Effect of Digital Extension and E-Learning Intervention and Adoption Among Cassava and Fish Farmers in Bayelsa State

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https://doi.org/10.56201/ijaes.vol.12.no10.2026.pg137.147

Abstract
This research investigated the effects of digital extension and e-learning intervention and adoption among cassava and fish farmers in Bayelsa State. A quasi-experimental design incorporating pre-test and post-test assessments was employed, involving 240 active smallholder farmers selected from Yenagoa, Ogbia and Sagbama Local Government Areas. Agricultural advisory content was delivered through WhatsApp groups, Interactive Voice Response (IVR) and YouTube videos over a twelve-week period. The data obtained were subjected to descriptive and inferential statistical analyses. The results indicated that farmers' technical knowledge improved after the interventions. Cassava and fish farmers acknowledged the positive contributions of the interventions, with fish farmers expressing greater perceived benefits. The interventions also shaped production decisions and farm management practices, particularly in fertiliser and feed application, input selection, disease control and weed management. Technology adoption emerged as a significant predictor of changes in farmers' practices after the interventions. Nevertheless, inconsistent mobile network connectivity, expensive data subscriptions, unreliable electricity and inadequate digital literacy limited effective engagement. The research concluded that digital extension and e-learning interventions offer opportunities for enhancing agricultural knowledge dissemination and improving farming practices. It recommended the establishment of public–private partnerships to improve rural network infrastructure and provide subsidised data packages for farmers.

Keywords: *digital extension, e-learning, cassava farmers, fish farmers, intervention, adoption.*

Introduction

Digital technologies are changing the manner in which farmers obtain agricultural information, develop practical skills and make decisions concerning production. Through mobile communication systems, internet-based platforms and electronic instructional materials, agricultural extension personnel can provide services to farmers beyond the restrictions of conventional face-to-face engagement. Digital extension combines agricultural science, information and communication technology, adult education and participatory knowledge exchange to encourage the dissemination and application of improved agricultural techniques. Digital extension is the delivery or enhancement of agricultural extension and advisory services through digital technologies, including mobile phones, smartphone applications, internet

platforms, multimedia materials, interactive messaging and voice-response systems. These technologies provide farmers with agricultural information, knowledge, advice and access to related services such as markets and farm inputs (Food and Agriculture Organization of the United Nations [FAO], 2023). Amoussohouia et al. (2024) consider digital extension services as tech-driven setups for delivering farming advisory services to farmers.

Digital extension can help reduce some of the difficulties associated with conventional extension delivery, which relies heavily on physical contact between extension workers and farmers. While direct engagement remains essential for practical demonstrations and personalised assistance, the effectiveness of conventional extension may be restricted by insufficient personnel, poor transportation, inadequate funding and the wide geographical distribution of farming communities. Fabregas et al. (2019) reviewed the potential of digital agricultural advisory services to expand information delivery and influence farmers' production decisions, demonstrating the relevance of technology-supported extension to agricultural development. Digital platforms can provide guidance on improved farming techniques, pest and disease control, weather conditions, market opportunities and farm management. However, the usefulness of such services depends on farmers' ability to obtain, understand and implement the information supplied, highlighting the importance of e-learning in digital agricultural extension.

E-learning interventions enable farmers to gain agricultural knowledge and practical skills through electronically delivered educational resources and learning activities. O'Neill (2023) regard e-learning as a technology-mediated form of instruction involving purposeful learning activities that can occur through online, electronic or digital platforms. It is the application of digital and communication technologies to deliver instructional materials, facilitate learner–teacher interaction and support the achievement of educational objectives (Al-Fraihat et al, 2020). E-learning interventions may involve mobile applications, demonstration videos, electronic manuals, online training, audio lessons and interactive discussion platforms that encourage organised or independent learning. Unlike conventional training that requires physical attendance, e-learning allows farmers to study at suitable times, repeat instructional demonstrations and learn according to their individual capacities. When integrated into extension delivery, e-learning can improve practical competence by providing technical information in accessible formats that farmers can review whenever necessary (Emeana et al. 2020). This is particularly important for cassava and fish farmers; whose production activities require relevant technical knowledge and appropriate practical instruction.

