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The Significant Role of ICT in Agricultural Technology Adoption

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Abstract

Information and Communication Technology (ICT) on technology adoption is profound and far-reaching, influencing how individuals, businesses, and organizations embrace and integrate new technological advancements. ICT in agriculture refers to the use of digital tools, systems, and innovations to improve agricultural practices, increase productivity, and enhance efficiency in the sector. ICT is gaining traction and enhancing access to agricultural information among researchers, extension agents, and farmers. Positive perception about ICT were found in all groups, but were highest among researchers, a finding that could be linked to increasing education and use intensity. This study aims to find out the awareness of the use of ICTs in agriculture among farmers. The total 200 farmers were selected purposively for the present study. The data were collected through personal interview and analysed by using appropriate statistical methods like mean, standard deviation and T-test for the interpretation of the data. This study revealed farmers demographic characteristics and educational status in Dhamdha and Patan, located in the Durg District of Chhattisgarh, India. The demographic distribution revealed variations in gender, marital status, education levels, and family income between the two locations. The statistical analysis showed that the education status of farmers in both blocks has significantly impacted their agricultural practices. Although, the t-values and p-values indicated no significant difference in education levels between the two studied locations. However, the t-test results for knowledge of information and communication technology (ICT) in agriculture revealed a statistically significant difference between Dhamdha and Patan, with p-values below 0.05.

Keywords: ICT, Agriculture, Precision Agriculture, Technology adoption, Variable Rate Technology.

1. Introduction

Information and Communication Technology (ICT) on technology adoption is profound and far-reaching, influencing how individuals, businesses, and organizations embrace and integrate new technological advancements. In an increasingly connected world, ICT has become a fundamental enabler, providing the infrastructure, tools, and resources necessary for the seamless integration of emerging technologies. From facilitating communication and enhancing access to information, to streamlining processes and fostering innovation, ICT is at the core of driving faster and more widespread adoption of technology [1]. Its impact is not only seen in the efficiency and productivity gains it delivers but also in how it helps overcome barriers to adoption, such as cost, knowledge gaps, and resistance to change. As a result, ICT plays a crucial role in shaping the future of technology by enabling more accessible, scalable, and adaptive solutions across various sectors [2].

Information and Communication Technology (ICT) in agriculture refers to the use of digital tools, systems, and innovations to improve agricultural practices, increase productivity, and enhance efficiency in the sector. ICT encompasses a wide range of technologies, such as computers, mobile devices, internet connectivity, sensors, data analytics, and software applications, which can significantly transform the agricultural landscape [3].

ICTs are influencing how development initiatives and tactics are being carried out in India, both in urban and rural regions. Numerous efforts have demonstrated how ICTs have been meeting people's information and communication demands for rural development and agriculture. The number of people using smartphones, the Internet, WhatsApp, TV, and newspapers, magazines, journals, and bulletins is growing daily. ICTs facilitate the quick exchange of ideas and information, and they also play a significant part in improving farmers' quality of life by enabling them to share and expand their knowledge [4]. Through several experiments with creative ICTs initiatives in agricultural and rural development from an Indian viewpoint, the ICT landscape is evolving daily.

In agriculture, information is just as important as land and money. Improved agricultural technologies can be transmitted more quickly, leading to a revolution in agriculture. Even now, the most significant source of information on agricultural extension is the media. For the various sources of information that households have at their disposal, improving the quality and dependability of the information is their top priority. It could only be accomplished by employing ICTs to disseminate agricultural information in rural areas, yet these areas lack adequate ICT infrastructure. However, we must first look at telecom connections in rural areas before introducing new ICTs in agriculture. According to Economic Times, as of December 2018, 23.90 percent of rural Indians have internet access and 59.20 percent had cell phones. In addition to the poor internet penetration rate, rural areas have extremely low spending capacity for mobile services. All customers from both urban and rural areas make less than Rs. 40 per month on average. This implies that the figure for rural markets alone will be much lower.

