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ASSESSMENT OF DIGITAL TECHNOLOGIES IN AGRICULTURE WITH PARTICULAR REFERENCE TO DIGITAL DERA INITIATIVE IN PUNJAB, PAKISTAN

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ABSTRACT

Modern machinery, computerized instruments, and information and communication technologies (ICTs) are transforming agriculture through the digital revolution, enabling increased production and informed decision-making. Several cutting-edge technologies are being integrated into agriculture, including robotics, the Internet of Things (IoT), big data, artificial intelligence, machine learning, GPS, and remote sensing. These innovations are increasing yields while lowering prices and having a smaller negative impact on the environment. The Digital Dera initiative (DDI) was launched in the district of Pakpattan to provide digital services regarding agriculture and extension. The purpose of this study was to examine the impact of digital technologies in agriculture and also examine the effectiveness of the DDI in Pakpattan. The cross-sectional research design was followed to conduct the study. The study was conducted in Punjab Province; purposive sampling was employed for this study. Almost 120 farmers were purposively selected as beneficiaries of the initiative. The survey was conducted using a well-structured and validated interview schedule, and the results were analyzed through SPSS. According to data, smartphones had the highest number of users, 81.7%, followed by the internet, 72.5% users. While leverage sensors and solar-powered pumps also had more than half of the users. Farmers ranked their access to digital tools through the Digital Dera project in 1st place (mean = 4.34), which was considered too high. The Pearson correlation coefficient shows a significant and negative relationship between the age of farmers and the use of various digital tools. But there is a highly significant and positive relationship between the education of farmers and the use of digital tools. There is a need to promote government schemes and subsidies among farmers so that they can take advantage of this opportunity.

***Keywords*:** Digital technologies; Digital dera; Precision agriculture; Access to digital tools; Rural development.

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1. INTRODUCTION

With a population of 229 million, Pakistan is a developing nation in South Asia. Despite having the sixth-highest population, its GDP ranks 43rd globally. Pakistan's economy is fueled by agriculture, which also makes a substantial contribution to the nation's development. However, traditional farming practices and outdated technologies have impeded growth. This industry is vital for several reasons, including the fact that it generates raw materials for industry and supports our trade with other countries. Forty-five percent of Pakistan's total foreign exchange exports are made up of items. Approximately 24% of Pakistan's GDP is derived from agriculture, which also generates a substantial amount of foreign revenue through exports. Approximately 37.4% of the labor force was employed in the agricultural sector. For around 64% of Pakistan's population, agriculture serves as their primary or secondary source of income. The food and dairy industries also contribute to the cottage industry (Government of Pakistan, 2025).

Using digital technologies to connect agricultural production from the paddock to the consumer is known as "digital agriculture." By providing additional tools and information to help farmers make informed decisions and boost productivity, the agricultural sector can benefit from these technologies (Agriculture Victoria, 2021).

The digital revolution is transforming agriculture through the use of modern machinery, computerized tools, and information and communication technologies (ICTs), improving decision-making and productivity. Several cutting-edge technologies are being integrated into agriculture, including robotics, the Internet of Things (IoT), big data, artificial intelligence, machine learning, GPS, and remote sensing. These innovations are increasing yields while lowering prices and having a smaller negative impact on the environment. Production potential is being unlocked by data-driven solutions in a sustainable and resource-efficient manner (Mhlanga & Ndhlovu, 2023).

The advent of digital technology has led to a significant increase in global connectivity. Mobile devices are being used in a smaller, faster, cheaper, and more efficient manner. Assistance is being provided to numerous farms and companies, enabling them to make more informed decisions. Farmers are receiving assistance to improve their operational management and utilize more precise amounts of fertilizer and water. Numerous chores, including planning farming activities, budgeting, reporting, and tracking various tasks and performances, are made easier by digital technologies. Agronomy, communication, livestock handling facilities, farm machinery, and other fields all use digital technology (Padhy et al., 2022). Farmers may now remotely operate their fields and more effectively oversee agricultural operations due to digitalization. Due to the previously described interconnection of agricultural sensors, actuators, and devices, IoT will soon enable automatic real-time interaction, control, and decision-making. This will reduce the amount of work that needs to be done by humans, save time, and boost profit and yield (Toma et al., 2016).

