



Influence of Digital Financial Services on Agricultural Productivity among Smallholder Farmers in Musanze District, Rwanda

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Abstract: Digital financial services (DFS) have emerged as important tools for promoting financial inclusion and supporting agricultural activities in developing countries. This study examined the influence of digital financial services on agricultural productivity among smallholder farmers in Musanze District, Rwanda. Specifically, it assessed the influence of mobile money, digital credit, digital savings, and digital payment services on agricultural productivity. A quantitative research design was employed, targeting 5,500 smallholder farmers. A sample of 373 farmers was selected, yielding 332 valid responses and an 89.0% response rate. Data were analyzed using descriptive statistics, Pearson correlation, and multiple linear regression. The findings revealed strong and significant positive relationships between agricultural productivity and mobile money ($r = .843, p < .01$), digital credit ($r = .770, p < .01$), digital savings ($r = .722, p < .01$), and digital payments ($r = .820, p < .01$). The multiple regression model explained 81.0% of the variation in agricultural productivity ($R^2 = .810$). The study concludes that digital financial services significantly contribute to agricultural productivity by facilitating financial transactions, improving access to agricultural resources, strengthening financial management, and supporting market participation. The study recommends strengthening digital financial infrastructure and literacy, expanding appropriate digital credit and savings products, and improving the reliability and affordability of digital payment services.

Keywords: digital financial services, mobile money, digital credit, digital savings, digital payments, agricultural productivity, smallholder farmers, Rwanda.

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1. Introduction

Agriculture remains a major driver of livelihoods, food security, employment, and rural economic development in developing countries, where smallholder farmers constitute a substantial share of agricultural producers. However, the productivity of smallholder agriculture is often constrained by limited access to financial resources, productive inputs, markets, and appropriate technologies. Financial constraints are particularly important because farmers require timely resources to purchase seeds, fertilizers, pesticides, livestock, equipment, and other inputs. Limited working capital, high transaction costs, inadequate access to formal

financial institutions, and irregular agricultural incomes can therefore restrict farmers' ability to invest in productive activities and respond effectively to seasonal agricultural requirements. Improving access to appropriate financial services has consequently become an important component of strategies aimed at strengthening agricultural productivity and rural development.

Technological advancements in the financial industry have progressively changed how financial services are provided and accessed globally. For people and households that have historically experienced obstacles to traditional financial services, digital financial services (DFS), such as mobile money, digital credit, digital

savings, and digital payments, offer increased options. Users do not need to travel to actual financial institutions in order to transfer money, make payments, save, borrow, and carry out financial activities using mobile phones and other digital platforms. These services have the ability to lower transaction costs, speed up financial transactions, make working capital more accessible, and increase farmers' market involvement in agricultural contexts. Therefore, by allowing farmers to mobilize and manage financial resources when they are most required, digital banking may increase agricultural production.

The potential contribution of DFS to agriculture is particularly relevant for smallholder farmers, whose financial needs are intimately connected to seasonal production cycles. Digital credit, for example, can provide relatively rapid access to working capital for purchasing agricultural inputs, while digital savings can assist farmers in accumulating resources for future production activities. Mobile money can facilitate the transfer of funds between farmers, suppliers, buyers, and family members, while digital payments can make the purchase and sale of agricultural goods more efficient. These mechanisms can reduce reliance on cash transactions and potentially improve farmers' ability to obtain inputs on time, manage farm finances, and participate in agricultural markets. Nevertheless, access to digital financial services does not necessarily translate automatically into higher agricultural productivity. Their contribution may depend on affordability, reliability, digital and financial literacy, access to digital infrastructure, and farmers' ability to use the services for productive purposes.

In sub-Saharan Africa, the expansion of mobile technology and digital financial platforms has created significant opportunities for increasing financial inclusion among populations traditionally underserved by formal financial institutions. Despite this progress, rural populations continue to experience barriers related to infrastructure, digital skills, income levels, and access to suitable financial products. For smallholder farmers, these challenges may be particularly significant because agricultural incomes are often seasonal and vulnerable to production and market risks. Consequently, understanding whether and how specific digital financial services contribute to agricultural productivity is important for designing financial inclusion strategies that extend beyond access to financial services and focus on their productive outcomes.

