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IMPACT OF INFORMATION COMMUNICATION TECHNOLOGIES (ICTS) ON WHEAT FARMER'S PROFITABILITY IN SOUTH PUNJAB, PAKISTAN

Sobia Saeed[1], Muhammad Siddique[2], Arsal Ali[*3], Muhammad Hamza[4], Muhammad Umer[5], Muhammad Taimoor[6], Shaista Maken[7]

[1]*Institute of Business Management Sciences (IBMS) University of Agriculture Faisalabad, Pakistan*
[2,*3,4,5,6,7] *College of Economics and Management, Northwest A&F University, Yangling 712100, China*

[*3]syedarsalalishah786@gmail.com

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Corresponding Author: *
1. sobiasaeed261@gmail.com
2.siddique.muhammad@nwafu.edu.cn
4.hamza.muhammad@nwafu.edu.cn
5. umer@nwafu.edu.cn
6.taimooruaf@gmail.com
7.shaista.maken@nwafu.edu.cn
3*syedarsalalishah786@gmail.com

Abstract
The use of information communication technologies (ICTs) is becoming inevitable day by day in agriculture with the advancement in this sector. This study attempts to find the role of ICTs to increase the profitability of farmers in south Punjab. The multistage sampling design was used to select wheat farmers from two districts of South Punjab Multan and Muzaffargarh. From each district, one tehsil will be selected to access the use of ICTs by farmers. Face-to-face interviews of farmers were conducted on the pre-defined questionnaire and subjected to a regression model by using R software for data analysis and estimation of results. The results showed that the use of ICTs tools has a significant positive relationship with profitability per acre. More educated farmers are using ICTs tools more to get different information. The study also showed that age has a negative relationship with the use of ICTs and education has a positive relationship with the use of ICTs tools. The conventional input cost has a positive relationship with profit per acre showing that farmers using ICTs tools to get different information have less input cost and more profit per acre. Mobile phones, tv, and others like newspapers, Agri websites, and application tools are frequently used ICTs tools as per this study. The study suggested that other ICTs tools such as the use of the mobile application to get a different crops and market-related information also need to scale up among farmers through training and extending extension services.

INTRODUCTION

Information and communication technologies (ICTs) are any instruments or systems that allow data to be collected via exchanged through communication or action. Radio, television, and the Internet can all provide relevant and timely information that aids in decision-making regarding the most efficient and profitable use of resources (Ekbia & Evans, 2009; Ommani & Chizari, 2008). Information and communication technologies (ICT) have rapidly expanded throughout society and have been essential to rural development. In recent years, ICT has produced notable outcomes in nearly every aspect of rural life (Fawole & Olajide, 2012). Primarily residing in rural regions of developing nations, these smallholder farmers are ill-equipped to understand production techniques and market prospects, particularly with regard to novel crops and cultivars (Kalidou et al., 2024; Minot and Sawyer, 2016; Phiri et al., 2019). They also lack access to agro-meteorological information (Khan et al., 2020; Ndimbo et al., 2021), market information, and information related to financial services that ICT help to improve smallholder agriculture and transform rural livelihoods (Nyagango et al., 2023). ICTs are widely acknowledged as both instruments for economic development and progress (Appiah-Otoo & Song, 2021; Farhadi et al., 2012; Karaman Aksentijevic et al., 2021; Usman et al., 2021) and as agents of the empowerment of women, fostering greater economic power (Cummings & O'Neil, 2015), independence (Mackey & Petrucka, 2021), and involvement in domestic decision-making (Zheng & Lu, 2021). ICTs provide a means of being more empowered in a variety of areas (Hilbert, 2011; Mackey & Petrucka, 2022). ICT initiatives can also help with finance access, education, healthcare, and the development of non-farm rural companies, as explained by Nyika (2020). With this in mind, we seek to analyze ICT on wheat farmer profitability in South Punjab, Pakistan and uncover the underlying reasons behind farmers' ICT Tools choses associated with trading under this structure.

Agriculture sector plays an essential role in economic growth contributing 22.9 percent GDP and 37.4 percent in employment generation, ensures food security and provides raw material to the industrial sector. Wheat has a significant part in the Pakistani food economy, both in terms of production and consumption. Wheat production has witnessed a record growth of 11.6 percent, reaching 31.4 million tonnes compared to 28.2 million tonnes last year (GoP, 2024). In order to solve the rising demand for food grains, real efforts in agricultural research and extension are required. Even though it accounts for a significant portion of Pakistan's economy, the agricultural sector is falling behind in a number of areas, including poor market and connectivity deterioration, delayed and inaccurate information provided to farmers, a lack of adoption or gradual implementation of advancements in technology, small land holdings, low farm produce prices, and more. In the current technology era, it is imperative to create strategies to keep farmers informed about technologies, technological adoption, and pertinent material for agricultural output to speed up.