Digital technology can help reduce poverty and hunger more quickly in rural developing countries, where the majority of people depend on agriculture for their livelihood. Farmers who practice digital agriculture utilize cellphones and other tools that have the potential to significantly transform how communities secure and improve their standard of living (Gabriel & Gandorfer, 2022). Achieving the UN Sustainable Development Goal of a "world with zero hunger" by 2030 will require more resilient, inclusive, transparent, efficient, productive, and sustainable food systems (FAO, 2107).

The use of precision agriculture technologies is revolutionizing contemporary farming. Digital innovations, such as data analytics, wireless connectivity, data-driven gene editing, and information and communication technologies (ICTs), are being rapidly adopted in agriculture because they enhance the precision of decision-making and practices (Maloku, 2020). Digital technologies can assist farmers with crop management, reduce information costs, and enhance their access to markets and financial support (Butt, 2017).

The Punjab government is committed to utilizing various ICT methods to provide the rural population with up-to-date information, thereby improving agricultural productivity, reducing poverty rates, and ultimately promoting sustainable rural development. A variety of extension services are offered to rural residents in their native tongues using various ICT techniques (Government of Punjab, 2020a). The two main issues facing the agricultural information and management system are farmers' limited access to pertinent information and the adoption of suitable agricultural technologies in the context of climate change. Farmers in Punjab, Pakistan, face several challenges, including low yields, diseases, bug and pest infestations, high input costs, and a lack of acceptance of appropriate technologies (Abdullah et al., 2014; Butt, 2017). ICT for agricultural development significantly impacts rural development and is a key determinant of a nation's level of advanced farming, as seen in Pakistan (Government of Punjab, 2020b).

The Punjab government launched several initiatives about modern agriculture technology transfer via ICT services and applications, e.g. information system for agricultural marketing, Mobile messaging (farmer database), the Fruits & Vegetables Project website in Punjab, the Land Record Spatial Data Infrastructure, the Monitoring Extension Services (Agri. Smart) program, the Punjab agricultural extension Facebook pages, electronic paperwork and reporting, Charting soil fertility at the community level, radio, TV, and FM services; updating Manteca records through SAP software; Shadbad dehqan project; Zarai baithak project; Fertilizer calculation project; Citizen contact center (toll free no.), updating services for agricultural extension, etc (Government of Punjab, 2023).

Digital Dera is launched by an agriculture think tank Aamer Hayat Bhandara and Fouad Riaz Bajwa with the collaboration of Director General Agriculture (Punjab Agriculture Department) and NGO's. The goal of Digital Dera is to digitalize agriculture in South Punjab's rural, fertile areas by giving local farmers access to a community internet network (Hashmi, 2021; Luqman, 2021). It was founded in the isolated agricultural area of Chak No. 26/SP, District Pakpattan, in cooperation with Agriculture Republic, Internet Society, Accountability Lab, PTCL, and Hayat Farms. It attempts to improve access to digital agricultural resources by offering free internet connectivity. Future plans call for the introduction of IoT-integrated smart villages centered on agriculture (Qasim, 2021; Saeed, 2021; Jamal, 2021).

The goal of Digital Dera is to provide internet connectivity and access to the digital knowledge economy, empowering local farmers. Additionally, it serves as a digital hub for planning awareness-raising and capacity-building events aimed at educating young people and small farmers about climate change policy, food security, and the transparency and accountability of agriculture. The facility, according to the farmers, not only helps them learn new farming methods but also connects them with agricultural specialists, enabling them to receive guidance on a range of topics, from planting to harvesting. They added that they now have access to the most recent agricultural research and innovative farming methods for optimizing yield while reducing the need for inputs on the farm (Business Recorder, 2021).

Pakistan lags well behind other nations in the use of digital technologies in agriculture, including China, Israel, India, the Netherlands, and the United States. There is an urgent need to reconsider agricultural tactics. ICT services and applications, such as phone (robo/voice calls), cell phone (robo/voice calls and Short Message Service/SMS), and computer (internet), are highly valuable in raising awareness and having a wide coverage of farmers, among other extension methods and technology transfer strategies (Government of Punjab 2020a). In this digital era, there is a need for an information hub system that enables all stakeholders to communicate with each other with just one click. The purpose of this study is to examine the impact of digital technologies in agriculture and also examine the effectiveness of DDI in Pakpattan. There is a need to study the Digital Dera initiative (DDI) as the model village. If Digital Dera has an impressive impact on production and farmers' livelihoods, then there will be a need to expand this initiative to more farms. The objectives of the study were to assess digital technologies in agriculture, with a particular focus on the DDI in Pakpattan District, Punjab, Pakistan. Additionally, this study aimed to determine the extent of farmers' adoption of digital technologies and to investigate the effectiveness of the DDI in increasing farm income.

