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Effectiveness of ICT-Based Agricultural Extension Services on Farmers' Productivity in Kano State, Nigeria.

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Abstract

This study assesses the effectiveness of information and communication technology (ICT)-based agricultural extension services on farmers' productivity in Kano State, Nigeria. A multi-stage sampling technique was used to select 380 farming households from six local government areas (Doguwa, Tudun Wada, Dambatta, Bichi, Gaya and Wudil) in three Agricultural Development Programme zones, and data were collected with a structured questionnaire. Descriptive statistics were used to analyse the socio-economic characteristics of the respondents. Most respondents were male (97.11%) and married (88.42%), and 67.10% were aged 41–60 years. Secondary education was the most common level (35.53%), while 18.42% had no formal education. Most farmers (92.37%) cultivated 1–5 hectares, and 43.68% had 11–20 years of farming experience. About 86.58% earned ₦10,000,000 or less from farming. Only 11.32% had access to credit, 52.63% had contact with extension services, and 84.74% belonged to cooperative associations. The sampled farmers were mostly male, middle-aged or older smallholders with limited access to credit and uneven extension contact. Extension programmes should therefore use channels that reach farmers with little formal education, such as voice messages and radio, work through cooperatives, and address credit constraints.

Keywords: ICT-based extension, agricultural extension, farmers' productivity, effectiveness.

INTRODUCTION

Agriculture remains the backbone of Nigeria's economy, employing a large share of the labour force and contributing approximately 23.69% to national gross domestic product (National Bureau of Statistics [NBS], 2023). Despite the country's agro-ecological potential, smallholder productivity, particularly in grain-producing states such as Kano, is held back by limited access to timely technical information, quality inputs and weather forecasts (National Agricultural Extension and Research Liaison Services [NAERLS], 2022; Aina *et al.*, 2022). Traditional extension systems have struggled with high agent-to-farmer ratios, often estimated at one agent to every 5,000–10,000 farmers (Olorunfemi *et al.*, 2020), and this has increased interest in information and communication technologies (ICTs) as a way of widening coverage.

ICTs, including mobile phones, short message service (SMS), Interactive Voice Response (IVR), radio and decision-support applications, have been promoted to improve extension delivery (Akinwalere & Adekunle, 2022; Adedoyin & Ayeni,

2024). Platforms such as e-extension portals and mobile advisory services link research institutes directly to the farm gate. Meta-analyses summarised by Fabregas *et al.* (2019) suggest that digital advisory services raise yields by about 4% and the odds of adopting recommended practices by 22%. Nigerian studies report that ICTs improve the timeliness of information and the adoption of improved practices, which in turn raise crop yields and household income (Bolarinwa & Oyeyinka, 2021; Olanrewaju *et al.*, 2023).

Different tools suit different groups of farmers. IVR delivers advice in local languages and so bypasses text-based barriers for farmers with low literacy (Maredia *et al.*, 2022). Decision-support applications that analyse soil and weather data to give planting advice are moving from trial to field use in Nigeria and can reduce waste of costly inputs such as fertiliser (Oyelami *et al.*, 2023). In northern Nigeria, a decision-support application for rice farmers improved productivity, with the largest and most consistent gains where advice was bundled with fertiliser; the gains peaked in the second year and then declined, which raises the question of sustainability without



continued support (Owusu *et al.*, 2025). SMS reminders had a positive and significant effect on the productivity of smallholder farmers in northern Nigeria, with 52% of respondents reporting rapid increases in yield (Sennuga *et al.*, 2020). Radio remains the most accessible ICT device in rural Kano and allows a single extension agent to reach very large numbers of farmers in Hausa (Asenso-Okyere & Ayalew-Mekonnen, 2012), while WhatsApp and other social media are used by younger farmers to obtain market prices (Oyediji *et al.*, 2024).

