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Original research article

Factors affecting the use of climate information services for agriculture: Evidence from Iran

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ABSTRACT

The use of Climate Information Services (CIS) is considered the most important solution for the long-term adaptation of the agricultural sector in dealing with the challenges caused by climate change. While there are examples of successful CIS programs in the agricultural sector of developed countries, there are barriers to successfully using CIS programs for farmers in developing countries. In this regard, this research was carried out with two general objectives: (i) identifying the factors affecting the use of CIS by farmers, and (ii) providing practical policies for applying this information in the agricultural sector of Iran. A comprehensive Technology Acceptance Model (TAM) theory was used as the theoretical framework for this research, and self-efficacy (SE), social norm (SN), and perceived trust (PT) were added as variables. This research was conducted using structural equation modeling (SEM), and a designed questionnaire was used as the data-gathering instrument. The statistical population of this research includes all farmers of Dezful city in Khuzestan province (southwest of Iran). The findings of the research showed that the initial TAM explains 0.537 % of the variance of farmers' behavioral intention in using CIS. The three primary TAM constructs included Attitude, Perceived Usefulness (PU), and Perceived Ease of Use (PEOU), all of which had positive effects on farmers' willingness. Most importantly, by including SE, SN, and PT variables, the developed TAM can increase the model's ability to predict farmers' intentions by 13.5 %.

Practical implications

Today, it is an obvious fact that climate changes are an integral part of the economic and social systems of human societies. Climate changes, if not properly managed, can have destructive effects on people's livelihoods. Therefore, using strategies and solutions to deal with climate change phenomena is an undeniable necessity. In Iran, crisis management strategies are used to deal with the negative impacts of climate change (Savari et al., 2022). However, many studies show that crisis management has lost its effectiveness in dealing with the effects of climate change, and it is necessary to use risk management strategies instead of crisis management (Tran et al., 2021). In the risk management approach, farmers are aware of the occurrence time of the phenomenon, and they are also aware of the solutions to deal with it before it happens. Eventually, they can minimize its destructive effects. In this regard, the use of CIS as one of the most substantial risk management strategies can help reduce the effects of climate change in the agricultural sector. In developing countries, especially in Iran, using meteorological information is not easily accepted by farmers and faces many challenges. In this regard, this research was conducted with two general objectives: (1) understanding why farmers don't apply CIS, and (2) providing practical policies for planners and policymakers in this field.

The results showed that (1) many Iranian farmers do not have the proper self-efficacy to use climatic information. Therefore, policymakers in this field should organize related training courses and workshops for farmers to make them aware of the usefulness of this information. In addition, meteorological information providers should not only provide information but also provide suitable agricultural recommendations. (2) Many farmers do not trust the content of CIS and weather information providers. In this regard, it is suggested that policymakers provide accurate forecasts by developing meteorological stations so that farmers can trust them. (3) Another factor affecting the acceptance of CIS by farmers is social norms. In other words, it is suggested to spread

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meteorological information and agricultural recommendations by people who have high social influence among the farmers so that it becomes a stable social norm in the long run. Consequently, all farmers will apply this information."

Data availability

No data was used for the research described in the article.

1. Introduction

Climate science studies show that the climate is changing rapidly (Intergovernmental Panel on Climate Change (IPCC), 2018; Meinshausen et al., 2022; Savari and Khaleghi, 2023). Extreme climate events are recognized as the main environmental threats facing the global economy at different scales (IPCC, 2022a; UNDRR, 2020; WMO, 2020). Globally, there is increasing evidence that climate change is one of the greatest challenges to sustainable development of agriculture and food systems (Faye et al., 2018; IPCC, 2014; Luedeling et al., 2016), food security and nutrition (Bradbear and Friel, 2013; Collier and Dercon, 2014; Nagoda and Nightingale, 2017). Changes in precipitation patterns and rising temperatures may adversely affect climate-sensitive sectors such as agriculture (Dube et al., 2016, Barati et al., 2023). Unfavorable climate conditions and lack of water, have led to the closure of farms and displacement of farmers, especially in countries with large villages such as India, Bangladesh, and China. Ultimately, these countries experienced a decline in agricultural production (Ahmad et al., 2011; Sikder and Xiaoying, 2014). The decline in agricultural production in these Asian countries had a major impact on global food security because the Asian market produces only approximately two-thirds of the global food supply (Warner et al., 2022). In addition, the literature shows that Approximately 33 % of global agricultural systems are affected by climate change (Ray et al., 2015; Warner et al., 2022). Some of the most significant negative impacts of climate change on rural and agricultural communities in Iran include food insecurity (Savari et al., 2023a), reduced cultivated area (Sadeghi et al., 2020), increased dust phenomenon (Savari et al., 2022), housing destruction (Valizadeh et al., 2021), migration from rural to urban societies (Sabzali Parikhani et al., 2018), decline in the economic situation of rural households (Savari et al., 2023b) and poverty (Savari et al., 2023c). Climate change is having a more severe impact on farmers in general, and small-scale farmers in particular; especially those dependent on rain-fed agriculture for their livelihoods (Abbam et al., 2018; Chepkoech et al., 2020; Owusu et al., 2021). CIS facilitates farmers' adaptation decisions to climate conditions and increases their preparedness against shocks (IPCC, 2022a; IPCC, 2022b; United Nations, 2022). Therefore, the use of CIS has become an important topic in the policymaking of production risk management and resilient agriculture (UNFCCC, 2020; IPCC, 2018; IPCC, 2012; Kiem and Verdon-Kidd, 2011).

Reducing the vulnerability and improving the resilience of farmers against climate change requires the availability and effective use of practical climate information and, in particular, meteorological forecasts (Wamalwa et al., 2016; Mase and Prokopy, 2014). Climate information is a collection of data, methods, and instruments (Singh et al., 2018), and refers to short-term climate forecasts through seasonal forecasts, and also long-term information on climate changes in different decades (Nkiaka et al., 2019; Singh et al., 2018). However, the provision of information and its usage by farmers faces various obstacles and problems that limit its effectiveness. Therefore, for effective adaptation by farmers, it is important to assess key factors that restrict the assimilation of climate information (Antwi-Agyei et al., 2021; Antwi-Agyei et al., 2020; Vincent et al., 2017; Nkiaka et al., 2019; Singh et al., 2018; Antwi-Agyei et al., 2021).

