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Digital Technology Use for Agricultural Extension Information among Rural Leaders in Tel Kayf District

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HIGHLIGHTS

- Rural leaders showed favourable use of digital technology for agricultural information.
- Age, education and information sources were the major predictors of digital technology use.
- High mobile phone prices and Internet costs were the major constraints to digital use.

ARTICLE INFO

Keywords: Digital technology, ICT adoption, Internet access, Iraq, Mobile phone use, Nineveh.

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ABSTRACT

Digital technology has become increasingly important as an extension support tool, facilitating access to current agricultural information. The current research evaluated the utilisation of digital technology by rural leaders to obtain agricultural information in Tel Kayf District, Nineveh Governorate, Iraq. A multi-stage sampling method was applied and 101 rural leaders were selected from three villages. The data were collected in June 2024 via face-to-face interviews employing a structured questionnaire. The use of digital technology was evaluated using 20 statements on a five-point rating scale. Mean, standard deviation, relative importance, frequency, percentage and random forest regression were applied for the analysis. The findings showed mean item scores exceeded 4.0 on a five-point scale across all twenty statements. The random forest regression model achieved a test R^2 of 0.3920 in the utilisation of digital technology. Age was the most influential variable, followed by education and information sources. The high prices of modern mobile phones and Internet charges were the main barriers. The findings imply that the existing favourable use of digital technology among rural leaders can be leveraged through affordable Internet access, practical skill enhancement and locally relevant digital extension content to strengthen agricultural information dissemination in rural communities.

INTRODUCTION

Technology is an integral part of modern societies, affecting the generation, storage, retrieval and utilisation of information across various industries, including agriculture. Technology plays a crucial role in human development. However, its latest manifestation, namely digital technology, provides greater opportunities for communication, learning and decision-making (Ram et al., 2020). This shift is essential within the context of agriculture since the industry has direct impacts on food security, economic stability and development (Karikari et al., 2015). The development of agriculture relies not only on tangible resources and technological advances but also on rural populations' ability to access and utilise relevant information. The increasing use of digital technology in rural marketing and agriculture illustrates its potential to facilitate more efficient communication and enhance information transfer

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between institutions and farmers (Rushchitskaya et al., 2024). In this respect, agricultural extension is critical in linking research and technology with farmers through advice and behaviour modification (Olalekan, 2024; Shitu et al., 2025; Barman et al., 2026).

With rapid technological changes, there is a need for an extension system that can deliver relevant, location-based agricultural information. Digital means like mobile phones, Internet access, search engines and online advice websites play a significant role in reducing the distance between farmers, extension workers and scientific organisations (Yu et al., 2024). Additionally, rural leadership is key because leaders often play a role in decision-making and information dissemination in agriculture (Wilmot, 2024). Digital technology is therefore considered an important instrument for improving the functioning and sustainability of agricultural extension services. It reduces spatial and temporal barriers and opens wider communication channels for serving farming communities (Liu et al., 2023). However, the effective use of such technologies depends on users' access, education, skills, and confidence (Dibbern et al., 2024). The emergence of computers, the Internet, and mobile phones necessitates strengthening digital capacity among rural users and agricultural stakeholders (Amran et al., 2024).

In Iraq, recent attention to rural knowledge, environmental crisis management and agricultural information systems highlights the need to understand how rural communities respond to modern information sources (Al-Daudee & Masso, 2025). Educational institutions also have an important role in preparing competent agricultural human resources capable of using modern information systems for rural development (Cárdenas Alonso & Nieto Masot, 2022). However, evidence on the use of digital technology for agricultural information by rural leaders in Nineveh Governorate remains limited. Therefore, the present study is undertaken to assess the use of digital technology, such as mobile phones, internet access, search engines, agricultural websites, social media, digital communication tools, and computer-based agricultural calculations, used to obtain, process, or share agricultural information by rural leaders in the Tel Kayf District of Nineveh Governorate. Rural leaders often act as informal extension agents, opinion leaders, information brokers, peer educators and diffusion agents in rural communities. The study also examines the contributions of age, education, origin, information sources and training to digital technology use and identifies the major constraints limiting effective use of digital tools.

