GENDER DYNAMICS IN THE ADOPTION OF DIGITAL TOOLS IN UGANDA'S DAIRY SECTOR

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ABSTRACT

The adoption of digital tools in dairy farming has the potential to enhance productivity, efficiency, and market access. However, gender disparities exist in the utilisation of these technologies. This study examines gender differences in the adoption of digital tools, the willingness to adopt, and the barriers faced by male and female dairy farmers. Using a multistage sampling procedure, data were collected from 80 male and 40 female dairy farmers. Analytical techniques included frequency counts, percentages, t-tests, and the Ordinary Least Squares (OLS) regression model. Findings revealed that male dairy actors in Uganda have a slightly higher overall awareness of digital products (53.97 ± 14.7) than female actors (52.00 ± 20.69). Both men and women had low adoption levels of digital tools (females: 1.45 ± 3.83; Males: 1.75 ± 2.49), with male farmers slightly ahead in the use of mobile money applications (27.5%), digital marketing (22.5%), and e-learning platforms (27.5%). Willingness to adopt the unadopted digital tools was significantly higher among men (77.5%) compared to women (60.0%). Regression results showed the gendered barriers to technology adoption by women as limited access to technology (β = 1.425, p = 0.025), Cultural norms (β = 0.111, p = 0.026), and educational qualification (β = 0.111, p = 0.688), while men were only constrained by digital literacy (β = 0.124, p = 0.000). The study concludes that gender disparities in digital adoption are shaped by socioeconomic and cultural factors. To bridge this gap, targeted interventions such as women-focused digital literacy programs, subsidised access to digital tools, and gender-inclusive policy frameworks are recommended. Implementing these strategies will promote inclusive digital transformation in dairy farming, enhancing productivity and sustainability for both male and female farmers.

Keywords: digitalisation, gendered barriers, inclusive growth, innovations, rural development

INTRODUCTION

Digitalisation in agriculture, often referred to as "digital agriculture," involves the use of digital tools and technologies such as mobile applications, internet platforms, and data analytics to enhance agricultural productivity, efficiency, and market access. Studies have shown that digitalisation has the potential to revolutionise farming practices by improving access to real-time information, optimising resource use, and enhancing the decision-making processes of farmers (Ferris *et al*., 2017). In the context of dairy farming, digital technologies can support the management of livestock, improve milk yield through precision agriculture, and facilitate market access through digital platforms (Aker *et al*., 2016). However, the level of digital adoption in developing countries remains limited, particularly in sectors like dairy, where traditional practices still dominate.

Uganda's dairy sector is a critical component of the country's agricultural economy, providing livelihoods for millions of smallholder farmers (Katungi *et al.*, 2017). According to the Dairy Development Authority (2020), dairy farming contributes significantly to rural employment, food security, and income generation. Despite the sector's potential, challenges such as low productivity, poor infrastructure, and limited market access have hindered its growth. Digital technologies offer solutions to some of these challenges by enhancing productivity, improving supply chain management, and providing better market linkages. However, these technologies are often under-utilised, with uptake being slow, especially among rural smallholders and marginalised groups like women.

In Uganda's dairy sector, men predominantly occupy roles in commercial production, processing, and marketing, often controlling access to critical resources such as land, capital, and livestock. However, the women occupy the subsistence production level. Despite the dominance, men face challenges including limited access to modern dairy technologies, fluctuating milk prices, and inadequate cold chain infrastructure (EADD, 2018; FAO, 2020). Additionally, climate variability and feed scarcity affect productivity and profitability, particularly for small-scale male farmers. A growing body of literature highlights the importance of addressing gender inequalities in agriculture to achieve inclusive growth. Women make up a substantial portion of the agricultural labour force, particularly in sub-Saharan Africa, yet they consistently face barriers that limit their productivity and income (FAO, 2011). These barriers include limited access to land, financial services, education, and technology (Doss, 2018). Gender norms often restrict women's decision-making power and access to resources, further exacerbating these inequalities (Meinzen-Dick *et al*., 2019). Women typically play a critical role in livestock care and milk production,

but they are often excluded from decision-making processes, market activities, and technology adoption, which are dominated by men (Njuki and Sanginga, 2013).