In this context, various psychological theories and methods have been used to understand decision-making and perceptions in the CIS domain (Artikov et al., 2006). These theories determine the basis of behavior and show how behavior can be successfully modified (Savari et al., 2023b). In this regard, the Technology Acceptance Model (TAM) was used in this research because it is known as the most important and fundamental basis of technology acceptance (Rho et al., 2014; Kamal et al., 2020), and also the most widely used model in various research methods in the fields of sociology, psychology, and agriculture (Cacciamani et al., 2018; Gokcearslan, 2017; Ifenthaler and Schweinbenz, 2016; Kim and Jang, 2015; Sharifzadeh et al., 2017; Bagheri et al., 2021; Rezaei et al., 2019). Therefore, this study used a technology acceptance model to investigate the factors that influence farmers' willingness to use CIS.

2. Theoretical framework

The technology acceptance model is a model for predicting the acceptance level of a new technology by beneficiaries (Putri et al., 2023). TAM was introduced by Davis (1989), and then widely used in many studies. TAM itself is an adaptation of a theory developed by Fishbein, the Theory of Reasoned Action (TRA). TRA is based on an assumption that a person's reaction and perception about something, determines that person's attitude and behavior. The TAM added two major components to the TRA (Peng and Xu, 2023). Davis (1989) suggested that the usage attitude influences behavioral intentions, and this attitude is primarily determined by two constructs: perceived usefulness (PU) and perceived ease of use (PEOU). Therefore, Davis (1989) eliminated the subjective norm from the TRA model to develop the TAM model. Basically, PU and PEOU in TAM are important factors in adopting new behavior (Aung and San, 2021; Chen and Aklikokou, 2020). Meanwhile, Davis also argued that PU and PEOU are influenced by other external variables (Davis, 1989). Therefore, many studies have shown that TAM will have better explanatory power for continuous use intention if extended to exogenous variables (Lim and Zhang, 2022; Wu and Chen, 2017). Studies conducted with TAM showed that stakeholders' continuous intention to use is influenced by PU and PEOU (Savari et al., 2021). High PEOU relatively affects PU, which in turn affects the intention to a continuous use, and leads to the actual adoption of the new behavior (Dai et al., 2020; Hao et al., 2017). TAM proposed by Davis (1989) has been widely used in many studies on the adoption of new technologies among farmers to explain actual behaviors. Therefore, the main components of the TAM model include PEOU, PU, attitude towards use, and behavioral intention (Mohr and Kühl, 2021). PEOU refers to an individual's level of belief about the difficulty of using an innovation or the complexity of its use (Zhong et al., 2019). In other words, PEOU is the degree to which a user expects the system to be effortless to use (Ullah et al., 2021). PU indicates that a person believes that using a particular system will improve performance (Kim et al., 2008). In fact, perceived usefulness is the degree to which a person believes that using a certain system will improve his work performance in the organization (Savari et al., 2021). Attitudes toward a behavior indicate the context in which a person evaluates the behavior positively or negatively (Liu and Bridget, 2020; Ullah et al., 2021), and intention variables are highly predictive of real-world environmental behavior (Empidi and Emang, 2021; Marcos et al., 2021). Intention reflects the motivation or plan to engage in an action (Sánchez et al., 2018; Zhong et al., 2019) and also reflects the level of motivation, readiness, and willingness of a person to adopt a behavior (Eldredge et al., 2016). Finally, the four main hypotheses of this theory are presented as follows:

H1: Farmers' attitude towards CIS affects their intention to use it.
H2: Perceived usefulness of farmers about CIS affects their attitude.
H3: Perceived ease of use of farmers about CIS affects their attitude.
H4: Perceived ease of use of farmers about CIS affects their perceived usefulness.

2.1. Extended TAM

Despite the empirical validity and potency of the original TAM as an effective and powerful predictor for understanding and defining diverse behaviors (Kamal et al., 2020), Davis (1989) himself as the founder of this theory, developed the path of this theory. He believed that adding an external variable would keep the model open-ended, and adding different predictor variables for different subjects would increase the explanatory power of this model. In doing so, various studies also showed that TAM needs to add additional variables to improve its ability (Szajna, 1996; Wu and Wang, 2005; Kamal et al., 2020; Ly and Ly, 2022). These studies showed that adding variables of self-efficacy, subjective norm and trust in climate information are important and effective factors in farmers' behavioral intention to use CIS (Roudier et al., 2014; Parsi and Maleksaeidi, 2021; Abbasi et al., 2011; Park et al., 2014; Sarcheshmeh et al., 2018; Antwi-Agyei et al., 2021; Falloon et al., 2018; Haigh et al., 2015; Muema et al., 2018).

2.1.1. Self-efficacy

Various studies have shown that self-efficacy is an important variable in predicting behavior because the successful performance of a behavior does not depend only on a person's knowledge, but it also depends on personal beliefs about ability to complete the task (Bandura, 1977). A review of various studies has shown that self-efficacy is the first common external construct in TAM studies (Abdullah and Ward, 2016; Rezaei et al., 2019). In this regard, past studies have emphasized the key role of self-efficacy on people's perceived ease of using technology (Park, 2009; Chowet al., 2012; Park et al., 2014; Fathema et al., 2015; Al-Gahtani, 2016; Savari et al., 2021) because people's confidence in their skills and abilities can affect their judgments about the ease or difficulty of doing a certain task or using technology (Purnomo and Lee, 2013). Several other studies have shown a correlation between self-efficacy and perceived usefulness (Venkatesh and Davis, 1996; Wu et al., 2007; Park, 2009; Chow et al., 2012; Fathema et al., 2015; Ly and Ly, 2022). Therefore, self-efficacy plays a key role in interpreting and understanding climate and meteorological forecasts and provides sufficient motivation to use this information (Artikov et al., 2006; Hu et al., 2006; Parsi and Maleksaeidi, 2021). Therefore, farmers' access to appropriate CIS and the ability to use this information is essential for farmers as farm managers (Roudier et al., 2014). In this regard, the hypothesis of this section is presented as follows:

H5: Self-efficacy has a positive and significant effect on the perceived usefulness of climate information.
H6: Self-efficacy has a positive and significant effect on perceived ease of climate information.