Cassava production occupies a prominent position in Nigeria's agricultural economy because it contributes to household food security, farmers' livelihoods and the supply of raw materials for agro-processing industries. Improving productivity requires farmers to possess relevant knowledge of land preparation, the selection of healthy planting materials, appropriate planting methods, weed management, soil fertility, pest and disease control, harvesting and post-harvest handling. These production activities require access to reliable agricultural information and the ability to translate technical recommendations into practical farm operations. Digital extension offers opportunities to provide cassava farmers with timely advisory information through mobile telephone calls, text messages, WhatsApp groups and instructional videos. In their review of digital agricultural advisory services (Fabregas et al. 2019).

Fish farming is another important component of Nigeria's agricultural sector, contributing to food availability, income generation, employment and the supply of fish to domestic markets. Efficient fish production requires adequate technical knowledge of pond preparation, stocking density, feed formulation and application, water quality management, disease prevention, fish growth

monitoring, harvesting and post-harvest handling. Digital extension provides opportunities to deliver relevant production advice through mobile telephone calls, text messages, messaging groups and online resources, while e-learning interventions can present technical procedures through audio-visual demonstrations and electronic instructional materials (Oyetoro et al. 2023).

The effectiveness of digital extension and e-learning intervention and adoption in improving agricultural production depends largely on the quality of the intervention provided and the extent to which farmers accept, utilise and sustain the recommended technologies and practices. Digital extension and e-learning interventions are structured programmes designed to improve farmers' access to agricultural information, technical knowledge and decision-support services through digital technologies. An agricultural intervention may be defined as a deliberately planned programme or action that introduces knowledge, services, technologies or institutional support to address agricultural constraints and improve production or livelihood outcomes (Pawera et al., 2024). In addition, a digital agricultural extension intervention can be understood as a structured advisory programme that uses mobile phones, applications, messaging platforms, interactive voice-response systems, videos or other digital tools to provide farmers with timely and relevant production information (Oyinbo et al., 2022).

Adoption refers to the process through which farmers accept and use an agricultural innovation or service. Pawera et al. (2024) describe adoption as a decision process in which farmers obtain information, assess the expected benefits and costs of an innovation, experiment with it and decide whether to continue using it. It's the farmer's acceptance, utilisation and sustained application of a technology or recommended practice introduced through an agricultural intervention. This indicates that adoption is not limited to awareness or one-time participation; it includes regular use, continued application and possible adaptation of the innovation to local farming conditions. Adoption of digital extension and e-learning involves farmers' willingness and ability to access digital platforms, participate in electronic learning activities, interact with advisory content and apply the information received to cassava and fish production. At the first level, adoption may be reflected in farmers' use of WhatsApp groups, instructional videos, mobile applications, voice services or other digital channels. At the second level, it may be demonstrated through the application of improved production practices, such as appropriate fertiliser use, improved input selection, effective weed and disease management, proper fish feeding and improved water-quality control (Amoussohouia et al. 2024).

The implementation and adoption of digital extension and e-learning may be hindered by poor network connectivity, unreliable electricity, expensive internet services, inadequate access to appropriate digital devices, limited digital skills and a shortage of learning materials that reflect local agricultural realities. Differences in farmers' educational levels, preferred languages, confidence in using digital technologies and readiness to integrate new information into existing farming practices may further influence their participation. Amoussohouia et al. (2024) examined the factors affecting farmers' adoption of digital extension services, highlighting the need to consider the conditions that influence technology uptake. Consequently, the availability of digital platforms does not necessarily translate into effective utilisation or sustained adoption. In addition, cassava cultivation and fish farming have different technical and production requirements, necessitating an assessment of how well digital extension and e-learning channels respond to the specific needs of each group. It is therefore essential to evaluate the effectiveness of these interventions rather than assume that the delivery of agricultural information automatically leads to better farming decisions.

Purpose of the Study

The main aim of the study is to examine digital extension and e-learning intervention and adoption among cassava and fish farmers in Bayelsa State.