ICTs are essential in the agri-food business for providing quick access to information and knowledge regarding agricultural production. By lowering transaction costs, improving productivity, efficiency, and farmers' earnings, as well as by giving stakeholders more information and value, their efficient use of ICT can make agriculture more appealing (Rao, 2017). Berman (2008) demonstrated how emerging nations have benefited greatly from innovative ICT approaches. To obtain knowledge about how to handle pesticides on their farms properly, farmers now use a variety of websites (Joshi & Ayyangar, 2010). Sein and Furuholt (2009) assert that the internet might be used to research the function of the middleman. Farmer productivity and revenue have increased as a result of using mobile phones to interact with buyers before to travel and sell their goods at a profit (de Janvry et al., 1991, Grameen, 2007, Fafchamps & Vargas Hill 2005). They save money, time, and effort in this situation (Muto et al., 2011; Lee et al., 2013). It was demonstrated that farmers might readily obtain information by viewing television shows about agriculture (Murty and Albino, 2012). Muto and Yamano (2009) examined how mobile phones affected agricultural products and markets, providing information on market efficacy. Agricultural farmers are utilizing SMS services to be informed about the weather and application of pesticides on their farms (Murthy, 2009. Social media communication between farmers and extension agents can increase the rate at which new agricultural technology are adopted (BenYishay and Mobarak, 2013). One of the best ways to provide farmers with agricultural, technical, and scientific information is through radio (Murty & Albino, 2012).

Despite difficulties, In Pakistan, many country farmers are smallholders, uneducated, have insufficient support networks, to adopt new technology (ICT) due to poverty and unable to compete with market trends (Zakar and Zakar, 2009). Similarly, Pakistani farmers are relying on traditional communication sources such as the Agriculture Department's staff, friends, relatives, fellow farmers, and newspapers, as well as new communication sources such television, telephone, SMS services, radio, pesticides firms, zarai digest, pamphlets, agriculture websites, and neighbors, are the source of information of farmers. ICT advancement have lowered the cost and increased the speed and volume of data delivery (Ibrahim et al., 2018). Productivity and sustainability of the agriculture sector largely depend on the effectiveness and quality of extension services (Kimaro et. al, 2010). It is critical to provide farmers with the most up-to-date knowledge and modern farming abilities to keep them informed about every agricultural breakthrough (Sanaullah et al., 2020). In Pakistan, farmers are facing different issues of crop protection, storage, and marketing of their products. With different view on using ICT and advance research to address issue (Khan et al., 2010). ICTs have the potential to supplement currently ineffective extension services, particularly to ensure that farmers have access to different agriculture technologies, markets, and weather all of which contribute to the development of the agriculture sector in developing countries (Yaseen et al., 2016). Bell and Shahbaz (2018) challenged this claim, claiming that "farmers' demands (including location-specific information and the needs of the youth and women) are rarely collected or analyzed" in the context of the use of information communication technology in agricultural extension in Pakistan. Ali et al. (2016) the majority of Baluchistan's farmers used outmoded ICTs to get agricultural information (Radio & Television). Farmers' use of ICTs is hampered by several of factors, including a lack of internet and mobile service in rural areas, ignorance of ICTs, illiteracy, and unfavorable economic conditions. ICTs can augment the currently inefficient extension services, especially to guarantee that farmers have access to various agricultural technology, markets, and weather, all of which promote the growth of the farming sector in developing nations (Yaseen et al., 2016).

Several studies have found that ICT has aided farmers in Pakistan in embracing contemporary agricultural technology and learning about different varieties, market accessibility, methodologies, preferences, pricing patterns, climate, crop growth levels, and other crucial factors. Moreover, no systematic study was found regarding the impact of ICT on wheat farmer's profitability. Therefore, this study analyzes the scale of ICT use by farmers and examines how well ICT affects agricultural productivity, with particular attention paid to South Punjab. The impact of cell phones, TV, radio, and the internet were the key topic of this study.

Review of Literature

Numerous modules related to detection, communications, data monitoring systems, and data usage were added to this model to remotely examine the agricultural environment. This study was conducted to build a farming model that would benefit Pakistani farmers. Aker (2010) used data at the trader level and unique demands to estimate how mobile phones affected price dispersion throughout Nigerian grain markets. Mobile phone coverage in Nigeria minimized the movement of grain prices by 16%. Kante et al. (2011) conclude from a study that farmers now have access to the essential ICT support they need to disseminate critical information on the farming practices practiced in their region. Ali (2012) showed that the main sociodemographic factors affecting farmers' adoption of ICT-based systems were their social category, income, and educational attainment. Chhachhar et al. (2014) established that Information and communication technology was identified as being essential to the expansion of agriculture in developing countries. (Ali et al, 2016) investigated that net profit per acre and agricultural productivity in Zambia are improved by ICTs.