METHODOLOGY

The study was conducted in selected villages of Tel Kayf District, Nineveh Governorate, Iraq. The research population consisted of farmers from five villages in the Alqosh area. A multi-stage sampling procedure was followed. First, three villages were randomly selected from the five, resulting in an accessible population of 270 farmers. Second, potential rural agricultural leaders were identified in consultation with village-level key informants and local agricultural personnel. Rural agricultural leaders were defined as active farmers locally recognised for their ability to access, interpret and share agricultural information. Identification criteria included active involvement in farming, regular interaction with other farmers, use of multiple information sources and participation in communicating agricultural information within the local farming community. From these, 101 rural agricultural leaders were selected for interview, representing 37.4% of the accessible farmer population.

Primary data were collected in June 2024 through personal interviews using a structured questionnaire. The questionnaire had two sections: the first covered age, education, origin, sources of agricultural information and participation in digital technology training; the second measured the use of digital technology to obtain agricultural information. Initially, 25 statements were prepared after reviewing literature and consulting subject specialists. After expert screening, 20 statements were retained for final data collection. Digital technology usage was assessed using a 20-item, five-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree). Content validity was established through expert review by 20 experts from the Universities of Mosul and Dohuk. Items with at least 80% agreement were retained. A pilot study (n=20) yielded a Cronbach's alpha of 0.85, indicating acceptable internal consistency.

Data analysis was done through mean, standard deviation, rank, relative weight, frequency and percentages. The digital technology use score was predicted through a random forest regression model. The random forest technique is preferred due to its ability to accommodate non-linear interaction and relationships among predictors (Breiman, 2001). Model performance was evaluated using the coefficient of determination (R^2), mean absolute error (MAE) and root mean square error (RMSE). Feature importance and Shapley Additive Explanations (SHAP) values were used to interpret the models (Lundberg & Lee, 2017).

RESULTS

Digital technology adoption among rural leaders

According to Table 1, rural leaders extensively used digital technology to access agricultural information. The mean values for all 20 statements ranged from 4.00 to 4.49, indicating a positive trend toward the adoption of digital technologies in agricultural activities. The weights were also relatively high, ranging from 0.800 to 0.897, suggesting that digital technology was a significant source of agricultural information for respondents.

"The digital technology enables me to access current information at an agricultural level," obtained the first rank with a mean score of 4.49 and a relative weight of 0.897. "The Internet allows me to access agricultural information," ranked second with a mean score of 4.47 and a relative weight of 0.893. "I remain updated on the global happenings using digital technology," occupied the third position with a mean score of 4.43 and a relative weight of 0.885. Based on the above findings, it can be concluded that respondents used digital devices to access current agricultural information.

Those statements about the usefulness of the technology at the farm level also received high rankings. "The use of digital technology makes it easy for me to do my agriculture practice" was fourth on the list with an average score of 4.41. "The Internet makes most of the things needed for agricultural practice available" was fifth with an average score of 4.39. The ease of agricultural activities due to mobile phone use ranked sixth, with an average score of 4.38.

Table 1. Use of digital technology by rural leaders for agricultural information

Rank	Statement	Mean	Standard Deviation	Relative Weight
1	Digital technology helps me obtain up-to-date information at the agricultural level.	4.49	0.57	0.898
2	The Internet helps me get timely agricultural information.	4.47	0.69	0.894
3	I keep pace with developments in the world through my use of digital technology.	4.43	0.67	0.886
4	Digital technology helps me practice my agricultural work more easily.	4.41	0.61	0.882
5	The Internet contributes to obtaining most of the resources I need in my agricultural work.	4.39	0.84	0.878
6	Using a mobile phone helps make agricultural operations easier.	4.38	0.84	0.876
7	Digital technology helps me gain up-to-date information about agriculture.	4.35	0.78	0.870
8	Digital technology reduces the effort expended in some work.	4.34	0.84	0.868
9	My use of digital technology helps me develop my learning abilities.	4.26	0.80	0.852
10	Ease of calling and getting help while using a mobile phone.	4.25	0.89	0.850
11	Most digital technology helps me obtain up-to-date information in agriculture.	4.22	0.87	0.844
12	I prefer to use the Google search engine to obtain agricultural information.	4.21	0.83	0.842
13	I cannot do without my mobile phone because I always need it in my agricultural work.	4.15	0.90	0.830
14	The programs I use to make production calculations save me from relying on other people.	4.11	0.98	0.822
15	Most of the calculations related to agriculture I tabulate using the computer.	4.07	0.82	0.814
16	I compare what I encounter on the farm with the pictures on the Internet.	4.06	0.90	0.812
17	Most of the problems I face in my agricultural work I find a solution for using search engines.	4.05	1.10	0.810
18	I cannot do without the Internet on my mobile phone while I work as a farmer.	4.02	1.10	0.804
19	I always search for the type of diseases that affect my crops in search engines.	4.01	0.84	0.802
20	I rely on social media to obtain agricultural information.	4.00	1.10	0.800