2. MATERIALS AND METHODS

According to Clough & Nutbrown (2002), a researcher must always be certain of the approach that will provide them with a thorough understanding of the material he is looking for. Accordingly, research designs must to be trustworthy and grounded in science (Drew et al., 2008). A survey research design was used in this study.

2.1. Interviewing

Numerous researchers have used the survey research approach in pertinent studies (Siddiqui, 2006; Khan, 2010). Interviewing respondents is a crucial component of survey research design as it elicits the necessary information from them and provides researchers with a profound understanding of significant findings (Ashraf, 2008). The significance of survey research design was taken into account when choosing respondents and gathering data for the study. Additionally, a cross-sectional survey was used, which simulates data collection at a certain point in time, but the time duration is not fixed and can extend up to several months. The study was conducted in Punjab province, and purposive sampling was used to conduct this study.

2.2. Stages of the Digital Dera initiative (DDI)

2.2.1. First Stage: At first stage, Pakpattan district was selected purposively because DDI was already working in this district. There are 2 Tehsils in Pakpattan.

2.2.2. 2nd Stage: At the 2nd stage, Pakpattan tehsil was selected purposively. There are 33 Union councils.

2.2.3. 3rd Stage: In the 3rd stage, the purposive sampling technique was used to select Union Council 5, as our study village, 26/SP, falls within this Union Council. The targeted population consisted of 1500 farmers, because there were 1500 farmers registered in the Digital Dera project.

2.2.4. 4th Stage: At 4th stage, 120 respondents were selected purposively who were beneficiaries of the initiative. The sample size was determined by using the online sample size calculator. Therefore, the estimated sample size was 120 farmers, based on a 95% confidence level, a 5% confidence interval, and a population proportion of 10%.

An interview schedule was used as a research instrument. In addition, the publications of Irfan (2005), Muhammad et al. (2008) and Khan (2010) were reviewed for relevant research articles to inform the development of the interview schedule. A five-point Likert scale was used to gather data on the extent and perceptions. Using face and content validity techniques, the validity of the study instruments was examined. A panel of specialists from the Institute of Agricultural Extension, Education, and Rural Development of the University of Agriculture, Faisalabad, received the instrument for this reason. They all offered advice and made a few suggestions for enhancements, which the researcher used to give the instruments their final form. 10 farmers were interviewed in order to pre-test the instruments. These 10 responders were excluded from the sample. The researcher made a few small adjustments based on her pre-testing expertise. Reliability is the extent to which a survey instrument is consistent with the things it assesses. An instrument's reliability can be assessed using various techniques. The degree of internal consistency, as measured by Cronbach's alpha, is frequently used to assess the reliability of research instruments (Lodhi, 2003; Idrees, 2003). Using the Statistical Package for Social Sciences (SPSS), Cronbach's Alpha was calculated. The average internal consistency value that was found was 0.807.

3. RESULTS AND DISCUSSION

3.1. Demographic Characteristics of Respondents

Respondents' age, education, land ownership, tenancy status, income level, farmed area, and crop cultivation are among their demographic attributes. According to Rehman et al. (2013), access to agricultural information has a substantial correlation with farmers' demographic characteristics, such as age, education, and landholding, following the adoption of technology. The degree to which people utilized various digital tools to acquire information from these contemporary instruments depended on their age, gender, income, and land ownership (Jenkins et al., 2011; Thompson, 2012; Sohail & AlJabri, 2014).

An important factor in determining human behavior is age. According to Siddiqui et al. (2022), age affects behavior and increases exposure to structured events. According to Mickler and Staudinger (2008), people get better at understanding commonplace events as they get older. As one ages, they naturally become more mature and capable of making judgements with greater mental strength. The information presented in Table 1 shows that respondents in the age range of 31 to 40 years old were the most prevalent (34.2%), followed by respondents in the age range of 41 to 50 years old (25.0%). Moreover, little under one-fourth (23.3%) of the respondents were between the ages of 21 and 30.