Saidu et al. (2017) examined the potential benefits and limitations of ICT's influence on agriculture. In order to generate revenue, share relevant information, conduct research, improve market operations, link the agricultural sector globally, and prepare for economic growth, the report asserted that ICT was essential to the agriculture sector. Awan et al. (2018) found that the primary barriers to the successful integration of ICT in agricultural growth were a lack of farmers, inadequate ICT infrastructure, a lack of electricity, a lack of human resources, and a need for knowledge and communication norms. Salam and Khan (2020) reported that agriculture extension is the latest agricultural technology as a means of disseminating information to rural communities and inspiring them to embrace them, which can be accomplished vi improving communication among relevant parties.

Abdullahi et al. (2021) claimed that the usage of ICT can aid in the advancement of the agricultural business sector, particularly in nations looking for new opportunities. Ahmad et al. (2021) results showed the movement from radio to television to mobile phones is based on the total use of ICT tools for agricultural information transmission. Farmers claimed that a communication barrier preventing them from contributing to the agriculture sector is a lack of access to ICT tools. Numerous research has been conducted to show how ICT increases agricultural yield. Even though research focuses on a broad variety of specific activities, the study will concentrate on the important ICT components that have an impact on agricultural productivity and are commonly discussed in the literature. There has been much research in Pakistan looking at the overall effects of ICT on agriculture. It is difficult to find studies that looked at the micro-level effects of ICT on South Punjab's agricultural output in Pakistan. Consequently, a micro-empirical investigation is required for this topic. By choosing districts in Pakistan's South Punjab province, the study bridges a gap in the body of knowledge regarding the effect of ICT on the productivity of agriculture.

Conceptual framework

Information and communication technologies (ICTs) continue to hold enormous promise for South Punjab's rural development in agriculture, industry, education, and healthcare. Figure 1 shows a conceptual framework. These services will affect income, efficiency, the marketplace linkage, and the capacity of farmers to work effectively and effectively. Finally, information and communication technology (ICT) has a trickle-down effect in terms of enhanced output from agriculture.

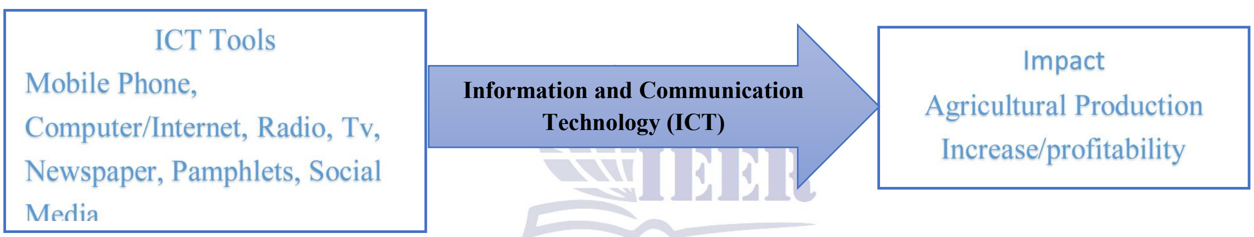

Figure 1: Conceptual Framework

Research methodology

The methodology employed in the investigation are described in this section. Study population, sampling techniques, procedures, sample size calculation, data collection methods (including types, sources, and methodologies), data analysis, reliability are all covered.

Study area

This study was carried out in the districts of Muzaffargarh and Multan. One tehsil will be chosen from each district to provide farmers with access to ICTs. These regions were chosen because they produced a lot of wheat, and the researcher was interested in how ICT affected agricultural output in general and wheat output in precise. The selection of these Tehsils was also motivated by their interest in learning more about the locations where ICT was used and accessed for agricultural information of ICT resources in the study area.

Study population

The target population for this study was farmers who had some understanding of, access to, and use of ICT for agricultural productivity. Farmers were selected from different parts of a Tehsil in South Punjab, Pakistan. Within this framework, the researcher asked farmers about their opinions regarding ICTs, land, labor, traditional capital used in diverse agriculture, and ICT availability and use.