In Rwanda, digital financial services have developed alongside national efforts to promote financial inclusion, digital transformation, agricultural modernization, and inclusive economic development. The increasing availability of mobile-based financial services provides opportunities for farmers to conduct transactions, save, obtain credit, and make payments through digital channels. However, the existence and expansion of these services do not by themselves establish their

effectiveness in improving agricultural outcomes. Evidence is therefore needed on whether farmers' use of specific DFS dimensions is associated with measurable improvements in agricultural productivity. This issue is especially important in rural and predominantly agricultural areas where smallholder farmers depend on timely access to financial resources and markets.

Although previous studies have examined digital finance and financial inclusion, an important empirical gap remains concerning the relationship between specific digital financial services and agricultural productivity among smallholder farmers. Much of the existing literature tends to examine digital financial inclusion broadly or focuses on outcomes such as financial access, household welfare, consumption, or business performance. Less attention has been given to disaggregating digital financial services into mobile money, digital credit, digital savings, and digital payments and examining their individual influence on agricultural productivity. Furthermore, evidence from Rwanda remains relatively limited at the district level, particularly in agriculturally important areas such as Musanze District. This geographical and conceptual gap limits understanding of how digital financial services contribute to agricultural productivity within specific local agricultural contexts.

Therefore, the study looked at how digital financial services affected smallholder farmers' agricultural output in Rwanda's Musanze District. It evaluated the impact of digital savings, digital payments, digital credit, and mobile money on agricultural output. The study offers a more thorough knowledge of the ways in which digital finance may assist agricultural production by looking at these elements independently. The need for empirical data to help policymakers, financial service providers, agricultural organizations, and development professionals create digital financial products and interventions that address the real financial and productive needs of smallholder farmers justifies the study. By offering district-level data from Rwanda, the findings further add to the expanding body of research on digital financial inclusion and agricultural development.

1.2 Problem statement

Despite Rwanda's progress in financial inclusion and the growth of mobile money, digital credit, digital savings, and digital payment services, agricultural productivity among smallholder farmers has not improved consistently. Farmers continue to face limited access to timely finance, underuse of productive inputs, high transaction costs, and unstable income, all of which constrain crop output and market participation. Musanze District, a major producer of potatoes, maize, and vegetables, has widespread access to digital financial services in principle, yet this availability does not confirm their actual influence on productivity. Existing

Rwandan studies emphasize financial inclusion broadly, leaving little district-level evidence on how each DFS dimension individually affects agricultural productivity. This study addresses that gap by examining whether, and to what extent, these four DFS dimensions influence agricultural productivity among smallholder farmers in Musanze District.

1.3. Objective of the study

1.3.1. General Objective

To assess the influence of digital financial services on agricultural productivity among smallholder farmers in Musanze District, Rwanda.

1.3.2. Specific objectives

1. To examine the influence of mobile money services on agricultural productivity among smallholder farmers in Musanze District, Rwanda.
2. To assess the influence of digital credit services on agricultural productivity among smallholder farmers in Musanze District, Rwanda.
3. To determine the influence of digital savings services on agricultural productivity among smallholder farmers in Musanze District, Rwanda.
4. To evaluate the influence of digital payment services on agricultural productivity among smallholder farmers in Musanze District, Rwanda.

1.4 Hypotheses of the study

H₀₁: Mobile money services have no significant influence on agricultural productivity among smallholder farmers in Musanze District.

H₀₂: Digital credit services have no significant influence on agricultural productivity among smallholder farmers in Musanze District, Rwanda.

H₀₃: Digital savings have no significant influence on agricultural productivity among smallholder farmers in Musanze District.

H₀₄: Digital payment services have no significant influence on agricultural productivity among smallholder farmers in Musanze District, Rwanda.

2. Literature Review

2.1. Conceptual review

2.1.1. Digital Financial Services

Digital Financial Services (DFS) are financial products and transactions delivered through digital technologies, including mobile phones, internet platforms, mobile applications, and electronic payment systems (World Bank, 2022). They include mobile money, digital credit, digital savings, and digital payments, which can expand financial inclusion by reducing geographical and transaction barriers. For smallholder farmers, DFS can facilitate access to financial resources, timely payments, savings, credit, and agricultural markets. However, effective utilization depends on accessibility, affordability, digital literacy, and trust (OECD, 2022). In this study, DFS are represented by mobile money, digital credit, digital savings, and digital payments.