1. determine the pre-intervention and post-intervention levels of knowledge of cassava and fish farmers exposed to digital extension and e-learning interventions in Bayelsa State.
2. determine the effect of digital extension and e-learning adoption by cassava and fish farmers following the intervention in Bayelsa State.
3. Analyze the effect of digital extension and e-learning adoption on the agricultural production decisions and management practices of cassava and fish farmers in Bayelsa State.
4. Evaluate the constraints limiting the effective implementation and adoption of digital and e-learning intervention of cassava and fish farmers in Bayelsa State.

Research Questions

The following research questions were considered

1. What are the pre-intervention and post-intervention levels of knowledge among cassava and fish farmers exposed to digital extension and e-learning interventions in Bayelsa State?
2. What is the effect of digital extension and e-learning adoption by cassava and fish farmers following the intervention in Bayelsa State?
3. What is the effect of digital extension and e-learning adoption on the agricultural production decisions and management practices of cassava and fish farmers in Bayelsa State?
4. What are the constraints limiting the effective implementation and adoption of digital and e-learning interventions among cassava and fish farmers in Bayelsa State?

Hypotheses

The following hypotheses were developed

1. There is no significant difference between the pre-intervention and post-intervention levels of knowledge of cassava and fish farmers exposed to digital extension and e-learning interventions in Bayelsa State.
2. Digital extension and e-learning adoption has no significant effect on cassava and fish farmers following the intervention in Bayelsa State.
3. Digital extension and e-learning adoption has no significant effect on the agricultural production decisions and management practices of cassava and fish farmers in Bayelsa State.

Methodology

The study adopted a quasi-experimental research design, specifically a one-group pre-test and post-test design. The design involved assessing farmers before and after the digital extension and e-learning interventions. The study was conducted in three phases: baseline assessment, intervention delivery and endline assessment. The target population comprised active smallholder cassava and fish farmers in Bayelsa State who used or had access to mobile telecommunication networks. Cassava farmers included those involved in cultivation and processing, while fish farmers comprised operators using earthen ponds, concrete tanks or tarpaulin systems. A multi-stage sampling technique was used to select the respondents. Yenagoa, Ogbia and Sagbama Local Government Areas were purposively selected based on their cassava and fish farming activities. Five Farming communities were selected from each Local Government Area, followed by the random selection of respondents from agricultural extension registers and cooperative databases. The sample comprised 240 farmers, including 120 cassava farmers and 120 fish farmers. The

intervention was implemented over twelve weeks through three digital communication and learning channels. These comprised dedicated WhatsApp Business groups for multimedia information exchange, Interactive Voice Response (IVR) systems for automated agricultural updates delivered through local-language telephone messages, and customised YouTube instructional videos demonstrating practical farming techniques.

Data were collected using the Digital Extension and E-learning Intervention Questionnaire (DEEIQ), which comprised four sections. Section A covered respondents' socioeconomic characteristics, Section B assessed technical knowledge before and after the intervention, Section C measured digital platform adoption and changes in farm management practices, and Section D examined constraints using a four-point scale ranging from Very Severe to Not a Constraint. Face and content validity were established through reviews by agricultural extension lecturers and measurement and evaluation specialists. Reliability was assessed through a pilot test involving 30 cassava and fish farmers who were excluded from the main study. Cronbach's alpha was used to determine the internal consistency of the rating-scale items, while the test–retest method was applied to the knowledge test, with a reliability coefficient of 0.76 specified as the minimum acceptable value. The data were analysed using descriptive and inferential statistics. Frequencies, percentages, means and standard deviations summarised respondents' characteristics, platform adoption and implementation constraints. A paired-samples t-test was used to compare pre-test and post-test knowledge scores, while multiple regression analysis examined the relationship between platform adoption and farmers' production decisions and management practices. All hypotheses were tested at the 0.05 level of significance.

Results

Research Question 1: determine the pre-intervention and post-intervention levels of knowledge of cassava and fish farmers exposed to digital extension and e-learning interventions in Bayelsa State.

