

## ADOPTION OF DIGITAL TECHNOLOGIES IN AGRICULTURE: ANALYZING AWARENESS, UTILIZATION AND ADOPTION CHALLENGES AMONG FARMERS IN DISTRICT FAISALABAD

Asghar Ali<sup>1</sup>, Ghadah Al Murshidi<sup>2</sup>, Nageeb Mohammed Aldawdahi<sup>3</sup>, Maitha Mohammed Almeraisi<sup>4</sup> and Shekha Khamis Alshamsi<sup>4</sup>

<sup>1</sup>Institute of Agricultural Extension Education & Rural Development, University of Agriculture, Faisalabad

<sup>2</sup>Learning and Educational Leadership Department, College of Education, UAE University, Al Ain, Abu Dhabi, P. O. Box 15551, UAE

<sup>3</sup>Department of Agricultural Extension and Rural Society, College of Food and Agriculture Sciences, King Saud University, P. O. Box 2d60, Riyadh 11451, Saudi Arabia

<sup>4</sup>College of Humanities and Social Sciences, United Arab Emirates University (UAE)

\*Corresponding author: [asgharali2878@gmail.com](mailto:asgharali2878@gmail.com)

### ABSTRACT

Governments are paying great attention and making efforts to promote digital agriculture for increasing productivity, resource use, and sustainability. Instead of enormous potential, the rate and levels of adoption are, however, not consistent across geographical areas and groups of farmers. This study examined the determinants of the adoption of digital agricultural technologies among farmers in Punjab, Pakistan. It employed quantitative survey-based approach to collect data from 120 farmers selected through stratified sampling, including smallholder farmers (50%), medium-scale farmers (30%) and large-scale farmers (20%). Results showed a high to medium level of awareness of farmers regarding digital technologies. A significant majority of farmers utilize smartphones (81.7 %) and the internet (70.1 %). The use of Weather forecast apps was 57.5% and of disease detection apps 23.33%. The adoption of soil monitors, drones, smart irrigation and digital marketing apps was marginal. Was. The significant obstacles in the way of the adoption of advanced digital technologies were high cost, no access, and inadequate training. Findings suggest comprehensive training programs for farmers to raise their digital literacy regarding agricultural apps, as well as their financial support in order to ease their access to modern technologies.

**Keywords:** Digital agriculture, Adoption, Agricultural innovation, Social economic issues, and Rural development

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Article History (2025-010) || Received: 12 Feb 2024 || Revised: 13 Mar 2025 || Accepted: 15 Mar 2025 || Published Online: 2025

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### 1. INTRODUCTION

Punjab is the most populous province and an agricultural hub, occupying 75 percent of agricultural lands. It is responsible for the food security and economic stability of the country. Nevertheless, the agriculture sector faces numerous challenges such as low productivity, shortage of water, climate change, and dominance of obsolete agricultural methods (Ali & Peerzado, 2021). In order to combat these challenges, digital agriculture can provide a potential solution. Digital technologies i.e. precision farming (use of GPS, drones, and sensors to collect, analyze and share data on crops) can transform agriculture by boosting productivity and efficiency (World Bank, 2020a, b).

Government of Punjab is making efforts on the digitization of agriculture but there exist many barriers in technology transfer. Although certain progressive farmers and agribusinesses have adopted new advancements such as digital apps for crop disease identification, monitoring through drones and digital marketplaces, a considerable percentage of smallholder farmers still lack access to such technologies and continue the use of traditional practices (Qaim, 2020). Some of the studies have determined socioeconomic, technological, institutional, and behavioral factors that define the adoption of digital farming tools. Small-scale farmers face significant hindrances due to economic limitations, lack of awareness and capacity building training, and poor access to credit (Rehman et al., 2022). Poor digital literacy and knowledge regarding the usefulness of such tools are major hurdles in the adoption (Kamilaris et al., 2019; Ashraf et al., 2021).