2.1.2. Mobile Money Services

Mobile money refers to electronic financial services that enable users to store, send, receive, and withdraw funds through mobile phones without necessarily using conventional bank accounts (GSMA, 2023). For smallholder farmers, it facilitates agricultural payments, input purchases, labor costs, and transfers to suppliers and households. Mobile money can reduce transaction costs, improve liquidity management, and enhance access to financial services, particularly in rural areas. Evidence from East Africa shows that mobile money can strengthen financial inclusion and household economic resilience (Suri, 2022), while its expansion in Rwanda has increased access to financial services among rural populations (BNR, 2023). Thus, mobile money may support agricultural productivity by enabling timely financial transactions.

2.1.3. Digital Credit Services

Digital credit refers to loans accessed, processed, and disbursed through digital platforms such as mobile applications, USSD services, and online financial systems (OECD, 2022). For smallholder farmers, digital credit can provide timely working capital for purchasing seeds, fertilizers, pesticides, labor, and other agricultural inputs. It can reduce barriers associated with conventional lending and facilitate quicker access to financial resources (World Bank, 2023). However, effective use depends on affordability, financial literacy, responsible lending, and borrowers' repayment capacity (IMF, 2022). Thus, digital credit may support agricultural productivity by enabling farmers to make timely investments in production activities.

2.1.4. Digital Savings Services

Digital savings involve depositing and managing money through electronic accounts and mobile-based financial platforms (Demirgüç-Kunt et al., 2022). They are particularly relevant to smallholder farmers whose incomes are often seasonal and unpredictable. Digital savings enable farmers to accumulate resources for

future production, manage income fluctuations, and finance agricultural inputs and unexpected expenses. They can also promote financial discipline and reduce the risks associated with holding cash. Access to savings services can strengthen investment capacity and economic resilience (World Bank, 2023). In Rwanda, digital financial products have expanded opportunities for farmers to manage and save agricultural income electronically (BNR, 2023).

2.1.5. Digital Payment Services

Digital payment services involve electronic transactions conducted through mobile money, banking applications, digital wallets, cards, QR codes, and other digital platforms. For smallholder farmers, they facilitate payments to suppliers, workers, transporters, and other agricultural service providers, as well as receipt of payments from buyers. Digital payments can reduce transaction costs, delays, and risks associated with cash transactions while improving the efficiency and transparency of agricultural transactions (World Bank, 2022). By enabling faster and more secure payments, digital payment services can support timely access to agricultural inputs and markets, potentially improving farm efficiency and productivity.

2.1.6. Agricultural Productivity

The efficiency with which resources like land, labor, money, and other inputs are converted into agricultural outputs are known as agricultural productivity (FAO, 2022). Indicators including crop production, farm income, output value, and input efficiency can be used to evaluate it. Access to markets, information, technology, financial resources, and productive inputs all affect smallholder farmers' output. By facilitating timely input purchases, lowering transaction costs, increasing market participation, and boosting access to financing, digital financial services may boost productivity. The dependent variable in this study is agricultural productivity, which is determined by market participation, crop production, farm revenue, input-use efficiency, and access to agricultural information.

2.2. Theoretical Review

2.2.1. Access to Credit Theory holds that access to financial resources enables investment in productive activities. It underpins the study's focus on whether digital credit helps farmers overcome financial constraints to purchase inputs like seeds, fertilizer, and labor.

2.2.2. Technology Acceptance Model (TAM) (Davis, 1989) explains technology adoption through perceived usefulness and ease of use, framing why farmers adopt mobile money and digital payment services.

2.2.3. Agricultural Household Production Theory discusses how farm households divide their limited resources land, labor, capital, and income between productivity and consumption, connecting financial access and digital savings to improved resource planning, input acquisition, and market involvement.

2.2.4. Financial Intermediation Theory explains how financial systems transfer resources between savers and borrowers while reducing transaction costs and information barriers, supporting the overall link between all four DFS dimensions and agricultural productivity.

The study was informed by the theoretical proposition that improved access to financial resources can enhance households' ability to acquire productive assets and inputs, manage financial risks, and participate in economic activities. Within agriculture, digital financial services can therefore influence productivity by improving the availability, accessibility, and management of financial resources.

2.3. Empirical Review

This section reviews prior empirical studies examining how digital financial services mobile money, digital credit, digital savings, and digital payments influence agricultural productivity across different contexts.

2.3.1. Mobile Money and agricultural Productivity

Mobile money has been widely studied as a financial inclusion tool, particularly in rural areas lacking traditional banking access. In Kenya, Kimani and Ouma (2023) found that services like M-Pesa improved farmers' ability to manage earnings and receive market payments, leading to better output through increased liquidity and greater investment in high-yield seeds and fertilizer. Similarly, Mwakyusa and Msuya (2022) observed in Tanzania that mobile money adoption boosted agricultural productivity by reducing transaction costs and improving smallholder farmers' access to market payments.

