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INVESTIGATING THE ROLE OF DIGITAL FINANCE IN THE FINANCIAL RESILIENCE OF SMALLHOLDER FARMERS IN ADAMAWA STATE, NIGERIA

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ABSTRACT

Smallholder farmers frequently experience exclusion from formal financial systems, and this situation constrains their productive capacity, heightens vulnerability to shocks and weakens their ability to cultivate resilience. This paper explores the contribution of digital finance to the financial resilience of smallholders in Adamawa State, North-East Nigeria; a region simultaneously navigating economic fragility and climate-induced volatility. The population for this study is 1,728,800 smallholder farmers from nine (9) LGAs purposively selected from each of the three senatorial zones in the state. The multi-stage sampling approach was employed to select the research respondents for this study. The data was collected through a structured questionnaire administered to 400 farmers out of which 377 were filled and returned. The analytical strategy leaned on Partial Least Squares Structural Equation Modelling (PLS-SEM). Findings demonstrate that digital agriculture and social security exert significant and positive effects on financial resilience explained by 0.68 and 0.26 coefficients. Conversely, access to digital financial services though positively related but does not significantly predict resilience, likewise, insurance displayed a negative but significant association showing it did not reveal a consequential influence in resilience as explained by coefficients of 0.06 and -0.20 respectively. The study recommends investment in digital agricultural interventions including mobile tools for climate information, extension services and advise, digital platform for market access and prices. A foundational improvement of expanding mobile network coverage, improving internet connectivity, stabilising electricity supply and training in local languages and leveraging practical demonstrations are prerequisites for farmers to use digital services consistently and confidently. Also, authorities should align social protection programmes with climate adaptation initiatives such as funding for drought-resistant packages which magnify resilience effects. Insurance products should be redesigned to better meet farmers needs and efforts should be intensified to improve awareness and understanding of products among the farmers. Lastly, other researchers should extend the geographic scope to other Northern states facing similar climatic and socio-economic challenges, enabling regional comparisons.

Keywords*:* Digital finance, financial resilience, Smallholder farmers, Climate change, Northeastern Nigeria
JEL Classification Code:

Introduction

The fusion of digital innovation with financial services has reshaped the contours of economic participation worldwide, presenting new pathways for inclusion in settings where formal banking networks are absent (Dube et al., 2021). The development of the digital economy (digital finance) is highly uneven across the globe with different initiatives in the international community. The United States and China champion the digital world today as they control most of the relevant technologies and resources. In the global sphere, digital technologies have

induced changes in most industries including the agricultural sector by improving farm-level decision-making, giving farmers access to real-time weather, market pricing, and agricultural extension services, which results in improving the productivity, efficiency, and sustainability of methods of growing food (Abbasi et al., 2022). Although significant progress has been recorded by some sub-Saharan African countries, in including Nigeria as International Telecommunication Union as cited by Ozili (2018) shows that most developing countries still face considerable challenges while using digital technology in business transactions. In Adamawa State, where agriculture remains the backbone of household income, this transformation can potentially alter the lives of the poor. Climate change intensifies the stakes by introducing erratic rainfall, prolonged dry spells, and more frequent extreme weather events. Consequently, farmers must navigate not only the variability of markets and input prices but also a rapidly changing ecological backdrop that tests the resilience of traditional farming practices.

Digital finance covers a range of tools such as mobile money, online payments, agent banking, digital wallets, and agritech platforms that collectively lower the cost of delivering financial services to underserved communities. Scholars such as Huang and Tao (2019) have underscored how digital finance plugs gaps left by conventional banking by leveraging mobile networks and data technologies. These channels diminish the necessity for brick-and-mortar branches, thereby slashing costs and shortening the distance between service providers and rural populations.

Within the agriculture sector, the stakes are particularly high. Smallholders, who comprise close to 80 per cent of the agricultural workforce in many developing countries and produce the lion's share of food (Shimeles et al., 2018; Tsan et al., 2019) routinely struggle to obtain formal credit, secure insurance policies, and maintain consistent access to markets. Climate variability exacerbates these constraints (Ncoyini et al., 2022). Weather anomalies can destroy crops, undercut yields, and reduce household savings. In such a context digital finance presents a compelling opportunity as it can streamline payments, facilitate saving behaviour, support prudent borrowing and even provide access to index-based insurance products tailored to climate risk.

