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Awareness, usage and impact of digital transformation and smart agriculture technologies among farmers of Raipur district, Chhattisgarh

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Abstract

Digital transformation and smart agriculture technologies are increasingly regarded as important levers for improving farm-level decision-making, resource-use efficiency and productivity. Yet, farm-level evidence on their awareness, usage and actual before-after impact remains limited for central Indian states such as Chhattisgarh. The present study assessed the awareness and usage level of digital technologies among farmers of Raipur district. It evaluated the changes in agricultural practices and productivity before and after their adoption. A descriptive and analytical research design was adopted, and 100 farmers were selected from nine villages across three blocks (Arang, Abhanpur and Dharsiwa) through a multistage random sampling procedure. Primary data were collected using a pre-tested structured interview schedule and analysed using frequency, percentage, mean score and the Wilcoxon Signed-Rank Test. Results revealed that smartphone ownership (86.00%) and internet access (84.00%) were considerably high among respondents, while awareness was greatest for Digital Payment Systems (59.00%) and Mobile Agriculture Applications (53.00%), and markedly lower for IoT-Based Irrigation Systems (8.00%), Soil Health Testing Tools (9.00%) and GPS-Based Machinery (9.00%). Most farmers used mobile applications only occasionally (40.00%) or sometimes (39.00%) rather than regularly. The Wilcoxon Signed-Rank Test showed statistically significant improvement after adoption of digital technologies in the use of improved seeds (mean score 1.55 to 2.74; $W = 24.50$, $p < 0.001$), fertiliser and pesticide use (1.70 to 2.13; $W = 616.00$, $p < 0.001$) and crop productivity (1.73 to 2.10; $W = 896.50$, $p < 0.001$), whereas irrigation management, cost of cultivation and farm income did not change significantly ($p > 0.05$). The findings indicate that while basic digital tools have been widely adopted, translation of this adoption into productivity and economic gains remains partial, underscoring the need for targeted digital literacy programmes, improved rural connectivity and stronger extension support to help farmers realise the full benefits of digital agriculture.

Keywords: Digital transformation, smart agriculture, awareness and usage, Wilcoxon signed-rank test, Raipur district

1. Introduction

Agriculture remains the backbone of the Indian economy, providing livelihood to nearly half of the country's population and playing a central role in food security, employment generation and rural development. How, the sector continues to face persistent challenges such as climate variability, declining farm productivity, rising input costs, fragmented landholdings, labour shortages and market uncertainty, creating a pressing need for innovative, technology-driven solutions (FAO, 2022) [5].

Digital transformation in agriculture refers to the integration of digital technologies -- smartphones, mobile applications, the Internet of Things (IoT), Artificial Intelligence (AI), Geographic Information Systems (GIS), Global Positioning Systems (GPS), remote sensing, drones, cloud computing and digital advisory platforms -- into farming practices. These technologies give farmers real-time access to information on weather, crop management, pest and disease surveillance, irrigation scheduling, soil health, market prices, government schemes, insurance and financial services. Smart agriculture, also referred to as Agriculture 4.0 or precision agriculture, represents the next stage of this modernisation, combining sensors,

automated irrigation, satellite imagery and mobile-based advisory to support site-specific crop management and more efficient use of water and fertilisers (FAO, 2020) [4].

Globally, the adoption of digital agriculture has been associated with improved farm productivity, more efficient use of natural resources, reduced production costs and greater resilience to climate variability, and international bodies such as the FAO, the World Bank and the ITU continue to encourage its use for building inclusive, climate-resilient food systems. In India, the Government has introduced several initiatives -- the Digital India Mission, Digital Public Infrastructure for Agriculture, AgriStack, the Digital Crop Survey, Farmer Registry, e-NAM, PM-KISAN, the Soil Health Card Scheme, mKisan and Kisan Call Centres -- to strengthen the delivery of agricultural services through digital platforms, supported by the rapid expansion of smartphone ownership, affordable internet connectivity and digital payment systems (NITI Aayog, 2021) [13].

Chhattisgarh, popularly known as the “Rice Bowl of Central India,” offers expanding opportunities for digital and smart agriculture through diversification and value addition, and Raipur district -- as the capital region and home to Indira Gandhi Krishi Vishwavidyalaya (IGKV), Krishi Vigyan Kendras and other research and extension institutions -- provides favourable institutional conditions for the spread of digital tools among farmers. Yet the level of adoption reported in the district varies considerably across farming communities, and empirical, farm-level evidence on how much farmers actually know about these technologies, how they use them, and whether their use translates into measurable improvements in farming practices and productivity remains limited.