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People under thirty are typically referred to as "young," and it is commendable that young people are involved in agriculture. The healthy involvement of young people is also a concept for mainstreaming agriculture in the nation. The percentage of farmers over 50 years old was approximately 17.5%. The mentioned results are consistent with those of Muhammad et al. (2008), who discovered that about 65% of respondents were under 50 years old. However, the findings contradict those of Siddiqui (2016), who found that middle-aged respondents were the most dominant. They found that about 73% farmers were between 45 and 60 years old in the Tehsil Quetta.

Table 1: Demographic attributes of the respondents

Demographic attributes	Frequency	%
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)		
-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
Source of income		
Farming	14	11.7
Farming + business	06	05
Farming + job	13	10.8
Farming + livestock	72	60
Farming + any other	15	12.5

Education is often regarded as a catalyst for positive behavior in individuals and a means to advance society. Humans are strengthened by education, which also helps them comprehend the intricacies of daily life and society. Education is essential for farming communities to handle new problems in the field. Numerous research' findings indicate that farmers are switching to modern technologies to obtain agricultural information as their level of knowledge rises. The perceived usefulness and ease of use of digital technologies are highly influenced by the user's educational background (Mittal & Mehar, 2015). According to Molin (2017), one of the main barriers to technology adoption was educational attainment. This suggests that farmers' lower educational attainment will continue to reduce the chance of technology adoption. The data mentioned in Table 1 reveal that about 20.8% of the respondents were illiterate, followed by one-fifth (20%) who had only completed primary school. Those who were illiterate never attended formal schooling. In addition, 18.3% of respondents had completed eight years of education, 12.5% had completed 10 years and 16.7% had completed twelve years. Among farmers, more over half (59.4%) had completed more than eight years of education. This suggests that a large number of responders may be able to appreciate the difficulties of farming and that widespread adoption of technology may be occurring.

The amount of land that a farmer uses for crop cultivation and livestock rearing is referred to as their landholding, which is the unit of measurement for agricultural agriculture. Land ownership and farmers' information needs for farm management are closely related (Khan 2023). Based on the information shown in Table 1, small farmers with under fifteen acres of land made up the bulk of respondents (62.5%). Just 8.3% of respondents reported owning more than 20 acres of land. Data depicted that 12.5% of respondents had less than 5 acres of land, while 16.7% had 6-10 acres of land. Data showed that 1/3 (33.3%) had 11-15 acres of land and 29.2% of respondents had 16-20 acres of land. The extent of land holdings is distributed controversially, with small farmers making up the majority of landowners (86%) nationwide. The results are consistent with those of Hassan et al., (2011), who discovered that most respondents (78%) were small farmers with less than 12.5 acres of land. However, the findings of the Ganeshagouda et al. (2013) study showed 48% of small farmers, which runs counter to the findings of the current study in Karnataka (India). The study of Butt et al. (2022) also supports the present study that 83.7% of respondents were small landowners with 12.5 acres of land holding, followed by medium (15.0%).

The depicted data showed that the majority of farmers (35.8%) had 6-10 years of farming experience, followed by 26.7% who had 1-5 years of farming experience. Data showed that more than half (62.5%) of the respondents had less farming experience and they were young too. So, this situation indicates that maybe the new adopters of farming are more eager to adopt technologies and the adoption rate may be high. The findings are essentially comparable to those of Butt et al. (2022) who conducted their research in Punjab, Pakistan and found that the majority of respondents (53.0%) had 2–12 years of agricultural experience, followed by 13–22 years (37.7%) and beyond 23 years (9.3%). According to Paustian and Theuvsen (2017), the average experience in agricultural production is just 12.65 years. This is connected to the sample's high percentage of young farmers. This study also supported the current research.

Data quoted in Table 1 reveals that a majority (70.0%) of the respondents was owners. Interestingly, the percentage of owner-cum-tenants appeared meager (30%). This suggests that the respondents in the research area tended to utilize their own land resources. The findings of Khan (2010) and Hassan et al. (2011) stated that the majority of respondents were owner growers, corroborate the conclusions that have been presented above. The findings of Butt et al. (2022), which show that landlords made up the bulk of respondents (97.7%), were followed by tenants (2.0%) and homeowners (0.3%), respectively, provide additional support for this study.