Rural consumers will only purchase ICT equipment if they can clearly see the potential for a larger return on investment, according to the lesson. Therefore, for farmers to sign up and keep paying, any paid program in the region needs to be incredibly profitable. In order to guarantee the use of ICTs in agriculture, the government should concentrate on bolstering ICT infrastructures in rural areas.

2. Current Scenario of Digital Technologies in Agriculture

2.1. Precision Agriculture

Precision agriculture is an innovative approach that incorporates digital technologies to observe, measure, and analyse field variability to customize actions for optimal crop growth and soil management. The main premise of precision agriculture is to ensure that every portion of a field is managed optimally to enhance productivity while minimizing environmental impacts [5]. The cornerstone technologies in precision agriculture include GPS technology, remote sensing, and Variable Rate Technology (VRT).

2.2. GPS technology

GPS technology has been instrumental in the digital agriculture revolution, serving as the backbone for precision farming [6]. It offers the geographic information required to highlight locations of interest, organize field routes, and map field borders. This geolocation data allows for precise field navigation, ensuring that each farming operation is performed at the exact planned location. It also enables the tracking of equipment to avoid overlapping and skipping, optimizing field operations. GPS-guided machinery can perform tasks such as seeding, fertilizing, and spraying with higher precision, leading to more efficient use of resources, reduction of labour and time, and improvement in crop yields [7]. Recent advancements in GPS technology, such as the Real-Time Kinematic (RTK) positioning, provide accuracy levels within a few centi-meters. This ultra-precision enables tasks like row planting and site-specific management of soils and pests [8].

2.3. Remote sensing

Remote sensing technology is another crucial element in precision agriculture. It refers to the process of identifying, observing, and measuring objects without being in direct contact with them, primarily using satellite or airborne platforms [9]. Both passive and active sensors are used in agricultural remote sensing. Passive sensors detect natural radiation that is emitted or reflected by the object under observation, while active sensors emit radiation and then measure the reflection [10]. Its applications in agriculture provide information about crop health, soil condition, and field topography. Technologies like multispectral imaging and hyperspectral imaging are used to collect data in multiple wavelengths beyond the visible light spectrum. This data is processed to generate vegetation indices like the Normalized Difference Vegetation Index (NDVI), which is a key indicator of plant health and vigour [8]. In order to identify and control crop diseases and pests, remote sensing technology has also proven essential. With the aid of machine learning algorithms, remote sensing data can be used to predict disease outbreaks and infestations, enabling proactive control measures [11].

2.4. Variable Rate Technology (VRT)

Variable Rate Technology (VRT) or site-specific crop management (SSCM) is another integral aspect of precision agriculture. It allows for the application of inputs (seeds, fertilizers, pesticides) at varying rates across a field based on the site-specific requirements [12]. It uses data from GPS and remote sensing technologies to create management zones within a field. These zones are categorized based on soil type, nutrient status, water capacity, and other relevant parameters. Based on this zoning, inputs are applied in precise amounts where needed, optimizing input use efficiency, reducing costs, and minimizing environmental impacts [13]. Recent advancements in VRT include the integration of AI and machine learning algorithms to predict the optimal rates of inputs based on historical yield data and real-time field conditions. This predictive modelling improves the effectiveness of VRT, leading to improved yields and sustainability [14].

3. Challenges and Limitations

While digital technologies hold great potential for revolutionizing agriculture in India, their implementation is not without challenges.

3.1. Technical Challenges

Technical challenges often pose significant obstacles to the implementation of digital technologies in agriculture. For example, poor internet connectivity and inadequate infrastructure, particularly in rural and remote areas, can limit the use of technologies like IoT, AI, and cloud-based applications [15]. There is often a lack of interoperability between different digital technologies, making their integrated use challenging [16]. Additionally, the lack of technical knowledge and skills among farmers can be a barrier to the adoption and effective utilization of these technologies [17].

3.2. Economic Challenges

The cost of adopting digital technologies is another significant barrier. The high costs of hardware, software, and data services can be prohibitive for small and marginal farmers who make up a significant portion of India's farming community [18]. While these technologies can potentially yield cost savings and revenue gains in the long term, the uncertainty of these benefits can deter farmers from investing in them [19]. Access to credit is another economic challenge, as farmers often struggle to secure the necessary funds for technological investment [20].