The gender digital divide refers to the gap between men and women in terms of access to and use of digital technologies. According to the International Telecommunication Union (ITU), women in low- and middle-income countries are 10% less likely to own a mobile phone and 26% less likely to use mobile internet compared to men (ITU, 2020). Several factors contribute to this divide, including socio-cultural norms, lower levels of digital literacy among women, affordability, and limited access to financial resources (World Bank, 2019). These factors significantly affect women's ability to adopt and benefit from digital technologies in agriculture.

In the context of Uganda's dairy sector, gendered differences in digital access are exacerbated by rural-urban disparities, with rural women being particularly disadvantaged in terms of digital literacy and infrastructure (Asiimwe and Kamwesiga, 2020). This digital divide limits women's ability to access critical information such as weather forecasts, market prices, and veterinary services, all of which can improve their productivity and income in dairy farming.

Existing literature underscores the transformative potential of digital tools for improving gender equality in the agricultural value chains. Digital platforms, mobile applications, and e-extension services can enhance women's access to markets, information, and financial services, thereby boosting their productivity and income (Wodon and De la Brière, 2018). Studies from Kenya, for example, show that mobile-based dairy information services have increased milk yields and income of smallholder farmers, particularly when tailored to the needs of women (Tsan *et al*., 2019). However, for digitalisation to deliver gender-inclusive benefits, interventions must address the underlying gender inequalities in access to technology, education, and decision-making processes (Doss and Meinzen-Dick, 2015).

In Uganda, few studies have examined the intersection of digitalisation and gender in the dairy sector. A study by Okello *et al.* (2021) highlights that while digital tools such as mobile money and market information services have the potential to improve market access for dairy farmers, women remain disproportionately disadvantaged in their access to and use of these tools. This is due to gendered differences in literacy, control over income, and access to mobile phones. Furthermore, the authors argue that the design of digital interventions often overlooks the specific needs and constraints of women farmers, thus limiting their effectiveness in addressing gender disparities. Hence, the study advocates for inclusive growth.

Inclusive growth refers to economic growth that is distributed fairly across society and creates opportunities for all, particularly marginalised groups like women (Kabeer, 2015). In the context of the dairy sector, inclusive growth means ensuring that both women and men benefit equally from digital innovations and that barriers to women's participation are actively addressed. Digitalisation, when implemented with a gender lens, can contribute to women's economic empowerment by increasing their access to resources, markets, and decision-making platforms (Buvinic and Furst-Nichols, 2016).

Several frameworks for inclusive digitalisation emphasised the importance of gender-sensitive policies and interventions that account for the distinct challenges women face in adopting and using digital technologies (Heeks, 2020). These include improving women's digital literacy, ensuring the affordability of digital tools, and addressing socio-cultural barriers that limit women's mobility and decision-making power. By fostering an enabling environment for women to participate in the digital economy, inclusive growth in Uganda's dairy sector can be achieved.

While there is a growing body of research on digitalisation and gender in agriculture, there are significant gaps in the literature specific to Uganda's dairy sector. Most studies on digital agriculture focus on crop farming, with limited attention given to livestock and dairy. Furthermore, there is limited empirical evidence on the gendered impacts of digital tools in dairy farming in Uganda. Most studies that do exist are concentrated on mobile financial services, with less focus on other digital innovations such as e-extension services, market platforms, or digital data management systems for livestock. This study aims to address these gaps by providing a gendered analysis of the adoption and utilisation of digital technologies in Uganda's dairy sector, offering insights into the specific challenges and opportunities for women in this context.