Sample size determination

The sample size in research, particularly primary data, must be chosen to maximize accuracy predictive ability, cost-effectiveness, and flexibility while retaining accuracy, flexibility, and dependability. Researchers looked at farmers in the South Punjab region of Pakistan in the villages of Multan and Dera

Gazi Khan. The study included 200 farmers as a sample size. A convenience sampling technique was used to collect information and data from respondents. Cochran's Sample Size Formula was used to calculate the sample size $n = (z^2 pq)/e^2$

Where n= required sample size

Z = confidence level at 95% (standard value of 1.96),

p is the estimated proportion of the population with an attribute present in the question (in this case, p = 0.5, i.e., 50%)

e = desired level of precision (i.e., the margin of error) at 5% (standard value of 0.05)

Construction of data collection tools

The study collected primary data and the interview schedule is based on the following contents, Demographic characteristics of respondent's wheat farmers related to ICT. The other was data on land, labor, agricultural output, and traditional inputs like machinery, fertilizer, and pesticides. Finding out who is aware of information and communication technology (ICT) is the aim of this poll. The rate at which ICT is used identifies the users and non-users of wheat. Make recommendations for effective ICT use based on research.

Analysis of data

IBM Statistical Package for the Social Sciences (SPSS version 20.0) was used to analyze the data, and descriptive statistics were used to determine the mean and standard deviation of the scores for each construct. When the questionnaire was being created, input was used to make the necessary adjustments and further cost of wheat production analysis per acre by using R model to summarize the profit per acre.

Model specification

The method of structural equations is employed to calculate the influence of ICT on wheat farmer profitability, as well as the effects of age, education, conventional inputs, land, and labor on agricultural profitability per acre. Andrew Haye's Regression Process Model study was designed to provide more variable information through coefficient estimates. The coefficient determines the degree to which independent variables influence the dependent variable.

Model: impact of ICT on wheat farmer's profitability

The estimable model's practical shape, assuming various linear correlations among information and communication technology and profit per acre, is as follows:

It was calculated the using formula $y_i=\beta_0+\beta_1 x_{i1}+\beta_2 x_{i2}+\ldots+\beta_p x_{ip}+\epsilon$

Where, Y is the dependent variable (profit per acre), β_0 estimated intercept

XI = age, X2 = education, X3 = mobile phone, X4 = TV, X5 = News/meg/webs/application. X6 = seed cost, X7= seedbed preparation cost, X8= irrigation cost, X9= fertilizer cost

X10= pesticide cost ϵ_i is the random error.

Here: ϵ_i = The error term associated with data collection is considered to be evenly distributed with equal variance and zero mean. In this research the reason behind utilizing the multiple linear regression analysis by Andrew Hayes is to check the overall impact of multiple independents variables on the dependent variable (profit per acre).

Reliability

The internal reliability of the questionnaire survey was evaluated using the Cronbach's Alpha test. Israel (2012) a survey study with a sample size of at least 20 could yield significant results. With a Cronbach's alpha of 0.728 (73%) the items are considered reliable and have internal reliability. The level of Alpha's coefficient attests to the validity of the survey.

Results and discussions

This part comprises the descriptive analysis, as well as the model of structural equations results and conclusions. The main objective of the study was to evaluate how ICT works in agriculture. A research project's focus should be on both data collection and how the results are presented after analysis.

Demographic characteristics of respondents

The research collected demographic information from respondents, such as their age income, and educational status. The below-mentioned table provides a summary of respondents' demographics.

Table 1:Table 1. Demographic Breakdown of Respondents by Age Group.

Age		Frequency	Percentage
Young	>25	51	25.5
Middle	>35-45	91	45.5
Old	>50	58	29.0

Source: Author's own calculation

As mentioned in Table 1, respondents were divided into three groups. Middle-aged categories were prominent, with a percentage of (45.5). old aged respondent less prominent than middle age. Young respondents (25.5) generally showed less interest in and involvement with the agricultural sector. These results, which are more or less equivalent to those of Siddiqui (2006) and Muhammad et al., (2008) demonstrate the dominance of middle-aged respondents, preceded both young and old.

Table 2 :Table 2. Demographic Breakdown of Respondents by Education.

Education	Frequency	Percentage
Primary	75	37.5
Middle	62	31.0
Above matric	63	31.5

Source: Author's own calculation

As mentioned in Table 2, 37.5%, of the respondents have a formal education. It was found that old age was one of the factors contributing to low education. Before now, these senior responders had never been able to benefit from possibilities for further education. However, the tendency toward schooling was discernible among the younger responders. The findings show that 37.5% of respondents had, at the very least, no formal education. These findings differ from the primary respondents' results (37.5%) and those of respondents with primary to middle education (31.0 percent). just under 31% of respondents had at least their matric level of education, while 31.5 % were educated beyond the intermediate level.

Type of ICT a used by the farmers

The study was done concerning respect to ICT to find out whether the farmers were familiar with this term, it was essential to ask. Finding out about that is the first step toward adopting. It happens that people don't always know what they're using.