Earlier studies on ICT and digital agriculture in India and elsewhere have shown that digital tools can expand farmers’ access to agricultural knowledge and improve decision-making (Kumar and van Crowder, 2002; Aker, 2011; Kaur, 2014; Gandhi and Johnson, 2018; Nagesh, 2019) [9, 2, 8, 6, 12], and that ICT-enabled advisory services can be associated with improved crop management, more efficient input use and higher productivity (Adhiguru *et al.*, 2012; Ganesan *et al.*, 2013; Mittal and Mehar, 2016; Liakos *et al.*, 2020; Ayaz *et al.*, 2021; Singh *et al.*, 2025) [1, 7, 11, 10, 3, 14]. However, most of this evidence originates from other regions, and comparable district-level evidence combining both awareness/usage patterns and a formal before-after assessment of practice-level change is scarce for Chhattisgarh. The present study was therefore undertaken with two specific objectives: (i) to assess the awareness and usage level of digital technologies among farmers of Raipur district, and (ii) to evaluate the changes in agricultural practices and productivity of farmers before and after the adoption of digital transformation and smart agriculture technologies.

2. Materials and Methods

2.1 Research Design and Study Area

The study adopted a descriptive and analytical research design. The descriptive component was used to characterise farmers’ socio-economic profile and their level of awareness, usage and adoption of digital technologies, while the analytical component was used to assess the changes in agricultural practices and productivity before and after adoption. The study was conducted in Raipur district of Chhattisgarh, the capital region of the state and home to major agricultural institutions, including IGKV and several Krishi Vigyan Kendras, which have facilitated growing exposure to digital agriculture initiatives among local farmers.

2.2 Sampling Procedure

A multistage random sampling technique was employed. In the first stage, Raipur district was purposively selected. In the second stage, three blocks -- Arang, Abhanpur and Dharsiwa -- were selected on the basis of their agricultural importance and exposure to digital technologies. In the third stage, three villages were randomly selected from each block, giving a total of nine villages (Chhataud, Pacheda and Tekari in Arang; Palod, Bakhtara and Chhachhanpairi in Abhanpur; and Mandhar, Siltara and Saragaon in Dharsiwa). In the final stage, 11-12 farmers were randomly selected from each village, irrespective of their adoption status, yielding a total sample of 100 farmers comprising both adopters and non-adopters of digital and smart agriculture technologies.

2.3 Data Collection

Primary data were collected through personal interviews using a pre-tested, structured interview schedule comprising closed-ended, multiple-choice, Likert-type and ranking-based items covering respondents’ socio-economic profile, awareness of digital technologies, usage patterns, and agricultural practices and productivity before and after adoption. Secondary information was drawn from government reports, research journals, agricultural department publications and official records.

2.4 Statistical Tools of Analysis

Data were edited, coded, tabulated and analysed using frequency and percentage analysis to summarise the socio-economic profile of respondents, their awareness of digital technologies and their usage patterns. Mean scores were computed to compare responses before and after adoption. To test whether the observed before-after differences in agricultural practices and productivity were statistically significant, the Wilcoxon Signed-Rank Test -- a non-parametric test suitable for paired observations that does not require an assumption of normal distribution -- was applied at the 5 per cent level of significance ($\alpha = 0.05$). If $p \leq 0.05$, the null hypothesis of no difference was rejected; if $p > 0.05$, it was not rejected.

3. Results and Discussion

3.1 Socio-Demographic Profile of Respondents

The socio-economic profile of the 100 respondents is presented in Table 1. A majority of the farmers (54.00%) belonged to the 31-40 years age group, followed by those below 30 years (26.00%), with a mean age of 35.62 years, indicating that the sample was predominantly young and middle-aged. Regarding education, 45.00 per cent of farmers had completed secondary education and 25.00 per cent were graduates and above, while 10.00 per cent remained illiterate. Landholding size showed that small farmers (1-2 ha) formed the largest group (48.00%), followed by marginal farmers (25.00%), with a mean landholding of 1.82 ha, reflecting the generally small and fragmented operational holdings typical of the region. More than half of the respondents (51.00%) had 6-10 years of farming experience. Notably, smartphone ownership (86.00%) and internet access at the farm or residence (84.00%) were both considerably high, indicating that basic digital infrastructure has become widely available in the study area and provides a favourable base for digital agriculture adoption.

