



DIGITAL MEDIA AND PROMOTION OF SUSTAINABLE AGRICULTURAL PRACTICES: A STUDY OF NIGERIAN FARMERS

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Abstract

This study examined the role of digital media in promoting sustainable agricultural practices among Nigerian farmers. A cross-sectional survey design was employed with 384 smallholder farmers from four agricultural zones in Nigeria over a six-month period (March-August 2024). Data were collected using structured questionnaires and analysed using descriptive statistics, Chi-square tests and multiple regression analysis. Results showed that 67.4% of farmers had access to digital media platforms, with mobile phones being the most prevalent device (78.9%). Social media platforms, particularly WhatsApp (52.3%) and Facebook (41.7%), were the primary channels for accessing agricultural information. Digital media exposure significantly influenced the adoption of sustainable practices, with 58.6% of exposed farmers implementing at least three sustainable techniques compared to 23.1% of non-exposed farmers ($\chi^2 = 87.45, p < 0.001$). Multiple regression analysis showed that frequency of digital media use ($\beta = 0.412, p < 0.001$), content relevance ($\beta = 0.356, p < 0.001$) and digital literacy ($\beta = 0.289, p < 0.001$) significantly predicted sustainable practice adoption ($R^2 = 0.624$). However, significant barriers persisted, including poor internet connectivity (72.3%), lack of digital skills (54.7%) and high data costs (61.2%). The study concludes that digital media serves as a critical tool for agricultural transformation in Nigeria but requires supportive infrastructure and capacity-building interventions to maximize impact.

Keywords: Digital media, Sustainable agriculture, Nigerian farmers, Agricultural extension, Technology adoption

Introduction

Agriculture remains the backbone of Nigeria's economy, employing approximately 70% of the rural population and contributing significantly to the nation's Gross Domestic Product (Oladipo & Okon, 2024). However, Nigerian agriculture continues to face multiple challenges, including declining soil fertility, climate change impacts, inadequate extension services and limited access to timely agricultural information. The traditional agricultural extension system, characterized by face-to-face interactions between extension agents and farmers, has proven inadequate in reaching the millions of smallholder farmers dispersed across the country's diverse agro-ecological zones (Ogunyemi & Ajayi, 2021).

The advent of digital technologies has created unprecedented opportunities for transforming agricultural information dissemination and promoting sustainable farming practices. Digital media

platforms, including social media, mobile applications, radio, television and web-based platforms, have emerged as powerful tools for bridging the agricultural knowledge gap (Chinedu & Bello, 2024; Anyanwu et al., 2024). According to the Digital 2021 Global Overview Report, Nigeria has experienced exponential growth in internet penetration and mobile phone ownership, with over 104 million internet users and a mobile connection penetration rate of 85% (Digital 2021: Global overview report, 2021). This digital revolution presents unique possibilities for reaching farmers with timely, relevant and actionable agricultural information.

Recent scholarship has highlighted the transformative potential of digital technologies in African agriculture. Abate et al. (2023) examined why digital tools have not yet achieved scale in African agricultural markets despite their apparent benefits, identifying infrastructural deficits, low digital literacy and inadequate business models as key constraints. Similarly, Abdulai et al. (2023) documented the lived realities of smallholder farmers' engagement with digital tools in rural Northern Ghana, revealing significant disparities between digitalization rhetoric and actual farmer experiences. In the Nigerian context, Kolapo and Didunyemi (2024) investigated the effects of exposure on the adoption of agricultural smartphone apps among smallholder farmers in Southwest Nigeria, demonstrating positive correlations between app exposure and farm-level efficiency.

The promotion of sustainable agricultural practices through digital media has become increasingly critical in light of Nigeria's recent economic transformations, particularly the removal of fuel subsidies in 2023, which has significantly impacted agricultural production costs and food security (Ogunleye & Adeyemi, 2023). Digital media platforms offer cost-effective alternatives for disseminating information about sustainable practices such as organic farming, conservation agriculture, integrated pest management, agro forestry and water conservation techniques. However, empirical evidence on the extent to which Nigerian farmers access, utilize and benefit from digital media for agricultural purposes remains limited.