The study identifies a knowledge gap: while global research on digital finance and agricultural resilience is growing, evidence from North-East Nigeria and Adamawa State in particular is sparse. This study seeks to fill that void by testing four null hypotheses that examine the influence of insurance, digital agriculture, digital financial services access, and social security on the financial resilience of smallholder farmers in Adamawa State, Nigeria.

The four research hypotheses expressed in their null form were formulated as follows.

i. Ho1: Insurance has no impact on the financial resilience of smallholder farmers in Adamawa State.
ii. Ho2: Digital agriculture has no impact on the financial resilience of smallholder farmers in Adamawa State.
iii. Ho3: Access to digital services has no impact on the financial resilience of smallholder farmers in Adamawa State.
iv. Ho4: Social security has no impact on the financial resilience of smallholder farmers in Adamawa State.

The remaining paper is organised into sections two, three, four and five, covering the discussion of literature, details of the methodology, analysis of results and discussion, conclusions and recommendations.

2.0 Literature Review

2.1 Conceptual Review

2.1.1 Concept of Digital Finance

Digital finance operates at the intersection of technology, regulation, and user behaviour. Digital finance denotes financial services such as payments, savings, lending, insurance, and wealth management delivered primarily through digital channels. These services often rely on mobile phones and agent networks that allow users to cash in cash out, transfer funds, and access support without visiting traditional bank branches. With smartphones and basic feature phones increasingly accessible, digital ecosystems now blend communication tools, data analytics, and financial engineering to serve clients traditionally considered too risky or too remote (Otitoju et al., 2023). Digital financial inclusion has been defined as the deployment of cost-saving digital means to reach currently financially excluded and underserved populations with a range of formal financial services suited to their needs responsibly delivered at a cost affordable to customers and sustainable for providers (Godfrey et al., 2019).

In rural contexts particularly for smallholder farmers, digital finance opens avenues to resources previously out of reach. Mobile money platforms can accelerate the receipt of remittances from family members in urban areas, smoothing consumption when harvests fail. Digital savings tools allow farmers to set aside small amounts of income incrementally, building buffers that cushion against lean seasons. Agricultural e-commerce platforms connect farmers directly with buyers, reducing information asymmetries and in some cases improving farm-gate prices. Access to digital credit products particularly those underwritten by alternative data such as mobile transaction histories can help overcome the absence of collateral or formal credit histories.

2.1.2 Concept of Financial Resilience

Financial resilience is understood as the capability to absorb, adapt to, and recover from adverse financial events. For smallholder farmers, resilience may manifest in maintaining consumption during crop failure, repaying loans even when market prices drop or financing new farming methods when faced with long-term climatic shifts. Digital finance can bolster resilience by diversifying income sources, simplifying access to savings and credit, reducing transaction costs, and providing timely information that supports agile decision-making (Zhao & Shi, 2018).

2.2 Theoretical Framework: Asset and Income-Risk Poverty Theory

The theoretical lens guiding this research is grounded in the asset and financial/income risk poverty theory. This perspective, rooted in neoclassical economics posits that households with more assets either physical (land, livestock, equipment), financial (savings, investments) or human (skills, education) are better positioned to withstand income shocks. When unexpected events occur such as crop losses or medical emergencies, asset-rich households can liquidate or leverage their holdings to bridge the gap. By contrast, asset-poor households have limited options, making them more susceptible to falling into or remaining in poverty after shocks (Micheal & Travis, 2012).

