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Empirical evaluation of ethical practices and digitalization of agricultural system with the mediation of user behavior: A case study of Pakistan

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Pakistan is one developing country and 70% of the population is depending on Agriculture and faces a lack of innovation in the agriculture sector overall. the main objectives of our study were to i) identify ethical practices (knowledge-sharing, trustworthiness in loan providing, loyalty in professionalism, responsibility of actions, and accountability) of the agriculture departments and institutions or government towards improving digital technology in the agriculture sector. ii) Quantify the user behavior in the digitalization of the agricultural system. iii) Identify the intervening role of user behavior in the relation to ethical practices and agricultural technology development. The study examined 490 users of farming technologies who work in the agriculture sector in two provinces of Pakistan. Using the Baron and Kenny framework, this research confirmed the prediction that user behavior mediated the relationship between ethical practices and agricultural technology in a four-step process. The main outcomes of the study have revealed a positive and significant impact of ethical practices on the development of the digitalization of the agricultural system. Specifically, the study indicated that "user behavior" significantly mediates the association between ethical practices and agricultural technology development. Furthermore, this study proposes that it is essential for Pakistan's agriculture sector to nurture circumstances dedicated to better practices as it will not only attract more residents to agricultural growth but also help the agriculture sector achieve its eventual goal of increased productivity. Implications of this research study are deliberated and provide directions for future research in the area.

KEYWORDS

ethical practices, digitalization, user behavior, development, agricultural system, Pakistan

1 Introduction

Digitalization, the socio-technical process of implementing digital innovations is a pervasive trend. Big data, the Internet of Things (IoT), augmented reality, robotics, sensors, 3D printing, system integration, ubiquitous connectivity, artificial intelligence, machine learning, digital twins and blockchain are examples of digitalization phenomena and technologies (Klerkx et al., 2019; Lo et al., 2021; Mihai et al., 2022). Digital agriculture, also known as smart farming or e-agriculture, is a tool that digitally collects, store, analyze, and share electronic data and/or information in the agriculture (Le Roux, 2022). These technologies can give the agricultural business the tools and data it needs to make better decisions and increase productivity (Saiz-Rubio and Rovira-Más, 2020). Agricultural products hold an inimitable place

in human life and an inevitable requirement of livelihoods across the world. Advanced technologies to improve multiple aspects of agriculture have been developed in recent years (Pallathadka et al., 2021).

The global economy has entered a new phase due to the digitalization (Lorberg and Janusch, 2021). Sensors, drones, weather satellites, intelligent software algorithms, and robots are just a few examples of the technologies that make farming 'smart'. Drones and robots make time-consuming tasks more effective and efficient, such as irrigation, monitoring the health and location of a herd or driving it in a specific direction, sowing crops, and milking cows (Mohamed et al., 2021). Smart agriculture technology based on the Internet of Things (IoT) technologies has many advantages related to all agricultural processes and practices in real-time, which include irrigation and plant protection, improving product quality, fertilization process control, and disease prediction (Mohamed et al., 2021). Weather satellites and sensors provide information that can be used to tailor irrigation, fertilizer, and pesticides to the needs of plants, or to determine the best time to seed. Pesticides are sprayed over cropping areas in open-air or greenhouse settings to improve yield. Farmers can also use ML as part of precision agriculture management, in which agrichemicals are applied based on time, place, and affected crops. Farmers must accurately detect and classify crop quality features to increase product prices and reduce waste. Machines can use data to detect and reveal new traits that contribute significantly to crop quality. Agriculture's water management significantly impacts the agronomic, climatological, and hydrological balance. ML-based applications can estimate evapotranspiration daily weekly, or monthly, allowing irrigation systems to be used more effectively (Javaid et al., 2022).

Furthermore, all of these technologies provide data that can be aggregated and evaluated across farms in the region, providing farmers with even better insights (based on more data) and assisting them in reducing their environmental effects (Van der Burg et al., 2019). However, challenges persist in the development of digital agricultural and food technology, particularly in developing countries (Schelenz and Schopp, 2018). The developing nations have many challenges in implementing smart systems regarding the availability of infrastructure owned by the state and other capabilities possessed by individuals (Raza et al., 2022). Therefore, the barriers to the implementation of smart agricultural technology in developing countries can be explained simply: *a*) the availability of a suitable fourth or fifth-generation network is the most important factor in data transmission between sensors *via* the Internet. *b*) The availability of sensors as they are responsible for measuring the various phenomena and characteristics on the farm. *c*) Availability of devices and equipment capable of carrying out agricultural operations; *d*) trained experts based on smart farms. However, several factors also affect many farmers' adoption of smart farming technology, including weak socio-economic backgrounds and face many challenges due increasing cost of cultivation. These challenges need concrete strategies at different levels, from local to national. Many technological and natural science aspects of agricultural digitalization have a large quantity of literature (Kurbatova et al., 2019; Ukolova et al., 2020). Artificial intelligence, blockchain, big data, robotics, the IoT, system design, and other topics related to the technical optimization of farm production and food systems have gotten the most interest in this area. International research in this emerging field of agricultural technology has also concentrated on ethical innovation issues and principles (Eastwood et al., 2019; Lajoie-O'Malley et al., 2020). Therefore, an assessment of the existing literature has helped to recognize a significant gap that needs to be filled in this field. Empirical studies in this area are absent in the previous literature. However, there is a growing need for empirical evaluation of responsible and ethical activities to determine their protracted effect. To meet this aim, this research focuses on the empirical valuation to test the influence of ethical practices on the digitalization of the agricultural system of one developing country, Pakistan. We have developed a framework that allows gaining insight into the relations between ethical practices and the digitalization of the agriculture system.

