activities are crucial for household protein and income. Poultry flocks provide daily eggs for both home consumption and local markets, while goats serve as valuable financial assets that can be sold during emergencies, for school fees, or at cultural events (Palacios-Lopez et al., 2023) [15]. In Kenya, smallholder farmers often incorporate chickens and goats into mixed crop–livestock systems, with women taking a leading role in their management.

Poultry farming significantly contributes to household nutrition and income, while goats offer a vital safeguard against climate-related stocks, such as drought and feed shortages (Heifer International, 2025) [12]. Similarly, in Ethiopia, women often manage chickens and sheep on small plots near their homes, allowing them to actively participate in livestock-related decisions despite limited land ownership and the dominance of men in managing larger ruminants. Consequently, micro-livestock enterprises provide women with opportunities to earn income, bolster household food security, and enhance their involvement in rural agricultural economics (Majezwa & Jiba, 2026) [13]. These species are particularly crucial for women farmers, as they require less land and financial investment compared to larger ruminants, making them more accessible to manage.

Women's involvement in micro-livestock not only improves household food security and dietary variety but also enhances economic independence, which can positively influence decision-making power within families and communities (Palacios-Lopez et al., 2023; FAO, 2021) [15]. Table 1 presents the estimated micro-livestock populations across SSA and their significance for smallholders. Micro-livestock systems are important for helping poor farmers in sub-Saharan Africa. They are easy for women to use, work well in various environments, and provide food and money. This makes them key areas for policies and actions that support small farms and help them deal with climate change.

Table 1: Approximate micro-livestock populations in Sub-Saharan Africa, highlighting their importance to smallholder livelihoods (2020–2025).

Livestock Type	Estimated Population	Importance for Smallholders
Poultry (Chickens)	~2 billion	Widely kept; provides eggs and meat; key for income and nutrition
Goats	~438 million	Adaptive to arid conditions; source of meat and cash
Sheep	~384 million	Culturally and economically important; climate resilient
Pigs	~40 million	Localized nutritional and income source

3.4. Gender and Animal Agriculture in Sub-Saharan Africa

3.4.1. Women's Participation in Micro-Livestock as a Subsector of Animal Agriculture

In smallholder farming systems in Sub-Saharan Africa, the intersection of women's involvement in micro-livestock production and the growing presence of digital agricultural technologies offers a vital opportunity to bolster animal agriculture. Women often take the lead in managing poultry, goats, and sheep in many rural households, and gaining better access to digital tools—such as mobile advisory services, climate information platforms, digital finance, and online marketplaces—can greatly improve livestock management, productivity, and market participation. When these elements are effectively combined, the synergy between women, digital innovation, and micro-livestock farming not only boosts production efficiency and income but also enhances household nutrition, economic stability, and resilience in smallholder agricultural systems throughout Sub-Saharan Africa.

In sub-Saharan Africa (SSA), women are pivotal to agricultural production and significantly influence food security, rural economies, and family nutrition. In Commonwealth African nations, women represent approximately 43% of the agricultural workforce, although this percentage varies by region and country due to differences in farming systems, livestock management, and social structures (Commonwealth, 2024) [5]. In numerous SSA regions, women engage in a wide range of agricultural tasks, including preparing land, planting, and harvesting crops, as well as feeding, watering, and caring for small livestock, highlighting their vital role in sustaining agricultural livelihoods.

At the national level, the extent and characteristics of women's involvement in agricultural production across Sub-Saharan Africa exhibit considerable variation, influenced by diverse socioeconomic conditions, cultural practices, and institutional frameworks. In Nigeria, women represent a significant segment of smallholder agricultural producers, with estimates indicating that approximately 70–80% of small-scale farmers are women, particularly in the domains of food crop cultivation and livestock management. Nigerian women play a pivotal role in managing poultry, rearing goats, and trading animal products, thereby directly contributing to household nutrition, income generation, and participation in local market activities (Palacios-Lopez et al., 2023) [15].

In Kenya, women constitute more than half of the agricultural workforce and are actively engaged in smallholder dairying, poultry production, and horticulture within mixed farming systems. Despite their substantial contribution to agricultural productivity and rural livelihoods, Kenyan women often encounter structural barriers to land ownership and access to formal credit. These constraints hinder their ability to expand livestock enterprises, invest in advanced production technologies, and adopt innovative management practices that could enhance productivity and resilience (Heifer International, 2025) [12].