In the context of digital finance, this theory helps explain why specific financial tools might be more effective than others. Digital agriculture platforms that supply real-time price or weather data, for instance can help farmers invest in seeds or irrigation that yield higher returns, thus expanding their asset portfolios. Similarly, digital savings accounts enable households to accumulate financial capital over time. Social security payments delivered electronically such as conditional cash transfers or pensions can serve as stable income

streams that offset shocks. Meanwhile, poorly designed or underutilised insurance products may fail to deliver value if claims are difficult to process, premiums are unaffordable or the coverage does not align with the actual risks farmers face. By applying this theoretical framework, the study connects digital finance components to tangible resilience outcomes, framing digital tools as mechanisms that either facilitate or hinder asset growth and risk management.

2.3 Empirical review

A growing body of empirical research probes how digital finance influences inclusion, productivity and resilience across diverse contexts. Naveed (2025) examined the diffusion of digital banking in emerging markets, and concluded that mobile banking, digital wallets, and online payment systems are narrowing gender and rural-urban financial gaps. These tools bring banking interfaces into the hands of users who previously lacked physical branch access. In Ghana, Joseph et al. (2025) compared smallholder farmers linked to closed and active microfinance institutions (MFIs). Their findings show that when MFIs shut down, farmers lose access to loans, insurance, and business development services -yet productivity declines were modest because farmers drew on prior financial literacy, social networks, and alternative financing. The study suggest that resilience can stem from a blend of resources not just formal finance.

Dennis (2024) conducted a scoping review of technologies employed by smallholders across sub-Saharan Africa. The review catalogues digital innovations extension platforms, remote sensing technologies, mobile-based market information and highlights both opportunities and obstacles. Challenges include infrastructural deficits, limited digital literacy, and the need for localised content.

Mukaila (2024) assessed the drivers and their impact on fish farms' yields and income in Nigeria using Microcredit via digital innovation platforms. The results revealed that ownership of smartphones, awareness of digital agricultural innovation platforms, farmers' education, income, fish farming as a primary occupation, cooperative society and extension contacts positively influence farmers' access to microcredit from digital innovation platforms. Implying that Digital microcredit positively and significantly impacted fish farms' yield and farmers' income.

Gao and Gao (2024) analysed the impact of digital financial inclusion on agricultural industry chain resilience in China. They observed that digital financial services boost marketing and distribution resilience more noticeably than production or processing resilience. This suggests that digital finance may initially ease bottlenecks in market access and logistics before permeating upstream stages. Otitoju et al. (2023) assessed digital financial inclusion efforts in Nigeria and found that farmers' needs are often underserved. Barriers include weak infrastructure, difficulties in assessing creditworthiness, and insufficient financial and digital literacy. Gumbi et al. (2023) studied digital agriculture solutions, and concluded that a host of tools have been developed to address smallholder challenges, though scaling them sustainably remains a complex task.

Adeola (2023) reported that communities (Adamawa, Borno, Gombe, Yobe, Kebbi, Benue, Ebonyi, and FCT Abuja) in the North-Eastern region of Nigeria now benefit from the shared commitment of Mercy Corps and First City Monument Bank (FCMB) digital platforms to make a significant difference. Through their partnership and the USAID-funded "Feed the Future Nigeria Rural Resilience Activity," these institutions promote economic growth, social inclusion, and market resilience. Thereby transforming the lives of farmers and communities for a more sustainable and prosperous future.

Neves et al. (2023) conducted a meta-analysis covering 121 articles on digital financial services. They confirmed that perceived usefulness, ease of use, and security strongly influence adoption. Cultural dimensions also matter, as societies with stronger orientations toward monetary gain are more inclined to embrace digital finance when they deem it simple and secure. Parlasca et al. (2022) explored mobile financial service use among Kenyan farmers and discovered that while over 80 per cent used mobile money, only a small fraction applied it to agricultural transactions. This stresses that widespread adoption of mobile money for personal use does not automatically translate into transformative agricultural applications.

Dara (2018), as cited by Dube et al. (2021), argued that robust financial services sectors encourage saving and investment, thereby improving cash flows for low-income households and equipping them to handle emergencies. They further elaborated on digital finance's poverty reduction channels: cheaper remittances, improved credit conditions, and lower business costs.