People such as farmers, agripreneurs/agri-businesspersons/agri-entrepreneurs, as well as all others who work in the agriculture sector and use farming technology are users of agricultural technologies. User behavior refers to how individuals (users) engage with a product (Johansson, 2016). Mohamed and Hassan (2008) define "user behavior" as the way that people think, perceive, behave, and feel about information retrieval systems when they interact with a software interface. Furthermore, this study also focuses on the role of user behavior (users of agricultural technologies such as farmers, agripreneurs/agri-businesspersons/agri-entrepreneurs, etc.) as an intervening factor. Therefore, we can say that in this study, we also identify user behavior toward digital technologies in the context of the agriculture sector in Pakistan. Most importantly, we examine user behavior as a mediator role in the relationship between ethical practices and agricultural technology development. This approach provides a better understanding of the unknown impact. This is the first comprehensive research of its kind in Pakistan. The study's precise research questions are.

1. Do ethical practices (such as fairness in providing loans, respect for others, knowledge-sharing methods, honesty, loyalty, the responsibility of actions, and accountability of agricultural departments and institutions) affect the digitalization of the agricultural system in Pakistan?
2. Does user behavior play a mediating role in the relationship between ethical practices and agricultural technology development in Pakistan?

The study creates noteworthy contributions to the existing research by observing the interrelationship between ethical practices, digitalization of the agricultural system (agricultural technology development), and user behavior. Through the addition of the diffusion of innovation theory (Shang et al., 2021), we identify how ethical practices are associated with the digitalization of agricultural systems and user behavior in the agricultural sector, prolonging the inadequate research on the linkage between ethical practices and agricultural technology development. Furthermore, with limited research on ethical practices in Pakistan and the vast majority lacking clarity on ethical practices and the digitalization of the agricultural system in Pakistan, the study will benefit the Pakistani agricultural sector and help evaluate the role of ethical practices in digital agriculture on a global scale. Henceforth, the study attempts to recognize the gap and discourse in the arena of ethical practices in the agriculture sector by displaying how ethical practices increase agricultural technology development. The methodological contribution contains the usage of a mediation approach that will show how user behavior mediates the association between ethical practices and agricultural technology development.

The next sections make up the remainder of the research. The second step is to generate reviews and hypotheses from the acceptable literature. The third section discusses research methodologies. The fourth section goes with the study findings and discussion. In addition, section five contains a conclusion, limitations of the study, and future research directions.

2 Hypotheses development and research framework

Ethics theory is a theory or system that deals with human behavior values, such as the rightness and wrongness of specific activities, as well as the goodness and badness of the motives and ends of those actions (Frederiksen and Nielsen, 2013). Agricultural technology is becoming increasingly important, and development in technology has increased the scale, speed, and productivity of agricultural equipment, resulting in land more efficient cultivation. Seed, irrigation, and fertilizers have also considerably improved, assisting farmers in increasing harvests (Lopez, 2014). Ethical practices support the development of agricultural technology by dealing with the responsibility of actions in a professional manner while confirming the ethics theory (Madden and Thompson, 1987; Mahroof et al., 2021). Moreover, the ethical practices of agriculture departments also influence and motivate the users with the facilitation of the preeminent opportunities and services in digital technology (Kijsanayotin et al., 2009).

Farm management chores and upstream supply chain interactions are informed by gathered data, improved by setting and condition awareness, and triggered by real-time occurrences in the digital farming strategy (Wolfert et al., 2017). These data are collected using a variety of sensors to monitor animals, soil, water, and plants. The information is used to evaluate the past and forecasts the future to make more fast and more accurate decisions on the farm and in the supply chain, where the collection of data from various farms enables the so-called big data analysis (Carbonell, 2016). Policymakers and researchers are progressively moving to smart farming as a technological solution to address social issues related to agriculture, such as provenance and food traceability (Dawkins, 2016), animal welfare in livestock industries (Yeates, 2017), and the environmental impact of various farming practices (Busse et al., 2015). Most of the literature on digital farming focuses on its potential to improve agricultural practices and productivity (Rutten et al., 2013), although some researchers have looked at the socio-ethical consequences (Driessen and Heutinck, 2015; Carbonell, 2016). At the farm, the wider agricultural community, and society levels, these socio-ethical difficulties in digital farming have been recognized by Bos and Munnichs (2016). The practice of farming will be transformed by smart farming, with less 'hands-on management and a more data-driven approach (Eastwood et al., 2012). Different abilities and skills will be required across the agricultural team to apply and adapt smart farming technologies (Higgins et al., 2017), as well as customized advisory structures, potentially leading to displaced farm personnel and service suppliers. Therefore, all suppliers and agricultural departments, and institutions that are responsible for sharing knowledge about farming technology with farmers and agripreneurs, must deal with the responsibility of actions in a professional and qualified manner. Furthermore, the ethical practices of concerned departments or institutions affect the user behavior towards the adoption and use of digital agriculture.

The agricultural technology system in Pakistan as an underdeveloped country is still in the developing stage as compared to developed regions like the USA, Finland, and Europe (Bilsborrow, 1987; Lewandowski et al., 2003). Likewise, developed countries like (European Union, Canada, and the USA) acknowledged the significance of responsible ethical practices in the digitalization (Francer et al., 2014) and mostly took great initiatives to stimulate and opt for ethical practices in the agricultural technology (Madden and Thompson, 1987; Mahroof et al., 2021). Nevertheless, a developing country such as Pakistan is still in the early stage of development (Khan et al., 2020; Ikram et al., 2021). In addition, the implementation of ethical practices in the agricultural technology system in Pakistan is still weak. The behavior of users when using technologies has been generally addressed in the existing literature (Hsiao, 2018). The more innovations that are introduced, the more study is required to understand how users adopt and engage with them. This study also focused on testing user behavior towards ethical practices of agricultural departments and the adoption of farming technology. User behavior as it relates to data acquired from device users when they utilize the device's services (Keith et al., 2013). To describe user behavior, two basic theories were employed extensively; the Theory of Reasoned Action (Madden et al., 1992) and the Theory of Planned Behavior (Ajzen, 1991).