In Ethiopia, women contribute substantially to both crop and livestock systems, often assuming responsibility for the daily management of chickens, sheep, and goats within household farming systems. Cultural norms surrounding livestock ownership commonly assign women control over poultry and small ruminants, while men retain ownership and decision-making authority over larger animals, such as cattle and camels. This division creates distinct gendered domains of livestock management that shape women's opportunities for income generation and decision-making within rural households (Majezwa & Jiba, 2026) [13].

In Tanzania, women predominantly engage in small-scale poultry and goat production in numerous rural communities, where these enterprises offer accessible livelihood strategies with relatively low capital investment requirements. However, women frequently encounter limited access to agricultural extension services, veterinary support, and advanced livestock technologies, which hinders their capacity to adopt improved breeds or advanced husbandry practices. Emerging evidence indicates that women's involvement in producer groups and cooperative networks can substantially enhance outcomes, particularly when these groups are connected to training opportunities, financial services, and reliable market channels (FAO, 2021).

Despite their high engagement levels, women in SSA face a stark and unjust disparity in access to productive assets compared to men. This structural constraint severely limits their land ownership, access to credit, extension services, and decision-making authority. Across the region, land tenure systems are skewed in favor of male ownership, forcing women to farm on land that they neither own nor control. This inequity stifles their willingness and ability to invest in productivity-enhancing technologies or livestock enterprises, perpetuating a cycle of disadvantage (Commonwealth, 2024) [5]. Furthermore, women encounter formidable barriers in accessing agricultural credit, whether from formal financial institutions or microfinance programs. These barriers are rooted in limited collateral, restrictive lending practices, and socio-cultural norms that unjustly constrain their agency (GSMA, 2024) [10]. It is imperative that we address these inequities to unlock the full potential of women in agriculture and drive sustainable development in the region.

Extension and advisory services, which are critical for disseminating improved agronomic practices, veterinary care, and livestock management techniques, tend to reach men more effectively than women, owing to outreach designs that assume male participation and mobility. Consequently, women are frequently underserved by agricultural innovation systems, despite their essential roles (Palacios-Lopez et al., 2023) [15].

When women's participation in agriculture is bolstered through targeted policies, such as gender-responsive extension services, land rights reforms, women-focused

credit programs, and community-based training initiatives, significant improvements in productivity, income, and household welfare have been observed across sub-Saharan Africa (Heifer International, 2025; Majezwa & Jiba, 2026) [12, 13]. Enhancing women's involvement in agriculture is essential for achieving equitable and climate-resilient rural development in the region.

3.4.2. Gender in Micro-Livestock Management: Integral to Household Food Security, Nutrition, and Income Generation

In sub-Saharan Africa (SSA), women frequently oversee small-scale livestock enterprises, particularly those involving poultry, goats, and small ruminants, which play a crucial role in household food security, nutrition, and income generation. These micro-livestock systems are particularly accessible to women because of their lower initial capital requirements, limited land needs, and minimal labor demands compared to large ruminant production, such as cattle (Gwaka & Dubihlela, 2020; Palacios-Lopez et al., 2023) [11, 15]. For numerous rural households, the management of chickens and goats by women provides a consistent source of protein through eggs and meat, while surplus produce or animals can be sold to fulfil household cash requirements, cover educational expenses, and address emergency expenditures (FAO, 2021; Majezwa & Jiba, 2026) [13].

The duties involved in managing micro-livestock are varied and intricate. Women are responsible for tasks such as feeding, watering, health monitoring, breeding, and keeping records, often while juggling other household and farming responsibilities. In poultry systems, women usually handle brooding, vaccinations, and feed preparation, whereas in small ruminant systems, they make breeding decisions, detect diseases, and manage sales when animals are ready for the market (Heifer International, 2025) [12]. This expertise in management is vital for ensuring the productivity of flocks and herds and for reducing losses due to disease, predators, or environmental pressures. Research from East and Southern Africa shows that livestock herds managed by women tend to have better survival rates and more stable productivity compared to those in households where women have less decision-making power (Palacios-Lopez et al., 2023; Gwaka & Dubihlela, 2020) [15].

Despite their pivotal role, women encounter systemic barriers that hinder the success of micro-livestock ventures. Access to technology and information, such as mobile advisory services, climate risk tools, and digital market prices, is not equal due to the digital gender gap, with women trailing behind men in mobile phone ownership, Internet usage, and digital literacy (GSMA, 2024; FAO, 2021) [10]. Similarly, access to veterinary services and inputs, like vaccines, medications, and improved breeds, is often limited by mobility constraints, financial limitations, and socio-cultural norms that restrict women's interactions with extension officers or livestock markets (Heifer International, 2025; Majezwa & Jiba, 2026) [12, 13]. The intersection of gender and livestock management also influences household decision-making and economic outcomes.