McCampbell et al. (2021) tested smallholder banana farmers' readiness to use digital extension tools. Many required additional training, pointing to the need for capacity-building interventions. Coggins et al. (2021) discovered that a third of horticultural farmers in Kenya use digital platforms for market communication, though basic phone functions remained dominant. Kikulwe et al. (2019) showed that Kenyan farmers using mobile money sold a larger share of their produce and realised higher profits. Haider (2018) concluded that access to digital technologies, including mobile phones, the internet, and biometric authentication, opens the door for online banking and digital credit for the unbanked. Despite these extensive studies, few have scrutinised the nexus between digital finance and smallholder resilience in North-East Nigeria through a structural equation modelling lens.

3.0 Methodology

3.1 Research Design

The researchers adopted a cross-sectional survey design to capture farmers' experiences with digital finance and resilience. Respondents provided information at a single point in time, enabling the authors to map how different dimensions of digital finance correspond with resilience indicators.

3.2 Description of the study area

The study was carried out in rural Adamawa State, in the Northeast geopolitical zone of Nigeria, bordered by Borno to the Northwest, Gombe to the West, and Taraba to the Southwest, and shares a national border with Cameroon. Adamawa state comprises three geopolitical zones, which encompass the North, Central, and South zones with 21 local government areas distributed across the three zones. The twenty-one (21) Local Government Areas (LGAs) are Demsa, Fufore, Ganye, Girei, Gombi, Guyuk, Hong, Jada, Lamurde, Madagali, Maiha, Mayo-Belwa, Michika, Mubi North, Mubi South, Numan, Shelleng, Song, Toungo, Yola North, and Yola South, with Yola being the state capital. However, out of these (LGAs), the study was limited to two LGAs from the North: Michika and Maiha LGAs, three LGAs from the central zone: Gombi, Yola South, and Fufore LGAs, and four LGAs from the South zone: Mayo-Belwa, Ganye, Lamurde, and Shelenge, respectively, selected based on being high crop-producing areas.

3.3 Population and Sampling size

The study's targeted population is 1,728,800 smallholder farmers across the nine purposively selected Local Government Areas (LGAs) in Adamawa State. This population estimate was

derived from the National Population Commission (NPC) 2022 survey data projected at 2,161,000 residents, with the assertion that approximately 80 per cent of the state's residents engage in agriculture. The sample size of this study is 400 smallholder farmers determined using Slovin's formula. According to Adhikari (2021), Slovin's formula is necessary to determine the appropriate and sufficient sample size for a given population to ensure reliable estimates. Thus, the formula (Slovin's) is stated as:

$$n = \frac{N}{1 + N(e)^2}$$

Where:

N = population
e = error tolerance

Hence, in this study.

n = sample
N = farmers population (1,728,800)
e = error margin (5% i.e. 0.05)

$$n = \frac{1728800}{1 + 1728800(0.5)^2}$$

$$n = 400$$

The sample frame selection was as broad as the target population selection. The entire population of smallholder farmers in the smaller units was randomly selected, which makes up the sample frame. The Laplace (1814) sample frame formula was adapted.

The formula is:

$$S = \frac{V}{x} \times n$$

Where:

S = Sample frame
V = Population of each LGA
X = Total population of the nine selected LGAs
n = Sample size

Table 3.1: Selected LGAs with Farmer Population Distribution and Sample Frame

LGAs	Population	Sample Frame Procedure	Sample Frame
Michika	191,520	(191,520÷1,728,800) 400	44
Maiha	135,920	(135,920÷1,728,800) 400	31
Gombi	182,320	(182,320÷1,728,800) 400	42
Fufore	258,400	(258,400÷1,728,800) 400	60

Yola South	242,000	(242,000÷1,728,800) 400	56
Ganye	209,680	(209,680÷1,728,800) 400	49
Shelleng	183,200	(183,200÷1,728,800) 400	42
Lamuerde	137,280	(137,280÷1,728,800) 400	32
Mayo-Belwa	188,480	(188,480÷1,728,800) 400	44
Total	1,728,800		400

3.4 Sampling Technique

The multistage sampling technique was adopted for the selection of the Nine (9) LGAs purposively selection from the three (3) senatorial zones of the study area (Adamawa state) based on the number of local governments in each zone and being high crop-producing areas. The zone with more LGAs had higher chances of selection. Communities were further randomly selected from the Nine (9) LGAs based on being accessible communities with large farmlands for agrarian use. Respondents were also randomly selected from the smaller units (communities) with the assistance of the representative/agents of the smallholder farmers.