Despite the growing proliferation of digital media technologies in Nigeria, several critical gaps exist in understanding their role in promoting sustainable agricultural practices: There is insufficient empirical data on the actual level of digital media access among Nigerian smallholder farmers and their capacity to effectively utilise these platforms for agricultural information seeking. While urban-rural digital divides are widely acknowledged, the specific barriers faced by farmers in accessing and using digital agricultural content remain poorly documented (Abdulai, 2022). The relationship between digital media exposure and the actual adoption of sustainable agricultural practices among Nigerian farmers is not adequately established. While digital platforms disseminate agricultural information, the extent to which this exposure translates into rural change and practice adoption remains empirically underexplored (Abioye et al., 2024). The infrastructural challenges that hinder effective digital media utilisation for agricultural purposes in Nigeria, including electricity supply, internet connectivity and affordability, have not been comprehensively quantified in relation to sustainable agriculture promotion (Emmanuel et al., 2024).

This study pursued three specific objectives are:

- i. To assess the level of access to and usage patterns of digital media platforms among Nigerian smallholder farmers for agricultural information.
- ii. To examine the relationship between digital media exposure and the adoption of sustainable agricultural practices among Nigerian farmers.
- iii. To identify and evaluate the barriers constraining effective utilisation of digital media for promoting sustainable agriculture in Nigeria.

Two hypotheses were formulated to guide this investigation:

Ho1: There is no significant relationship between farmers' frequency of digital media use and their adoption of sustainable agricultural practices.

Ho2: Digital literacy levels do not significantly influence farmers' ability to utilise digital media for accessing agricultural information.

This study makes several important contributions to agricultural development scholarship and practice. First, it provides empirical evidence on the digital media landscape in Nigerian agriculture, offering baseline data essential for designing targeted digital agricultural extension interventions. Second, the study illuminates the mechanisms through which digital media influences sustainable practice adoption, thereby informing policy formulation and programme design. Third, by identifying specific barriers to digital media utilisation, the research offers actionable recommendations for enhancing digital agricultural extension services. Fourth, the findings contribute to the broader discourse on agricultural digitalization in Sub-Saharan Africa, adding Nigerian perspectives to the growing body of literature on digital tools in smallholder farming systems (Njuguna et al., 2024; Subramaniam et al., 2025). Finally, the study provides practical insights for agricultural development agencies, telecommunications companies, agritech startups and policymakers seeking to leverage digital technologies for agricultural transformation and food security enhancement.

Theoretical Framework

This study employs Rogers' (2003) Diffusion of Innovations Theory as its theoretical framework. The theory posits that innovation adoption is determined by five characteristics—relative advantage, compatibility, complexity, trial-ability and observability—and this occurs through communication channels (mass media and interpersonal networks) within social systems. Adopters are categorized as innovators, early adopters, early majority, late majority and laggards based on receptiveness. The theory explains how innovations—such as digital media technologies—spread through communication channels within social systems. In this context, digital media platforms represent innovations whose adoption depends on factors like compatibility, complexity and relative advantage. They also function as channels for diffusing information on sustainable agricultural techniques. The adopter categories reflect farmers' varied readiness to embrace digital platforms and new practices. The educated, higher-income farmers are usually the early adopters while resource-limited ones lag behind. Therefore, this theory is relevant as it explains how digital media usage influences the diffusion and adoption of sustainable farming practices within Nigeria's heterogeneous agricultural system.

Methodology

This study employed a cross-sectional survey research design to investigate digital media usage and sustainable agricultural practice adoption among Nigerian farmers. The cross-sectional approach was deemed appropriate as it enables the collection of data from a large sample at a specific point in time, facilitating the examination of relationships between variables (McQuail, 2021). The study was conducted across four major agricultural zones in Nigeria: The North-Central (Benue and Niger States), South-West (Oyo and Osun States), South-South (Rivers and Delta States) and North-West (Kaduna and Kano States). These zones were selected to ensure geographical diversity and representation of Nigeria's varied agro-ecological conditions, farming systems and digital infrastructure development levels.