Evidence from rural SSA indicates that when women have control over micro-livestock assets and income, households benefit from better dietary diversity, increased school attendance, and greater resilience to climate and economic shocks (Palacios-Lopez et al., 2023) [15]. Conversely, when men dominate decision-making regarding livestock resources, the advantages of these small-scale enterprises for household welfare can be diminished, underscoring the importance of women's agency in livestock production systems. Incorporating digital tools and gender-responsive strategies into micro-livestock systems has shown potential in addressing these challenges.

Mobile advisory services, digital finance platforms, and e-marketplaces provide women with timely veterinary advice, market information, and access to credit, thereby boosting productivity and resilience (FAO, 2021; Heifer International, 2025) [12]. For instance, WhatsApp-based poultry advisory networks in Kenya and Nigeria have enabled women to enhance flock health and market coordination, resulting in significant increases in egg production and household income (Majezwa & Jiba, 2026) [13]. However, these interventions must be adapted to local contexts, considering literacy levels, affordability, connectivity, and cultural norms to ensure equitable participation and impact.

Women play a vital role in managing small livestock, which improves family nutrition, boosts the economy, and helps adapt to climate change in SSA countries. By providing women with technology, support, financial services, and training, small livestock farming can become more productive and sustainable. This also encourages women to take on leadership roles in agriculture.

3.5. Digital Technology Applications in Micro-Livestock Farming: Tools and Solutions

Digital agriculture comprises a variety of technologies that enhance decision-making at the farm level, facilitate market access, and support climate adaptation. In sub-Saharan Africa (SSA), these digital tools are increasingly being implemented in smallholder micro-livestock systems. They provide farmers—particularly women who manage poultry, goats, and sheep—with access to real-time advisory services, market information, and financial platforms, thereby supporting improved productivity, resilience, and market integration (World Economic Forum, 2022; Heifer International, 2025) [12, 19].

Many digital agriculture solutions provide guidance on the health of micro livestock, market information, climate alerts, and financial services. More than 33 million small-scale farmers have signed up for digital agricultural services, which include updates on weather, market prices, and livestock management (World Economic Forum, 2022) [19]. The adoption of digital tools has been particularly transformative for micro-livestock systems, such as poultry and goat businesses, where timely guidance and market access can greatly enhance production results and income (Majezwa & Jiba, 2026) [13].

In sub-Saharan Africa (SSA), essential categories of digital tools that aid smallholder livestock production encompass technologies that improve access to information, market connectivity, financial inclusion, and climate resilience. Mobile extension and advisory platforms offer real-time advice on livestock health, disease prevention, feeding practices, breeding, and vaccination. Notable examples include the Livestock Info SMS in Nigeria and WhatsApp advisory groups in Kenya, which have significantly boosted survival rates and productivity in poultry and goat herds (Heifer International, 2025) [12].

Climate and weather information systems, often accessed via mobile or web-based applications, provide seasonal forecasts, early warning alerts, and climate-smart agricultural

advice. These tools assist farmers in adjusting feeding schedules, grazing patterns, and market timing to mitigate climate risks. For example, climate applications in Ethiopia and Tanzania deliver alerts for droughts and temperature extremes, directly affecting the management of small ruminants and poultry (FAO, 2021). Digital financial services, such as mobile money and e-payment platforms like M-Pesa in Kenya and EcoCash in Zimbabwe, offer access to savings, credit, and insurance products. By reducing reliance on cash transactions, these tools enhance market participation, empower women financially, and support investments in micro-livestock enterprises (GSMA, 2024) [10].

Despite the promising potential of these digital advancements, gender-specific obstacles persist. Women frequently face challenges, such as reduced access to mobile devices, limited digital skills, and restricted movement, which hinder their ability to fully utilize digital tools (FAO, 2021; GSMA, 2024) [10]. Therefore, incorporating gender-sensitive designs, such as mobile platforms in local languages, user-friendly interfaces, and training programs specifically, for women, is essential to boost adoption and effectiveness. In summary, the integration of digital technologies with micro-livestock systems presents an opportunity to improve productivity, income, and resilience, especially for enterprises managed by women, while also contributing to broader objectives of food security and climate adaptation in SSA.

Lastly, digital marketplaces link smallholders directly to buyers, broadening market access, cutting out intermediaries, and boosting profitability. Examples include livestock e-marketplaces in Nigeria, Ghana, and Kenya, where poultry, goats, and sheep can be sold efficiently, minimizing post-harvest losses and increasing income for smallholder households (World Economic Forum, 2022) [19]. Collectively, these digital tools create an integrated ecosystem that strengthens micro-livestock systems, promotes women's empowerment, and enhances climate resilience in smallholder agriculture in SSA. Table 2. Functional categories of digital tools used by smallholder livestock producers in SSA.