To manage land, livestock, and farm personnel more efficiently, digital technology is becoming very crucial. Agricultural specialties and organizations that are responsible for loan providing and knowledge sharing about farming technology to cultivators and agripreneurs need to deal with the responsibility of actions professionally. Farmers and agripreneurs (users) can be motivated to learn if the personnel in these departments are loyal and honest in their duties and perform respectfully. Alternatively, their attitude toward using farming technology will be positive, and they will be interested in learning how to use farming technology, resulting in increased agricultural technology development.

The following hypotheses are proposed based on the literature:

H1: The development of the agricultural technology system was positively influenced by ethical practices.

H2: Ethical Practices have a significant and positive effect on user behavior.

H3: User behavior has a positive effect on the development of agricultural technologies.

2.1 Equifinality hypothesis

Equifinality is the concept that a particular end state can be attained in a variety of possible ways. Hans Driesch invented the term and notion, which was eventually adopted by Ludwig von Bertalanffy (Drack, 2015). In this study, the focus is on achieving enhanced agricultural technology development, and the study expects to achieve this result through a diverse arrangement of ethical practices and user behavior. The hypothesized relations propose a causative chain leading from ethical practices and user behavior to agricultural technology development. Research also shows that both the digital agricultural development (Dahlberg, 1988) and ethical practices are complex concepts (de Rooij et al., 2010). Hence, the relationship between ethical practices and user behavior, which leads to improved agricultural technology development, cannot be straightforward as recognized in the majority of ethical practices literature. This recommends that the presence of multifaceted

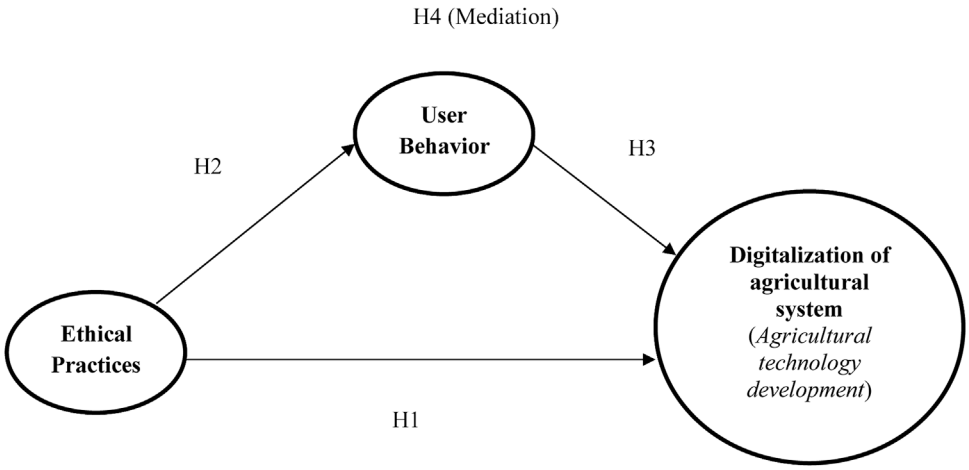

FIGURE 1
Conceptual framework.