Further, there are also infrastructure constraints such as underdeveloped internet connectivity and electricity supply in rural regions (Rehman et al., 2019). In addition, trust in technology can be a decisive factor since farmers would not embrace digital solutions if they doubt the validity of the tools and their compatibility with local

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**Citation:** Ali A, et al., 2025. Adoption of digital technologies in agriculture: analyzing awareness, utilization and adoption challenges among farmers in district Faisalabad. *Scientific Records* 2(1): 33-38. <https://doi.org/10.62324/SR/2025.017>

circumstances (Birner et al., 2021; Khan, 2012). Policies of the government and institutional support also matter. Policy frameworks, subsidies, and public-private collaborations have enhanced the process of adoption in many cases (FAO, 2021). In Punjab, digital solutions to agriculture are available (such as the smart farming initiatives by the PARC and agri-tech by the Punjab IT Board), but these programs have not expanded enough. Although there is an increasing interest in digital agriculture, little is known about how various adoption factors interact in the specific context of Punjab, Pakistan. This study is therefore designed to bridge this gap by investigating the major determinants of the adoption of digital agricultural tools among farmers in the Punjab. Specifically, it addresses the following objectives: (I) to explore the current adoption status of digital agriculture technologies among farmers and (II) to identify the major challenges farmers face in adopting and using digital technologies.

## 2. MATERIALS AND METHODS

This study employed a quantitative survey-based approach to examine the factors influencing the adoption of digital tools in Punjab's agriculture sector. The target population includes farmers (small-, medium-, and large-scale) from the district of Faisalabad. Given resource constraints, a sample of 120 respondents was selected using stratified random sampling to ensure representation across different farm sizes and regions (Krejcie & Morgan, 1970). The strata include smallholder farmers (<5 acres, 50%), medium-scale farmers (5-25 acres, 30%) and large-scale farmers (>25 acres, 20%). Data were collected through a structured questionnaire, divided into four sections: (A) demographic and socioeconomic profiles, (B) awareness and usage of digital tools, (C) factors affecting adoption (economic, technological, social, institutional), and (D) barriers to adoption (cost, literacy, infrastructure). Responses are recorded on a 5-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree) to quantify attitudes. The survey is administered by visiting rural areas and reaching farmers to collect data. Data analysis was conducted in SPSS and included descriptive statistics (frequencies, percentages) to summarize adoption trends, as well as binary logistic regression to identify key predictors of adoption (Hair et al., 2019). Limitations of this study include potential response bias and under-representation of remote farmers due to connectivity issues. Overall, the methodology ensures the collection of data to achieve objectives and to provide reliable, actionable insights for policymakers and agri-tech developers to enhance the adoption of digital agriculture technologies in Punjab (Dillman et al., 2014).

## 3. RESULTS

### 3.1. Demographic characteristics of respondents

Farmers' age, education, land ownership, tenancy status, income level, farmed area, and crop cultivation are demographic attributes. Studies have shown that the extent to which farmers use various digital tools in farming varies widely by age, gender, income, and land ownership (Jenkins et al., 2011; Mwombe et al., 2014; Rehman et al., 2013).

The data in Table 1 indicate that most respondents were in the 31-40-year-old age category (34.2%), followed by the 41- and 50-year-old age categories (25%). Furthermore, 23.3% of the respondents were in the young age group, aged 21-30 years. Farmers aged 50 and above accounted for approximately 17.5%. Findings are similar to those of Muhammad et al. (2008), Mhlanga & Ndhlovu (2023), and Padhy et al. (2022), who reported the dominance of middle-aged respondents.

Regarding education, 20.8% of respondents were illiterate, and 20% had primary-level education. 18.3% had completed 8 years of education, 12.5% had a matric certificate, and 16.7% had an intermediate certificate (12<sup>th</sup> grade). Education is a significant factor, as farmers' use of digital technologies depends on their level of education (Mittal & Mehar, 2016). According to Molin et al. (2017), low educational attainment was one of the principal bottlenecks to the adoption of technology. Results revealed that most of the respondents were small landowners. Only 8.3% of respondents reported owning more than 20 acres of land. These findings are in line with those of Hassan et al. (2011) and Khan (2010). Results further revealed that more than half (62.5%) of respondents were less experienced in farming and they were also young. The results are fundamentally similar to those of Butt et al. (2022). A significant majority of respondents (70.0%) were owners, followed by 30% who were owner-cum-tenants. These results are well aligned with national statistics on land ownership and distribution among farmers.