Table 2: Functional categories of digital tools used by smallholder livestock producers in Sub-Saharan Africa (2020–2025)

Digital Tool	Function	Examples in SSA
Mobile Advisory Services	Livestock health & husbandry guidance	Livestock Info SMS, WhatsApp advisory groups
Digital Finance	Payments, savings, credit access	Mobile money (M-Pesa, EcoCash)
Digital Marketplaces	Buyer–seller linkages	Online livestock trading platforms
Climate Information Platforms	Weather & risk forecasts	Climate apps with seasonal alerts (Kenya, Ethiopia)

3.6. Gendered Access to Digital Tools in Micro-Livestock Farming

The swift development of digital agricultural technologies is evident, yet rural women, who predominantly oversee poultry, goats, and sheep, still encounter systemic challenges in accessing and utilizing these tools. The integration of mobile phones, digital advisory services, e-finance platforms, and online marketplaces is progressively transforming the landscape of micro-livestock production and marketing. Nevertheless, enduring gender gaps in technology ownership, digital literacy, and decision-making power continue to restrict women's engagement and their potential to fully capitalize on these advancements (World Economic Forum, 2022; Heifer International, 2025) [12].

Women are 13% less likely than men to own a mobile phone, which limits their access to real-time information on livestock health, feeding practices, and market prices (World Economic Forum, 2022) [19]. For example, in rural areas of Nigeria and Kenya, mobile phone ownership among women ranges from 65% to 75%, whereas it is between 80% and 90% for men, highlighting both affordability issues and sociocultural barriers (GSMA, 2024) [10]. The gender gap extends to digital financial inclusion, where women are approximately 12% less likely than men to have formal financial accounts. This disparity restricts their access to digital credit, insurance, and savings services, which are essential for micro-livestock investments (Heifer International, 2025; FAO, 2021) [12].

In countries such as Tanzania and Ethiopia, women's adoption of mobile money is hindered by lower digital literacy, societal norms that limit their control over household finances, and restricted mobility to engage with agents or attend training sessions (GSMA, 2024) [10].

These gendered disparities in digital access have significant implications for micro-livestock systems, where women frequently manage poultry, goats, and sheep. Limited access to digital tools hampers their ability to receive timely alerts on livestock health, vaccination schedules, and husbandry practices, increasing their susceptibility to disease outbreaks and production losses. Additionally, it restricts women's participation in digital marketplaces, reduces opportunities for timely sales of livestock, limits household income, and diminishes bargaining power. Moreover, inadequate access to climate information systems impairs their ability to adapt feeding, grazing, and breeding practices in response to drought, heat stress, and other climate-related challenges.

Collectively, these digital inequities not only constrain productivity and profitability in micro-livestock enterprises but also weaken household food security and resilience, emphasizing the urgent need for gender-responsive interventions that enhance women's access to and effective use of digital agricultural technologies. Figure 3 illustrates gender disparities in digital access among smallholder farmers in SSA. Addressing the digital gender divide in micro-livestock systems requires targeted, gender-responsive strategies that focus on both access and capacity. Key measures include promoting affordable mobile ownership and connectivity for women, offering digital literacy training tailored to women farmers with content in local languages, and developing inclusive digital platforms that consider women's needs, time constraints, and literacy levels.

Furthermore, facilitating women-focused financial access, such as mobile-based credit and insurance products linked to micro-livestock enterprises, can empower women to invest in improved husbandry practices, expand production, and enhance resilience to climate and market shocks (FAO, 2021; Heifer International, 2025) [12]. Overcoming these barriers is

essential to ensure that women-managed micro-livestock enterprises can fully utilize digital tools to boost productivity, income, and climate resilience, while also contributing to broader gender equity in SSA's agricultural transformation.

Table 3: Gender disparities in digital access among smallholder farmers in Sub-Saharan Africa. Percentages represent average estimates across multiple countries (2020–2025).

Indicator	Men	Women	Gap
Mobile Phone Ownership	85 %	72 %	13 pp
Mobile Internet Usage	48 %	38 %	10 pp
Mobile Money Account Ownership	71 %	59 %	12 pp

3.7. Digital Technologies Supporting Micro-Livestock Systems

Digital technologies are playing an increasingly vital role in enhancing micro-livestock production systems in Sub-Saharan Africa (SSA) by refining husbandry practices, boosting market access, and bolstering climate resilience. These advancements are especially significant for women, who primarily oversee poultry, goats, and other small livestock species. When obstacles to access and adoption are overcome, digital tools can greatly enhance women's ability to manage livestock effectively, boost productivity, and engage more successfully in livestock markets (Majezwa & Jiba, 2026; Heifer International, 2025) [12, 13].