The availability of ICT tools does not by itself make extension more effective. Outcomes depend on digital literacy, the credibility and relevance of the information, network coverage and the reliability of infrastructure (Adio *et al.*, 2021; Bello & Salau, 2020; Sennuga *et al.*, 2024). In northern Nigeria, mobile phone ownership is high, but use of specialised agricultural applications is uneven because of data costs, irregular power for charging devices and language barriers (Akinwumi & Okunlola, 2020; Oyelami *et al.*, 2023; Yusuf & Musa, 2021). The cost of smartphones and data is a further barrier for subsistence farmers (Chiazoka *et al.*, 2021), as are weak connectivity and electricity in rural local government areas of Kano State (Abubakar *et al.*, 2024). Women make up a large part of the agricultural workforce but often have lower digital literacy and less control over the household money needed for data subscriptions and devices (Fadairo *et al.*, 2020; Nyagango *et al.*, 2023). Magaji and Musa (2024) observed that without local-language content and traditional knowledge, even sophisticated tools may not win the trust of rural smallholders.

The study draws on the Technology Acceptance Model (TAM) and the Diffusion of Innovations (DOI) theory. TAM holds that adoption of a technology depends on its perceived usefulness and perceived ease of use (Davis, 1989). A farmer who finds an SMS alert system easy to use and useful for crop yields is therefore more likely to adopt it. DOI theory explains how new ideas spread through a social system (Rogers, 2003). In northern Nigeria, diffusion depends on the relative advantage of ICTs over traditional methods, and on trialability and observability, for example, when a farmer sees a neighbour obtain higher yields from ICT-guided fertiliser application.

Evidence on the effect of ICT-based extension remains fragmented. Extension in Nigeria is limited by a shortage of personnel, with agent-to-farmer ratios often above 1:5,000 (Olorunfemi *et al.*, 2020), and by poor rural roads and inadequate funding that restrict coverage (Sennuga *et al.*, 2024). ICT has been presented as a leapfrog technology for rapid two-way communication, and some studies report better access to real-time climate-smart advice and gains in productivity (Aina *et al.*, 2022). Others describe a “pilot-itis” problem, in which small-scale digital successes fail to scale because of low uptake, content that farmers find irrelevant, or gaps in last-mile infrastructure (Adio *et al.*, 2021; Oyelami *et al.*, 2023). It is therefore necessary to find out how far ICT-based extension services improve productivity in Kano State.

This study addresses that need using a mixed-method empirical design.

The main objective of the study is to assess the effectiveness of ICT-based agricultural extension services on farmers’ productivity in Kano State. The specific objectives are to:

1. describe the socio-economic characteristics of farmers in Kano State;
2. determine the level of access to and use of ICT-based extension information among farmers in Kano State;
3. identify the socio-economic, institutional, and infrastructural factors that influence the effectiveness of ICT-based extension information;
4. determine the farmers’ perceptions of the timeliness, relevance, and credibility of ICT-based extension information in the study area;
5. determine the relationship between use of ICT-based extension information and farmers’ productivity; and
6. identify the problems that hinder the effective delivery of ICT-based extension information.

The following null hypotheses are tested at the 5% significance level:

H01: There is no significant relationship between farmers’ use of ICT-based extension services and their productivity.

H02: Socio-economic factors (education, age, farm size and income) have no significant moderating effect on the relationship between ICT use and farmers’ productivity.

H03: Institutional and infrastructural constraints (network coverage, power supply and extension agent training) do not significantly affect the effectiveness of ICT-based extension services.

MATERIAL AND METHODS

Description of the study area

The study was conducted in Kano State, located in Nigeria’s North-West geopolitical zone, with Kano city as its capital. Katsina State borders it to the northwest, Jigawa State to the northeast, Bauchi State to the southeast, and Kaduna State to the southwest (ZODML, 2023). It lies between latitudes 10°30’N and 13°N and longitudes 7°40’E and 10°35’E and covers 20,131 km² (Kano State Government, 2024). The 2006 census recorded 9,401,288 persons in the state (National Population Commission [NPC], 2006). The projected population is over 16.2 million, at a density of about 807 persons per km² (Kano State Government, 2024).

Kano State has a tropical savanna climate with a rainy season and a dry season. Mean annual rainfall is about 980 mm, most of it falling between June and September. A cool dry (Harmattan) season runs from December to February and is followed by a hot dry season from March to May. The vegetation is a transition between Sudan Savannah and Northern Guinea Savannah, with wooded savanna in the south and scrub vegetation in the north (ACReSAL, 2024).