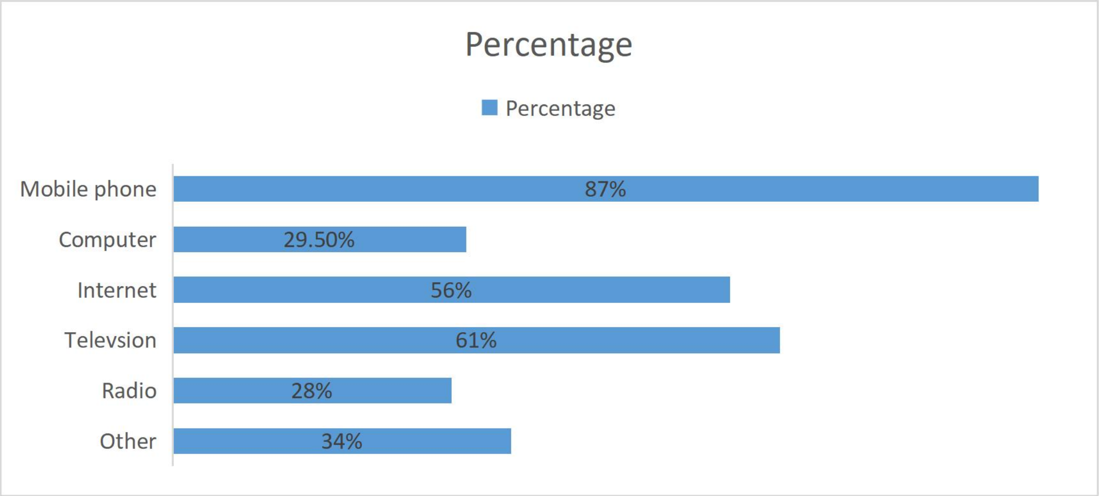

Figure 2 Type of ICT used by the farmers

Source: Author's own calculation

The bar graph illustrates the various ways farmers obtain agricultural data. Only 29.50% of farming households have a computer or laptop at home, and 61% of the farmers found agricultural information on television. Of these, 87% of farmers used mobile phones. In the same way, 56% of farmers accessed internet agricultural information online, compared to 28% who employed radio. The percentage of farmers who used alternative forms of ICT to obtain information about agricultural activities was just 34%. The study concludes that the internet, television, and cell phones were common and vital communication tools that provided farmers with knowledge and details about farming.

What types of agriculture information collected using ICT?

The participants were asked a general question on the many pieces of information that they had heard. Participants were asked to score their consistency on a ranking system of never, seldom, and always. Proportion of those who responded based on the type of information collected about the farm sector through ICT (a)

Table 3. Proportion of Respondents Collecting Agricultural Information via ICT.

Statements	F	%	F	%	F	%
Obtain information about new verities	97	48.5	57	28.5	46	23.5
Exchange of knowledge and ideas with fellow farmers	33	16.5	104	52.0	63	31.5
Communication between extension agents and farmers	63	31.5	95	47.5	42	21.0
Acquire information from research institution	97	48.5	42	21.0	61	30.5
Weather forecasting information	56	28.0	92	46.0	52	26.0
Learn skills regarding agriculture	48	24.0	103	51.5	51	25.5
Get information on farm input availability, cost & where to obtain	42	21.0	101	50.5	57	28.5
Information about credit	66	33.0	79	39.5	57	28.5
Innovation in agriculture	109	54.5	51	25.5	40	20.0
Location of marketers for farm product	57	28.5	101	50.5	42	21.0
The recommended dose of pesticides & fertilizers	50	25.0	88	44.0	62	31.0
Seed rate	68	34.0	88	44.0	44	22.0
Land preparation	101	50.5	58	29.0	41	20.5
Best planning techniques	88	44.0	63	31.5	49	24.5
Best time for harvesting	69	34.5	81	40.5	50	25.0
Method of disease prevention & control	46	23.0	102	51.0	52	26.0
Pest control	47	23.5	99	49.5	54	27.0
Searching for a place where my farm products are highly needed	48	24.0	102	51.0	51	25.5

Source: Author's own calculation

This table's 4, values indicate the frequency and proportion of participation. The data was analyzed to provide a score, ranking, mean, and standard deviation, as given in the table. The participants were distributed based on the type of knowledge they acquired about agriculture via ICT (b)

Table 4. Ranking of Agricultural Information Accessed Through ICT by Farmers.