3.7.1. Mobile Advisory and Extension Services

Mobile advisory platforms offer immediate advice on nutrition, disease control, vaccination timelines, and breeding techniques. This information is crucial for smallholder poultry and goat farmers, as it enhances husbandry results, lowers mortality rates, and boosts productivity, especially in the face of increasing climate challenges, such as droughts, heatwaves, and erratic rainfall (MDPI, 2021). In Nigeria, SMS-based services such as Livestock Info SMS provide prompt advice on disease outbreaks, vaccination schedules, and feed management for flocks managed by women. These services have led to decreased poultry mortality and improved flock productivity, thereby directly benefiting household nutrition and income (Palacios-Lopez et al., 2023) [15]. Similarly, in Kenya, WhatsApp groups and mobile advisory platforms facilitate peer-to-peer learning among women goat and poultry farmers, encouraging the adoption of better husbandry practices and enabling swift information exchange during climate events or disease outbreaks. These digital solutions have empowered women to manage livestock more effectively and adapt to environmental and market challenges (Heifer International, 2025) [12].

3.7.2. Digital Market Linkages

Digital marketplaces facilitate direct connections between smallholder producers and buyers, thereby eliminating intermediaries, enhancing price transparency, and reducing postharvest losses. These platforms are particularly empowering for women, who frequently encounter cultural, mobility, and financial barriers in traditional physical markets (FAO, 2021). In Ghana and Kenya, online livestock trading platforms enable female poultry and goat farmers to access regional and national markets, thereby expanding their customer base and enhancing income stability. When integrated with mobile money services, such as M-Pesa in Kenya and EcoCash in Zimbabwe, these digital marketplaces also facilitate secure payments and access to credit, thereby strengthening women's financial control and investment capacity within micro-livestock enterprises (GSMA, 2024) [10]. Table 4. Digital technologies supporting micro-livestock management and market participation for smallholders.

The integration of digital technologies into smallholder micro-livestock systems reveals both their transformative potential and ongoing challenges. These digital tools can substantially improve production efficiency, animal health, and income, particularly in women-led enterprises, such as poultry, goat, and sheep farming. By incorporating climate and risk information applications, these technologies empower farmers to modify feeding, breeding, and marketing strategies in response to seasonal changes and extreme weather events. However, despite these advancements, gender disparities in mobile ownership, digital literacy, and financial inclusion persist, limiting equitable access to benefits. This highlights the critical need for gender-responsive strategies to ensure that women can fully utilize digital innovations in micro-livestock production (World Economic Forum, 2022; Heifer International, 2025) [12,19]. Inclusively designed digital technologies can bolster micro-livestock resilience, enhance women's economic empowerment, and improve household food security, establishing these systems as climate-smart, pro-poor interventions across sub-Saharan Africa.

Table 4: Digital technologies supporting micro-livestock management and market participation for smallholders in Sub-Saharan Africa (2020–2025).

Tool Category	Function	Examples in SSA
Mobile Advisory Services	Livestock health & husbandry guidance	Livestock Info SMS, WhatsApp advisory groups
Digital Finance	Payments, savings, credit access	Mobile money (M-Pesa, EcoCash)
Digital Marketplaces	Buyer–seller linkages	Online livestock trading platforms
Climate & Risk Information Apps	Weather forecasts, early warning systems	Seasonal alerts via SMS and apps

3.8. Barriers to Women's Adoption of Digital Tools in Micro-Livestock Production

Despite the growing availability of digital technologies for smallholder agriculture, women in sub-Saharan Africa (SSA) continue to face significant structural, social, and economic challenges that impede their ability to effectively utilize these tools for micro-livestock management (CGIAR System, 2023; FAO, 2021). A range of interconnected factors restricts women's adoption of digital technologies in micro-livestock systems throughout SSA. In rural regions, widespread internet and connectivity issues, such as poor network coverage and slow internet speeds, limit access to mobile advisory platforms, marketplaces, and climate information tools.