The research was conducted over a six-month period from March 2024 to August 2024, encompassing both the dry and early rainy seasons to capture farmers during different agricultural cycles. The target population comprised smallholder farmers (defined as those cultivating less than 5 hectares of land) actively engaged in crop production across the selected states. According to the National Bureau of Statistics (2023), there are approximately 14.5 million smallholder farmers in the selected states. The

sample size was 400 determined using Yamane's (1967) formula for finite populations. After data cleaning, 384 valid responses were retained for analysis, representing a response rate of 96%.

A multi-stage sampling technique was employed. First, purposive sampling was used to select the four agricultural zones and eight states based on agricultural significance and digital infrastructure variability. Second, two Local Government Areas (LGAs) with high agricultural activity were randomly selected from each state, yielding 16 LGAs. Third, proportionate stratified random sampling was used to select farmers from each LGA based on the farming population, ensuring equitable representation. Finally, simple random sampling was applied to select individual respondents from farmer registers maintained by state Agricultural Development Programmes. Data were collected using a structured questionnaire titled "Digital Media and Sustainable Agriculture Questionnaire" (DMSAQ). The instrument comprised five sections: (A) socio-demographic characteristics, (B) digital media access and usage patterns, (C) digital literacy assessment, (D) sustainable agricultural practices adoption and (E) barriers to digital media utilisation. The questionnaire employed a combination of closed-ended questions, Likert-scale items (ranging from 1=Strongly Disagree to 5=Strongly Agree) and multiple-choice questions. The questionnaire was validated by three experts in agricultural extension, communication studies and rural sociology who assessed the content validity and made recommendations for improvement. A pilot study was conducted with 40 farmers not included in the main study and the instrument's reliability was tested using Cronbach's Alpha coefficient, which yielded a value of 0.87, indicating high internal consistency. Data were collected through face-to-face interviews conducted by 16 trained research assistants who were fluent in local languages. Questionnaires were administered in English and translated into Hausa, Yoruba and Igbo as needed.

Data were analysed using the Statistical Package for Social Sciences (SPSS) version 26.0. Descriptive statistics (frequencies, percentages, means and standard deviations) were used to summarize demographic characteristics, digital media access patterns and adoption levels. Inferential statistics, including Chi-square tests and multiple regression analysis, were employed to test hypotheses and examine relationships between variables.

Model Specification

A multiple regression model was specified to examine the predictive relationship between digital media variables and sustainable practice adoption:

$$Y = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \epsilon \dots\dots\dots\text{Equ. (2)}$$

Where:

- Y = Sustainable Agricultural Practices Adoption Score
- X₁ = Frequency of Digital Media Use
- X₂ = Content Relevance Score
- X₃ = Digital Literacy Level
- X₄ = Access to Digital Devices
- β₀ = Constant
- β₁, β₂, β₃, β₄ = Regression coefficients
- ε = Error term

The dependent variable (Y) was measured as a composite index ranging from 0-15, based on farmers' reported adoption of 15 sustainable practices. Independent variables were measured on appropriate scales validated through the pilot study.

Results

Socio-Demographic Characteristics of Respondents

Table 1: The socio-demographic characteristics of respondents provide essential background for understanding variations in digital media use and adoption of sustainable agricultural practices. As shown in Table 1, male farmers (60.2%) constituted the majority, reflecting gender dominance in Nigerian smallholder agriculture. Most respondents (42.4%) were between 36–50 years old, with a mean age of 43.7 years (SD = 11.2), indicating that middle-aged adults form the most active farming group.

Educational attainment varied considerably—about one-third (34.1%) had primary education, while 18.5% had no formal education, highlighting potential literacy challenges in accessing digital platforms. Farm size distribution shows that over half (58.1%) cultivated between 1–3 hectares, consistent with smallholder farming patterns. Farmers' experience ranged widely, averaging 16.3 years (SD = 8.7), suggesting substantial agricultural exposure. Income levels, however, suggested economic limitations, with 45.3% earning below ₦50,000 monthly, implying limited capacity for technology investments.