### 3.2. Current use of various Digital Tools

Table 2 illustrates respondents' awareness of multiple digital tools. Smartphones are a common technology, and the results showed that the majority of farmers (90%) were aware of their use in agriculture. 72.5% of farmers also mentioned using internet facilities for agriculture related tasks. The percentage of respondents who were aware of weather forecast apps was 68.3. Awareness of computer use was also high among farmers, with the majority (64.2%) reporting various uses. The percentage of farmers aware of drone technologies for various farming operations were 59.2%. Almost half of the farmers also reported awareness of various robotics/autonomous

machinery used in agriculture. However, the awareness of farmers about crop disease detection apps, sensors, smart irrigation systems and e-commerce and digital marketplaces was low with percentages of 38.3, 32.5, 31.7 and 20.8, respectively.

**Table 1:** Demographic attributes of the respondents

Demographic attributes	Frequency	Percentage
Age (years)		
21-30	28	23.3
31-40	41	34.2
41-50	30	25
Above 50	21	17.5
Education		
Illiterate	25	20.8
Primary	24	20
Middle	22	18.3
Matric	15	12.5
Intermediate	20	16.7
Graduate or above	14	11.7
Land holding (acres)		
1-5	15	12.5
6-10	20	16.7
11-15	40	33.3
16-20	35	29.2
Above 20	10	08.3
Farming experience (years)		
1-5	32	26.7
6-10	43	35.8
11-15	28	23.3
Above 15	17	14.2
Tenancy status		
Owner	84	70
Owner-cum-tenant	36	30
Tenant	00	00

**Table 2:** Farmers' awareness of various digital tools/technologies useful in agriculture

Digital Tools	Frequency	Percentage	Rank
Smart Phone	108	90	1
Internet	87	72.5	2
Weather forecast models	82	68.3	3
Computer use	77	64.2	4
Drones	71	59.2	5
Robotics/autonomous Machinery	61	50.8	6
Crop disease detection apps	46	38.3	7
Sensors	39	32.5	8
Smart irrigation systems	38	31.7	9
E-commerce and digital marketplaces	25	20.8	10

Table 3 highlights that a significant majority of farmers were using smartphones, with around 71% having internet access on their phones. Weather forecast technology is the most widely used service by farmers, as the majority of farmers (57.5%) have adopted it. A significant percentage of farmers (23.33) also stated that they use apps for disease detection. Around 9% of farmers have adopted smart irrigation technology. Further, 7.5% of farmers reported using a computer for farming, i.e., for record keeping or other tasks. Farmers reporting the use of e-commerce and digital marketplaces for the sale of their produce was 10.8%. Interestingly, only 1.66% of farmers reported using drones and robotic machinery.

Overall, the results show that, despite farmers' strong awareness of digital agricultural technologies, including smart irrigation, sensors, drones, robotic machines, and e-commerce platforms, actual use and adoption remain significantly lower. This disparity points out substantial barriers that keep them away of farmers. The hindrances range from socioeconomic constraints to infrastructure deficiencies to institutional barriers. Consequently, although a substantial proportion of respondents were aware of the technologies, their use remains low.

**Table 3:** Current use of various digital tools/technologies by farmers

Digital Tools	Frequency	Percentage	Rank
Smart Phone	98	81.7	1
Internet	85	70.83	2
Weather forecast apps/information	69	57.5	3
Computer use	9	7.5	7
Drones	2	1.66	9
Robotics/autonomous Machinery	2	1.66	9
Crop disease detection apps	28	23.33	4
Advanced sensors (soil or crop monitors)	6	5	8
Smart irrigation systems	11	9.1	6
E-commerce and digital marketplaces	13	10.83	5

Butt et al. (2022) stated that smartphones were used by 100 percent of respondents, telephones by 84.3 percent, and the Internet and computers by 69.3 percent of farmers. A study by Pivoto et al. (2019) and Maluku (2020) reported that over half of the farmers used forecast and trading apps to run their farms.