In nations such as Ethiopia, Tanzania, and northern Nigeria, these challenges impede the timely reception of disease alerts, feeding advice, and market updates (CGIAR System, 2023). Furthermore, low digital literacy poses an additional barrier, as many smallholders, especially women, lack training in using information and communication technology (ICT). In Kenya and Uganda, women managing poultry and goats have reported difficulties in navigating mobile advisory services, online marketplaces, and digital financial platforms, which restricts the potential productivity and income benefits from these technologies (Majezwa & Jiba, 2026) [13]. Affordability and infrastructure challenges also present significant obstacles. The high costs of mobile devices, data subscriptions, and unreliable electricity supplies disproportionately impact women, who often have less household bargaining power and limited financial means to acquire and maintain digital tools (GSMA, 2024) [10]. Moreover, social norms and gender inequalities limit women's mobility, decision-making power, and access to technology.

Cultural expectations, male-dominated control over devices, and household duties restrict women's participation in training programs and their ability to effectively use digital tools, a challenge that is particularly acute in West African and Sahelian contexts (Heifer International, 2025) [12]. Lastly, financial barriers, such as limited access to credit, mobile banking, and insurance, hinder women's ability to invest in livestock improvements or subscribe to premium digital services, thereby limiting the growth, productivity, and climate resilience of micro-livestock enterprises (FAO, 2021). Collectively, these constraints underscore the need for comprehensive, gender-responsive interventions to bridge the digital divide and enhance women-managed smallholder livestock systems. Table 5 summarizes the barriers to women's adoption of digital tools in micro-livestock production.

Table 5: Key barriers limiting women's adoption of digital agricultural technologies in Sub-Saharan Africa (2020–2025).

Barrier Type	Examples	Impact on Women
Infrastructure	Poor internet coverage, high data costs	Limits access to mobile tools, advisory services, and marketplaces
Digital Literacy	Lack of ICT training programs	Reduces effective use of advisory services and finance apps
Social Norms	Mobility restrictions, technology ownership inequities	Constrains access to tools and decision-making authority
Financial	Limited access to credit and mobile banking	Restricts investment in livestock and adoption of digital tools

Addressing these limitations requires the adoption of gender-responsive approaches that simultaneously improve access, develop skills, and create supportive environments for women smallholders. These strategies involve boosting rural connectivity and infrastructure by offering affordable mobile networks, solar energy solutions, and subsidized data plans; delivering targeted digital literacy and ICT training that offers practical advice on livestock management, market transactions, and climate adaptation; creating digital platforms that are gender-sensitive, taking into account women's time limitations, literacy levels, and socio-cultural norms; and broadening financial access through mobile credit, savings plans, and insurance products specifically designed for women-led micro-livestock enterprises (Heifer International, 2025; CGIAR System, 2023) [12]. By addressing these obstacles, women smallholders can fully utilize digital technologies to boost livestock productivity, enhance market participation, and strengthen household resilience, thereby promoting food security and gender equality across Sub-Saharan Africa.

3.9. Digital Platforms and Inclusion Initiatives for Women in Micro-Livestock Production in SSA

Digital platforms and initiatives focused on inclusion are being developed to boost women's participation in micro-livestock production, with the goal of enhancing productivity, market access, and climate resilience. These efforts aim to close the digital gender gap by equipping women with the necessary tools, training, and resources to effectively utilize digital technologies. The UN FAO Digital Villages Initiative is a continent-wide effort that encourages inclusive digital transformation. By incorporating mobile advisory services, digital marketplaces, and climate-smart agricultural information, the initiative boosts micro-livestock productivity and market involvement, particularly targeting women and young farmers. For instance, in Tanzania and Ghana, women involved in poultry and goat farming through Digital Villages have received real-time disease alerts, vaccination advice, and mobile market connections, leading to improved production efficiency and income (FAO, 2022). Local organizations are also playing a crucial role. Tech Herfrica, for example, operates in Kenya and Nigeria, offering digital literacy and financial inclusion training to women in rural areas. Through workshops, peer mentoring, and mobile advisory support, women managing poultry and goats acquire skills to use mobile money platforms, e-markets, and advisory apps, facilitating better herd management and market engagement (Tech Herfrica, 2021; Heifer International, 2025) [12, 17]. Other significant initiatives aiding women in micro-livestock systems include Digital Green in Ethiopia and Malawi, which educates women smallholders on climate-smart livestock practices using participatory videos and mobile platforms, effectively merging extension services with digital skills development. Similarly, SheTrades, active in several SSA countries, empowers women entrepreneurs, including micro-livestock producers, by providing access to online marketplaces and digital financial services, thus fostering economic empowerment and greater market integration. These initiatives illustrate how digital platforms can help overcome gender-specific barriers, such as mobility limitations, restricted financial access, and low digital literacy. By concentrating on women-managed micro-livestock systems, these programs boost productivity and promote household resilience, food security, and gender equality in rural SSA.