The research provides answers to the following questions:

1. What are the current levels of digital awareness and adoption in Uganda's dairy sector, and how do they differ between men and women?
2. Are the men and women dairy farmers willing to adopt digital technology?
3. What are the key barriers to digital adoption and utilisation by male and female dairy farmers

METHODOLOGY

This study was conducted in Southwest Uganda, a key dairy-producing region that significantly contributes to the country's total milk output. The region is home to a large population of

smallholder dairy farmers who depend on dairy farming as their primary source of income and livelihood. The dairy sector plays a crucial role in local economies by generating employment and improving food security. Southwest Uganda has a well-established dairy infrastructure, including milk collection centers, cooperatives, and processing plants. However, inefficiencies in the value chain limit the full utilisation of these facilities. Digitalisation presents an opportunity to enhance communication, reduce transaction costs, and improve coordination among stakeholders. Studying gender differences in digital tool adoption in this region would reveal the current state of digitalisation by gender and where concerted efforts should be made to enhance production efficiency in the dairy industry.

A multistage sampling procedure was used to select respondents. In stage one, the study identified the 16 districts in Southwest Uganda with significant dairy farming activities: Kabale, Kisoro, Rukungiri, Kanungu, Ntungamo, Mbarara, Bushenyi, Sheema, Mitooma, Rubirizi, Isingiro, Rubanda, Rukiga, Kiruhura, Rwampara, and Kazo. Stage two involves the random selection of four districts (Mbarara, Ntungamo, Kabale, and Rubanda) for data collection. Within these districts, extension agents working with dairy farmers were identified. The last stage involves a purposive sampling of 80 men and 40 women from the dairy value chain who could respond to an online questionnaire, while others were aided in filling out the questionnaire by trained enumerators. A structured survey questionnaire was used to collect data. The instrument included Likert scale items to measure the levels of digital adoption, willingness to adopt digital tools, and barriers to digital adoption, disaggregated by gender.

Data were analysed using descriptive statistics (frequency counts and percentages), Inferential statistics (t-tests to compare male and female adoption levels), and Ordinary Least Squares (OLS) regression analysis to identify factors influencing digital adoption among dairy farmers.

RESULTS AND DISCUSSIONS

Awareness of digital tools by gender

The data in Table 1 shows that male dairy actors have a slightly higher overall awareness of digital products (53.97 ± 14.7) than female actors (52.00 ± 20.69), suggesting men are more exposed to or involved in digital innovations across the milk value chain. Men ranked mobile money (2.85±1.43), digital payments (2.85±1.43), and digital marketing highest (2.58±1.42), highlighting their strong involvement in financial and commercial aspects of dairy farming. Women also prioritized finance (2.50±1.34) and learning tools (2.25±1.32), though their lower mean scores suggest relatively less engagement or access compared to men. Livestock management systems, automated milking systems, and inventory management tools received moderate attention from both groups. Interestingly, women ranked the awareness of automated milking systems slightly higher (1.80 vs. 1.70), possibly indicating increasing female involvement in handling livestock processes.

Both genders showed limited awareness (mean <1.6) of thermal cameras, gas sensors, 3d cameras, micro-doppler radar, ai-driven insights and predictive analytics. These tools are more advanced and less common, indicating gaps in exposure, affordability, or extension support. Farmer Apps were much more familiar to male respondents (1.98±1.11; 8th) than females (1.2±0.52; 31st), possibly due to men's greater phone ownership or control over digital devices. Digital logistics and process optimization tools were consistently low ranked for women, reflecting less involvement in transport and processing stages. AI-powered chatbots ranked higher among men (1.70±1.16; 9th) than women (1.48±0.75; 16th), suggesting greater male openness to AI-supported engagement.

Adoption of digital tools by gender

Table 2 shows that the only tools adopted by women (though at a much lower percentage) include online marketplaces (10.0%), digital marketing (10.0%), mobile money applications (15.0%) and digital payments (10.0%). It is important to note that no adoption was recorded for advanced precision dairy farming tools, such as automated milking systems, wearable health-monitoring devices, block-chain for traceability, AI-driven insights, predictive analytics and environmental sensors, as they all recorded 0.0% respectively. This suggests limited technological penetration in dairy farming, possibly due to high costs, lack of technical knowledge, and infrastructural constraints (Ferraz *et al*., 2024). It also shows gender differences in adoption, as men have a significantly higher adoption rate across most digital tools compared to women. These findings align with FAO (2021), which highlights that women in agriculture tend to adopt digital financial tools rather than technical farm management innovations due to lower access to capital and training. Most adopted tools by men include mobile money applications (27.5%), e-learning platforms (27.5%), digital marketing (22.5%), digital payments (22.5%), and online marketplaces (20.0%).