The low-ranked statements were associated with specialised applications of digital technology. Using computers for performing agricultural calculations, comparing farm issues with images on the Internet and searching for plant diseases using search engines were ranked lower on the list. "I depend on social media for getting agricultural information" was the last statement in the list with a mean rating of 4.00 and a relative weight of 0.800. Even the least favoured statement had a higher mean value, suggesting that social media was used, though less than other activities such as searching the Internet, using mobile phones and having up-to-date information.

Random forest regression model for digital technology use

The Random Forest regression model was estimated using age, education, origin, agricultural information sources and digital technology training as independent variables, with digital technology use score as the dependent variable. The dataset was split into training and test sets at 80:20 and out-of-bag validation was used as an additional internal validation procedure. The model achieved a training R^2 of 0.6879, with MAE and RMSE values of 0.0402 and 0.0552, respectively, indicating a good in-sample fit. However, the testing R^2 was lower at 0.3920, with MAE and RMSE values of 0.0898 and 0.1146, respectively. Out-of-bag (OOB) validation yielded an R^2 of 0.2830, with MAE and RMSE values of 0.0901 and 0.1125, respectively. These results indicate that the model explained 39.20% of the variation in unseen observations and 28.30% under OOB validation, suggesting moderate predictive performance. The disparity between the training and validation results suggests some degree of overfitting. Therefore, the testing and OOB results are considered more reliable indicators of model generalisation than the training R^2 alone.

Figure 1 presents the random forest feature importance scores, which show the relative contribution of each predictor to improving model prediction. Age was the most important predictor, with an importance score of 0.5428, indicating its strongest contribution to differences in digital technology use among rural leaders. Education ranked second with a score of 0.1906, followed by information sources with 0.1692. Training on digital technology had a comparatively lower importance score of 0.0688, while origin was the least important predictor with a score of 0.0287. This suggests that personal characteristics and exposure to information sources were more influential than origin in predicting digital technology use.

Figure 2 presents the SHAP summary plot, which offers a respondent-level interpretation of the same random forest model. While Figure 1 ranks predictors by overall importance, Figure 2 illustrates how each predictor contributed to the predicted digital technology use score for individual respondents. In the SHAP plot, each point represents the predictor contribution of one respondent. Positive SHAP values indicate that a predictor increased the predicted digital technology use score, whereas negative SHAP values indicate a reduction. The wider spread of points for age demonstrates that age had the strongest and most variable influence on model output. Education and information sources also showed visible contributions, confirming their importance in shaping digital technology use. Training and origin had narrower SHAP distributions, indicating comparatively weaker effects.

Reasons for not using digital technology

The results in Table 2 showed that the high prices of modern, high-quality mobile phones were the most frequently reported reason for not using digital technology to obtain agricultural information. This constraint was reported by 65 respondents, accounting for 64.4 per cent. The financial cost of Internet use ranked second, with 56 respondents (55.4 per cent). These findings indicated that economic barriers were the major constraints limiting the effective use of digital technology among rural leaders.