Key insights from these initiatives underscore the transformative potential of inclusive digital platforms and targeted programs in empowering women to fully engage in micro-livestock production and market activities, thereby enhancing household income and decision-making authority.

The integration of digital advisory services, financial tools, and marketplaces is crucial for strengthening the climate resilience of micro-livestock systems, enabling women to adapt feeding, breeding, and marketing strategies in response to environmental shocks. Moreover, partnerships between international agencies and local organizations are vital to ensure that interventions are context-specific, culturally appropriate, and scalable across Sub-Saharan Africa, maximizing both impact and sustainability.

3.10. Policy and Programmatic Recommendations

To fully harness the potential of digital agricultural technologies in enhancing women's participation in micro-livestock systems throughout Sub-Saharan Africa, it is essential for policymakers and development practitioners to implement targeted policy and programmatic interventions. These efforts should address the structural, social, and economic barriers that hinder progress, while simultaneously fostering livestock systems that are inclusive, climate-resilient, and attuned to gender considerations. These strategies must address structural, social, and economic barriers while fostering inclusive, climate-resilient, and gender-responsive livestock systems.

3.10.1. Invest in connectivity and infrastructure: It is essential to enhance affordable and dependable Internet access in rural regions, including mobile broadband and off-grid electricity solutions. Focus should be placed on areas with a high number of women-led micro-livestock businesses, such as poultry and goat farming communities in Ethiopia, Tanzania, and Ghana. By investing in solar-powered mobile charging stations, electricity shortages can be alleviated, thereby supporting the continuous use of digital tools for livestock management, market participation, and access to climate information (CGIAR System, 2023).

3.10.2. Promotion of Digital Literacy and Skills Development: It is imperative that digital training programs in rural areas are specifically designed to address the needs of women and youth. These programs should integrate mobile-based tutorials, peer-to-peer learning, and participatory workshops. The training content should emphasize micro-livestock husbandry, disease management, digital marketplaces, and financial services. This approach will empower women to utilize technology effectively for enhanced production, marketing, and income diversification (Tech Herfrica, 2021) [17].

3.10.3. Enhance Gender-Inclusive Digital Agricultural Policies: It essential for governments and development organizations to implement policies that require the inclusion of gender considerations in digital agriculture projects. This will ensure fair access to mobile advisory services, electronic marketplaces, and climate data systems. Additionally, policy frameworks should tackle cultural and institutional obstacles, such as limitations on technology ownership, restrictions on mobility, and sociocultural norms that hinder women's involvement (FAO, 2022).

3.10.4. Promote inclusive financial and insurance solutions: By combining digital technologies with microcredit, savings plans, and livestock insurance, women gain access to secure financial avenues for investing in poultry, goats, and other small livestock. Initiatives such as mobile money-linked livestock insurance in Kenya and Ghana illustrate how digital financial products can boost women's investment potential, lessen their susceptibility to climate-related disruptions, and enhance livestock productivity (Heifer International, 2025) [12]. Together, these strategies can empower women in micro-livestock systems, bolster household food security, increase income opportunities, and support climate-resilient rural livelihoods throughout SSA.

3.10.5. Implementation Considerations: To effectively leverage digital agricultural technologies and boost women's engagement in micro-livestock systems throughout Sub-Saharan Africa, policymakers and development practitioners must implement targeted policies and programmatic measures. Achieving success with gender-responsive digital interventions in these systems requires forming multi-stakeholder partnerships that include governments, NGOs, local digital innovators, and women farmer cooperatives. Such collaborations are crucial for ensuring coordination, scalability, and sustainability. Interventions must be tailored to the specific context, considering local livestock practices, digital access levels, literacy, and sociocultural norms that impact women's participation. Monitoring and evaluation frameworks should incorporate gender-disaggregated data to evaluate the effects on women's access to technology, livestock productivity, income generation, and climate resilience. By adhering to these implementation principles, Sub-Saharan Africa can foster inclusive, digitally enabled micro-livestock systems that empower women, improve household food security, strengthen rural economies, and enhance resilience to climate variability.

3.11. Research Gaps and Future Directions

Despite the increasing body of evidence concerning digital agriculture, women's participation, and micro-livestock systems in Sub-Saharan Africa (SSA), several research gaps persist that necessitate focused scholarly attention.

Gendered Digital Adoption: There is a scarcity of empirical studies examining the influence of sociocultural norms, literacy, and financial constraints on women's utilization of digital technologies in micro-livestock management. Longitudinal, household-level research is required to quantify adoption rates, behavioral patterns, and the differential impacts on productivity and income.