3.5 Method of Data Collection

The instrument for the data collection was the structured questionnaire, which was self-administered, featuring closed-ended items arranged on a five-point Likert scale ranging from "strongly disagree" (1) to "strongly agree" (5). The instrument comprised two sections: demographic details (age, gender, marital status, education, farming experience, geographic location, household size) and thematic items covering financial resilience, insurance, digital agriculture, access to digital financial services, and social security. The total questionnaires distributed was 400; however, the properly completed and returned were 377, hence used for the evaluation.

3.3 Data Analysis Procedures

The analytical plan combined descriptive statistics with multivariate techniques. Descriptive measures summarised demographic characteristics, while PLS-SEM analysed the relationships among latent constructs. PLS-SEM is particularly suited for exploratory models involving multiple constructs and indicators, especially when the research emphasises prediction.

Financial resilience is modelled as a function of insurance, digital agriculture, access to digital financial services, and social security, with estimated parameters capturing the strength and direction of each path as follows.

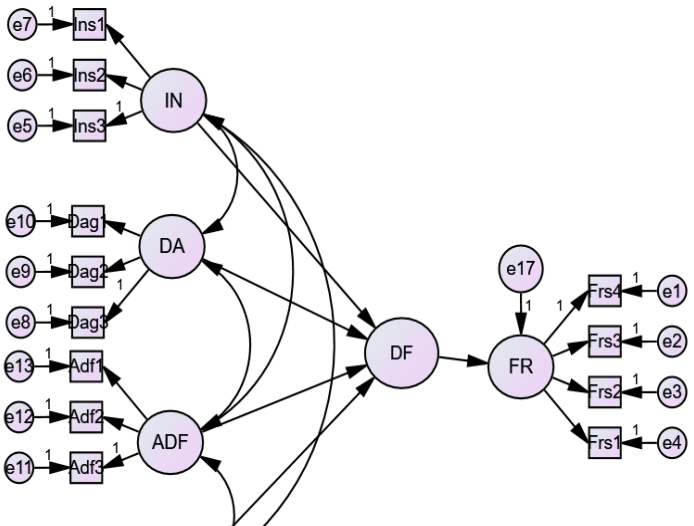

Figure 3.1: Path Analysis Model for an effect for Digital Finance Proxies on Financial Resilience of Smallholder Farmers in Adamawa State.

4.0 Results and discussion

4.1 Demographic Insights

The sample skews toward older adults: roughly nine in ten respondents were over 35, indicating that farming remains the livelihood of individuals in their productive years. The sample was predominantly male (234 respondents), reflecting gendered roles where men often own land or serve as household heads. Most participants were married (about 60.7 per cent), and the majority had completed at least primary or secondary education (343 respondents), suggesting literacy levels sufficient to engage with basic digital interfaces. Experienced farmers dominated the sample, with 89 per cent reporting six or more years in agriculture. The Southern zone provided the largest share of respondents (163 individuals), and a significant proportion (78 per cent) supported more than six dependants, highlighting the pressure to secure a steady income.

4.2 Measurement Model Validation

The analysis involved two stages: assessment of measurement models and evaluation of the structural model. The measurement model phase assessed reliability (factor loadings, Cronbach's alpha) and validity (Average Variance Extracted). Items with low loadings or high modification indices were removed to refine the constructs, specifically, one financial resilience item (Frs4) and one digital agriculture item (Dag1). Diagnoses for normality (kurtosis and skewness) confirmed that data fell within acceptable bounds, and variance inflation factor (VIF) tests indicated no problematic multicollinearity with values between 1.135 and 1.253.