3.3. Social and Ethical Considerations

Digital technologies raise several social and ethical issues. Data privacy is a major concern, as the use of digital technologies often involves the collection and sharing of sensitive data, including personal information and proprietary farming data [21, 22]. Other social consideration is the potential for digital divide, where farmers with more resources and better access to technology could benefit more from digital technologies, exacerbating inequality in the agricultural sector [8].

3.4. Policy and Regulatory Challenges

The policy and regulatory environment can also pose challenges to the adoption of digital technologies in agriculture. Existing laws and regulations may not adequately address issues related to data ownership, privacy, and security, creating uncertainty for farmers and technology providers [23]. The lack of supportive policies, such as subsidies for technological investment and training programs for farmers, can impede the adoption of digital technologies [24].

3.5. Review of Literature

The information and communication technology (ICT) is gaining traction and enhancing access to agricultural information among researchers, extension agents, and farmers. Positive perception about ICT were found in all groups, but were highest among researchers, a finding that could be linked to increasing education and use intensity. Author discovered that South Asia and Sub-Saharan Africa (SSA) have the least access to ICT resources. (Between urban and rural areas, as well as between the poorest and wealthiest 20 per cent of the population, there were two key access gaps). The poor rely on informal networks they trust for their information requirements, such as family, friends, and local leaders. Formal sources of information, such as NGOs, newspapers, and politicians, were, on the other hand, less trusted and used. Only about 2 per cent of low-income households, particularly in urban areas, have access to modern types of ICTs such as the Internet, fax, and PCs. It found that over 70 per cent of respondents thought the Internet was more useful, preferable, informative, easier to use, less priced, and time saving. More than half of those polled believed that their reliance on the Internet has risen. More than a third of those polled said the Internet has helped them enhance their professional skills [25,26]. The information and communication technology (ICT) is highly useful in accomplishing effective goals in institutional administration, such as improving the efficiency of information organisation, computation and processing of tasks and improving effective communication. Rich farmers are comparatively resourceful, have greater market surplus, have increased awareness and are connected to ICT devices for gathering information. [27,28]. 40% of extension professionals had a positive opinion towards ICTs in agricultural extension, followed by those who had a highly positive perspective (28.89 percent), a neutral attitude (20.00 percent), and an unfavourable attitude (11.11 percent) [29]. 58.9 per cent of respondents had somewhat favourable attitude towards ICTs, 41.1 per cent had an extremely favourable attitude, and none of the respondents in the research area had a slightly favourable attitude toward ICTs [30]. Farmers in an area had a clear and favourable perception of the importance of ICTs in extension service delivery, and they were also aware of ICTs. Farmers had access to radio, television, mobile (GSM) phones, and newspapers, but only the mobile (GSM) phone and radio were widely used. Agricultural scientists from Rajasthan and Gujarat who were proportionately selected for 29 Krishi Vigyan Kendra had a favourable perception about adopting ICTs for agricultural extension. A ratio that quantifies an organization's capacity to transform input resources such as labor, materials, machinery, etc.—into goods and services is called organizational productivity. Companies must be able to increase the productivity of their resources in order to stay competitive in current market [31,32]. It had positive perception towards the use of ICT tools in agricultural extension, and their utilisation were dependent on the demands and utility of the ICT tools for the purpose served. The sensible use of precision farming data is currently very limited, and only forward-thinking farmers have embraced precision agriculture despite these benefits. Adoption of precision farming in southeast Europe, including Italy, has been very low due to the small size of farms, infrequent contact of farmers with new technology, lack of knowledge about precision farming methods and the hefty initial investment costs. Italy started to embrace precision farming techniques and several research activities are being carried out [33,34,35].