These tools focus on financial transactions, knowledge acquisition, and market access, reinforcing previous research that men are more likely to explore new income-generating digital solutions (GSMA, 2023). FSD, Uganda (2024), established the contributions of grants from FSD to onboard farmers onto a digital cooperative

information system that registers their deliveries, prices, and net-pay calculations.

Table 1: Awareness of digital tools by gender

Digital Products	Male		Female	
	Mean±SD	Rank	Mean±SD	Rank
Livestock management system	1.75±0.95	8th	2.13±1.11	7th
Inventory Management Systems to ensure timely and accurate stock levels at all stages of the value chain	1.6±0.87	13th	1.85±0.99	9th
automated milking system	1.8±0.76	7th	1.70±0.91	12th
Feed mix optimisation and consumption monitor	1.65±0.86	12th	1.70±0.75	11th
Wearable Devices for Cows to Track health indicators like temperature, activity levels, and rumination	1.65±0.8	11th	1.60±0.81	13th
Environmental Sensors to monitor barn conditions like temperature, humidity, and ammonia levels to ensure optimal living conditions.	1.45±0.81	21th	1.45±0.71	17th
Milk Quality Sensors for Real-time analysis of milk composition for fat, protein, and somatic cell counts	1.5±0.88	16th	1.53±0.78	14th
Eyes sensor -Thermal cameras (early detection of infection.	1.45±0.81	22nd	1.43±0.78	18th
Eyes sensor -Thermal cameras (early detection of infection of mastitis)	1.5±0.99	17th	1.35±0.66	26th
3D cameras and automated weighing platforms (growth; frame size; body condition)	1.5±0.99	18th	1.30±0.56	27th
Micro-doppler radar	1.55±0.99	15th	1.25±0.49	31st
Cameras or light beams for lying times	1.45±0.68	23rd	1.25±0.48	30th
Acoustic recorders (coughing for early detection of respiratory disease	1.4±0.67	28th	1.35±0.70	26th
Gas sensors for monitoring the environment of housed cows (methane; ammonia	1.4±0.74	29th	1.25±0.58	32nd
Gas sensors for milk taints	1.4±0.74	28th	1.28±0.64	29th
Animal sensors collar	1.55±0.81	15th	1.35±0.63	22nd
Blockchain Technology for traceability	1.2±0.69	31st	1.35±0.73	24th
Supply chain management for fraud detection	1.25±0.63	30th	1.40±0.67	19th
Predictive Analytics to Forecast milk yield, detect health issues early, and optimize breeding schedules.	1.3±0.65	29th	1.35±0.66	23rd
Artificial intelligence (AI) driven Insights to analyse large datasets to improve farm management and production process decision-making.	1.45±0.88	24th	1.38±0.70	20th
Farmer Apps to provide farmers with real-time information on market prices, weather forecasts, and best practices	1.2±0.52	31th	1.98±1.11	8th
Consumer Apps to Educate consumers on product origins, quality, and nutritional information.	1.5±0.82	19th	1.75±0.95	10th
Automated Quality Control Use sensors and cameras to detect contaminants or inconsistencies in dairy products	1.65±0.98	12th	1.35±0.62	21st
Process Optimization which Automates and monitor production lines for pasteurization, packaging, and distribution.	1.45±0.81	25th	1.50±0.71	15th
Digital Logistics to track and manage transportation of milk and dairy products	1.5±0.88	20th	1.30±0.51	28th
Online Marketplaces to connect producers directly with consumers or retailers	1.95±1.22	6th	2.38±1.50	5th
Digital Marketing --use social media and digital campaigns to reach a wider audience	2.00±1.2	5th	2.58±1.42	3rd
mobile network money application	2.50±1.34	2nd	2.85±1.43	1st
Digital Payments of instant transactions between farmers, suppliers, and buyers	2.50±1.22	1st	2.80±1.34	2nd
Insurance Products	2.0±1.11	5th	2.33±1.13	6th