The confirmatory factor analyses for first- and second-order constructs yielded factor loadings predominantly above 0.6 after removing underperforming items. Average Variance Extracted (AVE) values ranged from 0.50 to 0.63, meeting the threshold for convergent validity. The model's Goodness-of-Fit indices (model fit) of Goodness-of-Fit index (GFI) (0.921), Comparative Fit Index (CFI) (0.915), Incremental Fit Index (IFI) (0.916), Normed Fit Index (NFI) (0.883), Tucker–Lewis Index (TLI) (0.885), and Root Mean Square Error of Approximation (RMSEA) (0.077) indicated an acceptable fit. The chi-square statistic (214.743) and the ratio of chi-square to degrees of freedom (3.205) also fell within recommended limits, supporting the measurement model's adequacy.

4.3 Structural Model and Hypothesis Testing

Following validation of the measurement and structural models, the hypotheses were tested to assess the relationships among the study variables. The study's hypotheses examined the

path from digital financial inclusion, insurance, digital agriculture, access to digital financial services (credit and savings), and social security to the financial resilience of smallholder farmers in Adamawa State. The structural model results for the hypotheses are presented in Fig. 4.1 for the path analysis and in Table 4.2 for the regression model summary.

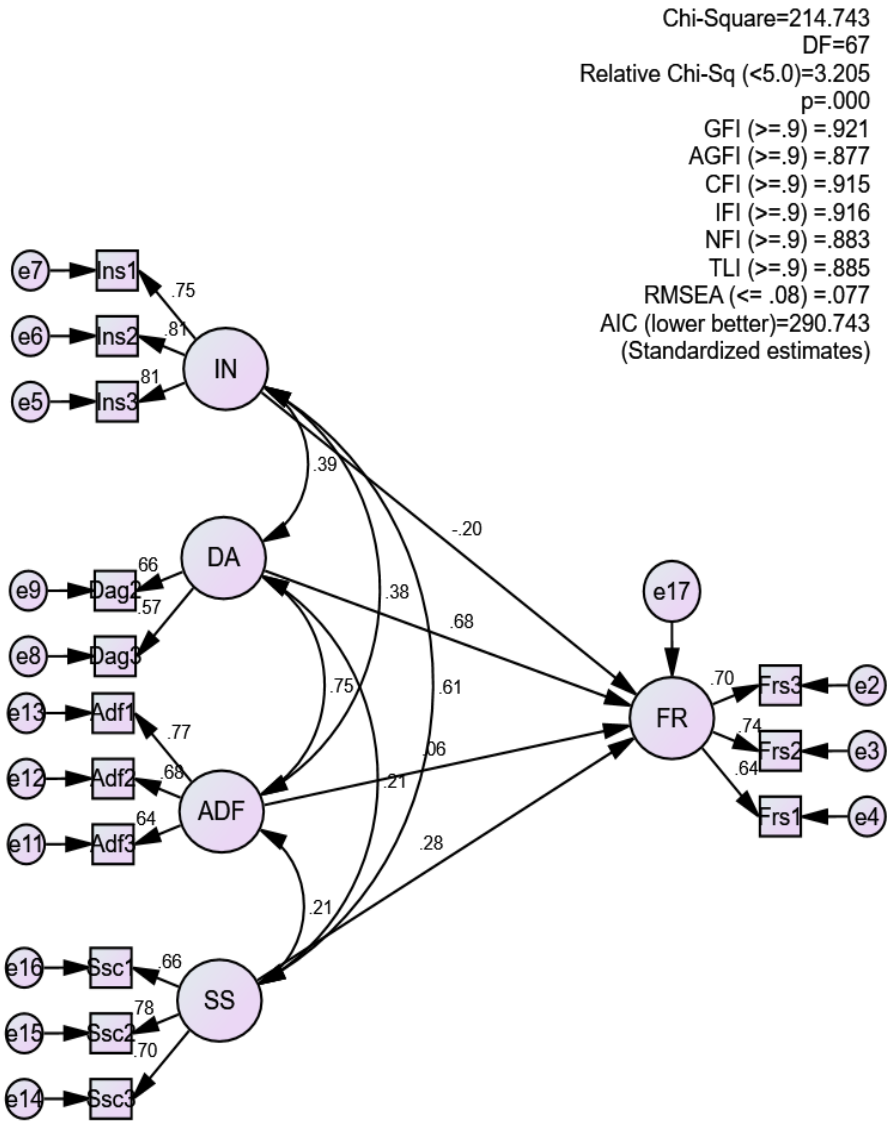

Figure 4.1: Structural Equation Model for the Hypothesised Role of Insurance, Digital Agriculture, Access to Digital Financial Services, and Social Security on Financial Resilience of Smallholder Farmers in Adamawa State.

Table 4.2: Regression Weights (Standardised) for Sub-Hypothesis

Hypothesised relationships	Estimate	S.E.	C.R.	P-value	Decision		
FR	<--	IN	-.20	.08	-1.98	.05	Rejected
FR	<---	DA	.68	.22	3.37	.000	Rejected
FR	<---	ADF	.06	.16	.35	.73	Accepted
FR	<---	SS	.28	.08	3.03	.000	Rejected

Notes: FR:- financial resilience; ADF:- access to digital financial services; DAG:- digital agriculture; IN:- insurance; SS:- social security; S.E.:- Standard Error; CR:- Critical Ratio.

Table 4.2 presents the results for hypotheses testing. The analysis evaluates the influence of insurance, digital agriculture, access to digital the financial services, and social security on financial resilience of smallholder farmers in Adamawa State.