Micro-livestock Productivity Metrics: While poultry, goats, and sheep have been extensively studied, there is a lack of data on the impact of digital tools on biological performance, disease incidence, and production efficiency under varying climatic conditions. Country-specific case studies could provide insights for scalable interventions.

Integration of Digital Platforms and Market Access: Research on the efficacy of digital marketplaces, mobile finance, and advisory services in enhancing market participation for women-managed livestock enterprises is limited. Studies should assess price realization, post-harvest loss reduction, and income security.

Climate Resilience Outcomes: The evidence linking digital technologies to adaptive capacity and resilience in smallholder micro-livestock systems remains fragmented.

Further investigations are necessary to understand how real-time climate information, predictive analytics, and early warning systems enhance women's decision-making in feeding, breeding, and market strategies.

Policy and Program Effectiveness: There are few evaluations of the impact of gender-responsive digital policies, extension programs, and financial services on strengthening micro-livestock systems. Comparative analyses across SSA countries could identify best practices and barriers to scaling up. Intersectional Analysis: Most research neglects to consider how age, education, household dynamics, and intra-household labour divisions influence women's engagement with digital tools. Intersectional studies can inform tailored interventions that maximize adoption and equity.

3.12. Future Research Priorities in Women-Led Micro-Livestock Farming and Digital Innovation

Future investigations should focus on conducting longitudinal and cross-national studies to assess the enduring impacts of digital technologies on micro-livestock systems managed by women in sub-Saharan Africa. It is also crucial to create comprehensive measurement frameworks that evaluate outcomes related to livestock productivity, household income, market access, and climate resilience simultaneously. Enhancing collaborative research partnerships among academic institutions, government bodies, NGOs, and women's cooperatives is vital for co-designing digital interventions that are tailored to the specific context and responsive to local livestock production systems. Furthermore, research should evaluate the cost-effectiveness, scalability, and sustainability of digital initiatives aimed at boosting women's participation and empowerment within livestock value chains. There is also a need to focus more on policy-oriented research to guide national strategies that support digital inclusion, gender equality, and climate-resilient development of smallholder livestock systems. Addressing these research gaps will provide actionable insights to optimize the adoption of digital technologies, empower female farmers, and strengthen micro-livestock systems, thereby contributing to improved food security and enhanced climate resilience across Sub-Saharan Africa.

4. Conclusion

Digital technologies offer a transformative opportunity for women involved in managing micro-livestock within smallholder agriculture in Sub-Saharan Africa (SSA), facilitating better access to up-to-date agricultural information, markets, financial services, and climate-smart practices. In SSA, micro-livestock systems, such as those involving poultry, goats, and sheep, play a crucial role in ensuring household food security, generating income, and empowering women. When these systems are combined with digital platforms, such as mobile advisory services, digital marketplaces, and financial services, productivity, resilience, and economic involvement can be greatly boosted. Despite progress, gender gaps in digital access, literacy, and usage continue to prevent women from fully leveraging these technologies.

Women smallholders, who mainly manage micro-livestock, face structural, socio-cultural, and economic barriers that limit their participation in digital agriculture programs. These obstacles include limited mobile phone ownership, inadequate internet connectivity in rural areas, cost issues, and societal norms that restrict technology use. Consequently, the potential advantages in productivity, market involvement, and climate resilience are not shared equally (CGIAR System, 2023; FAO, 2022). Addressing the digital gender gap is of paramount importance. Effective strategies should prioritize inclusive digital literacy programs, gender-responsive information and communication technology (ICT) policies, and the provision of affordable and reliable connectivity. Additionally, targeted financial instruments that empower women to access and utilize digital tools effectively are crucial.

Initiatives that involve co-creating digital solutions with female smallholders, while integrating local knowledge, cultural contexts, and livestock management practices, offer the greatest potential for sustainable impact. Investing in research, monitoring, and evaluation is important. It helps us understand how well digital tools work for women who manage small livestock. This information can guide policymaking and support solutions that fit different areas in SSA. In conclusion, the development of inclusive, gender-responsive digital ecosystems for micro-livestock production represents a strategic approach to fostering climate-resilient, equitable, and economically sustainable rural development in Sub-Saharan Africa (SSA). By empowering female smallholders through digital technologies, the region can concurrently enhance food security, improve livelihoods, and bolster resilience to climate variability, thereby achieving both social and economic development objectives.

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How to Cite This Article
Assan N, Marufu H. Digital tools, women, and micro-livestock farming: Enhancing productivity and resilience in smallholder animal agriculture in Sub-Saharan Africa. International Journal of Multidisciplinary Futuristic Development. 2026;7(1):49-60. doi:10.54660/IJMFD.2026.7.1.49-60.