**3.3. Challenges faced by the respondents regarding the use of various digital tools**

According to table 4a&b, farmers reported a range of challenges that vary specifically with different digital tools/technologies. Regarding the adoption of sensor technologies, the most significant constraints were the lack of ownership and affordability, as indicated by the scores, i.e., mean = 4.27 ± 0.645 and mean = 4.02 ± 1.029, respectively. Further, results showed that farmers believe the high cost of technology outweighs the economic benefits of its use (M = 3.89 ± 0.877). Further, farmers reported limited access to credit facilities (M = 3.68 ± 0.710) and a lack of training (M = 3.26 ± 1.081) in adopting innovative technologies, such as costly sensor technology. A similar pattern of constraints can be observed in the adoption of drone technology and Smart irrigation systems as well.

**Table 4a:** Challenges faced by the respondents regarding the use of various digital tools

Challenges	Internet	Smart phone	Forecast models and app (weather)	Trading platforms
	Means ± SD	Means ± SD	Means ± SD	Means ± SD
Lack of education	3.08 ± 1.546	2.91 ± 1.353	3.40 ± 1.219	3.95 ± 0.995
Lack of awareness	2.69 ± 1.052	2.58 ± 0.885	3.62 ± 0.810	3.86 ± 0.802
Lack of interest	3.25 ± 1.336	2.81 ± 1.154	2.88 ± 0.903	2.86 ± 1.422
Lack of time	2.29 ± 1.095	2.21 ± 1.137	1.51 ± 0.756	1.53 ± 0.697
Lack of Ownership	2.43 ± 0.976	3.67 ± 1.087	1.71 ± 0.834	
Poor Quality	3.03 ± 0.859	2.47 ± 1.209	2.52 ± 1.237	2.90 ± 1.331
Lack of credibility	2.96 ± 1.040	3.00 ± 1.123	2.98 ± 1.198	2.72 ± 1.037
Inadequate Information	2.78 ± 1.014	2.94 ± 1.285	2.81 ± 1.095	2.49 ± 1.021
High cost	3.63 ± 0.934	3.82 ± 0.539	1.85 ± 0.967	1.73 ± 0.877
Poor Feedback			2.49 ± 1.130	2.72 ± 1.037

Regarding the adoption and use of crop disease detection apps, the major constraint was a lack of training (M = 4.07 ± 1.125). Similarly, in e-commerce and digital marketplaces, farmers reported a lack of training as a major challenge (4.28 ± 0.645). The reason is that the technologies are software-based and there is no need to buy expensive hardware/machinery; therefore, the scores for the challenges of ownership and cost are comparatively low.

In conclusion, the greatest obstacles were found to be high cost, farmers' perception that expensive technology outweighs the economic benefits, and lack of ownership. In developing countries such as Pakistan, the majority of farmers are small landholders and, therefore, adopting costly technologies is quite difficult for them. Regarding the adoption of smart disease-monitoring apps and e-commerce, farmers reported a lack of training. These results are in accordance with the published literature. Pivoto et al. (2019) claim that the major barrier to the adoption of digital technologies in agriculture is their high cost. The study conducted by Rasekhi et al. (2015) found that slow internet connection, computer illiteracy, and inadequate expertise in computer use and internet use for agricultural applications were the major challenges. According to a study by Caffaro & Cavallo (2020), there were issues and limitations related to the use of ICT in agriculture. Low-level knowledge, lack of farmer training, high cost of ICT-related equipment, limited internet connectivity, inadequate infrastructure, limited coverage in rural settings, and lack of interactive communication were the factors that hindered the adoption of ICT. The major constraints revealed by Gabriel & Gandorfer (2022) in the adoption of digital technologies include high cost, financial

limitations, profile of the farmer (age, education, gender, risk-taking propensity), property characteristics (size of the property, type, endowment of resources), non-availability of infrastructures and no technical support.