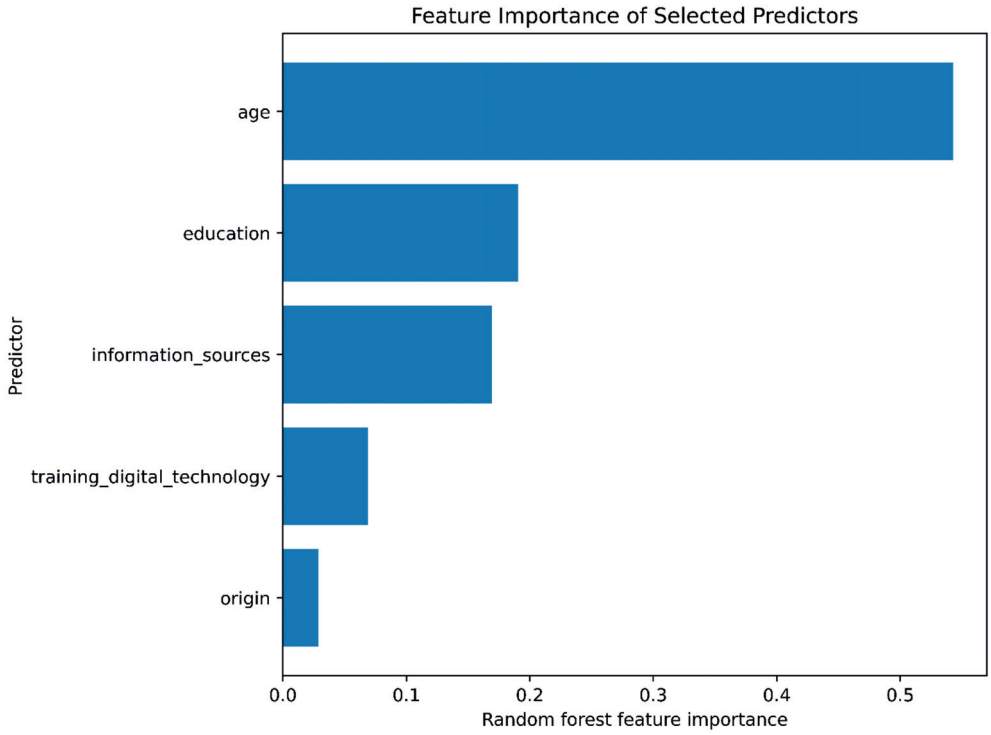

Figure 1. Random forest feature importance of predictors of digital technology use

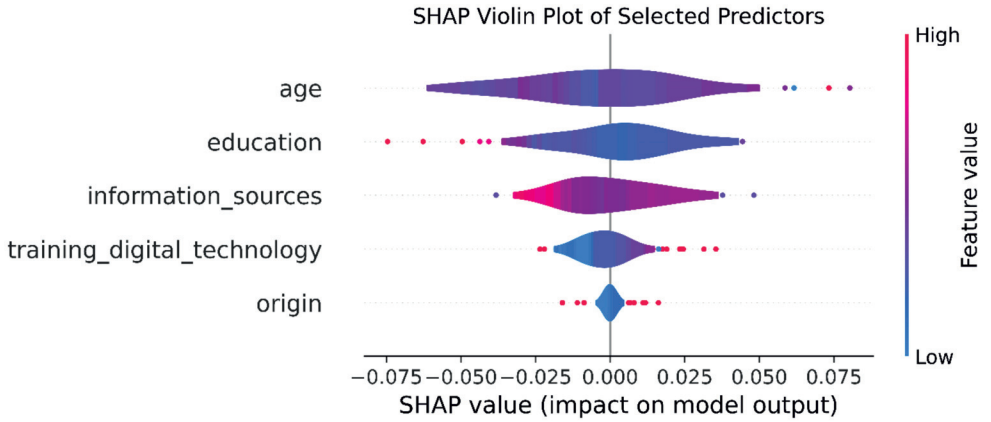

Figure 2. SHAP summary violin plot showing predictor contribution to digital technology use

Table 2. Reasons for not using digital technology to obtain agricultural information

Reason	Percentage
High prices of modern quality mobile phones	64.4
The financial cost of using the Internet	55.4
Lack of sufficient time to use digital technology	39.6
Lack of computer availability in the field	30.7
Lack of consistency in the effectiveness of digital technology in obtaining agricultural information	41.6
I do not know how to use the Internet to obtain agricultural information	34.7
I do not have enough experience to use a computer	30.7
I prefer to use the phone for communication only	22.8

The lack of consistency in the effectiveness of digital technology for obtaining agricultural information was reported by 42 respondents (41.6 per cent), while the lack of sufficient time to use digital technology was reported by 40 respondents (39.6 per cent). 35 respondents (34.7 per cent) reported a lack of knowledge about using the Internet for agricultural information. Lack of computer availability in the field and insufficient computer-use experience were each reported by 31 respondents, accounting for 30.7 per cent. The least reported reason was a preference for using the phone only for communication, reported by 23 respondents (22.8 per cent).