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One major factor influencing the adoption of technology is income. Previous studies have confirmed that increasing income levels encourage the adoption of technology and that technology adoption raises income levels in turn. Earlier studies have shown a positive and significant correlation between farmers' income and their use of contemporary ICT, indicating that wealthy, large farmers had greater access to information than did impoverished farmers (Tesfaye et al., 2016; Das and Ganesh-Kumar, 2017). A major factor in increasing income and reducing poverty is farm diversification (Michler & Josephson, 2017). The data presented in Table 1 indicate that farming and livestock rearing were the most prominent and dominant sources of income for the sampled farmers. A vast majority (60.0%) of respondents reported generating income from farming and livestock rearing. Approximately 64% of Pakistan's rural population earns a living from agriculture (GOP, 2023). Birthal et al. (2014), who identified agriculture and livestock rearing as the primary sources of income for 91% of farmers in India, provide additional support to the findings. According to Tarhini et al. (2014) and Ashraf et al. (2015), small farmers typically seek alternative means of income, while large farmers tend to focus on agriculture.

3.2. Years of Affiliation with Digital Dera Initiative (DDI)

Digital Dera provides access to various digital tools and also enables farmers to use these tools more effectively. So, the affiliation with DDI increases the adoption rate of the digital tools. That's why it is really important to check the affiliation duration of farmers with the Digital-Dera project. The data indicated that slightly less than half (44.2%) of the farmers had joined Digital Dera within the past year. Their affiliation period is less than one year. About 35% and 20.8% farmers are affiliated with Digital Dera for 1-2 years and more than 2 years, respectively. This situation predicted that most farmers joined Digital Dera after examining the effectiveness of the Digital Dera project.

3.3. Frequency of Participation

The frequency of farmers' participation in meetings plays a positive role in enhancing their understanding and skills in using digital technologies effectively and efficiently. The data indicated that half of the farmers participated every 2-3 months. Almost one-third participated monthly. While 10% farmers never participated in meetings. A very small number of farmers participated on a weekly and fortnightly basis, 8.3 and 4.2%, respectively.

3.4. Extent of Use of Various Digital Tools

Concerning the degree to which respondents used various digital tools, questions were posed. On a five-point Likert scale, where 1 denotes very low, 2 denotes low, 3 denotes medium, 4 denotes high, and 5 denotes very high, their answers were recorded. Table 2 represents data in this regard. According to the information presented in Table 2, the smartphone was the most popular and extensively used digital instrument. It fell under the high usage category, with a mean value of 4.06, but was used to a high extent. The Internet was the second most frequently used tool among respondents, with a mean value of 3.76, indicating medium to high usage rates. The extent of use of forecast models/apps also increased from a medium to a high rate, with a mean value of 3.72. The use of energy-efficient tractors and drones was also dismal, with mean values of 2.33 and 2.08, respectively, which fall short of the medium level. The rate of use of leverage sensors and solar-powered pumps is moderate, with mean values of 3.37 and 3.34, respectively. However, the use of computers, agri-websites, and trading platforms also served as a medium, with mean scores of 2.85, 3.18, and 3.25, respectively. Overall results indicate the dominance of smartphones and the internet in the study area; however, computers, drones, and energy-efficient tractors were categorized as having medium usage.

The findings are similar to those of Agwu et al. (2008), who reported that smartphones are a highly utilized information source among farmers in Abia and Enugu states. The results, however, contrast those of Kodagavallihatti et al. (2016), who revealed a poor usage of social media and the internet to obtain information about farm operations in Karnataka (India).

Table 2: Extent of use of various Digital tools by the respondents

Digital Tools	Weighted Score	Means	SD	Rank
Smart Phone	488	4.06	1.225	1
Internet	452	3.76	1.278	2
Forecast models and apps (weather)	446	3.72	0.918	3
Leverage sensors	404	3.37	1.092	4
Solar-powered Pumps	401	3.34	0.966	5
Trading Platforms	390	3.25	1.132	6
Agri-apps/websites	381	3.18	1.207	7
Computer	342	2.85	1.288	8
Energy-efficient Tractors	280	2.33	0.911	9
Drones	250	2.08	0.949	10

This suggests that, except for their cell phones, respondents in the research area were not very accustomed to using modern technologies. Other studies (Butt et al., 2022) revealed that the majority of respondents (46.36%) used agri-helplines/websites.

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3.5. Effectiveness of Digital-Dera initiative

One of the specific objectives of this research was to investigate the effectiveness of DDI regarding an increase in farm income. A centre known as "Digital Dera" provides farmers with free advice and information at any time regarding crop production, weather, climate change, new seeds, fertilizers, pesticides, and farming equipment. Therefore, it was necessary to look at the effectiveness of DDI on farm income and livelihood. Data in this regard are given in Table 3 by using the 5-likert scale (1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree).