Table 1: Distribution of respondents by pre- and post-intervention knowledge levels

Knowledge Category	Pre-Test Freq (Cassava)	Pre-Test % (Cassava)	Post-Test Freq (Cassava)	Post-Test %(Cassava)	Pre-Test Freq (Fish)	Pre-Test % (Fish)	Post-Test Freq (Fish)	Post-Test % (Fish)
Low (0–9)	78	65.0	12	10.0	84	70.0	9	7.5
Moderate (10–14)	32	26.7	28	23.3	26	21.7	21	17.5
High (15–20)	10	8.3	80	66.7	10	8.3	90	75.0
Total	**120**	**100.0**	**120**	**100.0**	**120**	**100.0**	**120**	**100.0**

Table 1 shows that prior to the intervention, low technical knowledge was recorded among 65.0% of cassava farmers and 70.0% of fish farmers. Following the intervention, 66.7% of cassava farmers and 75.0% of fish farmers attained a high level of technical knowledge. This improvement suggests that the digital learning resources delivered through WhatsApp, IVR and YouTube contributed to enhanced technical understanding among farmers in both agricultural subsectors.

Research Question 2: What is the effect of digital extension and e-learning adoption by cassava and fish farmers following the intervention in Bayelsa State?

Table 2: Level of effect of digital extension and e-learning adoption

Category of Effect	Cassava Farmers (Freq)	Cassava Farmers (%)	Fish Farmers (Freq)	Fish Farmers (%)	Combined Freq	Combined %
Low Effect	16	13.3	11	9.2	27	11.2
Moderate Effect	34	28.3	25	20.8	59	24.6
High Effect	70	58.4	84	70.0	154	64.2
Total	**120**	**100.0**	**120**	**100.0**	**240**	**100.0**

Table 2 shows that the digital intervention had a high overall effect on 58.4% of cassava farmers and 70.0% of fish farmers, resulting in a combined high effect rating of 64.2%. Fish farmers showed a higher adoption effect, driven by the immediate operational risks associated with aquaculture management.

Research Question 3: What is the effect of digital extension and e-learning adoption on the agricultural production decisions and management practices of cassava and fish farmers in Bayelsa State?

Table 3: Distribution of adopters based on influenced management practices

Production Decision Management Practice	Cassava High Influence (Freq)	Cassava High Influence (%)	Fish High Influence (Freq)	Fish High Influence (%)
Land Preparation & Pond Construction	68	56.7	81	67.5
Input Selection (Cuttings / Fingerlings)	92	76.7	98	81.7
Timing of Fertilizer / Feed Application	104	86.7	106	88.3
Disease & Weed Control Management	88	73.3	94	78.3
Post-Harvest Handling & Marketing	54	45.0	72	60.0

Table 3 shows that the intervention most influenced the timing of fertiliser and feed application among cassava farmers (86.7%) and fish farmers (88.3%). Input selection was also affected among cassava farmers (76.7%) and fish farmers (81.7%). These findings indicate improved decision-making regarding input selection and application timing.

Research Question 4: What are the constraints limiting the effective implementation and adoption of digital and e-learning interventions among cassava and fish farmers in Bayelsa State?

Table 4: Mean and standard deviation score distribution of implementation and adoption constraints

Constraints / Challenges	Cassava Mean	Cassava SD	Fish Mean	Fish SD	Pooled Mean	Remarks
Poor or unstable mobile network coverage	3.52	0.61	3.48	0.58	3.50	Very Severe
High cost of internet subscription/data bundles	3.44	0.68	3.36	0.71	3.40	Very Severe
Irregular or lack of electricity supply	3.21	0.74	3.15	0.72	3.18	Very Severe
Limited smartphone or digital literacy skills	2.65	0.82	2.42	0.85	2.54	Severe
Complex technical language in digital modules	2.15	0.91	1.98	0.88	2.07	Not a Constraint
Lack of device compatibility/storage space	2.10	0.88	2.02	0.90	2.06	Not a Constraint

Table 4 shows that four challenges were accepted as severe constraints, with mean scores above the criterion mean of 2.50, while two were rejected as barriers because their mean scores fell below the threshold. This indicates that infrastructural and economic challenges hindered the implementation and adoption of the digital interventions.