Table 1: Socio-Demographic Characteristics of Respondents (N=384)

Variable	Category	Frequency	Percentage
Gender	Male	231	60.2
	Female	153	39.8
Age Group	18-35 years	89	23.2
	36-50 years	163	42.4
	51-65 years	108	28.1
	Above 65 years	24	6.3
Education	No Formal Education	71	18.5
	Primary Education	131	34.1
	Secondary Education	121	31.5
	Tertiary Education	61	15.9
Farm Size	Below 1 hectare	42	10.9
	1-3 hectares	223	58.1
	3-5 hectares	119	31.0
Monthly Income	Below ₦50,000	174	45.3
	₦50,000-₦100,000	147	38.3
	Above ₦100,000	63	16.4
Farming Experience	5-10 years	103	26.8
	11-20 years	167	43.5
	Above 20 years	114	29.7

The demographic profile indicates a relatively mature and experienced farming population with moderate education and limited income, which may influence the rate and pattern of digital innovation adoption across rural communities.

Level of Access to and Usage Patterns of Digital Media Platforms

As shown in Table 2, the majority of farmers (67.4%) had access to at least one form of digital media, mainly through mobile phones (78.9%). Internet connectivity was reported by 52.1% of respondents, suggesting growing digital penetration but also revealing significant access disparities.

WhatsApp (52.3%) and Facebook (41.7%) emerged as the most used social media platforms, while traditional channels such as radio (48.7%) and television (34.9%) remained relevant sources of agricultural information. A considerable number of farmers participated in WhatsApp groups (44.8%) for sharing farming experiences and accessing expert advice. However, specialized digital tools like agricultural mobile apps (31.3%) and websites (23.4%) were less commonly used, reflecting literacy and cost constraints. In terms of usage frequency, only 27.3% of respondents accessed digital media daily, and 35.7% weekly, whereas others used it occasionally or rarely, underscoring uneven engagement levels.

Table 2: Digital Media Access and Usage Patterns (N=384)

Variable	Category	Frequency	Percentage
Access to Digital Media	Yes	259	67.4
	No	125	32.6
Device Ownership	Mobile Phone (any type)	303	78.9
	Smartphone	216	56.3
	Radio	258	67.2
	Television	186	48.4
	Computer/Tablet	37	9.6
Internet Access	Yes	200	52.1
	No	184	47.9
Social Media Platforms Used	WhatsApp	201	52.3
	Facebook	160	41.7
	YouTube	108	28.1
	Twitter/X	47	12.2
	Instagram	53	13.8
Agricultural Information Sources	Radio Programmes	187	48.7
	TV Agricultural Shows	134	34.9
	WhatsApp Farmer Groups	172	44.8
	Agricultural Apps	120	31.3
	Agricultural Websites	90	23.4
	SMS Services	98	25.5
Frequency of Use (Agricultural)	Daily	105	27.3
	Weekly	137	35.7
	Monthly	86	22.4
	Rarely/Never	56	14.6

Overall analysis of Table 2 shows that digital access among Nigerian smallholder farmers is expanding, primarily through affordable, user-friendly mobile platforms. However, infrastructural gaps, limited digital literacy, and inconsistent connectivity continue to restrict the full potential of digital media for agricultural knowledge dissemination and practice adoption.

Relationship Between Digital Media Exposure and Adoption of Sustainable Practices

This section examines how farmers' exposure to digital media influences their adoption of sustainable agricultural practices. Farmers were grouped into two categories—those with high digital exposure (daily or weekly users, n = 242) and those with low exposure (monthly, rare, or non-users, n = 142). Fifteen key

sustainable practices were assessed, including soil management, crop diversification, water conservation, and pest control techniques.

Table 3: Digital Media Exposure and Adoption of Sustainable Agricultural Practices (N=384)