Statements	Score	Ranking	Mean	S. D
Exchange of knowledge and ideas with fellow farmers	512	1	2.19	0.661
Learn skills regarding agriculture	498	2	2.13	0.742
Method of disease prevention & control	488	3	2.08	0.713
Searching for a place where my farm products are highly needed	481	4	2.06	0.694
Pest control	480	5	2.05	0.751
Weather forecasting information	475	6	2.03	0.090
Get information on farm input availability, cost & where to obtain	477	7	2.01	0.726
Communication between extension agents and farmers	469	8	2.00	0.738
location of marketers for farm product	452	9	1.93	0.708
Best time for harvesting	450	10	1.93	0.780
The recommended dose of pesticides & fertilizers	450	11	1.93	0.780
Seed rate	429	12	1.83	0.748
Information about credit	429	13	1.83	0.748
Best planning techniques	428	14	1.83	0.805
Obtain information about new verities	408	15	1.76	0.782
Land preparation	401	16	1.71	0.758
Acquire information from research institution	396	17	1.69	0.755
Innovation in agriculture	386	18	1.65	0.795

Source: Author's own calculation

This table 5, Learning about agriculture-related skills came in second place (score-498 & mean of 2.13) after exchanging knowledge and ideas with other farmers (score-512 & mean of 2.19). Finding areas where farm products are urgently needed and disease prevention and control methods ranked third and fourth, respectively, with scores of 488 and a mean of 2.08 and 481 and a mean of 2.06. Weather forecasts, input data accessibility, and communication with extension agents were scored 477, 475, and 469, respectively, with mean values of 2.03, 2.01, and 2.00. Acquiring data from an investigation center and creative expertise were placed 17th and 18th, respectively, with scores of 396 and 386, and mean values of 1.69 and 1.65.

Results of Model

Analysis of variance of dependent and independent variables.

Table 5. Analysis of Variance (ANOVA) for the Impact of ICT on Profit Per Acre.

ANOVA	*Df*	*Ss*	*Ms*	*F*	*Significance F*
Regression	12	2.61E+09	2.37E+08	4.461954	5.64E-06
Residual	188	1E+10	53167396		
Total	200	1.26E+10			

Source: Author's own calculation

Analysis of variance shows that F significant value is more than the F calculated value (Table 5) These results independent variables show a significant impact on the dependent variable profit per acre. The independent variables play their role in the profit per acre of wheat farmers. Different other studies also show the same results where the ANOVA is significant to show the significant impact of independent variables (ICTs) on dependent variables (Raza and Mahmood, 2015).

Table 6. Statistical Analysis of ICT Tools Usage: Mean, Standard Deviation, and Coefficient of Variation.

Variable	Mean	SD	CV
Age	38.82	8.13	20.96
Education	0.31	0.46	149.56
Mobile phone	0.31	0.46	149.56
TV	0.25	0.43	173.63
News/Magazines/websites/Application tools	0.27	0.45	162.77

Source: Author's own calculation

The mean, standard deviation, and coefficient of variation showed that greater variation exists among the studied population. The CV of different variables is more than 20. The greater variations exist among the farmers to use the ICTs tools Table 6 Similarly, variations are also greater in the number of acres, profit per acre, and pesticide cost. This data showed that variations exist among the farmers in the land, different input costs, and profits per acre with the use of ICTs tools.

Table 7. Statistical Analysis of Profit per Acre and Associated Input Costs.

Variable	Definition	Mean	S. D
Profit	Profit per acre	37950.32	9877.99
Fertilizer	Fertilizer Cost per acre	13747.17	1632.88
Irrigation	Irrigation cost per acre	2955.5	341.65
Labour	Labour Cost per acre	2106	104.49
Pesticide	Pesticide cost per acre	1247.5	255.57
Seedbed	Seedbed preparation cost per acre	3269.7	250.51
Seed	Seed Cost per acre	3071.34	258.34
Land	Total Land (Acre)	11.055	4.04

Source: Author's own calculation

According to this Table, 7 the average profit (per acre) gained by the farmers is 37950 rupees with a standard deviation 9877.9. The value of S.D is very high which indicates that the profit per acre for the farmers is not near to the value of the mean. It means the profits of farmers may vary depending on the farming activities that they have adopted on their farms. Similarly, the average cost of irrigation, labor, pesticides, seedbed preparation, and seed can be seen in the table 7. The values of S.D for all these inputs are very high which means the farmers pay different costs for all these inputs depending on their input sources. It can also be observed from the table 8 that the average land holding of farmers in the study area is about 11 acres. The value of the standard deviation is 4.04 which indicates that most farmers have near to 11 acres of land.

The goodness of fit Statistics

In this section, the regression analysis demonstrates that wheat farmers' per-acre yields rise dramatically when they employ ICTs. Various research found that if the R square value is low, the model is unfit to predict the relationship between the dependent and independent variables. However, this is not true for every data. A model with a lower R square value can also be used to explain the link between dependent and independent variables (Chicco et al., 2021). The adjusted R square value is 0.207, indicating that adding more input variables will increase the model's value by 20%. In other words, the model explains 20% of the variance caused by the relationship between dependent and independent variables.

Table 8. Regression analysis of dependent variable with independent variables.