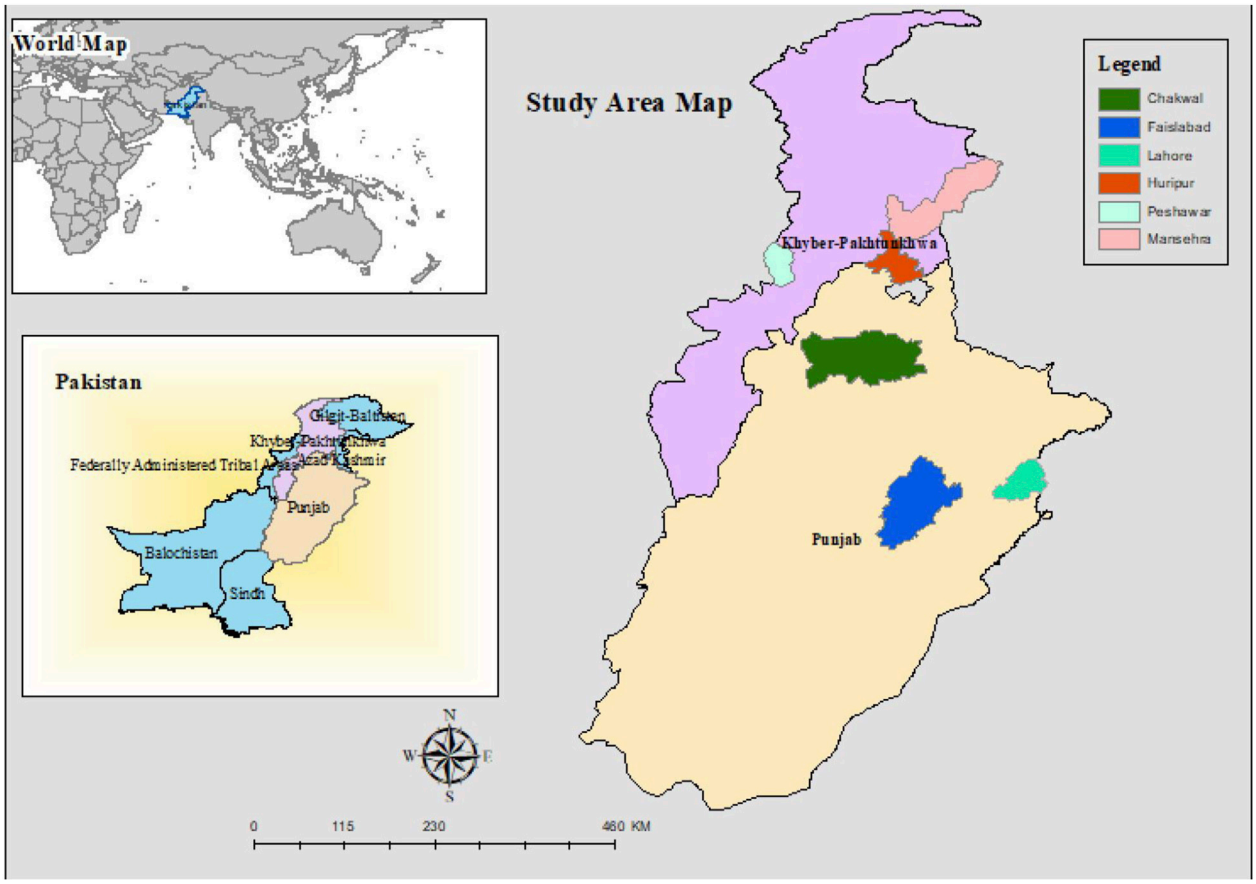

FIGURE 2
Map of the study area (ArcGIS 10.7).

configurations of ethical practices and user behavior are related to agricultural technology development. In keeping with this view, this study assumes the following hypothesis:

H4: User behavior mediates the relationship between "ethical practices" and "agricultural technology development" (Figure 1).

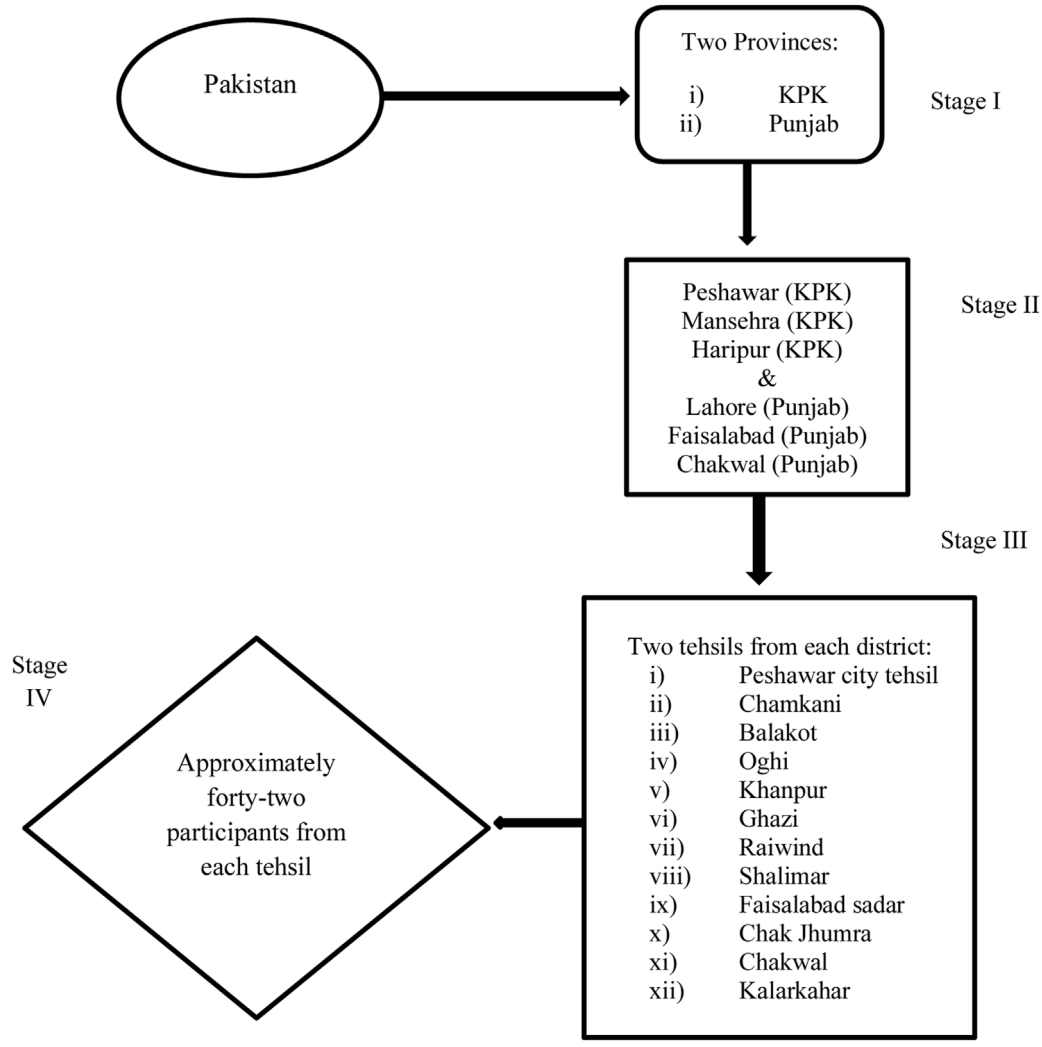

FIGURE 3
Stages of sampling to select sample.