E-learning Platforms for training and accessing material expert advice	2.25±1.32	3rd	2.48±1.25	4th

No women reported using e-learning platforms or insurance products, even though digital education could enhance their skills and resilience in dairy farming. FAO (2022) suggests that lower digital literacy and fewer training opportunities for women contribute to this gap. Possible barriers limiting women's adoption include lack of access to devices and internet connectivity (Meemken and Bellemare, 2021), lower control over farm resources and decision-making (Kassie *et al*., 2020) and cultural norms that restrict women's participation in technology-driven activities (World Bank, 2021).

Table 2: Adoption of digital tools by gender

Digital Practices	Male (%)	Female (%)
Automated Milking Systems	0.0	0.0
Livestock Management Systems	5.0	0.0
Feed optimisation and consumption monitor	5.0	0.0
Wearable devices for cows to track health indicators like temperature, activity levels, and rumination	0.0	0.0
Environmental Sensors to monitor barn conditions like temperature, humidity, and ammonia levels to ensure optimal living conditions	10.0	0.0
Automated Quality Control Use sensors and cameras to detect contaminants or inconsistencies in dairy products	0.0	0.0
Process Optimisation, which automates and monitors production lines for pasteurisation, packaging, and distribution	5.0	0.0
Thermal cameras (early detection of infection of mastitis	0.0	0.0
3D cameras and automated weighing platforms (growth, frame size, body condition	0.0	0.0
Gas sensors for milk taints	0.0	0.0
Animal sensors collars	0.0	0.0
Digital Logistics to track and manage the transportation of milk and dairy products	0.0	0.0
Inventory Management Systems to ensure timely and accurate stock levels at all stages of the value chain	10.0	0.0
Online Marketplaces to connect producers directly with consumers or retailers	20.0	10.0
Digital Marketing-use social media and digital campaigns to reach a wider audience	22.5	10.0
Mobile money application	27.5	15.0
Digital Payments of instant transactions between farmers, suppliers, and buyers	22.5	10.0
Insurance Products	12.5	0.0
E-learning Platforms for training and accessing material, expert advice	27.5	0.0
AI-powered chatbots to answer farmers' questions and provide support	0.0	0.0

Adopted = 1, not adopted = 0

Level of adoption of digital practices

Data in Table 3 shows that 95.0% of women and 100.0% of men fall into the low adoption category. Only 5.0% of women reached a moderate adoption level, while no respondent (0.0%), male or female, achieved a high adoption level. The mean scores are very low (Females: 1.45 ± 3.83; Males: 1.75 ± 2.49). This suggests that digitalization in dairy farming remains minimal and underutilised, regardless of gender.

Although men have a marginally higher mean score (1.75 vs. 1.45), the difference is statistically significant (t = 2.187; p = 0.024). This indicates that men are marginally more engaged with digital tools than women, possibly due to better access to resources, education, and decision-making power. However, the overall adoption remains low among genders. It aligns with previous findings (FAO, 2021; GSMA, 2023) that even when men have greater access to technology, overall digital adoption in rural agricultural settings remains weak due to infrastructural, financial, and knowledge barriers.