**Table 4b:** Challenges faced by the respondents regarding the adoption of various digital tools

Challenges	Advanced sensors (soil or monitors)	Drones or crop	Drones	Smart irrigation systems	Crop disease detection apps	E-commerce and digital marketplaces
	Means ± SD	Means ± SD	Means ± SD	Means ± SD	Means ± SD	Means ± SD
Lack of interest	2.41 ± 0.983	1.94 ± 0.998	2.08 ± 0.780	2.11 ± 0.577	2.86 ± 1.422	
Lack of time	1.49 ± 0.767	1.77 ± 0.796	1.41 ± 0.642	1.37 ± 0.634	1.53 ± 0.697	
Lack of Ownership	4.27 ± 0.645	4.37 ± 0.484	4.36 ± 0.482	4.14 ± 0.725		
Lack of self-training	3.26 ± 1.081	3.34 ± 0.874	1.95 ± 1.076	2.67 ± 1.125		
Lack of real proof regarding economic benefits	2.35 ± 1.050	2.55 ± 1.151	1.70 ± 0.958	2.50 ± 0.970	2.49 ± 1.021	
Technology cost outweighs the economic benefits	3.89 ± 0.877	4.05 ± 0.606	3.16 ± 0.889	3.75 ± 0.701	1.73 ± 0.877	
Limited access to credit	3.68 ± 0.710	3.84 ± 0.449	3.88 ± 0.865	3.76 ± 0.635	2.72 ± 1.037	
High cost	4.02 ± 1.029	4.23 ± 0.965	3.93 ± 0.896	4.51 ± 0.502	2.72 ± 1.037	

#### 4. CONCLUSION

This paper examined farmers’ awareness, current usage levels, and the major constraints determining the adoption of digital tools/technologies in agriculture. Findings revealed that farmers were well aware of most of the digital tools and technologies used in modern farming. However, the adoption of certain technologies was low. The majority of farmers were using smartphones. The usage of weather forecast apps, disease detection apps and smart irrigation technologies by farmers was also considerable. However, the adoption of drones, soil and crop monitors, and e-commerce is marginal among the farming community. The most significant obstacles were found to be high cost, farmers’ perception that expensive technology outweighs the economic benefits, and a lack of ownership. Regarding the adoption of smart disease-monitoring apps and e-commerce, farmers cited a lack of training as a major barrier. The study recommends policy initiatives that must focus on digital literacy, accessibility, inexpensive technological solutions, institution-related subsidies, and, most importantly, farmers' training.

#### Declarations

**Funding:** This study didn’t receive any funding from any agencies in the public, commercial, or non-profit sector.

**Conflicts of Interest:** Authors have no conflicts of interest.

**Data Availability:** Data will be available from the corresponding author upon request.

**Ethics Statement:** The studies involving humans were approved by the Institute of Agricultural Extension, Education, and Rural Development, University of Agriculture, Faisalabad. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

**Authors’ Contribution:** Asghar Ali; Conceptualization, Data Curation, Data Collection, Writing, Nageeb Mohammed Aldawdahi; Methodology, Review and Editing, Maitha Mohammed Almeraisi; Data Original draft, Shekha Khamis Alshamsi; Formal Data Analysis, Writing, Dr. Ghadah Al Murshidi; Review and Editing, Writing

**Generative AI Statements:** The authors declare that no Gen AI/DeepSeek was used in the writing/creation of this manuscript.

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**Citation:** Ali A, et al., 2025. Adoption of digital technologies in agriculture: analyzing awareness, utilization and adoption challenges among farmers in district Faisalabad. *Scientific Records* 2(1): 33-38. <https://doi.org/10.62324/SR/2025.017>

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