The structural model produced a standardised path coefficient of -0.20 with a p-value of 0.05, indicating a significant negative relationship between insurance and resilience. This implies that for every one-unit increase in insurance, financial resilience reduces by 0.20. Consequently, the null hypothesis 1 which posited that insurance has no effect on financial resilience was rejected. This suggests that smallholder farmers with lower financial resilience were more likely to take up insurance. Thus, indicating that existing insurance products may not effectively safeguard such farmers or that their penetration and usage are insufficient to influence resilience metrics. Claims processing challenges, limited coverage options or premium affordability could be contributing factors. This study's findings align with Neves et al. (2023) who conducted a meta-analysis covering 121 articles on digital financial services. They confirmed that perceived usefulness, ease of use, and security strongly influence adoption. Cultural dimensions also matter as societies with stronger orientations toward monetary gain are more inclined to embrace digital finance when they deem it simple and secure. Also, Dube et al. (2021) emphasised the relevance of a well-functioning financial services sector which will enable people to save thus building resilience in economies where savings are redirected towards operational expenses and invested in capital. This will result to improving cash flows for low-income consumers in unforeseen emergencies.

The relationship between digital agriculture and financial resilience revealed a coefficient of 0.68 with a p-value < 0.001, thus indicating a positive significant effect. This implies that for every one-unit increase in digital agriculture, resilience also increases by 0.68. Hypothesis 2 stated that digital agriculture exerts no influence on resilience. Here, the results contradict the null leading to the rejection in favour of the alternative. Digital agriculture encompassing tools such as mobile-based extension services, weather alerts, market information platforms, and farm management applications appears to enhance resilience by informing better decision-making, reducing waste, and expanding market reach. Corroborating these findings, Dennis (2024) conducted a scoping review of technologies employed by smallholders across sub-Saharan Africa. The review catalogues digital innovations extension platforms, remote sensing technologies, and mobile-based market information, and highlights both opportunities and obstacles. Also, Zhang et al. (2019) confirm that new financial media, such as mobile payments have enhanced the supply capacity of digital inclusive financial products including savings, credit, insurance, investment, and finance thereby promoting the transfer and distribution of financial resources over time. It increases rural households' enthusiasm for investment and financial management with the advantages of easy access and convenience, optimises investment decisions and enhances rural households' resilience.