2.1.2. Social norms

There is an opinion that social pressure can have effects on doing or not doing a certain behavior (Ashraf, 2018). This term refers to the social influences of people such as family members, friends, neighbors, and colleagues (Savari et al., 2023a). When people expect others to approve or disapprove of their actions, this influences people's willingness to perform certain actions (La Barbera and Ajzen, 2020). Several empirical studies showed a positive correlation between social norms and people's behavioral tendencies (Ashraf, 2019; Ashraf et al., 2010, 2019; George, 2004; Savari et al., 2023a; Parsi and Maleksaeidi, 2021). Therefore, social norms have always played a fundamental role in people's decision-making (Rezaei et al., 2019). In addition, various studies have pointed out the impact of social norms on perceived usefulness (Park, 2009; Teo, 2010; Abbasi et al., 2011; Park et al., 2014; Sarcheshmeh et al., 2018) and They found that when a behavior is socially approved, it affects the perception of its usefulness by other people (Rezaei et al., 2019). Moreover, in developing countries, people often live in joint family systems and are dependent on each other in many social and economic contexts. Thus, using a new technology or adopting a new behavior is not only visible to everyone, but the opinion of these people can affect the behavior of users to use a new technology (Kamal et al., 2020). In doing so, if a person believes that using climate information services is a desirable social behavior, the majority of people will approve it, and will use this information (Parsi and Maleksaeidi, 2021). In this regard, the hypothesis of this section is presented as follows:

H7: Social norms have a positive and significant effect on the perceived usefulness of climate information.
H8: Social norms have a positive and significant effect on farmers' willingness to use climate information.

2.1.3. Perceived trust (PT)

One of the most important variables mentioned in most studies related to climate information services is related to trust (Antwi-Agyei et al., 2021; Bouroncle et al., 2019; Falloon et al., 2018; Haigh et al., 2015; Muema et al., 2018; Vincent et al., 2017). Reliance on climate information can lead to the perceived usefulness of that information (Warner et al., 2022; Muema et al., 2018). If farmers do not trust the providers of climate information or think that the source of climate information is not reliable, they will not be willing to use this information (Gbangou et al., 2020). Trust in climate information can influence farmers' willingness to participate in climate change programs and listen to expert advice (Antwi-Agyei et al., 2021; Falloon et al., 2018; Haigh et al., 2015; Muema et al., 2018). In this regard, Diouf et al. (2019) in Senegal showed that if they trust climate information, their understanding of the usefulness of this information and their willingness to use it will be strengthened. In this regard, the hypotheses of this section are presented as follows:

H9: Perceived trust has a positive and significant effect on the perceived usefulness of climate information.
H10: Perceived trust has a positive and significant effect on farmers' willingness to use climate information.

3. Materials and methods

3.1. Statistical population and sampling method

The statistical population of the research included all rainfed farmers of Dezful City in Khuzestan province (Fig. 1). Based on Krejcie and Morgan (1970), 390 farmers were selected for the study. Multi-stage proportional stratified sampling method was used for sampling. In this way, at first, based on the classification of the Iran Statistics Center, this city was classified into four sections. In the next step, the sample size was determined based on the cultivated area of each part. Finally, in order to select samples with appropriate distribution, two rural district in each part were selected for study, and from rural district, two villages with the highest cultivated area were selected for study.

3.2. Study area

Khuzestan province is located in the southwestern part of Iran (Fig. 2). Khuzestan province's agricultural sector, with about 16 million tons of production, mainly contributes to Iran's food security and ranks first in some products such as sugarcane and wheat. Dezful is one of the cities of this province. In recent years, due to successive droughts, the amount of water resources has been severely reduced and several villages in this city have been evacuated. The temperature in this city reaches above 50 degrees Celsius, and forecasts indicate an increase in the average temperature in the following years (Masoudi and Elhaeesahar, 2016). The precipitation in this area is about 220 mm, but various parts of these regions are projected to become drier in the coming years as precipitation decreases (Masoudi and Elhaeesahar, 2016). Climate change, especially drought, is already posing significant challenges for farmers in the region. However, no research has been conducted on the

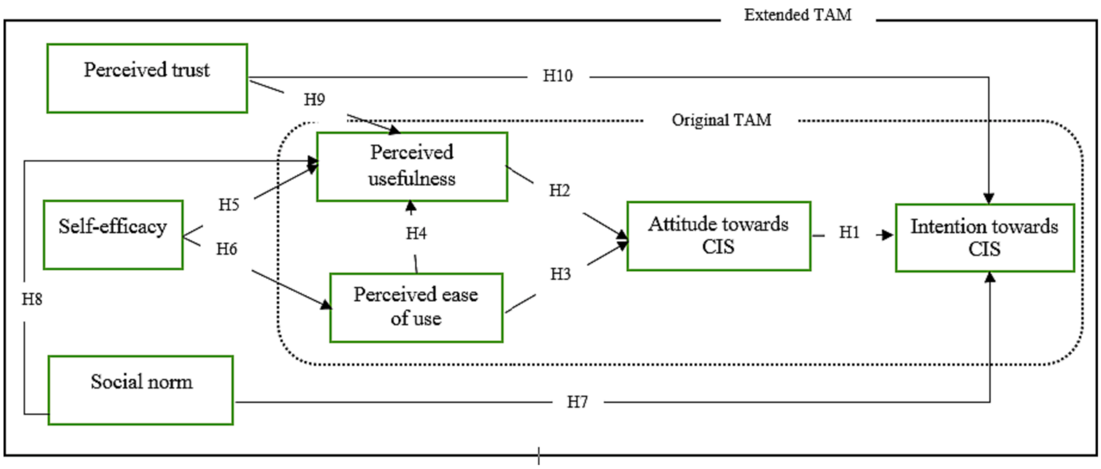

Fig. 1. Theoretical Framework.