2.3.2. Digital credit and Agricultural Productivity

Digital loans enhance agricultural productivity by offering smallholder farmers quick, low-documentation access to credit (Smith & Johnson, 2021). These loans enable investment in seeds, fertilizers, and machinery (Kumar et al., 2021), with flexible repayment plans aligned to farming cycles (Ochieng, 2019). Alternative data-driven credit assessments improve financial inclusion for underserved farmers (Chen & Wang, 2022), enabling adoption of climate-smart practices and risk mitigation (Miller et al., 2021). Overall, digital loans empower farmers to boost productivity, profitability, and agricultural sector development (World Bank, 2020).

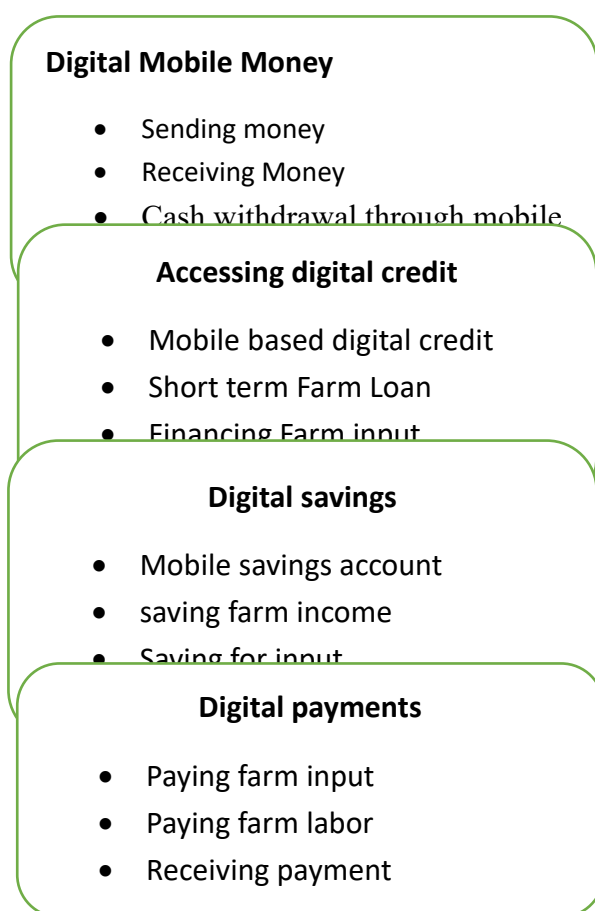
2.3.3. Digital Savings and Agricultural Productivity

Internet banking boosts agricultural productivity by improving farmers' access to capital, streamlining transactions, and enhancing financial literacy, particularly in -underserved rural areas (Mothobi & Grzybowski, 2019). Access to credit enables investment in seeds, fertilizer, and irrigation, improving yields (FAO, 2020). Digital payments reduce risks associated with cash handling, ensuring faster, more secure transactions between farmers, suppliers, and buyers (World Bank, 2022). Digital savings tools also support better financial planning, enabling farmers to save during harvest and access funds during lean periods, strengthening resilience (Aker et al., 2021).

2.3.4. Digital Payments and Agricultural Productivity

Independent variables

Digital Financial Services



Dependent variable

Agricultural productivity

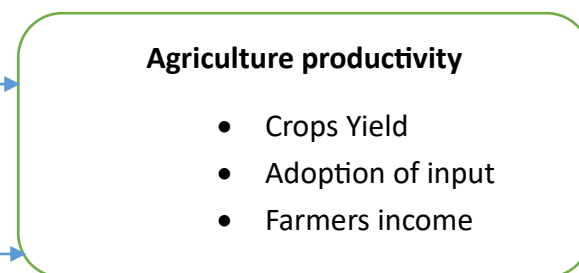


Figure 1 Conceptual Framework

Source. Researcher, 2026

2.5. Research Gap

Digital payments are cashless electronic transactions conducted via mobile platforms, banking apps, cards, or QR codes (World Bank, 2023), enabling secure, fast, and traceable transactions between farmers, cooperatives, financial institutions, and suppliers, as well as direct government subsidies and donor transfers. Integration with internet banking streamlines supply chain operations, reduces transaction costs, and eliminates payment delays. By facilitating direct payments, digital banking helps farmers avoid costly intermediaries, maximizing profitability. Transparency in digital systems also enables farmers to track transactions and receive payments promptly, strengthening trust in the agricultural financial ecosystem (Aker et al., 2021)