Table 3: Effectiveness of Digital-Dera initiative (DDI)

Statement	Weighted Score	Means	SD	Rank
DDI facilitated access to technology and digital tools that streamlined farm operations, leading to increased income.	521	4.34	0.601	1
I perceived that Digital-Dera has been instrumental in enhancing my farm income.	498	4.15	0.669	2
DDI provided practical guidance on diversifying income streams through additional agricultural activities or value-added products.	490	4.08	0.380	3
Input cost reduced due to leveraging sensors under the umbrella of DDI	473	3.94	0.919	4
DDI effectively addressed market challenges and provided solutions to improve sales and productivity.	415	3.46	0.859	5
DDI effectively connected me with financial resources and support to invest in increased productivity.	409	3.41	0.750	6
DDI provided information about pest/insect attacks through drones and sensors.	395	3.29	0.893	7
DDI provided valuable financial insights and strategies to optimize my farming income.	349	2.91	0.756	8
DDI effectively promoted access to government schemes and subsidies that have benefited farming income.	337	2.81	1.292	9

Table 3 showed that the Digital Dera project had a significant impact on the farmers' income and their access to digital tools and techniques. The data showed that farmers recorded responses indicating that the Digital Dera facilitated access to digital tools and techniques, which smoothed their farm operations and indirectly enhanced their income. Farmers ranked their access to digital tools through the Digital Dera project at 1st (mean=4.34), which is inclined towards high. Secondly, they ranked that DDI was very effective in enhancing their farm incomes through its services with 4.15 and 498 mean and weighted scores. Most of the farmers stated that Digital Dera provided them information and guidance on diversifying income sources like value addition. They ranked it at 3rd with a 4.08 mean score, which indicates a high rate of satisfaction. Farmers stated that they wasted their money on input products, fertilizers, pesticides, and weedicides. But their input cost reduced due to the inception of Digital Dera. They rank this aspect at 4th (mean=4.94). It provided the facilities of leverage sensors due to which farmers tested their soils and received requirement nutrient list. Now, they were avoiding applying fertilizers, pesticides, and weedicides openly. It also affected their income indirectly. Digital Dera also effectively addressed the marketing challenges by providing them with information regarding market trends. It reduced their input cost and increased their profit. They ranked it at 5th with 3.46 and 415 mean and weighted scores. But their satisfaction level was low regarding promotion of access to governmental schemes and subsidies, and valuable financial insights like loan schemes. They ranked these aspects at 9th and 8th, respectively (means 2.91 and 2.81), which showed a low level of effectiveness but inclined to medium. Weltin et al. (2021) concluded that growers can increase their financial gains by implementing digital technologies, which will result in higher yields and quality, lower labour costs, reduced water usage for irrigation, and decreased pesticide use. By lowering labor and input costs, raising yields, and enhancing quality, digital technologies can increase growers' financial gains. For every unit increase in digital technology adoption intensity, economic advantages rise by 30.4%.

3.6. Relationship between using Digital Tools and Demographic Features

The relationship between the degree of use of digital tools and demographic variables is the main topic of this section. Age, education, land ownership, and prior agricultural experience were regarded as independent factors in the demographic analysis. Utilizing digital tools to gather data on agricultural practices and information as dependent variables. The statistical test of Pearson correlation was employed to examine the relationship between the variables. This is used to determine how closely different variables are related to one another. The correlation coefficient, represented by "r", can be computed using the given formula:

$$r = \frac{b(Sx)}{(Sy)}$$

The formula represents the slope as "b," and the independent and dependent variables' standard deviations as "Sx" and "Sy." When all the points actually fall on a line with a positive slope, the correlation coefficient has a value of +1; when all the points actually fall on a line with a negative slope, it has a value of -1. When the value is very negative up to -1 or very positive up to +1, there is a strong linear relationship between the two variables, as demonstrated by the points being significantly closer to the line. Conversely, if no linear relationship is established between the two variables, the correlation coefficient value is almost zero. It illustrates that the two variables are unrelated to one another. There is always a chance that the correlation coefficient will be close to zero or equal to zero. According to

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Agesti and Finlay (1997), there will either be no relationship or a nonlinear relationship between the two variables.