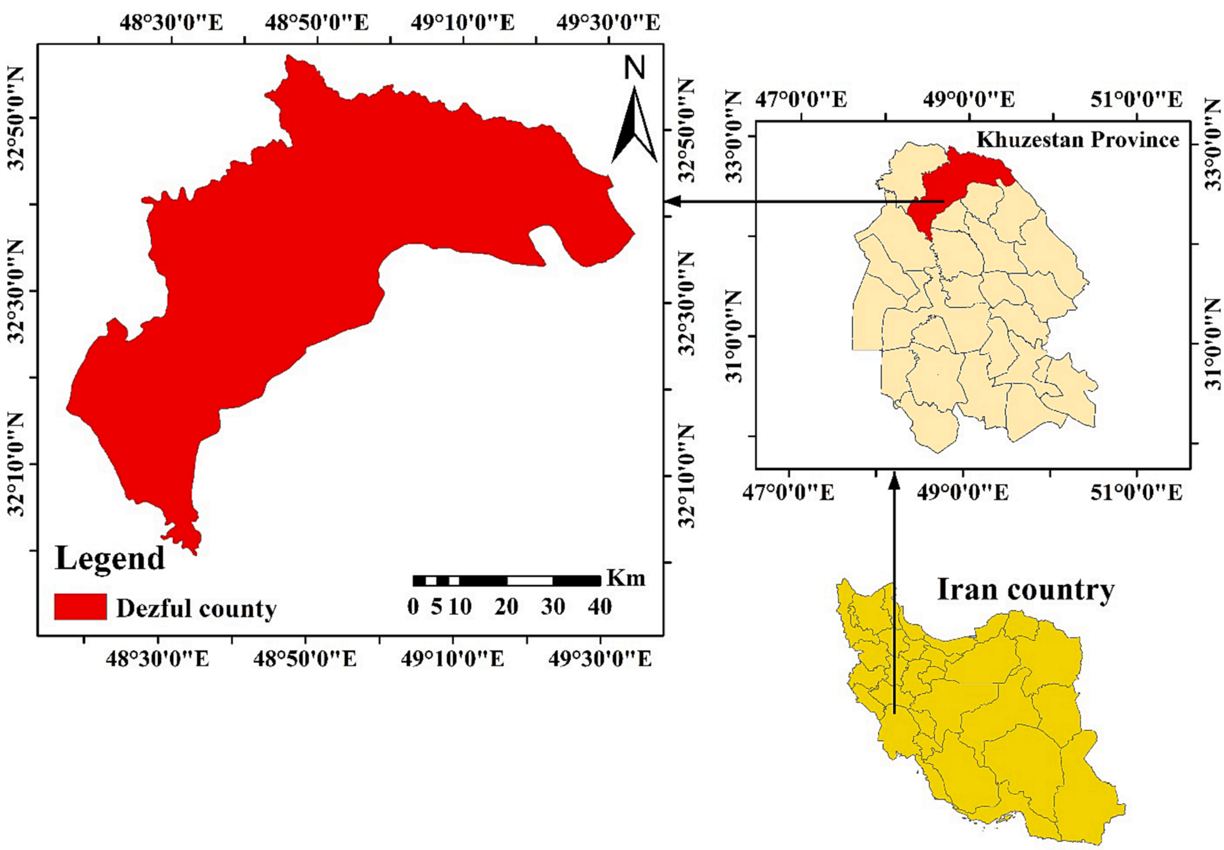

Fig. 2. Study area.

use of climate information in agricultural decision-making, nor farmers' trust and access to climate information in the region.

3.3. Participant

The average age of the respondents was 46.63 with a standard deviation of 16.07 years. The educational status of the respondents showed that nearly one-third of them had elementary education (28.36 percent) and only a small percentage of them (6.52 percent) had university degrees. The amount of cultivated area of agricultural products was 3.42 ha with a standard deviation of 1.14 ha. In addition, the results showed that the average number of family members, and agricultural work experience were 3.55 and 29.85 %, respectively. The results of the survey showed that only 18.52 % participated in training courses about how to use CIS.

3.4. Measurements

The main research tool was a questionnaire that consisted of two general parts. The first part included the individual characteristics and farmers' lands. The second part included 28 items to measure the constructs of the TAM model, which had seven subsections: (i) four items for measuring perceived trust (ii) four items for self-efficacy (iii) five items for social norm (iv) four items for perceived usefulness (v) three items for perceived ease of use (vi) four items for attitude towards CIS (vii), and four items for measuring intention towards CIS. In the next step, the respondents were asked to express their agreement or disagreement with the statements presented to measure the ordinal variables based on the Likert scale (1-very little to 5-very much). Using this statistical range reduces statistical problems (Fornell, 1992). One of the important points of this research was to measure the variables of this research by using previous studies. The items of the questionnaire are presented in Table 1.

Table 1
Research concepts and variables.

Components	Items	Reference
Perceived trust	Providers of climate information are knowledgeable and reliable people. Providing climate information is not up-to-date and cannot be used. I have full trust in CIS. climate forecasts are usually not accurate and reliable	Antwi-Agyei et al., 2021; Bouroncle et al., 2019; Falloon et al., 2018; Haigh et al., 2015; Parsi and Maleksaeidi, 2021
Self-efficacy	I am sure I can use CIS. I have the knowledge and skill to use climate information. I know how to use CIS. If I want, I can easily use CIS during cultivation.	Abdullah and Ward, 2016; Parsi and Maleksaeidi, 2021; Rezaei et al., 2019; Savari et al., 2023e
Social norms	If I use CIS while cultivating, the community will approve my work. The use of climate information during cultivation is a common and accepted matter. All farmers use CIS during cultivation. I feel under social pressure to use CIS in agriculture	Ajzen (2002); Francis et al. (2004); Ashraf, (2018); Rezaei et al., (2020); Savari, (2023)
Perceived usefulness	Climate information services can help me choose the time for planting Using CIS increases my cultivation success. Using CIS reduces production costs. The use of CIS increases the effectiveness of agricultural practices.	Artikov et al., 2006; Hu et al., 2006; Davis (1989);
Perceived ease of use	CIS is easy for me to use. From a technical point of view, CIS can be used easily. For me, how to use CIS is clear and understandable.	Davis (1989); Bagheri et al. (2021); Zhong et al. (2019); Savari et al. (2021)
Attitude towards CIS	It is wise to use CIS when farming. It is important to use CIS when farming It is useful to use CIS when farming It is necessary to use CIS during agriculture.	Ajzen (2002); Peng and Xu, 2023; Savari et al., 2021
Intention towards CIS	I tend to use CIS when during farming practices. I plan to use CIS during cultivation. I plant nothing without CIS. I would like to use CIS in the next cropping season, again.	Ajzen (2002); Ajzen (1991); Francis et al. (2004); Savari et al., 2021

3.5. Validity and reliability of instruments

In order to evaluate the measured indicators in general, the survey draft and questions were reviewed by an expert panel. This expert panel included professors of agricultural extension and education, environmental, psychology, social sciences, and agricultural sciences; and then based on their views, the desired reforms were made until final approval was reached. In addition, to check the reliability of the research tool, Cronbach's alpha and composite reliability coefficients were used, which had an acceptable value (Table 2).