Table 3: Level of adoption of digital practices

Obtained score ranges		Female		Male	
	Level	Frequency	%	Frequency	%
0 – 10	Low	38	95.0	80	100.0

11 – 20	Moderate	2.0	5.0	0.0	0.0
21 – 32	High	0.0	0.0	0.0	0.0
Mean		1.45±3.83		1.75±2.49	
T-test		t = 2.187; Sig. = 0.024			

Possible score range 0 – 32

Table 1 already indicated that most digital innovations (e.g., AI-driven insights, blockchain, predictive analytics, and automated milking systems) were completely unadopted. The low scores further confirm that most farmers, regardless of gender, are not engaging with digital solutions in their dairy enterprises. The World Bank (2022) affirmed Infrastructure deficits in rural areas. Fadeyi *et al*. (2022) affirmed the low level of adoption of digital technology among male and female dairy farmers in Uganda

The low level of adoption of digital tools implies limited productivity and efficiency, reduced market access, deepened gender inequality, inefficient resource management and hindered adoption of best practices (Fadeyi *et al*. 2022: Rural Finance and Investment Learning Centre (RFILC), 2024).

Level of willingness of non-adopted digital practices

Table 4 shows that 77.5% of men are in the "fully willing" category compared to 60.0% of women. Only 10.0% of men reported being "not willing", whereas 35.0% of women expressed unwillingness. The mean willingness score for men (24.55 ± 7.95) is higher than that of women (19.45 ± 11.94), indicating a significant difference in enthusiasm for adopting digital practices. The T-value (2.784) and p-value (0.006) indicate a significant gender gap in willingness to adopt digital tools. This suggests that while both men and women face adoption challenges, men are generally more willing to explore digital innovations than women. Women's lower willingness may be linked to existing socio-cultural barriers, lower digital literacy, and limited access to financial resources (FAO, 2021; GSMA, 2023). The fact that a majority of women (60%) are "fully willing" suggests that with proper interventions (e.g., training, access to credit), their adoption rates could increase.

Table 4: Level of willingness of non-adopted digital practices

		Female		Male	
	Categories	**Frequency**	**Percentage**	**Frequency**	**Percentage**
0 – 10	Not willing	14	35.0	8	10.0
11 – 20	Somewhat willing	2	5.0	10	12.5
21 – 32	Fully willing	24	60.0	62	77.5
Mean		19.45±11.94		24.55±7.95	
T-test		t = 2.784; Sig. = 0.006			

Possible score 0 – 32

Barriers to adoption of AI tools

The findings in Table 5 highlight that both men and women face multiple systemic, technical, and socio-cultural barriers to digital adoption in the milk value chain, though the ranking and perceived severity differ across gender lines. The top three barriers for male respondents are insufficient training and knowledge (4.65±0.48), Fluctuation in milk prices and market demand (4.65±0.48) and Limited technical support and expertise (4.65±0.58). These suggest that men are more concerned with technical capacity building, economic risks, and infrastructure-related support, which directly influence their decision to invest in digital tools. Other high-ranking barriers include high investment costs (4.60±0.59), low literacy levels (4.60±0.50) and lack of awareness (4.55±0.60). These point to structural and economic constraints, particularly for small-scale male producers.

For female respondents, the top barriers are language barriers and literacy challenges (4.48±0.55), poor coordination among value chain actors (4.45±0.55), traditional mindsets and resistance to change (4.45±0.56), inadequate strategic vision and leadership (4.43±0.55) and high investment costs (4.43±0.74). This indicates that women are particularly affected by social, institutional, and educational challenges, including gendered cultural norms and limited access to inclusive leadership structures. Notably, lack of training, which ranks 1st for men, ranks 20th for women (4.20±0.88), possibly due to limited training access rather than awareness of its absence. Misconceptions about digitalization complexity are much lower-ranked for women (21st) than for men (8th), suggesting women may be less exposed to digital options to even develop such misconceptions.

Men face more barriers related to investment, market dynamics, and technical knowledge, likely reflecting their higher involvement in commercial and operational aspects of dairy farming. Women are more constrained by socio-cultural barriers, language and literacy issues, and limited strategic

inclusion, underscoring their marginalized access to decision-making spaces and resources.