Table 1: Socio-demographic profile of respondents (N = 100)

Characteristic / Category	Frequency (f)	Percentage (%)
Age: Up to 30 years	26	26.00
Age: 31-40 years	54	54.00
Age: 41-50 years	11	11.00
Age: Above 50 years	9	9.00
Education: Illiterate	10	10.00
Education: Primary	20	20.00
Education: Secondary	45	45.00
Education: Graduate and above	25	25.00
Landholding: Marginal (< 1 ha)	25	25.00
Landholding: Small (1-2 ha)	48	48.00
Landholding: Medium (2-4 ha)	17	17.00
Landholding: Large (> 4 ha)	10	10.00
Farming experience: Up to 5 years	30	30.00
Farming experience: 6-10 years	51	51.00
Farming experience: 11-20 years	10	10.00
Farming experience: Above 20 years	9	9.00
Smartphone ownership: Yes	86	86.00
Smartphone ownership: No	14	14.00
Internet access: Yes	84	84.00
Internet access: No	16	16.00
Total	100	100.00

Mean age = 35.62 years; Mean landholding = 1.82 ha (Source: Field survey data)

3.2 Awareness of Digital Technologies

The distribution of respondents according to their awareness of specific digital technologies is presented in Table 2. Awareness was highest for Digital Payment Systems, such as UPI and DBT (59.00%), and Mobile Agriculture Applications, such as Kisan and weather apps (53.00%). In contrast, awareness of more advanced tools remained markedly low: only 22.00 per cent of farmers were aware of Drone Technology, while Soil Health

Testing Applications and GPS-Based Machinery were each known to only 9.00 per cent of respondents, and IoT-Based Irrigation Systems recorded the lowest awareness of all (8.00%). This pattern indicates that farmers' digital exposure in the study area is largely confined to basic communication and transaction-related tools, while precision-farming technologies have yet to reach the majority of the farming community.

Table 2: Awareness of digital technologies among farmers (N = 100)

Digital Technology	Aware (f)	Aware (%)	Not Aware (f)	Not Aware (%)
Digital Payment Systems (UPI, DBT)	59	59.00	41	41.00
Mobile Agriculture Apps (Kisan/Weather Apps)	53	53.00	47	47.00
Drone Technology in Agriculture	22	22.00	78	78.00
Soil Health Testing Apps/Tools	9	9.00	91	91.00
GPS-Based Machinery	9	9.00	91	91.00
IoT-Based Irrigation Systems	8	8.00	92	92.00

(Source: Field survey data)

This uneven pattern of awareness is broadly consistent with Kumar and van Crowder (2002) ^[9] and Aker (2011) ^[12], who reported that while basic ICT tools spread relatively quickly among farming communities, inadequate infrastructure and low digital literacy continued to restrict awareness of more advanced technologies. It also mirrors Nagesh (2019) ^[12], who observed that younger farmers were generally more receptive to ICT-based tools, which is consistent with the predominantly young and middle-aged composition of the present sample.

3.3 Usage Pattern of Digital Technologies

Table 3 presents the frequency with which farmers used mobile applications for obtaining agricultural information. Most farmers used such applications only occasionally (40.00%) or sometimes (39.00%), while 13.00 per cent reported never using them. Only a small proportion of farmers used mobile applications often (6.00%) or always (2.00%). This suggests that although smartphone ownership and awareness of basic digital tools were high, regular and consistent use of these tools for agricultural decision-making remained limited among the majority of farmers.

Table 3: Usage level of mobile applications for agricultural information (N = 100)

Usage Level	Frequency (f)	Percentage (%)
Never	13	13.00
Occasionally	40	40.00
Sometimes	39	39.00
Often	6	6.00
Always	2	2.00
Total	100	100.00

Source: Field survey data 2025-2026

This gap between high ownership/awareness and comparatively low regular usage aligns with Kaur (2014) ^[8] and Gandhi and Johnson (2018) ^[6], who found that the effective utilisation of ICT-based advisory services depended heavily on farmers' educational background and the extent of publicity and training provided, rather than on device access alone. It suggests that expanding access to smartphones and connectivity, while necessary, is not by itself sufficient to ensure sustained and effective use of digital agricultural tools.

3.4 Changes in Agricultural Practices and Productivity Before and After Adoption

The changes in agricultural practices and productivity before and after the adoption of digital transformation and smart agriculture technologies were evaluated using the Wilcoxon Signed-Rank Test across six indicators, and the results are summarised in Table 4. Statistically significant improvement was observed in the use of improved seeds, with the mean score rising from 1.55 before adoption to 2.74 after adoption ($W = 24.50$, $p < 0.001$). Fertiliser and pesticide use also improved significantly, with the mean score increasing from 1.70 to 2.13 ($W = 616.00$, $p < 0.001$), reflecting greater reliance on weather-based advisories and expert recommendations for timely input application. Crop productivity showed a significant

improvement as well, with the mean score rising from 1.73 to 2.10 ($W = 896.50$, $p < 0.001$), indicating that timely access to weather forecasts, pest and disease advisories and market information supported better production decisions.