Hypotheses 1: There is no significant difference between the pre-intervention and post-intervention levels of knowledge of cassava and fish farmers exposed to digital extension and e-learning interventions in Bayelsa State.

Table 5: Paired-samples t-test of pre- and post-intervention knowledge scores

Farmer Group	Mean Pre-Test	Mean Post-Test	Mean Diff	SD	t-value	df	p-value	Decision
Cassava Farmers	8.12	15.65	-7.53	2.14	-38.51	119	0.001	Reject
Fish Farmers	7.45	16.32	-8.87	1.98	-49.03	119	0.001	Reject

The findings in Table 5 show that, prior to the intervention, cassava farmers recorded a pre-test technical-knowledge mean score of 8.12, whereas fish farmers obtained a mean score of 7.45. The t-test revealed a statistically significant difference between the pre-test and post-test scores among cassava farmers ($t = -38.51$, $p < 0.001$), as the p-value was lower than the 0.05 significance level. A significant difference was similarly observed among fish farmers ($t = -49.03$, $p < 0.001$). Accordingly, the first null hypothesis (H_{01}) was rejected.

Hypothesis 2: Digital extension and e-learning adoption has no significant effect on cassava and fish farmers following the intervention in Bayelsa State.

Table 4: simple linear regression of adoption level on post-intervention behavioral shifts

Model	Coefficient Beta	Standard Error	t-value	p-value	R	R^2	F-value	Decision
Constant	4.312	0.521	8.276	< 0.001				
Digital Adoption	0.784	0.043	18.232	< 0.001	0.763	0.582	332.41	Reject

The findings in Table 6 show that the simple linear regression model produced an R-value of 0.763 and an R-squared value of 0.582. This indicates that digital adoption accounted for 58.2% of the variation in post-intervention behavioural changes. The regression analysis further demonstrated a significant positive predictive relationship between digital adoption and post-intervention behavioural change, as reflected by a beta coefficient of 0.784, a t-value of 18.232, an F-value of 332.41 and a p-value below 0.001. Since the p-value was lower than the 0.05 significance level, the second null hypothesis (H_{02}) was rejected.

Hypothesis 3: Digital extension and e-learning adoption has no significant effect on the agricultural production decisions and management practices of cassava and fish farmers in Bayelsa State.

Table 7: Multiple Regression of Platform Channel Adoption on Production Decision Index

Variable / Platform	Unstandardized	Standard Error	t-value	p-value	Model Diagnostics	Decision
Constant	2.115	0.412	5.133	0.001	R = 0.812	
WhatsApp Clusters	0.452	0.051	8.863	0.001	R^2 = 0.659	Reject
IVR Systems	0.231	0.048	4.813	0.001	F-value = 151.78	Reject
YouTube Modules	0.314	0.055	5.709	0.001	Prob > F = < 0.001	Reject

Table 7 shows that the intervention had the greatest influence on the timing of fertiliser and feed application among cassava farmers (86.7%) and fish farmers (88.3%), followed by input selection at 76.7% and 81.7%, respectively. Post-harvest handling and marketing recorded the lowest high-influence ratings among cassava farmers (45.0%) and fish farmers (60.0%). These findings suggest that the intervention influenced farm management practices more strongly than post-harvest and marketing activities.

Discuss of Findings

Digital Extension and E-Learning Interventions and Farmers' Technical Knowledge

The findings demonstrated that digital extension and e-learning interventions enhanced the technical knowledge of cassava and fish farmers. Although many farmers initially exhibited limited technical knowledge, a substantial proportion attained higher knowledge levels after participating in the intervention. This suggests that WhatsApp, Interactive Voice Response (IVR) and YouTube instructional videos facilitated access to relevant agricultural information. This result corresponds with Arouna et al. (2021), who found that personalised mobile-based agricultural advice improved outcomes among rice farmers in Nigeria. The statistically significant differences

between pre-test and post-test results further confirmed the improvement in farmers' technical knowledge following the intervention.