3 Methods of the study

3.1 Study site, population sample, and data collection

This study is carried out in two provinces of Pakistan, namely the Khyber Pakhtunkhwa (abbreviated as KPK) province and Punjab. We have selected three districts from each province, namely Peshawar, Mansehra, and Haripur from KPK and Lahore, Faisalabad, and Chakwal from Punjab which is shown in Figure 2. The sample universe includes farmers, agripreneurs/agri-businesspersons/agri-entrepreneurs, and the residents of the study area who were directly and keenly involved in the agriculture sector and are users of digital technology. A multi-stage stratified random sampling technique (Figure 3) was used to choose settings for the study (Manzoor et al., 2021). In the first phase, the choice of the study area is two provinces of Pakistan; in the second stage, three districts of each province, because these districts have many residents and departments working in the agricultural sector. In the third stage, two tehsils are randomly chosen from each district. Tehsil is a name used to explain the administrative divisions of a district (Manzoor et al., 2021). In the fourth and last stage, approximately forty-two participants were randomly selected from each Tehsil.

To achieve the study objective, data has been collected through the questionnaire survey method from the users of the digital agricultural technologies of Pakistan. The study participants are users of digital farming technologies such as farmers, Agri-preneurs, agri-businesspeople, agri-entrepreneurs, etc., and all others who work in the agriculture sector and users of agricultural technology. We first prepared the questionnaire in the English language and then translated it into Urdu with the help of multilingual specialists to confirm content quality and clarity. With the help of a senior researcher, we identified and distributed the questionnaire to those interested in contributing to the study. All respondents were requested to self-administer their answers fairly and then return them to the person in charge. A total of 500 questionnaires have been distributed to the target population from June 2021 to October 2021 (the selection of participants was according to Figure 3). Total 490 responses were received out of 500 disseminated questionnaires, resulting in a 98 percent response rate. The remaining questionnaires that were fragmented or inaccurate were discarded.

3.2 Measurement of variables and explanations

Three main variables are used in this study, i.e., ethical practices, user behavior, and agricultural technology development. In the study, the explanatory variable is ethical practices that are based on agricultural department's and institutions' responsibilities towards the upgrade of all workers related to agricultural digital technologies. Such as all agricultural departments and institutions' current policies and practices for those who are recently working for the modification of agricultural workers regarding the usage and provision of digital technologies in the agriculture sector. In this study, we tested knowledge-sharing methods, fairness in providing loans, respect for others, honesty, loyalty in professionalism, responsibility of actions, and accountability of agricultural departments, and institutions (as a proxy for ethical practices). The proposed study referred to the existing research and picked 16 measurement items. However, the phrasing of the items was slightly changed to accommodate them in a study setting (Holton et al., 2009). The ethical practices variable is measured by five items scale. Moreover, the structure of the concept of ethical practice is allied with the instruction of Hood (2003) and Ladany et al. (1999). Example questions for ethical practices are "all agricultural departments are dedicated to their work and do their best to provide us services such as knowledge sharing about the adoption/use of digital technology respectfully" and "I am truly satisfied with agricultural institutes' equitable loan distribution".

User behavior is used as a mediator construct in this study. A mediator is a way for a predictor variable to influence an outcome variable. It is part of the causal pathway of an effect, and it explains how or why an effect occurs. A mediator is something that is caused by the predictor variables. It affects the dependent variable (MacKinnon, 2012). Users in our study are all those persons who are currently using digital farming technologies, and we tested their behavior to ethical practices (such as knowledge-sharing methods, fairness in providing loans, respect for others, honesty, loyalty in professionalism, responsibility, and accountability of agricultural departments, institutions, and the government). The items of user behavior have been adopted from the study of Nusairat et al. (2021), with four items measured on a scale. Sample elements for 'user behavior' are 'I am pleased with the assistance of the agricultural department in the use of farming technology and 'Agricultural institution personnel are loyal, honest, and competent in knowledge sharing about the use of farming technology.

Likewise, in the present study, we measure 'agricultural technology development' as a predicted variable which is measured through a proxy of digital technology provision, as well as awareness of the use of that technology, and the example question is 'I have used and knowledge of all sophisticated technologies such as robots, temperature and moisture sensors, aerial images, and GPS technology. Six items scale measured agricultural technology development. Furthermore, the survey questionnaire used a five-point Likert scale with "1" denoting "strongly disagree" and "5" denoting "strongly agree." Appendix A contains items of the variables (questionnaires).

3.3 Data analytic strategy

The main uses of regression analysis are forecasting and finding the cause-and-effect relationship between variables. The regression model was used for quantitative analysis to investigate the empirical relationship between two variables and the hypothesis testing (Manzoor et al., 2019a; Manzoor et al., 2019b). The mediation approach is an extension of the regression model (Preacher and Hayes, 2004). In this study, the data were evaluated by using the conceptual and statistical recommendations of Baron and Kenny (1986) and Holmbeck (1997) for determining the presence of a mediator effect. Baron and Kenny (1986) 's four-step mediation approach has been employed for analyses in which regression analyses are used and the significance of coefficients is estimated (Baron and Kenny, 1986). An ANOVA delivers a limited test of a mediational hypothesis as extensively discussed in Fiske et al. (1982). Rather, as recommended by Judd and Kenny (1981), a series of regression models should be measured. The three regression equations below should be assessed to test for mediation. First, the agricultural technology development measure was regressed on the ethical practice measure to see if there was a mediating impact (Path C in Figure 4A).

The regression model can be expressed as:

$$Y_i = \beta_0 + \beta_i X_i + \cdots + \varepsilon$$

where Y_i = dependent variable, X_i = independent variable, ß$_0$ = intercept, ßi = coefficient to be estimated, and e = error term.