2.4. Conceptual Framework

Existing studies confirm that digital financial services improve economic and agricultural outcomes through better liquidity, reduced transaction costs, and increased

investment in inputs (Kimani & Ouma, 2023; Smith & Johnson, 2021; World Bank, 2022, 2023). However, three gaps remain a geographical gap, with evidence concentrated in Kenya and Tanzania rather than Rwanda; a contextual gap, as studies emphasize financial inclusion or income rather than agricultural productivity; and an empirical gap, with limited research on the individual and combined influence of the four DFS dimensions. This study addresses these gaps using descriptive statistics, correlation, and regression analysis among smallholder farmers in Musanze District, Rwanda.

3. Methodologies

This study adopted a quantitative research design, appropriate for measuring relationships between identifiable variables and determining the extent to which digital financial services were associated with agricultural productivity among smallholder farmers. The quantitative approach enabled systematic collection of numerical data and the application of statistical techniques to establish patterns and relationships within the population, facilitating measurement of farmers'

experiences with digital financial services alongside their reported agricultural productivity.

The target population comprised 5,500 smallholder farmers in Musanze District, Rwanda, selected for their significant role in agricultural production and their potential to benefit from improved access to financial services. From this population, a sample of 373 farmers was drawn yielding 332 valid responses an 89.0% response rate that provided a strong basis for statistical analysis. These 332 respondents formed the empirical foundation for examining the relationship between the four dimensions of digital financial services (mobile money, digital credit, digital savings, and digital payment services) and agricultural productivity in the district.

4. Result and Discussion

4.1. Descriptive statistics of Mobile money

Table 1: Descriptive Statistics on Mobile Money Services

Statements	N	M	SD
I use mobile money to purchase agricultural inputs such as seeds, fertilizers, and pesticides.	332	4.02	0.824
I receive payments from buyers of my agricultural produce through mobile money.	332	4.25	0.983
I can easily withdraw cash from mobile money agents whenever I need funds for agricultural activities.	332	4.25	0.689
Using mobile money has reduced the risks associated with carrying cash when buying farm inputs or selling agricultural produce.	332	3.33	0.595
Mobile money helps me save time when making payments related to my farming activities.	332	4.25	0.603
Overall Mean		4.02	

Source: Primary data, 2026 –**Key:** Mean: M, Standard Deviation: SD

Findings show mobile money services positively influence agricultural productivity among smallholder farmers in Musanze District (mean = 4.02, SD = 0.739). Farmers use mobile money to purchase inputs, withdraw cash from agents, and receive payments from produce buyers efficiently, while it also saves time and moderately reduces cash-handling risks. These benefits improve liquidity, reduce transaction costs, and enable

timely agricultural investment. The results align with the Technology Acceptance Model and Financial Intermediation Theory, and corroborate prior studies (Kimani & Ouma, 2023; Mwakyusa & Msuya, 2022; Suri, 2022; BNR, 2023), confirming mobile money's role in enhancing financial accessibility, operational efficiency, and overall agricultural productivity.

Table 2: Descriptive Statistics on Digital Credit Services

Statements	N	M	SD
I use digital loans to purchase agricultural inputs such as seeds, fertilizers, and pesticides.	332	4.24	0.994
Digital credit enables me to obtain farming inputs at the right planting season.	332	4.52	0.718
Access to digital credit has improved my ability to expand agricultural production.	332	3.22	0.466
Digital credit services have reduced delays in financing my farming activities.	332	4.24	0.987
Digital credit has enabled me to increase crop production by investing in improved farming practices.	332	4.25	0.602
Overall Mean		4.09	

Source: Primary data, 2026 –**Key:** Mean: M, Standard Deviation: SD

Digital credit services positively influence agricultural productivity among smallholder farmers in Musanze District (mean = 4.09, SD = 0.753). Farmers reported using digital loans to purchase inputs on time, particularly during planting season, reducing financing delays and enabling investment in improved farming practices. Farm expansion showed only moderate improvement, reflecting persistent constraints such as

limited loan sizes and repayment burdens. These findings align with the Access to Credit and Financial Intermediation theories, and corroborate prior research (Smith & Johnson, 2021; Kumar et al., 2021; Chen & Wang, 2022; World Bank, 2020), confirming digital credit's role in enhancing financial access, timely production decisions, and agricultural productivity.