3.6. Data analysis

The data were analyzed after collecting and editing with SPSS and Smart PLS software. The Structural Equation Model (SEM) is a perspective that examines hypothesized patterns of direct and indirect relationships among a set of observed and latent variables. The structural equation model consists of two parts: the structural model (specifies the cause-effect structure between the latent variables) and the measurement model (specifies the relationships between the latent variables and the observed variables) (Khoshmaram et al., 2020). One of the most important reasons for researchers to use SEM is to test the theoretical framework of research (Harrington, 2009) and another advantage is to estimate measurement error (Hoyle, 2012). Smart PLS software is one of the latest methods of analyzing complex and multivariate data structures, whose main feature is the simultaneous analysis of several independent and dependent variables (Harrington, 2009). In addition, in order to provide a description of the status of the studied variables, the ISDM index was used (Gangadharappa et al., 2007):

Low: $A < \text{Mean}- 1/2\text{Sd}$.
Medium: $\text{Mean}- 1/2\text{Sd} < B < \text{Mean} + 1/2$.
High: $C > \text{Mean} + 1/2\text{Sd}$.

4. Results

4.1. Assessing the status of extended TAM variables among respondents

The results of examining the descriptive status of research variables showed that only two variables, social norm and attitude, are above the average (3 theoretical medians) and the rest of the variables are not in a good condition. This result shows that the studied farmers do not have high confidence in CIS. In addition, they have low self-efficacy and understanding of the usefulness of CIS, for this reason, they do not have a high intention in this field (Table 2).

4.2. Measurement models

In this section, Confirmatory Factor Analysis (CFA) was used to check the fitting of two measurement models (initial and developed). The results showed that the investigated models have a suitable fit (Table 3). At this stage, to evaluate the measurement model, the three stages of unidimensionality of indicators, validity, and reliability, and diagnostic validity should be investigated. The results of this section are presented below.

Unidimensionality: According to the results of the confirmatory factor analysis, it can be said that the standardized factor loading (ƛ) of all the selected indicators for the considered constructs was higher than 0.6, and statistically significant at the error level of one percent ($P < 0.01$). These results provided sufficient evidence to confirm the unidimensionality of the selected indicators in each of the measurement models. Therefore, it could be stated that the selected indicators for measuring the research constructs have been chosen correctly.

Validity and reliability: AVE, CR, and α values are also presented in Table 4. According to the fact that the reported values are higher than the recommended values, 0.5, 0.6, and 0.7, respectively; it can be stated

Table 2
Assessing the status of extended TAM variables among respondents.

Variable	Mean	Sd	ISDM Category					
			Low		Medium		High	
			Number	Percent	Number	Percent	Number	Percent
Perceived trust	2.46	0.852	168	43.07	149	38.20	73	18.73
Self-efficacy	2.85	0.752	124	31.79	185	47.43	81	20.78
Social norm	3.05	0.694	102	26.17	173	44.35	115	29.48
Perceived usefulness	2.64	0.748	105	26.92	187	47.94	98	25.14
Perceived ease of use	2.65	0.688	111	28.46	204	52.30	75	19.24
Attitude	3.15	0.804	90	23.09	196	50.25	104	26.66
Intention	2.78	0.729	97	24.88	213	54.61	80	20.51

Table 3
Fitting results of measurement models.

Constructs	Measurement item	Original TPB			Extended TPB		
		ƛ	t	Reliability and Validity statistics	ƛ	t	Reliability and Validity statistics
	Int1	0.822	45.609	AVE: 0.648	0.831	45.179	AVE: 0.648
Intention	Int2	0.815	40.319	CR: 0.880	0.834	49.744	CR: 0.880
	Int3	0.768	33.412	α: 0.819	0.751	32.039	α: 0.819
	Int4	0.813	42.518		0.801	40.011	
Attitude	Att1	0.796	31.158	AVE: 0.659	0.798	32.909	AVE: 0.659
	Att2	0.868	52.571	CR: 0.885	0.867	48.563	CR: 0.885
	Att3	0.808	33.314	α: 0.827	0.806	31.474	α: 0.827
	Att4	0.772	26.468		0.773	22.765	
	PU1	0.763	17.386	AVE: 0.640	0.676	20.586	AVE: 0.640
PU	PU2	0.887	41.367	CR: 0.875	0.892	49.330	CR: 0.840
	PU3	0.892	54.593	α: 0.808	0.886	75.879	α: 0.808
	PU4	0.724	18.037		0.724	20.207	
	PEOU1	0.611	13.719	AVE: 0.623	0.640	16.709	AVE: 0.624
PEOU	PEOU2	0.891	66.001	CR: 0.829	0.884	60.204	CR: 0.830
	PEOU3	0.838	34.502	α: 0.702	0.826	30.579	α: 0.702
	SE1	–	–		0.709	19.872	AVE: 0.622
SE	SE2	–	–		0.826	43.932	CR: 0.868
	SE3	–	–		0.802	35.968	α: 0.796
	SE4	–	–		0.813	40.857	
	PT1	–	–		0.828	46.673	AVE: 0.637
PT	PT2	–	–		0.818	36.631	CR: 0.875
	PT3	–	–		0.762	33.423	α: 0.810
	PT4	–	–		0.783	32.027	
SN	SN1	–	–		0.663	19.327	AVE: 0.526
	SN2	–	–		0.835	47.406	CR: 0.847
	SN3	–	–		0.705	22.699	α: 0.774
	SN4	–	–		0.742	28.170	
	SN5	–	–		0.669	17.840	

Table 4
Correlations with Square Roots of the AVE.

Constructs	1	2	3	4	5	6	7
1- Attitude	0.812[a]						
2- Intention	0.730**	0.805[a]					
3- PEOU	0.604**	0.607**	0.790[a]				
4- PT	0.563**	0.597**	0.526**	0.798[a]			
5- PU	0.329**	0.405**	0.318**	0.392**	0.800[a]		
6- SE	0.398**	0.452**	0.395**	0.214**	0.483**	0.798[a]	
7- SN	0.574**	0.718**	0.602**	0.617**	0.492**	0.482**	0.726[a]

**Correlation is significant at the < 0.01 level.
[a] square roots of AVE estimate.

that all the latent variables (constructs) of the proposed research model had good reliability and validity, Table 3.

Discriminant validity: The results showed that, in general, the average square root of the variance extracted for the research constructs (0.726 < AVE < 0.812) was greater than the correlation between them (0.214 < r < 0.730). This result showed that the diagnostic validity of the constructs in the proposed research model was confirmed (Table 4).