The proposed modified regression model is represented by the following equation, which is the regression line for evaluating the effect of ethical practices on agricultural technology development:

$$Agtd = a_0 + a_1 EP + a_2 Edu + a_3 Gd + a_4 Ag + e \quad (1)$$

Where Agtd is a predicted or explained variable which refers to Agricultural technology development; and EP is an independent or explanatory variable that denotes ethical practices. Education (Edu), Gander (Gd), and Age (Ag) are control variables. According to Baron and Kenny (1986), if the measured coefficient α_1 is significantly positive or if there is an association between the underlying variables, then the following test would be continued.

Second, the measure of user behavior was regressed on the measure of the ethical practice to create Path a (see Figure 4B) in the mediational chain. To accomplish this purpose, simple regression analysis was employed, with the mediator predicting the outcome, and the following regression line was created:

$$UB = a_0 + a_1 EP + a_2 Edu + a_3 Gd + a_4 Ag + e \quad (2)$$

Here, UB denotes user behavior. It is simply a mediator or the intermediary variable. It is also a predictor variable here. Ethical practices (EP) are an independent or explanatory variable; others are control variables. If the assessed coefficient α_1 is significantly positive, demonstrating that the independent variable accurately predicts the predicted variable, then the next step would be expected.

In the third equation, the agricultural technology development measure was regressed in both ethical practices and user behavior measures. This allowed for a test of whether user behavior was linked to agricultural technology development (Path b) and an estimation of the relationship between the ethical practices and the agricultural technology development controlling for user behavior (Path c').

The user behavior was then tested as an intermediary variable using regression analysis. Mediation analysis has been performed to determine whether UB mediates between EP and Agtd or not. The

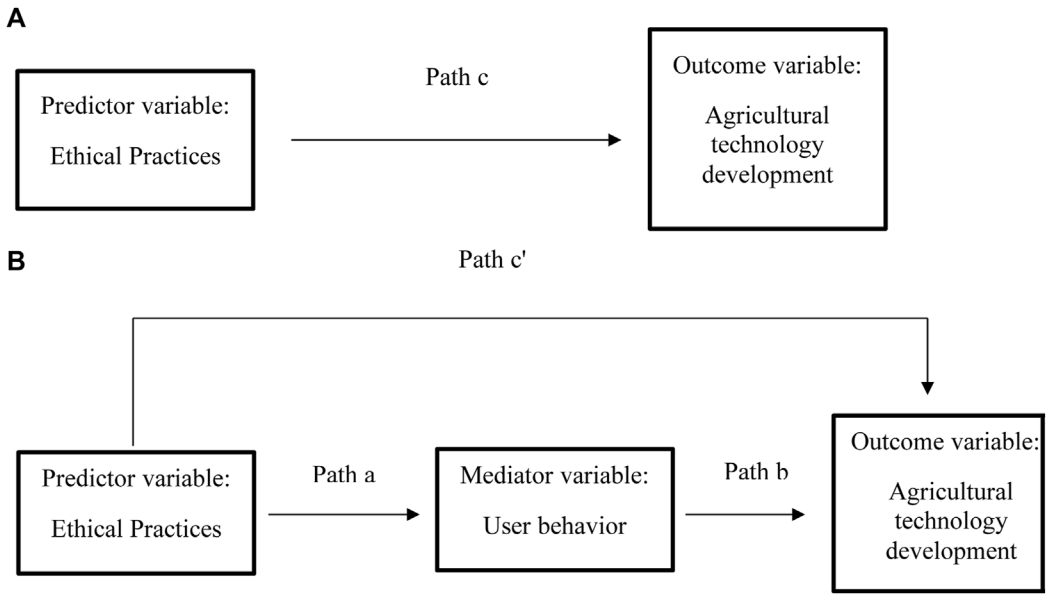

FIGURE 4
Diagrams of paths in the hypothesized mediational model.

development of agricultural technology (outcome variable), ethical practices (explanatory variable), and user behavior (intermediary or mediator variable) are all included in the model to create a new equation.

$$Agtd = a_0 + a_1EP + a_2UB + a_3Edu + a_4Gd + a_5Ag + e \quad (3)$$

In models 1 through 3, α_0 is a constant term, α_1, α_2 are the coefficients to be tested and ε is the error term. Control variables are used to improve a study's internal validity by minimizing the incidence of confounding and other extraneous variables (Christ, 2007). According to Baron and Kenny (1986) separate coefficients for each equation should be computed. There is no requirement to perform hierarchical or stepwise regression, or partial or semi-partial correlations. These three regression equations provide the assessments of the link of the mediational model.

4 Empirical results and discussion

A total 490 people (394 males, 96 females) from two provinces of Pakistan participated in the study. The highest age range of the respondents was 40–49 (34.1%). Most of the respondents (254: 51.8%) were from the KPK province and the rest (236: 48.2%) were from the Punjab province. Most of them (171: 34.9%) have higher secondary school certificates; others (169: 34.5%) were secondary school certificates holders; a few of them (42: 8.6%) were above higher secondary school certificates holders; remaining participants (108: 22%) were had Primary education and were illiterate. Most of the nature/type of participants (217: 44.3%) were farmers; agripreneurs/agribusinessmen/Agri entrepreneurs (187: 38.2%); and the rest of them (86: 17.5%) were other professionals working in the agriculture sector and were users of digital technology in the study area. The demographic information of the respondents was presented in Table 1.

TABLE 1 Demographic figures for participants.

Category	Frequency	Percentage
Gender		
Male	394	80.4
Female	96	19.6
Region		
KPK Province	254	51.8
Punjab Province	236	48.2
Age		
Below 29 years	56	11.4
30–39	91	18.6
40–49	167	34.1
50–59	128	26.1
60 above	48	9.8
Education		
Illiterate/Primary	108	22.0
Secondary school	169	34.5
Higher secondary school	171	34.9
Above higher secondary	42	8.6
Type		
Farmers	217	44.3
Agripreneurs/agribusinessmen/agri-entrepreneur	187	38.2
Other	86	17.5

TABLE 2 Means, standard deviations, reliability estimates, and correlations for study variables.