Sustainable Practice	High Digital Exposure (n=242)	Low Digital Exposure (n=142)	Difference
	Adopted (%)	Adopted (%)	(%)
Organic Fertilizer Use	165 (68.2%)	46 (32.4%)	35.8
Conservation Tillage	132 (54.5%)	32 (22.5%)	32.0
Crop Rotation	148 (61.2%)	41 (28.9%)	32.3
Integrated Pest Management	120 (49.6%)	26 (18.3%)	31.3
Water Conservation Techniques	126 (52.1%)	35 (24.6%)	27.5
Agroforestry Practices	93 (38.4%)	22 (15.5%)	22.9
Cover Cropping	101 (41.7%)	27 (19.0%)	22.7
Improved Seed Varieties	175 (72.3%)	59 (41.5%)	30.8
Soil Testing	83 (34.3%)	17 (12.0%)	22.3
Drip Irrigation	68 (28.1%)	12 (8.5%)	19.6
Composting	142 (58.7%)	38 (26.8%)	31.9
Intercropping	153 (63.2%)	50 (35.2%)	28.0
Mulching	116 (47.9%)	29 (20.4%)	27.5
Green Manuring	88 (36.4%)	20 (14.1%)	22.3
Precision Agriculture Techniques	44 (18.2%)	6 (4.2%)	14.0
Mean Adoption Rate	55.8%	23.1%	32.7

The results reveal that farmers with high digital media exposure achieved a mean adoption rate of 55.8%, compared with 23.1% among low-exposure farmers—a difference of 32.7 percentage points. This indicates that frequent interaction with digital media substantially enhances the likelihood of adopting sustainable practices.

The greatest adoption gaps appeared in organic fertilizer use (35.8%), crop rotation (32.3%), and conservation tillage (32.0%), showing that digital media is most effective for knowledge-intensive practices requiring continuous learning and information exchange. In contrast, adoption of capital-intensive technologies such as drip irrigation and precision agriculture remained low, reflecting the role of financial and infrastructural barriers.

These findings affirm that digital media serves as a critical vehicle for disseminating agricultural knowledge and promoting behavioural change. Consistent with Fabregas et al. (2024) and Kolapo and Didunyemi (2024), digital exposure enables farmers to access, share, and apply information that drives innovation. However, as Abate et al. (2023) caution, the full potential of digital diffusion depends on addressing economic and infrastructural inequalities that limit resource-poor farmers’ ability to implement what they learn.

Barriers to Effective Utilisation of Digital Media

Table 4 presents the findings related to the third research objective, focusing on barriers that hinder effective utilisation of digital media among farmers. The results indicate that these challenges are both infrastructural and socio-economic in nature, collectively constraining the capacity of farmers to fully benefit from digital agricultural innovations.

Table 4: Barriers to Effective Digital Media Utilisation (N=384)

Barrier	Frequency	Percentage	Severity Rating (1-5)	Mean Score
Poor Internet Connectivity	278	72.4	Various	4.3
High Data Costs	235	61.2	Various	4.1
Lack of Digital Literacy	210	54.7	Various	3.8
Inadequate Electricity Supply	253	65.9	Various	4.2
Language Barriers	189	49.2	Various	3.6
Limited Relevant Content	176	45.8	Various	3.5
Cost of Digital Devices	198	51.6	Various	3.9
Lack of Awareness	167	43.5	Various	3.4
Technical Challenges	194	50.5	Various	3.7
Trust/Reliability Concerns	156	40.6	Various	3.3
Time Constraints	143	37.2	Various	3.2
Age-Related Difficulties	128	33.3	Various	3.1

Analysis of severity ratings (on a scale of 1-5, where 5 represents "very severe") suggested that poor internet connectivity received the highest mean severity score (4.3), followed by inadequate electricity supply (4.2) and high data costs (4.1). The findings indicate that farmers face multiple barriers to effective digital media use, dominated by infrastructural challenges such as poor internet connectivity, inadequate electricity, and high data costs. Economic constraints, particularly the high cost of devices and data, further limit access among low-income farmers. Limited digital literacy also hampers effective utilisation, underscoring the need for continuous capacity-building initiatives. Additionally, language barriers and lack of localised agricultural content reduce the relevance of available digital information. Trust and reliability concerns, along with low awareness and technical difficulties, further discourage engagement. Consistent with Emmanuel et al. (2024), Abdulai (2022), Lwoga (2010), and Quinn (2024), these findings emphasise that digital transformation in rural agriculture requires an integrated approach that addresses infrastructure, affordability, skills, content localisation, and credibility. A coordinated effort across these dimensions is essential for digital media to achieve its transformative potential in agricultural development.