Kano is a major commercial and industrial centre in Nigeria and West Africa. The state economy rests on agriculture, trade and manufacturing. Kano is a leading producer of groundnut, sorghum, millet, maize, rice and cotton, and its manufacturing sector produces textiles, leather goods and processed foods (Mogro, 2024). The Hausa-Fulani are the dominant ethnic group, and most inhabitants are engaged in agriculture, trading, craftwork, and animal husbandry (Bayero University Kano, 2023). Family life and social relations are strongly influenced by Islamic teachings and respect for elders (Kano State Government, 2024).

Sampling technique and sample size

The study population comprised registered smallholder farmers who benefit from agricultural extension services in Kano State. Records of the Kano Agricultural and Rural Development Authority (KNARDA) show about 1.5 million farming households across the 44 local government areas (LGAs) of the state. A multi-stage sampling technique was used to select respondents. In the first stage, the state was

grouped into three Agricultural Development Programme (ADP) zones (Rano, Dambatta and Gaya). In the second stage, two LGAs were selected from each zone, giving six LGAs: Doguwa and Tudun Wada (Rano zone), Dambatta and Bichi (Dambatta zone), and Gaya and Wudil (Gaya zone). In the third stage, the list of registered farming households in each LGA was used as the sampling frame, which gave 3,650 households in total. A sample of 380 households was drawn, which includes an allowance for potential non-response.

The sample was allocated to the LGAs in proportion to the number of registered households in each, using:

$$x = (X / N) \times n \dots \dots \dots (1)$$

where x = sample size per LGA, X = number of registered households in the LGA, N = total number of registered households in the six LGAs (3,650), and n = final sample size (380). The selected zones, LGAs, registered households, and sample from each LGA are presented in Table 1.

Table 1: Selected zones, LGAs and sample size of farming households

Zone	LGA	Registered households	Proportional allocation	Final sample (n)
Rano	Doguwa	700	19.2%	73
Rano	Tudun Wada	700	19.2%	73
Dambatta	Dambatta	700	19.2%	73
Dambatta	Bichi	700	19.2%	73
Gaya	Gaya	425	11.6%	44
Gaya	Wudil	425	11.6%	44
Total		3,650	100%	380

Source: KNARDA records and author's computation (2026).

Operational definitions of key terms

Agricultural extension services are formal and informal advisory services that transmit technologies, practices, and market information to farmers to improve productivity and livelihoods. ICTs are electronic tools and platforms used to store, retrieve, transmit, and manipulate information; in this study, they include mobile phones (voice and SMS), smartphone applications, internet platforms, radio, IVR, and other digital advisory channels. ICT-based extension services are the delivery of extension content (technical advice, market information and weather information) through ICT channels, either alone or as part of blended face-to-face and digital approaches. Productivity is cropping yield per hectare and net output per unit area for the selected crop, and also output per unit of labour where data permit. Effectiveness is the extent to which ICT-based extension achieves its intended outcomes, namely increased knowledge, adoption of recommended practices and measurable improvement in productivity.

Data collection

Data were collected using a structured questionnaire.

Data analysis

Descriptive statistics (frequencies, percentages and means) were used to analyse the socio-economic characteristics of the farmers.

RESULTS AND DISCUSSION

Socio-economic characteristics of the farmers

Table 2 presents the socio-economic characteristics of the farmers in the study area. These characteristics influence farmers' access to information, adoption of innovations, productivity, and use of ICT facilities. The results indicate that farmers aged 51–60 years constituted the largest age group, accounting for 34.47% of the respondents. This was followed by farmers aged 41–50 years (32.63%), those aged 31–40 years (24.74%), and farmers aged 21–30 years (8.16%).

Table 2: Distribution of farmers according to their socio-economic characteristics.

Variables	Frequency	Percentage	Mean
Age (years)			
21–30	31	8.16	56 years
31–40	94	24.74	
41–50	124	32.63	
51–60	131	34.47	
Sex			
Male	369	97.11	
Female	11	2.89	
Marital status			
Single	35	9.21	
Married	336	88.42	
Widow	8	2.11	
Widower	1	0.26	
Household size (persons)			
1–5	130	34.21	10 persons
6–10	103	27.11	
11–15	90	23.68	
16–20	57	15.00	
Educational level			
No formal education	70	18.42	
Primary education	109	28.68	
Secondary education	135	35.53	
Tertiary education	52	13.68	
Vocational	14	3.68	
Farming experience (years)			
1–10	49	12.89	22 years
11–20	166	43.68	
21–30	131	34.47	
31–40	34	8.95	
Farm size (hectares)			
1–5	351	92.37	3 hectares
6–10	23	6.05	
11–15	6	1.58	