Variables	Mean	Std. Div	α	1	2	3
1. Ethical Practices	3.340	1.084	0.91	—	0.233**	0.167**
2. User behavior	3.381	1.054	0.85	—	—	0.128**
3. Agricultural technology development	3.245	1.190	0.94	—	—	—

**$p < 0.01$, and Cronbach's coefficient α.

TABLE 3 Testing for User behavior as a mediator using multiple regression.

Steps in testing for mediation	Estimated coefficient (T-values)	B	SE B	95% CI	R-square
Model 1) Testing step 1 (Path c) Outcome: Agricultural technology development Predictor: ethical practices Control: other variables	0.125** (2.792)	0.135	0.048	0.040, 0.230	0.025
Model 2) Testing step 2 (Path a) Outcome: User behavior Predictor: ethical practices Control: other variables	0.226** (5.226)	0.205	0.039	0.128, 0.282	0.311
Model 3) Testing step 3 (Path b and c') Outcome: Agricultural technology development Mediator: User behavior (Part b) Predictor: ethical practices Control: other variables	0.145** (3.103) 0.093* (2.024)	0.173 0.100	0.056 0.049	0.063, 0.282 0.003, 0.197	0.044

Note. CI, confidence interval. *$p < 0.05$; **$p < 0.01$.

All the current study variables' means, standard deviations, reliability evaluations, and intercorrelations are listed in Table 2. Ethical practices significantly correlated with both user behavior and agricultural technology development in the expected direction: ethical practices were positively associated with both user behavior (r = 0.233, $p < 0.01$) and agricultural technology development (r = 0.167, $p < 0.01$). User behavior is also positively connected with agricultural technology development (r = 0.128, $p < 0.01$) as expected. The results of the correlation matrix were consistent with those of the previous study (Manzoor et al., 2021; Manzoor et al., 2022). Multicollinearity was generally low and did not pose a serious problem.

Table 3 comprises the analyses essential to investigate the mediational hypothesis. Following the steps defined before for estimating mediation, first, we confirmed that the predictor (ethical practices) is linked to the predicted variable (agricultural technology development) by regressing agricultural technology development on ethical practices (Step 1). Ethical practices were significantly associated with the development of agricultural technology (H1: B = 0.135, estimated coefficient = 0.125, $p < 0.01$), path c was significant and the mediation requirement in Step 1 was met. This finding suggests that ethical practices influence the development of agricultural technologies. The coefficient for the variable is positive and significant at the level of 1%. This empirical evidence confirms that the ethical practices of agricultural departments/institutions have a positive effect on farming technology development. This means that farmers, agri-preneurs, and others can easily obtain services and assistance from the agricultural department. These findings are consistent with previous studies by Veisi et al. (2016) and (Driessen and Heutinck, 2015).

Next, to find that ethical practices are linked to the hypothesized mediator (user behavior) we regressed user behavior on ethical practices (Step 2). Ethical practices were also significantly related to user behavior (H2: B = 0.205, estimated coefficient = 0.226, $p < 0.01$), and consequently the condition for Step 2 was met (Path a was significant). These results showed that ethical practices have a positive effect on user behavior. The p-value (<0.01) indicated the significant effect of ethical practices on user behavior which is less than the cutoff point. In other words, ethical practices of agricultural departments/institutions (such as their loyalty to professionalism, honesty, fairness in loan provision, respect for learners, the responsibility of actions, and accountability) increase the positive behavior of users of farming technology, which in turn increases development in the use of agricultural technologies. This could be attributed to the notion that ethical practices of the agricultural institutions and departments advance individual adaptability and individual learning pledges that are expected to improve individual capabilities and further lead to individual contentment and positive user behavior (Hansen, 1996). Adoption of digital technologies and learning and gaining knowledge about the usage of the technologies from the agricultural departments promote optimistic user behavior, which in turn is helpful in the development of digital technologies in the agricultural sector of the country.

Likewise, to examine whether the hypothesized mediator (user behavior) is associated with the predicted (agricultural technology development) we regressed agricultural technology development simultaneously on both ethical practices and user behavior (Step 3). User behavior was significantly linked with agricultural technology development controlling for ethical practices (H3: B = 0.173, coefficient estimated = 0.145, $p < 0.01$). Path b was significant and the requirement for Step 3 was met. This third regression equation also offered an estimation of path c', the relationship between ethical practices and agricultural technology development, controlling for user behavior. We have evidence for complete mediation when path c' is zero. Nevertheless, path c' was still significant (B = 0.100, estimated coefficient = 0.093, $p < 0.05$), though it is less than path c (B = 0.135, estimated coefficient = 0.125, $p < 0.01$), and this proposes partial mediation (H4). Therefore, the outcomes of the present study endorse the significant effect of user behavior on agricultural technology development. The results specify that user behavior significantly and positively affects digital technology development, which

successively increases the productivity of the agricultural sector. These outcomes support the claims put forth by the scholars' (Hong et al., 2006; Liao et al., 2009). User behavior helps people in knowledge-intensive settings in developing a shared understanding and deriving value from knowledge. More specifically, positive user behavior towards the use of digital technology improves internal satisfaction because it is an interest to develop access, share, and use of knowledge, that develops efficiency in carrying out one's tasks, which can be important to improve technology adoption. This demonstrates that ethical practices can help user behavior and thus promote high agricultural technology development.

Equifinality presence, rapidly increasing in the literature (Barrett, 2019), and can be found in our case in the context of ethical practices and user behavior combinations that can lead to development in agricultural technology, which has not yet been measured in the literature. The mediation analysis thus shows that ethical practices considerably contribute to the high productivity in the agricultural sector through digital technology development.