Hypothesis Testing- Hypothesis One

H₀₁: There is no significant relationship between farmers' frequency of digital media use and their adoption of sustainable agricultural practices.

To test this hypothesis, a Chi-square test of independence was conducted, examining the relationship between frequency of digital media use (categorized as Daily, Weekly, Monthly, Rarely/Never) and adoption levels of sustainable practices (categorized as Low: 0-5 practices, Medium: 6-10 practices, High: 11-15 practices).

Table 5: Chi-Square Analysis - Frequency of Digital Media Use and Sustainable Practice Adoption (N=384)

Frequency of Use	Low Adoption (0-5)	Medium Adoption (6-10)	High Adoption (11-15)	Total
Daily	12 (11.4%)	41 (39.0%)	52 (49.5%)	105
Weekly	23 (16.8%)	58 (42.3%)	56 (40.9%)	137
Monthly	38 (44.2%)	34 (39.5%)	14 (16.3%)	86
Rarely/Never	46 (82.1%)	8 (14.3%)	2 (3.6%)	56
Total	119	141	124	384

Chi-Square Statistics:

$\chi^2 = 145.73$

df = 6

p-value < 0.001

Cramer's V = 0.435 (strong effect size)

The Chi-square analysis yielded a statistically significant result ($\chi^2 = 145.73$, df = 6, $p < 0.001$), indicating a strong relationship between frequency of digital media use and adoption of sustainable practices. The null hypothesis was therefore rejected. The Cramer's V value of 0.435 suggests a strong effect size, demonstrating that frequency of digital media use substantially influences practice adoption. Examination of the cross tabulation reveals clear patterns: among daily users, 49.5% exhibited high adoption levels compared to only 3.6% of those who rarely or never used digital media. Conversely, 82.1% of rare/non-users showed low adoption levels. These findings corroborate research by Mulaudzi et al. (2024) on social media utilisation among South African farmers, demonstrating that consistent engagement with digital platforms enhances agricultural knowledge and practice adoption.

Hypothesis Two

H₀2: Digital literacy levels do not significantly influence farmers' ability to utilise digital media for accessing agricultural information.

To test this hypothesis, digital literacy was measured using a composite index (range: 0-20) assessing basic digital skills and farmers' ability to utilise digital media was measured by their reported success in accessing relevant agricultural information (categorized as Low, Moderate, High effectiveness). A one-way ANOVA was conducted to examine differences across groups.

Table 6: ANOVA Analysis - Digital Literacy and Digital Media Utilisation Effectiveness (N=384)

Digital Literacy Level	N	Mean Utilisation Score	SD	Min	Max
Low (0-7)	142	2.8	1.3	1	6
Moderate (8-14)	167	5.6	1.7	3	9
High (15-20)	75	8.4	1.2	6	10
Total	384	5.1	2.6	1	10

ANOVA Results:

F-statistic = 287.43

df (between groups) = 2

df (within groups) = 381

p-value < 0.001

Eta-squared (η^2) = 0.601 (large effect size)

Post-hoc Tukey HSD Test:

Low vs. Moderate: Mean Difference = -2.8, $p < 0.001$
 Low vs. High: Mean Difference = -5.6, $p < 0.001$
 Moderate vs. High: Mean Difference = -2.8, $p < 0.001$

The ANOVA results showed statistically significant differences in digital media utilisation effectiveness across digital literacy levels ($F = 287.43, p < 0.001$). The null hypothesis was therefore rejected. The eta-squared value of 0.601 indicates that digital literacy explains approximately 60.1% of the variance in utilisation effectiveness, representing a large effect size.

Post-hoc comparisons using Tukey HSD test showed that all pairwise differences were statistically significant ($p < 0.001$). Farmers with high digital literacy demonstrated substantially greater effectiveness ($M = 8.4, SD = 1.2$) compared to those with moderate ($M = 5.6, SD = 1.7$) or low ($M = 2.8, SD = 1.3$) literacy levels. These findings align with research by Ferguson et al. (2024) on digital technologies during COVID-19, which emphasised that digital literacy serves as a critical determinant of farmers' capacity to benefit from digital agricultural services. Similarly, FAO (2023) highlighted digital skills development as essential for strengthening digital agricultural extension systems.