4.3. Measurement and structural model

In order to check the fit of the structural model of the research, the variables of perceived trust, self-efficacy, social norms, perceived usefulness, perceived ease of use, attitude, and intention were used to evaluate the goodness of fit (Table 5). The results indicated that the structural model of the research has a good fit and the data of the research was a suitable support for the theoretical model of the research.

As mentioned before, to test the hypotheses in the form of the

Table 5
Summary of Goodness of Fit Indices for the Measurement Model.

Fit index	SRMR	D-G1	D-G2	NFI	RMS-Theta
Suggested Value	<0.1	>0.05	>0.05	>0.90	≤0.12
Original TAM	0.08	0.352	0.542	0.97	0.08
Extended TAM	0.07	0.402	0.571	0.98	0.07

proposed conceptual model of the research, the method of path analysis (structural model evaluation) was used. The model of the research path is presented by displaying factor loadings and t-values in Figs. 3 and 4; and the summary of the evaluation results of the structural model of the research is presented in Table 5.

Hypothesis testing: At this stage, the results of the final impact of variables on farmers' intention to use CIS are presented in Table 6. Based on the results of the table, it can be said that all research hypotheses in the two primary and developed TAM models have become significant. In addition, it can be said that in the initial model, the variables explained 53.7 % of the variance of the dependent variable (intention to use CIS), but the developed model was able to increase the explanatory power of the model to 13.5 %.

5. Discussion

In this research, a social-psychological model was used to investigate the farmers' willingness to use CIS. In general, this article had two objectives (1) Investigating the power of TAM concerning farmers' behavioral intention and 2) Improving the explanatory power of TAM by identifying important variables such as SE, PT, and SN. The results showed that adding important variables in this field increases the explanatory power of the model significantly (13.5 %). In general, the new modified model was able to explain 67.2 % of the variance of farmers' behavioral intention to use CIS. In other words, the modified model including SE, PT, and SN is a more appropriate model than the original TAM, because the model is built in such a way that with a positive change in each of these three variables, it can have a positive effect on farmers' intention to use CIS.

Based on the results of SEM, the first hypothesis of the research regarding the influence of attitude on farmers' intention to use CIS was confirmed. The results of this section are in line with studies of Parsi and Maleksaeidi (2021); Sarcheshmeh et al. (2018); Antwi-Agyei et al. (2021); Warner et al. (2022). Ajzen and Fishbein (2005) always emphasized in their research that attitude is the key to understanding behavioral intentions. Attitude, in particular, is the first key factor affecting the intention of the individual in the theory of planned behavior (Gao et al., 2017) and plays a major role in directing behavior (Rezaei et al., 2019). A possible explanation for this phenomenon is that attitude affects how people think (Damalas and Koutroubas, 2018; Savari and Khaleghi, 2023b) and how they act (Bondori et al., 2018) because attitude always refers to a positive or negative evaluation of a behavior (Sánchez et al., 2018). Therefore, if farmers have a positive attitude toward the use of CIS, they will use it for their agricultural planning (Warner et al., 2022). One of the important factors influencing farmers' evaluation is having a previous positive experience in this field (Parsi and Maleksaeidi, 2021). If farmers have used CIS in the past and achieved satisfactory results, they will use this information again in the future.

The results of the second research hypothesis showed the impact of PU on the attitude of farmers towards the use of CIS. The findings of Mohr and Kühl (2021); Zhong et al. (2019); Dai et al. (2020); Hao et al. (2017) confirmed the results of this section. The analysis of this finding shows that the studied farmers have well understood the advantages of using CIS and they always believe that using CIS can have economic and social benefits for them. Farmers' perception of the usefulness of a technology can have a great impact on the use of technology (Hori et al., 2013). For climate information and climate forecasts to be useful, they must be accompanied by agricultural recommendations to facilitate the decision-making process for the farmer at the farm level (Nkiaka et al., 2019; Dilling and Lemos, 2011). In addition, if farmers receive useful information from CIS in terms of the type of crops to be cultivated, determination of growth stage, time of planting, time to fight against pests and diseases, diagnosis of unfavorable climate conditions, fight against weeds, and determination of soil moisture, ultimately farmers will have a positive attitude towards CIS (Motha and Stefanski, 2006). In

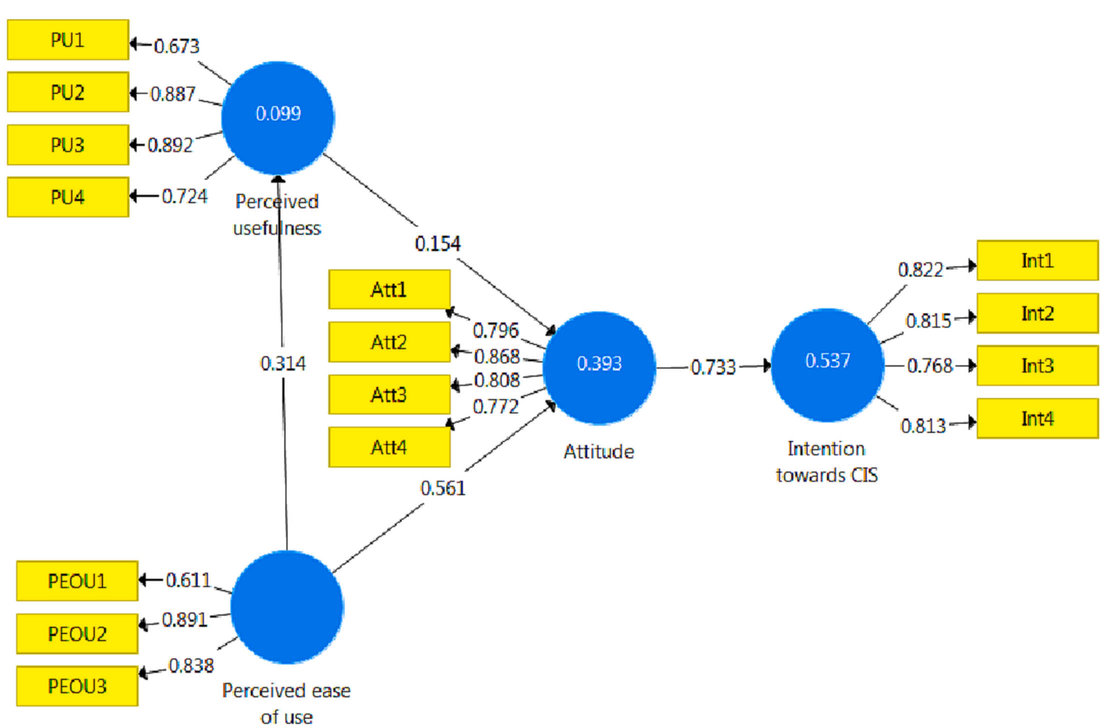

Fig. 3. Original TPB structural model with standardized path coefficients.