Variables	Frequency	Percentage	Mean
Farm income (₦)			
≤ 5,000,000	172	45.26	₦60,244.22
5,000,001–10,000,000	157	41.32	
10,000,001–15,000,000	40	10.53	
15,000,001–20,000,000	1	0.26	
> 20,000,000	10	2.63	
Access to credit			
Had access	43	11.32	
No access	337	88.68	
Extension contact			
Had contact	200	52.63	
No contact	180	47.37	
Membership of cooperative association			
Members	322	84.74	
Non-members	58	15.26	

Source: Field Survey, 2026.

The distribution suggests that farming activities in the study area were dominated by middle-aged and older farmers. The relatively small proportion of younger farmers may indicate limited participation by young people in agricultural production, although further evidence would be required to establish the reasons for this pattern.

The substantial representation of farmers aged 41–60 years may have implications for agricultural productivity and the adoption of improved farming practices. Farmers within these age groups may have accumulated considerable practical experience, knowledge of local farming conditions, and familiarity with seasonal production patterns. Such experience can support decision-making and the management of farming risks.

However, older farmers may require appropriate training when introduced to unfamiliar technologies, particularly digital agricultural information services. Younger farmers may be more willing to experiment with some digital tools, although age alone does not determine an individual's ability or willingness to adopt technology. The results also show that males constituted 97.11% of the respondents, while females accounted for 2.89%. This indicates a substantial imbalance in the sex composition of the sampled farmers.

The low representation of female farmers may reflect differences in access to farmland, productive resources, agricultural opportunities, or participation in the particular farming activities covered by the study. However, the table

alone cannot establish which factors explain the observed difference.

The predominance of male respondents also has implications for the design and delivery of agricultural extension services. If extension programmes rely mainly on interactions with male farmers, the information provided may not adequately reach women who participate in agricultural production, processing, storage, and marketing.

Female farmers may face particular challenges in accessing land, credit, extension personnel, and agricultural information. These challenges should be investigated rather than assumed to apply uniformly to all women in the study area.

The findings indicate that married farmers accounted for 88.42% of the respondents. Single farmers constituted 9.21%, while widows and widowers accounted for 2.11% and 0.26%, respectively.

The high proportion of married farmers suggests that farming is commonly undertaken by individuals with family responsibilities in the study area. Family members may contribute labour to farm operations, particularly during land preparation, planting, weeding, harvesting, and post-harvest activities.

Marriage and family responsibilities may also influence household expenditure, labour allocation, and decisions concerning farm investment. Nevertheless, marital status alone does not establish whether a farmer has access to family labour or possesses greater financial resources.

The results show that 34.21% of the respondents belonged to households with 1–5 members, while 27.11% had household sizes of 6–10 members. Farmers with 11–15 household members constituted 23.68%, whereas those with 16–20 members accounted for 15.00%.

The distribution indicates that household size varied considerably among respondents, with a substantial proportion belonging to relatively large households. Household size may influence agricultural production through the availability of family labour. Larger households may provide additional workers for farm operations, potentially reducing dependence on hired labour.

The findings indicate that 35.53% of respondents had secondary education, while 28.68% had primary education. Farmers with no formal education constituted 18.42%, those with tertiary education accounted for 13.68%, and those with vocational education represented 3.68%.

The results suggest that respondents had different levels of formal education, with secondary education representing the largest category. A considerable proportion had either no formal education or only primary education.

Education can influence farmers' ability to understand technical information, interpret written instructions, maintain farm records, compare production costs, and assess improved agricultural technologies. However, formal education does not automatically translate into greater adoption of improved practices. Access to information, practical skills, affordability, infrastructure, and perceived usefulness also influence adoption.

The proportion of respondents without formal education highlights the need for extension approaches that do not depend entirely on written materials. Demonstrations, illustrations, local-language communication, and practical instruction can help farmers understand new technologies.

The results indicate that 43.68% of respondents had 11–20 years of farming experience. Farmers with 21–30 years of experience constituted 34.47%, while those with 1–10 years accounted for 12.89%. Farmers with 31–40 years of experience represented 8.95%.