Multiple Regression Analysis

To further explore predictors of sustainable practice adoption, multiple regression analysis was conducted using the model specified in the methodology section. The results are presented below:

Regression Model Summary:

Multiple R = 0.790
 $R^2 = 0.624$
 Adjusted $R^2 = 0.618$
 Standard Error = 2.47
 F-statistic = 157.34, $p < 0.001$

Regression Coefficients:

Predictor Variable	β (Standardized)	B (Unstandardized)	SE	t-value	p-value
(Constant)	-	1.34	0.52	2.58	0.010
Frequency of Digital Media Use (X_1)	0.412	0.89	0.08	11.13	< 0.001
Content Relevance Score (X_2)	0.356	0.72	0.07	10.29	< 0.001
Digital Literacy Level (X_3)	0.289	0.34	0.04	8.50	< 0.001
Access to Digital Devices (X_4)	0.187	0.56	0.09	6.22	< 0.001

The regression model was statistically significant ($F = 157.34, p < 0.001$), with an R^2 value of 0.624, indicating that 62.4% of the variance in sustainable practice adoption could be explained by the four predictor variables. All predictors made significant independent contributions to the model ($p < 0.001$). Frequency of digital media use emerged as the strongest predictor ($\beta = 0.412$), followed by content relevance ($\beta = 0.356$), digital literacy level ($\beta = 0.289$) and access to digital devices ($\beta = 0.187$). These findings suggest that both the quantity (frequency) and quality (relevance) of digital media engagement, coupled with users' capacity to navigate digital platforms, significantly influence adoption outcomes. The results support arguments by Njuguna et al. (2024) that digitalization's contribution to sustainable

agricultural transformation in Africa depends on multiple intersecting factors beyond mere technological availability.

Discussion of findings

The findings of this study offer strong empirical evidence of digital media's growing yet uneven role in advancing sustainable agricultural practices among Nigerian farmers, interpreted through Rogers' Diffusion of Innovations (DOI) Theory. With 67.4% of farmers accessing digital media—mainly via mobile phones (78.9%)—diffusion is progressing but constrained by infrastructural and socio-economic barriers. This aligns with Abate et al. (2023), who identified limited access as a major obstacle to digital innovation scaling in African agriculture. Only 52.1% reported reliable internet connectivity, revealing infrastructural weaknesses such as poor electricity and network coverage, consistent with Emmanuel et al. (2024). These barriers slow the rate of adoption by limiting observability and trialability of innovations, major DOI attributes.

WhatsApp (52.3%) and Facebook (41.7%) dominate digital communication, corroborating Mulaudzi et al. (2024) and Murphy (2024), who found social media's affordability enhances compatibility with farmers' existing behaviours. Conversely, the low use of agricultural apps (31.3%) and websites (23.4%) supports Coggins et al. (2021), showing that innovations diffuse faster when they align with established communication routines.

Farmers with high digital exposure adopted sustainable practices (55.8%) at much higher rates than low-exposure counterparts (23.1%), supporting DOI's principle that perceived advantages accelerate adoption. This pattern mirrors Fabregas et al. (2024), who observed that digital information enhances behavioural change. Practices such as organic fertilizer use and crop rotation—being knowledge-intensive—reflect the *knowledge and persuasion* stages of diffusion (Kolapo & Didunyemi, 2024). However, low uptake of capital-intensive techniques like drip irrigation underscores Abate et al.'s (2023) point that information alone cannot overcome financial barriers.

Digital literacy significantly affects utilisation: high-literacy farmers (mean 8.4) performed far better than low-literacy peers (2.8), explaining 60.1% of variance. This validates Rogers' view that education and socio-economic status shape adoption readiness. Over half (54.7%) exhibited low literacy, especially older farmers, reinforcing Ferguson et al.'s (2024) finding that digital divides widen without training. Major constraints—poor connectivity (72.4%), unreliable electricity (65.9%), and high data costs (61.2%)—mirror Abdulai et al. (2023), who emphasized infrastructural fragility as a diffusion bottleneck. Language barriers (49.2%) further hinder accessibility, echoing Lwoga's (2010) call for localised agricultural content.