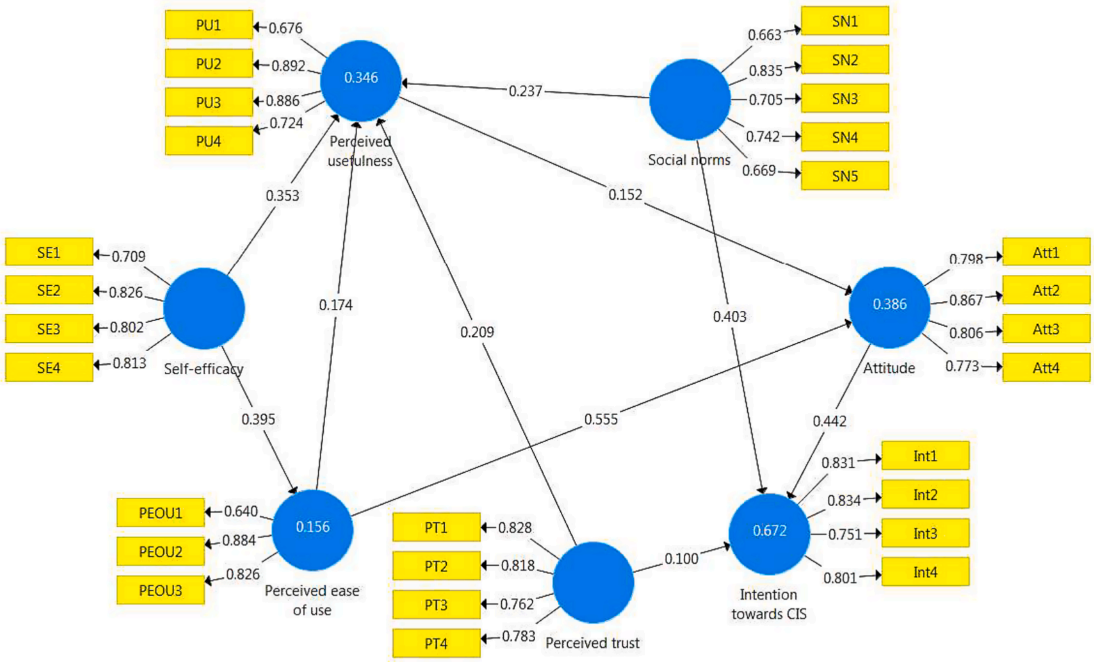

Fig. 4. Extended TAM structural model with standardized path coefficients.

Table 6
The results of the research hypotheses.

Hypothesis	Original TAM				Extend TAM			
	γ	t	Result	R^2	γ	t	Result	R^2
H1: Attitude → Intention	0.733	26.632	Confirm	0.537	0.442	10.063	Confirm	0.672
H2: PU → Attitude	0.154	4.725	Confirm		0.152	4.969	Confirm	
H3: PEOU → Attitude	0.561	12.580	Confirm		0.555	12.500	Confirm	
H4: PEOU → PU	0.314	7.498	Confirm		0.174	4.854	Confirm	
H5: SE → PU	–	–	–		0.353	7.711	Confirm	
H6: SE → PEOU	–	–	–		0.395	8.623	Confirm	
H7: SN → Intention	–	–	–		0.403	8.880	Confirm	
H8: SN → PU	–	–	–		0.237	3.969	Confirm	
H9: PT → PU	–	–	–		0.209	4.469	Confirm	
H10: PT → Intention	–	–	–		0.100	3.015	Confirm	

addition, it can be said that the use of CIS can significantly increase the effectiveness and efficiency of agricultural inputs. If the farmers realize that applying CIS can have many economic advantages for them, they will have a favorable attitude toward it.

The findings of Aung and San. (2021); Chen and Aklikokou. (2020); Savari et al. (2021); Rezaei et al. (2019); Davis (1989); emphasize the results of the third hypothesis of the research about the effect of PEOU on the attitude of farmers. Researchers believe that PEOU can create a positive attitude to change behavior (Verma and Sinha, 2018). Specifically, PEOU is related to the nature of a task and the inherent characteristics of a technology such as clarity, ease of use, and flexibility (Rezaei et al., 2019). In this context, it can be said that climate information is useful for dealing with threats caused by climate change when it is presented to farmers in an understandable way (Muema et al., 2018). Farmers who know how to use CIS, or find it easy to learn, will probably find a favorable attitude toward its use.

Regarding the fourth hypothesis, the results showed the influence of the PEOU variable on PU. Various studies (Mohr and Kühl, 2021; Sharifzadeh et al., 2017; Bagheri et al., 2021) believe that the promotion of new technologies and new methods is generally not well accepted among farmers who do not have advanced technical knowledge and skills (Bagheri et al., 2021). Therefore, for many farmers, in addition to being useful, the complexity level of technology is also important (Sharifzadeh et al., 2017), because the complexity level of technology has an inverse relationship with the level of technology acceptance (Kamal et al., 2020). Therefore, if CIS is presented in an understandably way for farmers, it will usually be very effective in the usefulness of this information for farmers. One of the basic solutions that can be useful in this field is holding workshops and training courses so that farmers can learn about the advantages and benefits of CIS.

Furthermore, the results of this study showed that self-efficacy affects PU (confirmation of hypothesis 5) and PEOU (confirmation of hypothesis 6). Self-efficacy is therefore a fundamental variable that can be included in the TAM construct. It can be said that people's confidence in their abilities and skills or their understanding of the ease and difficulty of using a technology can affect their understanding of the ease and usefulness of that technology (Rezaei et al., 2019). There are various studies that confirmed the effect of self-efficacy on PU (Venkatesh and Davis, 1996; Wu et al., 2007; Park, 2009; Chow et al., 2012; Fathema et al., 2015; Ly and Ly, 2022), and PEOU (Park, 2009; Chowet al., 2012; Park et al., 2014; Fathema et al., 2015; Al-Gahtani, 2016; Savari et al., 2021). Self-efficacy beliefs play an important role in people's points of view in different situations. These beliefs play a fundamental role in determining people's feelings, thoughts, and actions (De Fátima Goulão, 2014; Shiri et al., 2011). People with high self-efficacy choose challenging issues and objectives to work on deeply (Valois et al., 2017), actively find ways to overcome them, and ultimately, expect desired results from their efforts (Sungur and Güngören, 2009). But people with low self-efficacy avoid challenging issues. These people have weak commitments to their objectives, and when faced with obstacles, instead of looking for solutions, they focus on their failures and negative results (Zimmerman, 2008).