Table 3: Descriptive Statistics on Digital Savings Services

Statements	N	M	SD
I use digital savings services to save money for purchasing agricultural inputs during the planting season.	332	4.57	0.739
Digital savings help me keep money safely for future farming activities.	332	4.24	0.496
Saving money through digital platforms enables me to respond quickly to unexpected farming expenses.	332	4.37	0.695
Digital savings services encourage me to invest more in agricultural production.	332	4.25	0.803
Using digital savings services has improved my financial preparedness for farming activities.	332	4.38	0.651
Overall Mean		4.36	

Source: Field data, 2026 –**Key:** Mean: M, Standard Deviation: SD

Digital savings services positively influence agricultural productivity among smallholder farmers in Musanze District (mean = 4.36, SD = 0.677). Respondents reported saving for planting-season inputs, improved financial preparedness, and quicker responses to unexpected farming expenses, while also being encouraged to invest more and store funds securely. These findings align with the Agricultural Household

Production Theory and Financial Intermediation Theory, and corroborate prior research (Demirgüç-Kunt et al., 2022; World Bank, 2023; BNR, 2023; Aker et al., 2021), confirming that digital savings strengthen farmers' financial resilience, enable disciplined resource mobilization, and support productive investment, ultimately contributing to improved agricultural productivity.

Table 4: Descriptive Statistics on Digital Payment Services

Statements	N	M	SD
I use digital payment services to pay for agricultural inputs purchased from suppliers.	332	4.31	0.748
Digital payment services enable me to receive payments for my agricultural produce more quickly.	332	4.32	0.71
Digital payment services have reduced delays in completing financial transactions related to farming activities.	332	4.25	0.803
Using digital payment services has improved the efficiency of buying and selling agricultural products.	332	4.25	0.983
Digital payment services have made financial transactions in my farming activities more secure and convenient.	332	4.3	0.719
Overall Mean		4.29	

Source: Field data, 2026 –**Key:** Mean: M, Standard Deviation: SD

Digital payment services positively influence agricultural productivity among smallholder farmers in Musanze District (mean = 4.29, SD = 0.793). Respondents reported faster receipt of payments for produce, convenient payment of input suppliers, enhanced transaction security, reduced delays, and improved marketing efficiency. These benefits strengthen cash flow, financial management, and market

participation, contributing to timely execution of farming activities and increased productivity. The Financial Intermediation Theory, which emphasizes how effective financial systems lower transaction costs and facilitate transactions throughout the agricultural value chain, and the Technology Acceptance Model, which explains adoption through perceived usefulness and ease of use, corroborate the results

Table 5: Descriptive Statistics on Agricultural Productivity

Statements	N	M	SD
My agricultural production has increased over the past three years.	332	3.96	0.819
I harvest more crops because I can access agricultural inputs on time.	332	4.25	0.703
My farming income has improved due to increased agricultural production.	332	4.24	0.994
I am able to sell a larger proportion of my agricultural produce in the market.	332	4.52	0.718
My overall farming productivity has improved compared to previous farming seasons.	332	3.85	0.654
Overall Mean		4.16	

Source: Field data, 2026 –**Key:** Mean: M, Standard Deviation: SD

Agricultural productivity among smallholder farmers in Musanze District has generally improved (mean = 4.16, SD = 0.778). Respondents reported greater market participation, timely input access enabling higher yields, increased farming income, and gradual production growth over three years, though overall productivity gains were more modest than other indicators. These improvements suggest farmers are becoming more market-oriented and commercially productive, partly

attributable to digital financial services enhancing access to finance, inputs, and markets. Findings align with FAO (2020), World Bank (2023), and BNR (2023), confirming that digital financial services strengthen agricultural commercialization, financial inclusion, and rural household incomes in Rwanda.