DISCUSSION

Rural leaders in Nineveh effectively used digital technology to acquire agricultural information, as evidenced by very high mean scores across all twenty statements. Digital technology has become a crucial component of their agricultural information-seeking behaviour, particularly for obtaining timely, up-to-date information. This suggests leaders value its speed, accessibility and ability to provide timely information at the farm level, aligning with Mukherjee and Jha (2024) observed that farmers use ICTs for information gathering. Digital technology was also considered useful

for practical agricultural work. The moderate ranking of computerised calculations, image analysis and disease search indicates that more complex applications were less utilised. This supports Panda et al., (2019) and Chaturvedi & Vatta (2025) findings that farmers prefer digital technology for simple farm processes over technical purposes.

The random forest regression model accounted for a considerable amount of variance in digital technology usage. Age was the top predictor, followed by education and sources of information. The significance of age implies that rural leaders' digital behaviour is influenced by personal experience, decision-making roles and familiarity with farming environments. Education is also crucial, as educated individuals are expected to analyse digital agricultural information efficiently (Chandra et al., 2024). Information sources strongly influenced digital technology use, with leaders connecting to diverse agricultural information sources more likely to use digital tools effectively. This suggests digital media complements existing extension, interpersonal and institutional information systems, rather than operating in isolation (Pradhan et al., 2025). Training on digital technology had a meaningful but comparatively lower contribution. Internet access and digital training significantly improve farmers' adoption of sustainable agricultural practices, productivity and welfare (Sher et al., 2025). Sahoo et al. (2025) reported that ICT-oriented training improved the capacity of extension personnel and farmers to use digital tools for information dissemination and advisory support.

Constraints further explained the limits of digital technology use. High prices of modern mobile phones and the cost of Internet use were the leading barriers. Satapathy et al. (2024) also identified cost, access and skill-related barriers as major constraints in ICT adoption in agriculture. Lack of time, limited computer availability, inadequate Internet knowledge and limited computer experience indicated a financial, infrastructural and skill-based digital divide (Sondara et al., 2023). Sen et al. (2024) similarly observed that digital extension adoption depended on device access, digital skills and confidence in using services.

Digital technology created opportunities for rural leaders to access agricultural information, but its effective use depended on education, exposure to information, training and affordability. Digital extension programmes in Nineveh should therefore focus on practical digital literacy, low-cost access, local-language content and field-level support. Inclusive extension strategies are required to ensure that digitally less-prepared farmers are not excluded from emerging agricultural information systems (Saha et al., 2024). The wider adoption of smart agricultural technologies also requires user readiness, institutional support and locally suitable implementation pathways (Prusty et al., 2025).

The study has certain limitations. Although predictor selection was guided by diffusion and digital-divide perspectives, the study did not directly measure all constructs commonly used in formal technology-adoption models. Therefore, the findings should be interpreted as explaining selected socio-demographic, informational, and capacity-related correlates of digital technology. Future studies may include these constructs to develop a more comprehensive model of digital technology adoption among rural agricultural leaders, potentially applying technology-acceptance frameworks such as the Unified Theory of Acceptance and Use of Technology (UTAUT) to examine how performance expectancy, effort expectancy, facilitating conditions, price value and behavioural intention shape adoption (Zhang et al., 2024).

CONCLUSION

The findings indicate that the use of digital technology by rural leaders to obtain agricultural information is favourable. Digital technology is used to acquire the latest, up-to-date agricultural information, to make farm work easier and to support agricultural decision-making. Age is a significant predictor of digital technology use, followed by educational qualification and sources of information. The major barriers encountered are the high cost of modern mobile phones, high Internet rates, limited time, insufficient computers and limited digital technology experience. The study contributes to digital agricultural extension by showing that rural leaders can serve as strategic entry points for strengthening digital information flow in farming communities. Improving their digital capacity may improve the reach, credibility and local relevance of agricultural advisory services. Therefore, extension organisations should develop village-level digital leadership models that combine affordable internet access, practical digital literacy training, locally relevant agricultural content and regular institutional support.

DECLARATIONS

Ethics approval and informed consent: Throughout the study, the respondents were asked for their informed consent.

Conflict of interest: The research was carried out without any financial or commercial ties that might be seen as a potential conflict of interest, according to the authors. The authors affirm that they carefully examined, amended and edited the content as necessary when preparing this work. The final content of this publication is entirely the authors' responsibility.

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