Research therefore shows that self-efficacy plays a crucial role in shaping individual behavior and achieving goals, successfully (Steese et al., 2006). The importance of the self-efficacy variable in the use of CIS is due to two reasons: (1) the high illiteracy among farmers due to the lack of proper training (Agricultural Development Officer Navrongo, 2019) and the resistance of many rural communities to accept new behaviors (Nkuba et al., 2021), because in drought adaptation studies, access to climate information and provision of meteorological technical recommendations are mentioned as an efficient strategy (World Bank, 2008), and another important issue is the self-efficacy in using this information, which has a great impact on farmers' decision-making (Singh et al., 2018; Davis et al., 2016). Therefore, having appropriate self-efficacy can affect the PEOU and PU of CIS (Georgeson et al., 2017). For example, Antwi-Agyei et al. (2021) showed in their research that the lack of people's awareness and self-efficacy is a big obstacle for using CIS among farmers. Therefore, there is a need for farmers to understand CIS to help them make important decisions. In this regard, there is a need to give farmers basic training on how to absorb CIS so that they can use information absorption while improving self-efficacy.

The results of the study showed that social norms have a significant effect on PU (confirmation of hypothesis 7) and farmers' intentions (confirmation of hypothesis 8). There are other studies in this field that support the effectivenss of social norms on PU (Park, 2009; Teo, 2010; Abbasi et al., 2011; Park et al., 2014; Sarcheshmeh et al., 2018), and behavioral intention (Ashraf, 2019; Ashraf et al., 2010, 2019; George, 2004; Savari et al., 2023a; Parsi and Maleksaeidi, 2021). In developing countries, people live within social and family systems, and their behaviors and beliefs influence each other (Kamal et al., 2020). Studies show that social norms have a powerful role in accepting or rejecting a behavior (Ashraf, 2018) because social norms refer to social pressures and influences affecting behavior (Savari et al., 2023b). Usually, in societies where behavior is accepted as a social norm, it will be difficult for other members of the society to exceed it (Savari et al., 2023a). In rural communities, social norms have a high value and as a social pressure, it always monitors people's behavior (Parsi and Maleksaeidi, 2021). People always seek to confirm the opinions of society members when applying new behavior, if a behavior is approved by all society members, it will be more welcome (Rezaei et al., 2019). Therefore, if the CIS application is recognized as a social norm, it will have a positive effect on the understanding of the usefulness of this information among farmers and will ultimately facilitate its use among farmers because it has an undeniable role in farmers' decision-making.

Finally, in examining the effect of PT on PU (hypothesis 9) and the willingness of farmers (hypothesis 10), the results confirmed these two hypotheses. Failure to deliver information on time is one of the important factors of lack of trust in CIS (Antwi-Agyei et al., 2021; Ouédraogo et al., 2018). Studies by Gitonga et al. (2020) and Haigh et al. (2015) showed that if CIS packages are provided on time, farmers can make rational agricultural decisions. Farmers always prefer to receive climate forecasts at least one month and at most two months before the start of the rainy season (Amegnaglo et al., 2017). This finding is supported by Mittal (2016) where farmers emphasized that providing timely and accurate CIS packages will help farmers make informed decisions and reduce production costs and lead to increased trust to CIS. Various studies have also shown the more accurately CIS is provided, the more effective it is for farmers to understand the usefulness of this information and ultimately its use (Warner et al., 2022; Muema et al., 2018). This is while the lack of trust in this information among farmers, especially in developing countries, is the main barrier to absorbing this information (Parsi and Maleksaeidi, 2021). The lack of trust in climate information can happen for two reasons: (1) information is usually not provided on time and many farmers do not have enough time to absorb this information, and therefore, they cannot use it in their decisions (Warner et al., 2022) and (2) having had a negative experience in trusting CIS; it is possible that in developing countries, due to the lack of appropriate technologies, accurate forecasts have not been available to farmers (Mittal, 2016). Therefore, based on the results of this research, it can be said that paying attention to the categories of trust, social norms, self-efficacy, understanding of ease, and ease of use are variables that strongly influence farmers' decisions, and it is better for policymakers. This field should pay basic attention to these variables. Therefore, based on the results of the research, it can be declared that paying attention to trust, social norms, self-efficacy, understanding of ease, and ease of use are variables that strongly influence farmers' decisions, and it is better for policymakers to pay much more attention to these variables.

6. Conclusion and limitations

Using CIS, especially for agriculture, can have a significant effect on the performance and economic well-being of farmers due to climate diversity. However, usually, this information is not accepted and used by farmers. In doing so, this research was conducted to identify the factors affecting farmers' intention to use CIS. In this research, the developed theory of TAM was applied. The results of the research showed that in general, the new modified model, or in other words the inclusion of SE, PT, and SN can explain 67.2 % of the variance of farmers' behavioral intention towards using CIS. In other words, this inclusion is a more appropriate model than the original TAM because it has improved the power of the model by 13.5 %. Despite the important results, this research had three limitations: (i) The first limitation of the research is that in the present research, farmers' intention to use CIS was investigated, although the intention is closely related to the behavior, it definitely cannot represent farmers' behavior. it is better to investigate farmers' behavior in future research. (ii) The developed TAM model in this research was able to predict 67.2 % of farmers' intention, although this percentage is acceptable for prediction for social research, still part of the variance remains. It is better to improve the predictive power of the model by identifying important variables in future research. (iii) Quantitative paradigm was used in this research. It is better to investigate the barriers to using CIS among farmers more precisely in future research using a qualitative paradigm.

CRediT authorship contribution statement

Moslem Savari: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. **Milad Zhoolideh:** Conceptualization, Data curation, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. **Mohammad Limuie:** Investigation, Methodology, Project administration, Resources, Writing – original draft.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

No data was used for the research described in the article.

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