4.2. Inferential Statistics

Table 6. Pearson Correlation Matrix

		X1	X2	X3	X4	Y
Mobile Money Services (X ₁)	Pearson Correlation	1				
	Sig. (2-tailed)					
	N	332				
Digital Credit Services (X ₂)	Pearson Correlation	.878**	1			
	Sig. (2-tailed)	.000				
	N	332	332			
Digital Savings Services (X ₃)	Pearson Correlation	.558**	.598**	1		
	Sig. (2-tailed)	.000	.000			
	N	332	332	332		
Digital Payment Services (X ₄)	Pearson Correlation	.979**	.875**	.551**	1	
	Sig. (2-tailed)	.000	.000	.000		
	N	332	332	332	332	
Agricultural Productivity (Y)	Pearson Correlation	.843**	.770**	.722**	.820**	1
	Sig. (2-tailed)	.000	.000	.000	.000	
	N	332	332	332	332	332

** . Correlation is significant at the 0.01 level (2-tailed).

Pearson correlation results reveal statistically significant, strong positive relationships between all four digital financial service dimensions and agricultural productivity in Musanze District ($p = 0.000$, $\alpha = 0.01$). Mobile money showed the strongest association ($r = 0.843$), followed by digital payment services ($r = 0.820$), digital credit ($r = 0.770$), and digital savings ($r = 0.722$). These findings indicate that farmers who actively use these services are better positioned to access inputs on time, finance farming activities, participate in markets, and manage finances efficiently. Overall, greater adoption of digital financial services is associated with improved agricultural productivity among smallholder

farmers.5.6 Overall Influence of Digital Financial Services

4.2.1. Linear Regression Analysis

Multiple linear regression was conducted to determine how mobile money, digital credit, digital savings, and digital payment services jointly predict agricultural productivity in Musanze District, while controlling for each other's effects. Model fitness, explanatory power, and predictor significance were assessed using the Model Summary, ANOVA, and Regression Coefficients tables.

Table 7: Model Summary

Model	R	R Square	Adjusted Square	R Std. Error of the Estimate
1	.900 ^a	.810	.807	.22151

a. Predictors: (Constant), Digital Payment Services, Digital Savings Services, Digital Credit Services, Mobile Money Services

The regression model shows strong explanatory power, with an R Square of 0.810, indicating that 81.0% of the variation in agricultural productivity among smallholder farmers in Musanze District is explained by the four DFS dimensions combined. The Adjusted R Square (0.807) confirms this high explanatory power after accounting for the number of predictors, while the low Standard

Error of the Estimate (0.222) indicates good model fit. These results demonstrate that digital financial services are important determinants of agricultural productivity, suggesting that policymakers, financial institutions, and stakeholders should continue promoting DFS adoption and accessibility to enhance farmers' input purchasing, financing, and market participation.

Table 8: ANOVA Results

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	67.659	4	16.915	347.970	.000 ^b
	Residual	15.898	327	.049		
	Total	83.557	331			

a. Dependent Variable: Agricultural Productivity

b. Predictors: (Constant), Digital Payment Services, Digital Savings Services, Digital Credit Services, Mobile Money Services

ANOVA results confirm that the overall regression model was statistically significant, $F(4, 327) = 347.970$, $p < 0.001$, demonstrating that the model significantly outperformed one without the independent variables in predicting agricultural productivity. This finding supports rejection of the null hypothesis that digital financial services have no collective influence on agricultural productivity among smallholder farmers in

Musanze District. Consequently, mobile money, digital credit, digital savings, and digital payment services jointly and significantly explained variations in agricultural productivity, confirming the regression model's appropriateness for examining the relationship between digital financial services and agricultural productivity among smallholder farmers in Musanze District, Rwanda.

Table 9: Regression Coefficients Results

Model	Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	T	Sig.
(Constant)	.752	.128		5.867	.000
Mobile Money Services (X1)	.811	.112	.881	7.241	.000
Digital Credit Services (X2)	.132	.045	.148	2.933	.004
Digital Savings Services (X3)	.511	.042	.371	12.167	.000
Digital Payment Services (X4)	.296	.081	.255	3.654	.000

a. Dependent Variable: Agricultural Productivity

Regression coefficients show mobile money ($\beta = 0.881$), digital credit ($\beta = 0.148$), digital savings ($\beta = 0.371$), and digital payment services ($\beta = 0.255$) all had positive, statistically significant influences on agricultural productivity, with mobile money the strongest predictor. Findings align with TAM, Access to Credit Theory, Agricultural Household Production Theory, and

Financial Intermediation Theory, and are consistent with prior studies (Kimani & Ouma, 2023; Smith & Johnson, 2021; Demirgüç-Kunt et al., 2022). All null hypotheses were rejected ($p < 0.05$), confirming digital financial services significantly enhance farmers' financial access, input acquisition, and agricultural productivity in Musanze District.