Table 5: Barriers to the adoption of digitalisation in the milk value chain

Barriers	Male		Female	
	Mean±SD	Rank	Mean±SD	Rank
Lack of awareness about the benefits and potential of digital technologies.	4.55±0.60	6th	4.43±0.9	7th
Misconceptions about the complexity and necessity of digitalization	4.50±0.61	8th	4.18±0.9	21st
Lack of internet connectivity in rural areas.	4.45±0.75	10th	4.33±0.76	16th
Insufficient access to reliable electricity	4.35±0.82	19th	4.35±0.73	14th
Lack of access to credit facilities/ financial aids	4.40±0.75	14th	4.30±0.79	17th
High investment requirement for purchasing and implementing digital technologies	4.6±0.59	5th	4.43±0.74	5th
Fluctuation in milk prices and market demand impacting investment decision	4.65±0.48	2nd	4.35±0.74	14th
Insufficient training and knowledge among farmers and workers.	4.65±0.48	1st	4.20±0.88	20th
Limited availability of technical support and expertise.	4.65±0.58	3rd	4.28±0.84	18th
Lack of coordination and communication among different stakeholders in the value chain	4.50±0.75	9th	4.45±0.55	2nd
Language barrier and literacy, particularly in regions with low education levels.	4.45±0.60	11th	4.48±0.55	1st
Low literacy level	4.60±0.50	4th	4.35±0.66	11th
Unavailability of most digital tools in the region	4.50±0.59	7th	4.38±0.62	9th
Difficulty in understanding and utilising digital tools and interfaces	4.4±0.74	13th	4.35±0.48	10th
Disparities in digital adoption rates among producers, processors, and distributor	4.35±0.81	18th	4.40±0.49	8th
Difficulty in managing and integrating digital technologies into existing operations.	4.45±0.50	12th	4.43±0.63	6th
Inadequate leadership and strategic vision for digital transformation	4.35±0.80	17th	4.43±0.55	4th
Traditional mindsets and practices that resist technological adoption.	4.35±0.58	16th	4.45±0.56	3rd
Lack of trust in new technologies and their impact on livelihood	4.35±0.48	15th	4.20±0.82	19th
Inequity in digital technologies and internet access between urban and rural areas.	4.15±0.74	20th	4.35±0.66	11th
Socioeconomic disparities affecting the ability to adopt digital solutions	4.15±0.86	21st	4.33±0.65	15th

Regression analysis of gendered barriers to the adoption of digital tools

Findings in Table 6 show that limited access to technology was not significant for men (*β = -0.254, p = 0.212*) but was significant for women (*β = 1.425, p = 0.025*), indicating that limited access is a major barrier for female farmers. FAO (2022) reports that women in rural areas often face more barriers to accessing digital tools due to affordability and infrastructural constraints. Abate *et al.* (2023) highlights that gender gaps in access to mobile phones and the internet persist, limiting women's ability to engage in digital agriculture. Also, cultural norms were significant for men (*β = 5.477, p = 0.028*), suggesting that cultural factors may influence men's adoption, possibly through expectations around traditional farming methods and also, significant for women (*β = 0.111, p = 0.026*), indicating that cultural restrictions such as societal gender roles affect their digital adoption. GSMA (2023) finds that cultural biases often limit women's ability to access digital tools, as men are more likely to control household technology. Kassie *et al*. (2020) show that in Africa, traditional gender norms discourage women from engaging in modern farming practices that require digital tools.

Education (highest qualification) was significant for men (*β = 1.071, p = 0.010*), indicating that higher education boosts digital adoption, however, it was negative but not significant for women (*β = -1.42, p = 0.206*), implying that formal education alone does not

necessarily lead to digital adoption among female farmers. World Bank (2021) suggests that while education enhances digital literacy, other barriers (such as access and cultural constraints) may prevent women from utilising digital tools effectively. Aker and Ksoll (2019) argue that education alone is insufficient for women if they lack decision-making power within households. Specialisation in the Dairy Value Chain was not significant for men or women, though a negative trend is observed for women ($\beta = -1.283$, $p = 0.087$). FAO (2020) states that sector-specific constraints (such as labour division in dairy farming) might affect digital adoption differently across value chains. Meemken and Bellemare (2021) note that women in dairy farming may have limited control over financial decisions, reducing their likelihood of investing in digital tools. Digital Literacy was highly significant for both men ($\beta = 0.124$, $p = 0.000$) and women ($\beta = 0.125$, $p = 0.028$), indicating that literacy is crucial for adoption. UNESCO (2022) reports that digital literacy is a key enabler for technology use, but women often lag due to educational and infrastructural barriers. Aker *et al.* (2019) highlight the importance of digital training programs in increasing adoption rates, particularly for women.