Despite China's significant contribution to the global ICT field, there is a dearth of empirical data regarding the use of ICTs in China's rural farming sector. Accordingly, the first three studies showed that smartphone use had a positive impact on rural Chinese farmers' profit diversity, non-agricultural income, and agricultural productivity and revenue. The favourable impact of MIT use on Pakistani rural households' financial security. In China's rural communities, Smartphone use enhances subjective well-being. These assessments, however, did not look into patterns in producers' adoption of MIT or the probable impact of MIT adoption on wheat productivity. Thus, additional empirical research is required in developing nations like Pakistan to gauge the potential effects of MIT adoption on economic growth and agricultural output [36,37,38]. This study aims to find out the awareness of the use of ICTs in agriculture among farmers.

4. Methodology

4.1. Study Area

The present investigation was carried out during the year of 2023-24 in 10 selected villages in Durg, Dhamdha & Patan Block of Durg district of Chhattisgarh state (Figure 1). Randomly ten farmers got selected from each village.

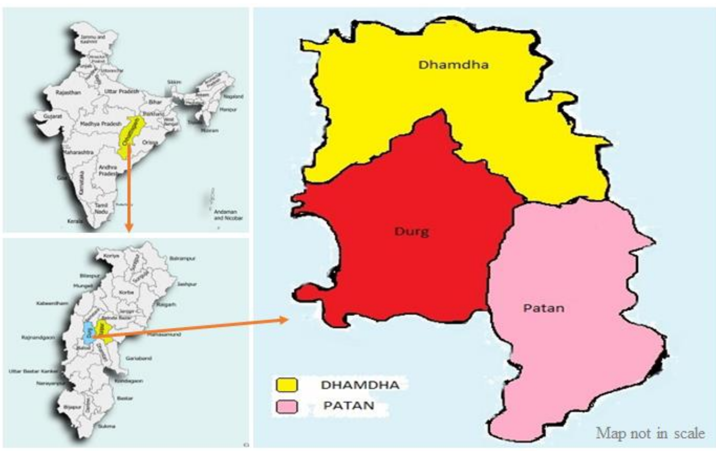

Figure.1. Study location map

4.2. Study Population

The total 200 farmers were selected purposively for the present study. The data were collected through personal interview and analysed by using appropriate statistical methods like mean, standard deviation and T-test for the interpretation of the data.

4.3. Statistical Analysis

4.3.1. Data tabulation and Sorting

Data tabulation and sorting is done in MS-Excel open-source software. All the calculation carried out in this software.

4.3.2. Arithmetic mean (μ)

Arithmetic mean of data set was calculated according to Nag & Ahmed (2023) [39] by following Formula:

$$Arithmetic\ Mean\ (\mu) = \frac{\sum X_i}{n}$$

Where,

$\mu = Arithmetic\ mean$

$X_i = i^{th}\ value$

$n = Numbers\ of\ variable\ in\ data\ set$

4.3.3. Standard Deviation

Standard deviation is a measure according to explained by Koshurai, K. (2023). It used to understand how the data points in a set are spread out from the mean value. It indicates the extent of the data's variation and shows how far individual data points deviate from the average [40].

$$Standard\ Deviation\ (\sigma) = \sqrt{\frac{(X - \bar{X}^2)}{n-1}}$$

Where,

$\sigma = Arithmetic\ mean,$

$Xi = Terms\ given\ in\ the\ data,$

$\bar{X} = Mean\ of\ the\ data, n = Total\ no.of\ terms$

4.3.4. Test of Significance (T- Test)

For the test of significance used t-Test [41]. This statistical method determined the significance changes between means of two groups. It helps us to determine whether the data sets belong to the same group or not.

$$\boldsymbol{t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{s_1{}^2}{n_1} + \frac{s_2{}^2}{n_2}}}}$$

Where,

- $(\overline{x_1})$ *and* $(\bar{x}_2)$ are the means of the two groups.
- $(s_1{}^2)$ *and* $(s_2{}^2)$ are the standard deviations of the two groups.
- (n_1) *and* (n_2) denote size of the two groups sample.