The distribution suggests that many respondents had accumulated substantial experience in farming. Such experience may help farmers understand local climatic conditions, recognise common production problems, manage seasonal activities, and make decisions based on previous outcomes.

Experienced farmers may also possess valuable indigenous knowledge that can complement information provided by agricultural extension personnel. However, experience does not necessarily guarantee higher productivity or willingness to adopt new technologies. The relationship between experience and technology adoption requires empirical investigation.

The results show that 92.37% of respondents cultivated between 1 and 5 hectares. Farmers cultivating 6–10 hectares

accounted for 6.05%, while those cultivating 11–15 hectares represented 1.58%.

The distribution indicates that most respondents operated relatively small farms. Farm size may influence production decisions, the scale of operations, choice of technologies, access to machinery, and capacity to generate marketable surpluses.

Farmers operating small holdings may face difficulties investing in expensive technologies, irrigation facilities, mechanisation, and other production inputs. However, small farm size does not necessarily imply low productivity.

Appropriate technologies and effective management can help smallholder farmers increase output per hectare.

The results indicate that 45.26% of respondents fell within the farm-income category of ₦5,000,000 or less, while 41.32% were within the ₦5,000,001–₦10,000,000 category. Farmers earning ₦10,000,001–₦15,000,000 accounted for 10.53%. The remaining respondents were distributed across the higher income categories.

The distribution suggests that the two lowest reported income categories contained the largest proportions of respondents. Farm income can affect farmers' capacity to purchase improved seeds, fertilisers, agrochemicals, machinery services, and other inputs. It may also influence their ability to invest in digital devices and internet services.

Farmers with limited income may find it difficult to adopt technologies that require substantial initial expenditure. However, the table does not establish whether reported income represents gross farm revenue or net farm income after production costs. This distinction is important because high revenue does not necessarily indicate high profitability.

The findings indicate that 11.32% of respondents had access to credit, whereas 88.68% did not. The high proportion reporting no access suggests that agricultural financing may be a major concern among the respondents.

Access to credit can help farmers obtain inputs at the appropriate time, hire labour, acquire equipment, and invest in improved production technologies. Limited access may restrict farmers' capacity to adopt recommended practices even when they understand their benefits.

The results indicate that 52.63% of respondents had contact with agricultural extension services, while 47.37% reported no contact. Although slightly more than half reported extension contact, the proportion without such contact remains substantial.

Extension contact enables farmers to obtain information on improved production practices, pest and disease management, fertiliser application, climate-related risks, post-harvest handling, and market opportunities. The benefits depend on the quality, frequency, relevance, and timeliness of the information provided.

The findings also indicate the importance of examining alternative communication channels where extension personnel cannot visit every farming community regularly.

The results show that 84.74% of respondents belonged to cooperative associations, while 15.26% were non-members. This suggests that cooperative organisations may provide an important channel for reaching farmers in the study area.

Cooperatives can support members through collective input purchases, access to agricultural information, savings and credit arrangements, marketing, and sharing farming experiences. They may also provide a convenient platform for extension personnel to organise training.

Membership alone does not guarantee that farmers receive these benefits. The effectiveness of cooperatives depends on management, financial capacity, leadership, participation, and the services available to members.

Conclusion

In conclusion, the results suggest that the sampled farmers were predominantly middle-aged or older, male, married, and experienced in farming. Most were reported to operate relatively small farms, while a large proportion belonged to cooperative associations. The results also point to possible challenges relating to access to agricultural credit and extension services.

These characteristics are relevant to the planning and delivery of agricultural development programmes. Effective interventions should consider farmers' educational backgrounds, available resources, farming experience, financial capacity, and access to agricultural information.

Improving access to credit, strengthening extension services, promoting appropriate technologies, and building the capacity of farmer cooperatives may help address some of the challenges suggested by the results.

Recommendations

Promote appropriate digital agricultural information services. Information should reach farmers through channels they can access and understand. Mobile messaging, voice calls, agricultural radio and suitable digital platforms can complement conventional extension visits, and services should take account of language, network coverage, device ownership and communication costs.

Strengthen farmer cooperatives. Farmer associations should be supported to improve management, financial capacity and services to members. Cooperatives can serve as channels for extension training, input distribution, collective marketing and access to financial institutions.

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