Regression Statistics: Profit per acre (10 variables, n=200)				
	R-Squared	**Adj. R-Sqr.**	**Std.Err.Reg.**	**Std. Dev.**
	0.207	0.160	0.189	0.205
Variable	**Coefficient**	**St. Err.**	**t-statistic**	**P-value**
Constant	0.568	0.088	6.436	0.000
Age	-0.016	0.056	-0.280	0.780
Education	0.065	0.030	2.181	0.030
Mobile_phone	-0.015	0.030	-0.501	0.617
TV	-0.196	0.058	-3.391	0.001
New/Mag/Web/applications	0.215	0.055	3.872	0.000
Fertlizer_	0.301	0.120	2.506	0.013
Irrigation_	-0.110	0.061	-1.810	0.072
Labour_	0.000190	0.039	0.005	0.996
Seedbed_preparation_	-0.198	0.083	-2.387	0.018
Seed_Cost	-0.208	0.075	-2.761	0.006

Source: Author's own calculation

According to this table 8, farmers' ages have no major impact on profit per acre wheat yield. According to the findings of one study, 42% of respondents over the age of 35 earned more profit per acre and used ICT tools to retrieve various faring-related data. The use of various ICT tools to increase profit per acre is also dependent on farmer literacy (Khan et al., 2022). The outcomes of this study indicated that there may be more factors other than age such as land holding, education, etc. that influence the profit per acre. Education has a positive and significant relationship with farmers' per-acre profit. Farmers' education level is also highly important in the utilization of ICT tools and how to obtain information for various inputs to utilize, such as variety selection, soil preparation, irrigation application, and fertilizers. Information on market trends can also be anticipated by using ICT technologies that help to get higher price of the product and ultimately allow to acquire more profit per acre (Arfan et al., 2012).

The usage of mobile phones had no substantial positive effect on the per-acre production of study farmers. In many research, cell phones are used to obtain various information such as weather forecasts and crop advisories supplied by extension and other agricultural departments. Lee and Bellemare (2013) suggest using mobile phones to obtain information on crop husbandry techniques and boost per-acre yields. In the present study, the lack of a connection between the use of mobile phones and profit per acre suggested that there is a need to educate farmers by strengthening the extension mechanism to use mobile phone technology more positively to retrieve different agricultural information that helps to increase profit per acre.

The use of TV had a significant relationship with profit per acre showing that farmers also get the information from TV that contribute to an increase in per acre profit of farmers. The same results were also found in a study where the use of ICTs tools such as mobile phones, TV, and the internet has a positive impact on agriculture production. These ICTs tools helped in the adoption of innovation in agriculture and the use of efficient techniques, decrease input costs, and increased income and profit (Yaseen et al., 2016). The other ICTs tools for example Newspapers, magazines, and other websites/application use also have a significant relationship with profit per acre. The results showed that other ICTs tools also need to explore for example mobile applications to fetch different information about agriculture. A study showed that the use of this mobile applications such as plantix, kissan diary, and satellite yield estimation greatly contribute to the knowledge of farmers and help to receive different information for example weather prediction, disease and insect attack, application of pesticides and irrigation (Qiang et al., 2012).

The regression analysis shows that seed, seedbed preparation and irrigation cost had significant relationship with per-acre profit. The results showed that farmers using ICTs tools helped to decrease these costs that ultimately helped to increase profit per acre. The irrigation cost was significant showing that with use of ICTs tools the precise irrigation by getting weather predictions helped to reduce the cost and increase the profit per acre. The fertilizers cost also had a significant relation with profit per acre. The significant relationship between fertilizers cost and profit per acre showed that farmers were retrieving different information for example crop advisory to apply balance fertilizers, reduce input cost of fertilizers and increase profit per acre. The seed bed preparation cost was also significant with profit per acre depicting that the decrease in seed bed preparation cost helped to contribute to more profit per acre and use of ICTs tools contributed to decreasing seed bed preparation cost.

The seed cost was also significant with profit per acre showed that farmers using ICTs tools fetched information for example in form of crop advisory that helped decrease seed cost and increase profit per acre. A study showed that the use of ICTs tools has a positive impact on agriculture production (Ali et al., 2016). The results also state that a greater impact of ICTs tools, level of education, and input cost on profit per acre. The results of this study are also justified by different other studies where the use of ICTs tools is used to get agriculture information and increase profitability (Chhachhar et.al, (2014). The mobile phone and television remained significant contributors to improving agriculture production (Chavula, 2014).

Conclusions and policy recommendation

This section summarizes the study's findings, which show that farmers benefit from the availability and use of ICT tools for agricultural data. However, the study also found that there is still opportunity for improvement in the use and access of ICT tools to achieve positive outcomes in the agriculture sector. Thus, in order to encourage farmers to engage in farming operations, the section offers policy implications for better administration in the future for maximizing advantages.