Table 10: Summary of Hypotheses Testing

Hypothesis	Beta (β)	t-value	Sig.	Decision
H₀₁: Mobile money services have no statistically significant influence on agricultural productivity among smallholder farmers in Musanze District.	0.881	7.236	.000	Rejected
H₀₂: Digital credit services have no statistically significant influence on agricultural productivity among smallholder farmers in Musanze District.	0.881	7.241	.000	Rejected
H₀₃: Digital savings services have no statistically significant influence on agricultural productivity among smallholder farmers in Musanze District.	0.148	2.933	.004	Rejected
H₀₄: Digital payment services have no statistically significant influence on agricultural productivity among smallholder farmers in Musanze District.	0.371	12.167	.000	Rejected

Source: Field data, 2026

5. Conclusion and Recommendation

5.1. Conclusion

This study examined the effect of digital financial services on agricultural productivity among smallholder farmers in Musanze District, Rwanda, focusing on Mobile Money Services (MMS), Digital Credit Services (DCS), Digital Savings Services (DSS), and Digital Payment Services (DPS). Descriptive statistics, Pearson correlation, and multiple regression techniques were applied to a sample of 332 smallholder farmers after confirming that the model met the requirements of statistical adequacy. The regression model was statistically significant ($F = 347.970$, $p < 0.001$) and explained 81.0% ($R^2 = 0.810$) of the variation in agricultural productivity, indicating that digital financial services significantly contribute to explaining differences in agricultural productivity among smallholder farmers in Musanze District.

The findings showed that Mobile Money Services (MMS) had the strongest significant positive effect on agricultural productivity ($\beta = 0.881$, $p < 0.001$), emphasizing its central role in facilitating timely input purchases and efficient payments. Digital Savings Services (DSS) also had a significant positive effect ($\beta = 0.371$, $p < 0.001$), followed by Digital Payment Services (DPS) ($\beta = 0.255$, $p < 0.001$) and Digital Credit Services (DCS) ($\beta = 0.148$, $p = 0.004$), which, although statistically significant, recorded the weakest influence among the predictors. The study concludes that expanding access to mobile money and strengthening digital savings mechanisms are the most important financial practices for improving agricultural productivity and sustainable rural livelihoods among smallholder farmers in Rwanda.

5.2. Recommendations

Based on the findings of this study, the following recommendations have been made:

1. Financial service providers should expand digital financial services tailored to the needs of smallholder farmers. Products should reflect agricultural production cycles and farmers' seasonal income patterns.
2. Policymakers and financial institutions should strengthen access to appropriate digital credit. Digital agricultural credit should be affordable, transparent, and structured around farmers' capacity to repay after generating agricultural income.
3. Digital savings products should be promoted among smallholder farmers. Financial education programs can help farmers understand the benefits of saving and develop

habits of allocating agricultural income toward future production.

4. Digital payment infrastructure should be expanded and strengthened throughout rural agricultural areas. Reliable digital payment systems can reduce transaction costs and facilitate interactions among farmers, suppliers, buyers, cooperatives, and financial institutions.
5. Farmers should receive greater digital and financial literacy training. Access to technology does not automatically guarantee effective utilization. Farmers need the knowledge and skills required to conduct digital transactions safely, understand financial products, manage digital credit, and protect themselves against fraud.
6. Digital financial service providers should prioritize reliability and affordability. Network interruptions, transaction charges, limited access points, and other barriers can reduce the usefulness of digital services, particularly for smallholder farmers operating on narrow margins.
7. Agricultural institutions should strengthen collaboration with financial service providers. Such collaboration can facilitate the development of digital financial products linked to agricultural value chains, farmer cooperatives, input supply systems, and agricultural markets.

5.3. Overall Contribution of the Study

The study contributes to the growing literature on digital financial inclusion and agricultural development by demonstrating that digital financial services are relevant to the economic activities of smallholder farmers in Rwanda. Rather than considering digital finance as a single service, the study examined four dimensions: mobile money, digital credit, digital savings, and digital payments, providing a more differentiated understanding of the potential pathways through which digital finance can support agriculture.

The strong positive relationship between mobile money and agricultural productivity further emphasizes the potential importance of mobile-enabled financial services in rural economies. The findings provide evidence that digital financial inclusion can extend beyond general household financial access and become an enabling factor within agricultural production and market systems.

For Rwanda, where agricultural transformation and digitalization are important components of socioeconomic development, strengthening the connection between digital financial services and smallholder agriculture represents an important policy opportunity.

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