5. Result

5.1. Demographic Profile

The Table 1 demonstrate the demographic information along with their percentage distributions for two locations, Dhamdha and Patan which located in Durg District of Chhattisgarh, India. In terms of gender, males constitute 32 and 56 percent Dhamdha and Patan respectively, while females make up 68 and 44 percent respectively. Regarding marital status, single individuals account for 47 percent in Dhamdha and 35 percent in Patan, whereas married individuals represent 46 percent and 50 percent, respectively. Divorced and widowed individuals comprise a smaller percentage, with divorced individuals at 2 percent in Dhamdha and 7 percent in Patan, while widows account for 5 percent and 8 percent, respectively. Education levels show that illiteracy is slightly higher in Dhamdha (6 percent) than in Patan (3 percent), with primary, middle, high school, and college-level education varying between 12-16 percent and 3-39 percent across both locations. Family income distribution indicates that a higher percentage of individuals in Dhamdha fall within the 33000-40000 range (34 percent), while in Patan, the highest percentage is in the 25000-32000 range (35 percent).

Table.1. Demographic data

Demographic Variable	Dhamdha	Patan	(%)
Gender			
Male	32	56	44
Female	68	44	56
Marital Status			
Single	47	35	41
Married	46	50	48
Divorced	2	7	4.5
Widow	5	8	6.5
Education			
Illiterate	6	3	4.5
Primary School	12	15	13.5
Middle School	39	37	38
High School	27	33	30
College Level	16	12	14
Family Income			
8000-12000	13	24	18.5
12000-24000	21	15	18
25000-32000	32	35	33.5
33000-40000	34	26	30

Source: Primary Data

5.2. Test of Significance

5.2.1. Impact of educational status on ICT adoption

The calculated t-value is -1.07 at 5% of significance level, which does not exceed the critical t-value of ±2.353. The one-tailed p-value is 0.181, which is greater than the conventional significance level ($\alpha = 0.05$). Since the p-value is greater than 0.05, Hence, it is concluded education status of the farmers from Dhamdha block has significantly impacted. Likewise, the calculated t-value is -0.91 at 5% significance level, which is also lower than the critical t-value of ±2.353. The one-tailed p-value is obtained 0.214, which is also greater than 0.05. Since the p>0.05 education status has significantly impacted of the farmers in Patan block.

Table 2 Educational Status to the respondents

Variables	**Dhamdha**	**Patan**
Mean	20	20
Variance	147	158.25
Observation	4	4
Hypothesis	30	30
T	-1.07	-0.91
DF	3	3
P(T<=t) One-tail	0.181	0.214
T Critical One tail	2.353	2.353
Standard Deviation	13.095	14.456
Standard Error	5.856	2.891

Impact of the knowledge of Information & Communication Technology

Table.3. Information & Communication Technology

Variables	**Dhamdha**	**Patan**
Mean	14.57	20.66
Variance	28.666	82.3
Observation	6	5
Hypothesis	30	30
T	-7.92	-3.35
DF	5	4
P(T<=t) One-tail	0.000257	0.014
T Critical One tail	2.015	2.131
Standard Deviation	7.020	13.231
Standard Error	2.653	2.205

The calculated t-values were -7.92 for Dhamdha and -3.35 for Patan at 5% of significance level. Whereas, the one-tailed p-value was 0.000257 and 0.014 for Dhamdha and Patan block respectively. The one-tailed critical t-values were 2.015 and 2.131 for Dhamdha and Patan, respectively. Since the $p<0.05$ (0.000257 for Dhamdha and 0.014 for Patan), this indicates that there is a statistically significant difference in the means between the two groups. It is concluded the knowledge of information & communication technology in agriculture has significantly impacted to adoption of the innovation in farming.

6. Conclusion

This study revealed farmers demographic characteristics and educational status in Dhamdha and Patan, located in the Durg District of Chhattisgarh, India. The demographic distribution revealed variations in gender, marital status, education levels, and family income between the two locations. The statistical analysis showed that the education status of farmers in both blocks has significantly impacted their agricultural practices. Although, the t-values and p-values indicated no significant difference in education levels between the two studied locations. However, the t-test results for knowledge of information and communication technology (ICT) in agriculture revealed a statistically significant difference between Dhamdha and Patan, with p-values below 0.05. This suggests that ICT knowledge plays a significant role in the adoption of innovative farming practices. Collectively, the findings highlight the importance of education and technological awareness in enhancing agricultural adoption and productivity in both regions.

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