Knowledge of various ICT tools, access to a wide range of sources, use to obtain additional agricultural data, the significance and challenges farmers face in obtaining agricultural data, the prevalence of conventional inputs (pesticides, fertilizers, seed, labor, seedbed, irrigation, and land) in agricultural activities, and the advantages of ICT use in agriculture are the primary goals of this study. This study concludes by stating that the availability and use of ICT tools for obtaining information promotes farmers' agricultural progress while also presenting limits This study's findings indicated that there is still room for enhancement in the access to and utilization of these tools for efficient outcomes in the agriculture sector.

According to the survey, cell phones, television, and the internet are the most commonly used and crucial kinds of information and communication technology. The survey finds that participant most known instrument, the mobile phone, is the most desirable since it permits them to readily communicate with individuals. Television also helps to disseminate agricultural information by presenting a variety of agriculture-related programming. The internet is also useful for providing information on many agricultural tasks. Additionally, participants had relatively simple utilization of social media for exchanging information and communicating with other individuals. Farmers have significant challenges to embracing ICT due to a lack of basic competencies, trust in their capacity to utilize ICT infrastructure, and training and exposure. Some are impeded by human limitations, such as farmers' a lack of education which creates linguistic obstacles and age problems. According to the questionnaire, the main source for accessibility was themselves given that computers, radios, newspapers, and agricultural websites are less approachable than mobile phones, televisions, and social media. The data shown indicated that the main barrier to farmers' effective use of ICTs was a lack of basic understanding of how to use them, which suggests a lack of instruction and practical experience.

ICT tools were used for a variety of reasons, according to the study. The main justifications were cost-effectiveness, ease of availability, and ease of access to information on the agriculture industry. The majority of farmers receive knowledge about seeds and fertilizers before learning about irrigation techniques, according to the report. The results of the study indicate that basic inputs, labor, and education all have a favorable impact on agricultural output, while the land has a significant link with it. The use of ICTs tools also helped to decrease the input cost and increase per-acre profit. Total land in acres has a negative impact on profit per acre but the impact is not significant. This showed that a greater number of acres are not concerned for use of ICTs as more education and young age of farmers. The data showed that variations exist among the farmers in the land, different input costs, and profit per acre with the use of ICTs tools. The significant ANOVA showed that the independent variables showed a significant impact on the dependent variable profit per acre. The regression analysis shows that seed, seedbed preparation and irrigation cost had significant relationship with per-acre profit. The results showed that farmers using ICTs tools helped to decrease these costs that ultimately helped to increase profit per acre. The irrigation cost was significant showing that with use of ICTs tools the precise irrigation by getting weather predictions helped to reduce the cost and increase the profit per acre. A study showed that the use of ICTs tools has a positive impact on agriculture production

Farmers' opinions on the efficiency of ICT in spreading agricultural information vary widely. The farmers usually concur that the use of ICT technology was prompted by the need for quick access to information sources that were essential for farmers, a desire to travel less or even save money, and want to get the right information at the right time. Lack of access to ICT-related tools, including computers and the internet, makes some people insecure when using services, particularly those on mobile phones, because they are not as familiar with them and do not know how to utilize them properly to get the most out of the. Farmers are unable to use their phones due to inadequate network access. According to the research's conclusions, there was no evidence of internet use for obtaining agricultural information. Farmers need to be motivated as well as made aware of the benefits of using the internet for agricultural purposes. To raise knowledge and interest among farmers, a large effort is required. When discussing agricultural information, all of the sources should be used to promote one another. A crucial tool for agricultural data in this context is information and communications technology (ICT). Because of a lack of network coverage, electricity, internet signal strength, and development infrastructure, ICT resources are not available in South Punjab's rural areas. Therefore, it is essential to build and equip rural areas with necessary infrastructures, such as a network to provide services closer to people, such as internet access, and dependable energy without load shedding. Roads, bridges, telephones, and other infrastructure that is readily available in rural areas should be used to connect remote locations.

Suggestions for future research

❖ Future research in this field could focus on the efficient collaboration of ICTs. This will guide research can be done with the best ICT usage and improve the transformation of information and knowledge and also help guide and remedy ICT defects.

❖ Additionally, it would help direct and inform the best ICT approach for gathering information and encouraging stakeholders' and consumers' involvement in agricultural production.

❖ Further research can therefore determine the cost of ICT to alternative options for agricultural production, efficiency, profitability, and marketing.

❖ Only South Punjab, Pakistan, was the subject of this study. It is possible to perform additional research on other Pakistani provinces or on a bigger scale to examine how ICT affects agricultural productivity and how effective ICT is for generating net profit.

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