Table 4 represents the relationship among socio-economic characteristics and the use of digital tools in agriculture:

a) Pearson correlation coefficient shows a significant and negative relationship between age and use of digital tools. It means that older farmers were adopting digital tools at a low rate as compared to the younger farming community. Similarly, farmers' age had a highly significant and negative relationship with internet, smartphones, computers, forecast, trading apps, drones, energy-efficient tractors, and agri. (agriculture) helpline and agri. website. It means that young farmers in the study area were using the internet, smartphones, computers, forecasting and trading apps, drones, and energy-efficient tractors for agri. helpline and agri. Website for agriculture as compared to old-age farmers. In the case of solar-powered pumps, a highly insignificant and negative relationship with age was observed, indicating that the age group has a minimal effect on the use of solar-powered pumps.

b) There was a highly significant and positive relationship between the education of the farmers and the use of the internet, smartphones, computers, leverage sensors, forecast, and trading apps, agriculture helpline, and agri. website. It can be concluded that farmers with higher education were more inclined towards the use of the internet, smartphones, computers, leveraging sensors, forecasting, and trading apps in agriculture. helpline and agri. Website as compared to illiterate farmers. There was a less significant and positive relationship between education and the use of drones and solar-powered pumps. The Pearson correlation coefficient revealed a highly significant and negative relationship between education and the use of energy-efficient tractors.

c) Mobile phone had a positive relationship with landholding. It means that farmers with large landholdings were using mobile phones to obtain agricultural information, while small farmers obtained it from other sources. Similarly, there is a significant and positive relationship between landholding and the use of drones, leveraging sensors, and energy-efficient tractors. Similarly, a substantial and negative relationship was found between the area under cultivation and trading platforms, forecast apps, computers, phones, and agri. Helplines. It can be concluded from the data that farmers with a larger area under cultivation make more use of the internet and mobile phones for obtaining agricultural information compared to other ICTs.

Table 4: Relationship between demographic characteristics (N=120) and using digital tools for agriculture

Digital Tools	Age		Education		Land Holding	
	Pearson Corr.	Sig.	Pearson Corr.	Sig.	Pearson Corr.	Sig.
Internet	-0.588**	0.000	0.776**	0.000	0.663**	0.000
Smart Phones	-0.620**	0.000	0.745**	0.000	0.662**	0.000
Computer	-0.561**	0.000	0.777**	0.000	-0.557**	0.000
Agri-apps/websites	-0.625**	0.000	0.840**	0.000	-0.697**	0.000
Forecast models and apps (weather)	-0.649**	0.000	0.625**	0.000	-0.345**	0.000
Leverage Sensors	-0.721**	0.000	0.789**	0.000	0.533**	0.000
Drones	-0.504**	0.257	0.141*	0.008	0.234*	0.000
Solar-powered Pumps	-0.044*	0.631	0.184*	0.044	0.106	0.247
Energy-efficient Tractors	-0.623**	0.014	-0.356**	0.088	0.210*	0.000
Trading Platforms	-0.489**	0.000	0.765**	0.000	-0.358**	0.000

Pearson Corr.=Pearson Correlation; Sig. = Significance level (2-tailed)

According to the report, farmers are switching to current digital technology to obtain agricultural information as their level of knowledge rises. The perceived usefulness and ease of use of digital technologies are highly influenced by the user's educational background (Mittal & Mehar, 2015). Jain & Rekha (2017) postulate that farmers' adoption of new interactive technologies to improve agricultural performance requires knowledge and information, and that farmers' adoption of new technologies is positively connected with their degree of education.

4. CONCLUSION AND RECOMMENDATION

This research concludes that the internet, smartphones, forecast models/apps, leverage sensors, and solar-powered pumps were used by the farmers at a high rate. Digital Dera has a fruitful impact on the farmers' income and livelihood. Due to the inception of Digital Dera, they gained a good understanding and better skills to use digital tools more accurately and efficiently. They have easy access to the digital tools as compared to before the inception of Digital Dera. Digital Dera provides them with diversified sources of income, such as value addition to agricultural products and agricultural entrepreneurship. Recommendations are:

a) Findings show that the promotion of the governmental schemes and subsidies by Digital Dera was low. So, there is a need to promote governmental schemes and subsidies among the farmers so that they can avail this opportunity.

b) Data shows that the adoption rate of drones and energy-efficient tractors is low. So, the government should provide subsidies and training on drones and energy-efficient tractors to the service providers.

c) Overall, Digital Dera has fruitful results. So, the government should implement such projects in several villages. Digital Dera should have an online portal/information hub system where all stakeholders can connect with each other.

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

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