Model Fit: The R^2 value is slightly higher for men (*0.601*) than for women (*0.520*), suggesting that other unmeasured barriers might influence women's adoption. The F-statistic is significant for both groups, but the model performs better for men ($F = 10.441$, $p = 0.000$) than for women ($F = 2.641$, $p = 0.030$).

Table 6: Gendered barriers to the adoption of digital tools (Linear regression (OLS) analysis)

Adoption of Digital Tools	Male			Female		
	Coef. (β)	p-value	Sig.	Coef.(β)	t-value	Sig.
(Constant)	86.819	8.242	0.000	53.591	8.348	0.000
Limited access to technology	-0.254	-1.272	0.212	1.425*	0.092	0.025
Cultural Norms	5.477	2.303	0.028	0.111*	0.688	0.026
Highest qualification	1.071	2.732	0.010	-1.42**	-1.276	0.206
Specialization in the dairy value chain	0.352	0.762	0.451	-1.283	-1.732	0.087
Digital literacy	0.124**	4.720	0.000	0.125**	0.011	0.028
R square	0.601			0.520		
F	10.441			2.641		
Sig.	0.000			0.030		

Severity of barriers to adopting digital practices

The distribution of severity levels in Table 7 shows that among females, 90.0% reported experiencing "very severe" barriers, while 10.0% faced "severe" barriers. No female respondents categorised the barriers as "less severe." For males, 87.5% reported "very severe" barriers, 10.0% faced "severe" barriers, and 2.5% considered the barriers "less severe." The mean Scores for females were 93.40 ± 8.67 and for Males 91.40 ± 8.68, which suggests that, on average, women perceive slightly higher barriers to adopting digital practices than men. The t-value of 1.189 and p-value of 0.237 indicate that the difference in perceived severity between males and females is not statistically significant ($p > 0.05$). This implies that while women report slightly higher severity, the difference is not large enough to be considered statistically meaningful.

Table 7: Severity of barriers to adopting digital practices

28		Female		Male	
Obtained score	Severity	Frequency	Percentage	Frequency	Percentage
21 – 49	Less severe	0	0.0	2	2.5
50 – 77	Severe	4	10.0	8	10.0
78 – 105	Very severe	36	90.0	70	87.5
Mean		93.40±8.67		91.40±8.68	
T-test		t-value = 1.189; Sig. = 0.237			

CONCLUSION AND RECOMMENDATIONS

The study concludes that gender disparities exist in awareness, adoption and willingness to adopt digital tools among dairy farmers, with men having slightly higher levels of awareness, adoption rates and greater willingness to adopt digital innovations. Women face greater socio-economic and cultural barriers, which hinder their ability to adopt and utilise digital tools effectively. Although awareness positively influences adoption for both genders, women require targeted interventions to bridge the digital divide in dairy farming.

There is a need to improve women's digital literacy and awareness through training programs to enhance technical skills. Peer learning and mentorship should be promoted to increase adoption rates among female farmers. Also, the government should enhance accessibility to digital tools for

women through subsidized access to digital technologies. cooperative-based technology sharing models could be facilitated to reduce costs. The government and NGO should engage community leaders and policymakers to challenge restrictive norms that limit women's participation in digital agriculture, while gender-inclusive policies should be enacted to encourage equal access to digital tools. Mobile money services and digital payment systems tailored to women's needs should be expanded. Financial incentives and microcredit programs for female farmers to invest in digital technologies could be introduced. Government and private-sector partnerships should be developed to enhance the availability and affordability of digital tools while integrating gender-sensitive frameworks into national agricultural digitalization strategies.

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