The estimated coefficient for the relationship between access to digital financial services (credit and savings) and resilience was 0.06, with a p-value of 0.73, implying a positive but statistically insignificant relationship. Thus, this implies that when access to digital financial services increases by 1 unit, resilience increases by 0.06, suggesting that access to digital services has limited predictive power for financial resilience. Hypothesis 3, which stated that access to digital financial services (credit and savings) has no effect on resilience was therefore retained. This outcome may reflect the limited use of digital financial services for agriculture-specific needs as highlighted by Parlasca et al. (2022). Farmers might be using digital channels primarily for personal transactions rather than farm investment or risk mitigation. Likewise, McCampbell et al. (2021) tested smallholder banana farmers' readiness to use digital extension

tools. Many required additional training, pointing to the need for capacity-building interventions. Otitoju et al. (2023) assessed digital financial inclusion efforts in Nigeria and found that farmers' needs are often underserved. Barriers include weak infrastructure, difficulties in assessing creditworthiness and insufficient financial and digital literacy hinders usage of the products.

The analysis for the relationship between social security and resilience found a coefficient of 0.28 (p-value = 0.00), denoting a positive and significant impact and prompting rejection of the null which argued that social security arrangements do not influence resilience. Social security potentially including government cash transfers, pensions, or community-based support delivered through digital mechanisms helps stabilise household income and reduce uncertainty, enabling farmers to plan, invest and absorb shocks more effectively. Relating to the finding of the study, Joseph et al. (2025) compared smallholder farmers linked to closed and active microfinance institutions (MFIs). Their findings show that when MFIs shut down, farmers lose access to loans, insurance, and business development services yet productivity declines were modest because farmers drew on prior financial literacy, social networks, and alternative financing. The study hints that resilience can stem from a blend of resources, not only formal finance.

The overall study outcome indicates that digital agriculture and social security are the most potent levers among the tested variables. Digital agriculture's substantial coefficient underscores the value of information-rich platforms in boosting productivity and enabling swift responses to climatic or market shifts. Social security's moderate yet significant effect highlights the importance of predictable income sources especially when climate change introduces abrupt losses. However, insurance is a significant but negative path to resilience, hinting at a disconnect between product design and farmers' realities. Insurance products might be poorly aligned with local risk profiles or suffer from trust deficits due to delayed payouts. The limited effect of digital financial service access suggests that simply having mobile money accounts or digital savings options is not enough; the services must be tailored to agricultural cycles, provide competitive loan terms and integrate with broader support systems.

5.0 Conclusions and Recommendations

This study investigated the role of digital finance in the financial resilience of smallholder farmers in Adamawa State, Nigeria which was anchored in the asset and income risk framework. Survey questionnaires were used to collect data from four hundred respondents randomly selected from the nine agricultural local government areas of the state with three hundred and seventy-seven return rate for the evaluation. Four hypotheses of insurance and resilience, digital agriculture and resilience, digital financial services and resilience and social security and resilience of smallholder farmers were tested. The study findings demonstrate that certain digital finance components meaningfully strengthen financial resilience of smallholder farmers in Adamawa State. Digital agriculture tools provide actionable information that helps increase income and control costs among the farmers. Social security mechanisms, when reliably delivered, offer steady income streams that offset shocks. Insurance uptake remains limited in effect as the products design may be at a disconnect with farmers' realities i.e. poorly aligned with local risk in the study area, and access to digital financial services in their current forms are yet to translate into significant resilience gains for the farmers in Adamawa State.

Based on these conclusions, the study recommends investment in digital agricultural interventions including mobile tools for climate information, extension services and advice, and a digital platforms for market access and pricing, through collaboration between Agritech

firms, extension services, and farmer cooperatives to accelerate the rollout of tools. A foundational improvement of expanding mobile network coverage, improving internet connectivity, stabilising electricity supply and training in local languages and leveraging practical demonstrations are prerequisites for farmers to use digital services consistently and confidently. Also, authorities should align social protection programmes with climate adaptation initiatives such as funding for drought-resistant parkages which magnify resilience effects. Insurance products should be redesigned to better meet farmers needs and efforts should be intensified to improve awareness and understanding of products among the farmers.

5.1 Suggestions for Further Studies

Other researchers should extend the geographic scope to other Northern states facing similar climatic and socio-economic challenges, enabling regional comparisons.

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