However, the following conditions must be held to find the mediation (Baron and Kenny, 1986): First, the predictor variable must affect the outcome variable in the first equation; secondly, in the second equation the predictor variable must be proven to affect the mediator variable; and third, the mediator must influence the outcome variable in the third equation. If all these criteria hold in the predicted direction, the effect of the predictor variable on the outcome variable in the third equation must be smaller than in the first. Perfect mediation occurs when the independent variable has no influence when the mediator is controlled. These two variables should be connected because the explanatory variable is supposed to cause the mediator. When the independent variable predicts the dependent variable alone, it can have a smaller coefficient than when it predicts the outcome variable with the mediator, but the greater coefficient is not significant and the less one is (Manzoor et al., 2019c; Manzoor et al., 2021). On the other hand, the results are partial mediation, as such present study shows partial mediation. As a result, H4 is proven due to evidence of a partial mediation mechanism.

5 Conclusion, and implications

5.1 Conclusion

The current study observed whether the relations between ethical practices and agricultural technology development could be accounted for by user behavior. In addition, this work demonstrated how to apply multiple regression analyses to assessment for mediation in the study in a step-by-step way. User behavior partially mediated the association between ethical practices and agricultural technology development. Moreover, the results of this study establish a significant influence of ethical practices on agricultural technology development. This shows that ethical practices (knowledge-sharing methods, fairness in providing loans, respect for others, honesty, loyalty in professionalism, responsibility of actions, and accountability of agricultural departments, and institutions) can help in the development of digital technology. Furthermore, the outcomes prove that agricultural technology can improve and be modified through a combination of ethical practices and user behavior.

The study's findings indicate that ethical practices of agricultural institutions and departments in terms of organizing some programs and policies to knowledge sharing, providing loans, and being responsible for actions in the development of digital technology; these initiatives not only can help improve the interest of concerned people, but they can also significantly improve the productivity of agricultural sector in Pakistan. The research suggests that it is vital for the agriculture sector in Pakistan to foster a situation that focused on better practices as it will tend not merely to increase people's interest in agricultural development but will also help the agriculture sector achieve its goal of increased productivity.

5.2 Theoretical and methodological contributions

This study tried to unify the fragmented literature on ethical practices into a holistic approach and build a framework for ethical practice that may enhance user behavior and agricultural technology development. According to theoretical criteria, the interrelationships between ethical practices and user behavior are more intricate than encouraged by literature on agricultural technology development. Henceforth, the study with mediation found that specific combinations of ethical practices and user behavior of the digital technologies trigger higher development in agricultural technology rather than a direct effect of the ethical practices on digitalization in earlier studies. The present study stated that ethical practices and user behavior pave the way for higher development in digital technology. From a methodological perspective, this study's contribution comprises the use of a mediation approach that shows how user behavior mediates the association between ethical practices and agricultural technology development.

5.3 Implications, limitations, and future research directions

Both academics and practitioners will reap the benefit of this investigation. Apart from adding to the limited research on ethical practices and digitalization, the study supports the need to create an environment in the agricultural sector that fosters ethical practices and responsibilities. This would result in improved digital technology development and raise improved agricultural productivity in the country. The study assesses ethical practice in terms of knowledge sharing and knowledge utilization, the responsibility of actions, develop loan provision policies as critical processes that could help the development of agricultural technology to attain improved productivity. The combination of ethical practices with user behavior would further help develop agricultural technology that can ultimately help the agricultural sector attain higher productivity to reduce poverty in the country.

There are certain limitations to the study that should be acknowledged. First, while this study focuses on two provinces in Pakistan, more research should be done in the remaining areas. Second, the present study is from one country's perspective; we recommend that more qualitative research be carried out in other underdeveloped nations to boost the generalizability of the findings. Third, the present study applied survey data gathered from the farmers, agripreneurs, agri-businesspersons, and users of digital technology, for the crosschecking of results future research can be performed over secondary data. Finally, while we considered the

demographics of several participants, it may be claimed that such elements can moderate and mediate the links between ethical practices and the development of digital technology. Hence, we also call for more research into such consequences.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving human participants were reviewed and approved by Ethics Committee of Zhejiang University China. The patients/participants provided their written informed consent to participate in this study.

Author contributions

All authors contributed to the study conception and design. Material preparation, data collection, and analysis were performed by LW, FM, and JC. The first draft of the manuscript Was written by FM and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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APPENDIX A: (Questionnaires)

Ethical Practices.

1. All agricultural departments are dedicated to their work and strive to provide us with the best services possible.
2. Agriculture departments are enthusiastic about sharing techniques and knowledge about the adoption and use of digital technology in a respectful manner.
3. I am truly satisfied with agricultural institutes' equitable loan distribution.
4. The supervisor ensures adequate communication between the (Agriculture department) supervisor and farmers to provide appropriate supervisory backup.
5. There is no favoritism based on racial, ethnic, cultural, sexual orientation or gender issues toward us (farmers), and services are for all.

User Behavior.

1. I am pleased with the agricultural department's assistance in the utilization of farming technology.
2. Personnel at agricultural institutions are loyal, honest, and knowledgeable about how to apply farming technology.
3. I am at ease using the agricultural department's services.
4. After using their services, I feel more confident in my abilities.

Agricultural Technology Development.

1. I am using few farming technologies in my fields.
2. I have knowledge of all sophisticated technologies.
3. The usage of robots, temperature and moisture sensors, aerial images, and GPS technology is common in my area.
4. Online farming services are available in my area.
5. All agricultural technologies contribute to increased productivity.
6. In my area, farming technologies are cost-effective.