Trust deficits (40.6%) in online information highlight DOI's *communication channel* element—credible sources influence adoption. Quinn (2024) similarly found that partnerships with trusted institutions strengthen diffusion. Ogunleye and Adeyemi (2023) also noted digital media's policy role in communicating adaptive strategies amid Nigeria's post-subsidy reforms.

Traditional media remain vital for late adopters—radio (48.7%) and television (34.9%)—supporting Ogunyemi and Ajayi (2021) and Okechukwu (2023), who emphasized multi-channel diffusion. The significant content relevance coefficient ($\beta = 0.356$) supports DOI's *innovation attributes*, showing that message clarity and contextual framing determine uptake (Ibrahim et al., 2023; Adebayo & Umeh, 2022).

Regionally, Subramaniam et al. (2025) found that digitalization improves food security only when literacy, infrastructure, and institutional support align. Nigeria's 67.4% access rate still trails Kenya's "Silicon Savannah" (Njuguna et al., 2024), though similar systemic constraints apply.

As Chinedu and Bello (2024) contend, bridging Nigeria's agricultural digital divide requires addressing supply-side barriers—connectivity, infrastructure, content quality—and demand-side factors—literacy and trust. The regression model explaining 62.4% of adoption variance reinforces DOI's multidimensional logic: innovation diffusion depends on innovation characteristics, communication networks, and adopter readiness. Overall, findings confirm that digital media's transformative potential in Nigerian agriculture hinges on enhancing relative advantage, compatibility, and accessibility—core DOI attributes—through coordinated investments in infrastructure, digital literacy, and institutional credibility.

Conclusion

Digital media serves as a transformative catalyst for sustainable agriculture in Nigeria, enhancing information access and knowledge exchange among farmers. Empirical evidence shows that regular engagement with digital platforms significantly increases adoption of sustainable practices, complementing traditional extension systems. However, major infrastructural deficits—poor connectivity, unreliable electricity, and high data costs—alongside widespread digital literacy gaps, limit inclusive participation. These constraints risk deepening existing inequalities, favouring more educated or affluent farmers. The Nigerian experience reflects broader Sub-Saharan African trends where digitalization ambitions often outpace implementation. Nonetheless, growing mobile and internet penetration and widespread WhatsApp use offer strong foundations. Coordinated interventions that strengthen infrastructure, localise content, and build farmers' digital capacity are vital for sustainable digital agricultural transformation.

Recommendations

Based on the study's findings, the following recommendations are proposed:

1. Government and telecom companies should prioritize rural internet connectivity, reliable electricity supply, and implement agricultural data subsidy programmes to reduce costs for farmers.
2. Government should initiate comprehensive digital literacy training targeting older farmers and women, focusing on practical skills for accessing agricultural information and evaluating content credibility through extension services.
3. Government and telecom/media organisation should develop digital agricultural content in local languages (Hausa, Yoruba, Igbo) with culturally relevant, context-specific guidance involving farmers in participatory content development.
4. Government should adopt multi-channel approaches combining traditional media (radio, TV) with digital platforms while developing user-friendly apps with offline functionality and voice-based interfaces.
5. There should be established certification systems for reliable information sources to link farmers to financial services for technology adoption and integrate digital extension strategies into agricultural policies.

Contribution to Knowledge

This study makes several significant contributions to scholarly understanding and practical approaches to digital agricultural development:

1. Provides comprehensive data on Nigerian farmers' digital access and usage patterns, quantifying specific barriers like 72.4% connectivity issues and 54.7% lacking digital literacy.

2. Demonstrates that content relevance and frequency of use predict adoption better than mere access, challenging technological determinism and supporting social practice perspectives.
3. Advances multi-method research approaches combining descriptive analysis, hypothesis testing, and regression modeling for assessing digital intervention effectiveness in agriculture.
4. Contributes Nigerian perspectives to African agricultural digitalization literature, identifying both common patterns and context-specific factors like language diversity and policy environment.
5. Shows digitalization requires integration with broader interventions addressing infrastructure, education, and economic access, as 37.6% of adoption variance remains unexplained by digital factors alone.

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