In contrast, irrigation management (1.98 to 1.87; $W = 942.00$, $p = 0.2725$), cost of cultivation (1.86 to 1.87; $W = 760.00$, $p = 0.9299$) and farm income (1.92 to 2.06; $W = 905.00$, $p = 0.2479$) did not show statistically significant change, with all p-values exceeding the 5 per cent level of significance. The median score remained unchanged at 2.00 for all six indicators in both periods, indicating that while the central tendency of responses was stable, the underlying distribution shifted favourably for the three significant indicators.

Table 4: Wilcoxon Signed-Rank Test results for agricultural practices and productivity before and after adoption of digital technologies (N = 100)

Indicator	Mean (Before)	Mean (After)	Wilcoxon (W)	p-value	Decision
Use of improved seeds	1.55	2.74	24.50	<0.001	Significant
Fertiliser & pesticide use	1.70	2.13	616.00	<0.001	Significant
Irrigation management	1.98	1.87	942.00	0.2725	Non-significant
Crop productivity	1.73	2.10	896.50	<0.001	Significant
Cost of cultivation	1.86	1.87	760.00	0.9299	Non-significant
Farm income	1.92	2.06	905.00	0.2479	Non-significant

Source: Field survey data; median score = 2.00 for all indicators, both periods

These findings are consistent with Adhiguru *et al.* (2012)^[1] and Ganesan *et al.* (2013)^[7], who reported that ICT-enabled advisory services improved crop management and input-use efficiency among adopting farmers, and with Liakos *et al.* (2020)^[10] and Ayaz *et al.* (2021)^[3], who observed that smart farming and IoT-based technologies improved production practices and resource use, though high investment requirements and limited technical knowledge continued to constrain deeper economic gains. The absence of significant improvement in irrigation management, cost of cultivation and farm income in the present study similarly suggests that these outcomes are shaped by structural factors -- irrigation infrastructure, input costs, market conditions and climatic variability -- that are not resolved by information access alone, a pattern broadly consistent with the cautions raised by Mittal and Mehar (2016)^[11] and Singh *et al.* (2025)^[14] regarding the conditions under which digital adoption translates into farm-income gains.

Taken together, the results show that basic digital infrastructure and awareness -- smartphone ownership, internet access, and familiarity with digital payment and mobile advisory apps -- are now widespread among farmers of Raipur district, but awareness of more advanced precision-farming tools such as drones, IoT-based irrigation and GPS-guided machinery remains limited, and regular usage lags behind ownership and awareness. Where digital technologies were used, they were associated with statistically significant improvement in input-related practices (improved seeds, fertiliser and pesticide use) and in crop productivity, but not in irrigation management, cost of cultivation or farm income, indicating that the productivity benefits of digital adoption have not yet fully translated into corresponding economic gains for farmers in the study area.

4. Conclusion

The present study examined the awareness and usage of digital transformation and smart agriculture technologies among farmers of Raipur district, Chhattisgarh, and evaluated the changes in their agricultural practices and productivity before and after adoption. The findings revealed that while smartphone ownership and internet access were considerably high,

awareness remained concentrated in basic tools such as digital payment systems and mobile agriculture applications, with advanced technologies such as IoT-based irrigation, GPS-guided machinery and drones known to only a small minority of farmers. Regular usage of digital tools also lagged behind ownership and awareness, with most farmers using mobile applications only occasionally or sometimes.

The Wilcoxon Signed-Rank Test confirmed statistically significant improvement after adoption of digital technologies in the use of improved seeds, fertiliser and pesticide management, and crop productivity, demonstrating that digital transformation has begun to strengthen farmers' production practices in the study area. However, irrigation management, cost of cultivation and farm income did not show significant change, suggesting that the economic benefits of digital adoption remain constrained by infrastructural, financial and market-related factors that information access alone cannot resolve.

These findings underline the need for targeted digital literacy and technical training programmes, particularly to build awareness of advanced precision-farming tools, alongside improved rural connectivity and stronger extension and institutional support, so that farmers of Raipur district can move from basic digital adoption toward practices that also translate into sustained productivity and income gains.

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