Effect of Digital Extension and E-Learning Adoption among Farmers

The results showed that digital extension and e-learning interventions exerted a high effect on both cassava and fish farmers, although the effect was greater among fish farmers. This indicates that the digital channels provided useful production information for both groups. The stronger effect among fish farmers may be linked to the need for timely guidance on feeding, water quality and disease control in aquaculture. Similarly, Abioye et al. (2025) associated the adoption of mobile agricultural advisory technology with improved productivity among rice farmers in Nigeria.

Effect of Digital Extension and E-Learning Adoption on Production Decisions and Management Practices

The findings revealed that the interventions influenced decisions concerning the timing of fertiliser and feed application, as well as the selection of production inputs. Cassava farmers benefited from information relating to planting materials, fertiliser use and crop management, whereas fish farmers received relevant guidance on fingerling selection, feeding and disease prevention. However, the lower influence recorded for post-harvest handling and marketing indicates that these areas may require additional and more focused instructional materials. This finding is consistent with Arouna et al. (2021), who highlighted the practical benefits of personalised digital agricultural advice. Furthermore, the regression results showed that the adoption of WhatsApp, IVR and YouTube significantly influenced farmers' production decisions and management practices.

Constraints to Digital Extension and E-Learning Adoption

The results identified poor mobile network coverage, expensive internet data and unreliable electricity supply as major obstacles to adopting digital extension and e-learning. Inadequate digital literacy was another challenge affecting farmers' use of the platforms. These findings support Abioye et al. (2025), who identified training, access to extension services and smartphone ownership as relevant factors in the adoption of mobile agricultural advisory technologies in Nigeria. Addressing these barriers requires improved telecommunications infrastructure, affordable internet access, dependable electricity and practical digital skills training to facilitate effective and sustained use of digital agricultural learning platforms.

Conclusion

The findings demonstrated that digital extension and e-learning interventions enhanced the technical knowledge of cassava and fish farmers in Bayelsa State. The use of WhatsApp, Interactive Voice Response (IVR) and YouTube instructional videos improved farmers' understanding of relevant production and management practices. Adoption of these platforms also influenced farm management decisions, particularly fertiliser and feed application, input selection, and weed and disease control. Although both groups benefited, fish farmers reported a greater perceived effect. However, poor network coverage, high data costs, unreliable electricity and inadequate digital literacy limited effective participation. The findings indicate that digital extension and e-learning provide practical means of improving agricultural knowledge transfer and farm management decisions, particularly in Bayelsa State, where geographical barriers can restrict conventional extension services. Sustaining these benefits requires reliable connectivity,

affordable digital services and appropriate support for farmers with limited digital skills. Integrating digital interventions with existing agricultural extension services could further strengthen information dissemination, technology adoption and production practices among cassava and fish farmers.

Recommendations

It was recommended that:

1. Agricultural extension agencies in Bayelsa State should sustain the use of WhatsApp, interactive voice response (IVR) and YouTube instructional videos to improve cassava and fish farmers' technical knowledge and access to practical agricultural information.
2. Extension agents should adapt digital training content to the specific needs of cassava and fish farmers, strengthening the delivery approaches for cassava farmers while maintaining effective practices for fish farmers.
3. Agricultural extension agencies should intensify digital instruction on fertiliser and feed application, input selection, and weed, pest and disease management to improve farmers' production decisions and management practices.
4. Additional digital learning materials should be developed on post-harvest handling and marketing, including cassava processing and storage, as well as fish preservation and marketing, to address the areas where the interventions had comparatively lower influence.
5. Agricultural development agencies should establish regular follow-up activities to encourage farmers' continued adoption of WhatsApp, IVR and YouTube and assess how the knowledge acquired through these platforms is applied to farming practices.
6. Government and telecommunications providers should collaborate to improve mobile network coverage in rural and riverine communities, promote affordable data packages and support reliable electricity alternatives to reduce barriers to digital extension participation.
7. Agricultural extension agencies and farmer organisations should provide basic digital literacy training and make agricultural learning materials available in voice-based, downloadable and low-data formats to accommodate farmers with limited digital skills and inconsistent access to smartphones or internet services.

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