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What can I do as a farmer to reduce losses? Willingness to use meteorological information as an exit strategy to deal with meteorological hazards

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Meteorological information and forecasts are of great importance to reduce agro-meteorological hazards. However, the gap between production and application of these forecasts is one of the most ambiguous issues of crop management at the farmers' level. In this regard, investigating the factors influencing Iranian farmers willingness to use meteorological information and predictions was selected as the main aim of the present study. To this end, an extended version of Theory of Planned Behavior (TPB) was employed and modeled. The results revealed that attitude towards the use of meteorological information and predictions, subjective norms in the use of meteorological information and predictions, perceived behavioral control and self-identity in the use of meteorological information and prediction, and moral norm variables regarding the use of meteorological information and predictions positively and significantly affected willingness to use meteorological information and predictions. These variables could account for 46% of willingness to use meteorological information and predictions variance. According to the results, it was suggested that by creating multimedia programs, the agricultural community become aware of the benefits and consequences of using meteorological information in their activities. Furthermore, it was recommended that social cooperation and research groups be formed on the use of meteorological information in agricultural activities. This can contribute to examine the various dimensions (strengths, weaknesses, threats, and opportunities) of using meteorological information from a collective perspective. Making a social decision in this regard can have a profound effect on a person's subjective norms and dramatically increase the speed of using meteorological information. The results of this study can help policymakers and decision-makers in the field of agriculture to design suitable intervention programs for the effective use of meteorological information by farmers. Also, the results of this study help farmers to effectively reduce the impacts of meteorological hazards.

KEYWORDS

meteorological hazards, risk reduction, meteorological information and predictions, farmers' decisions, behavioral changes

1 Introduction

Climate change is among the top 10 threats to human life in this century (Karimi et al., 2022). Rising temperatures, widespread drought, food insecurity, fluctuations in rainfall are the most important consequences of climate change (Jones and Warner, 2016; Park et al., 2017; Leal Filho et al., 2023; Tong et al., 2023). In fact, climate change is one of the main challenges to agricultural sustainability for present and future generations and its effects are greater in arid and semi-arid regions than elsewhere (Zobeidi et al., 2016; El-Rawy et al., 2023; Farooq et al., 2023; Hounnou et al., 2023; Chetri et al., 2024). Extending the negative impacts of temperature fluctuations to more areas, water stresses, and severe weather events in the coming years could reduce crop productivity in many parts of the world (Smith et al., 2013).

International studies (Guo et al., 2022; Soko et al., 2023) show that in sub-Saharan Africa and South Asia, agricultural productivity will decline sharply. Therefore, increasing the efficiency of resources consumption and improving the management of agricultural decisions through the application of information obtained from climate forecasting systems, can be an important step towards greater adaptation to the conditions ahead of agriculture. This strategy can also quantitatively increase the yield of agricultural products and thus increase the economic wellbeing of farmers (Choi et al., 2015). Studies in some countries (Zuma-Netshiukhwi and Stigter, 2016; Baffour-Ata et al., 2022; Onyango et al., 2022; Javaid et al., 2022) indicate that meteorological forecasts have increased crop yields and net profits by 10–15 percent. The use of this information has also reduced the vulnerability of the agricultural sector and facilitated land preparation, detection of appropriate planting time, more efficient management of pests and diseases, and timely application of fertilizers (Cabrera et al., 2016).

Despite the great importance of using meteorological information and forecasts, the gap between production and application of these forecasts is one of the most ambiguous issues of crop management at the farmers' level (Baffour-Ata et al., 2022; Savari et al., 2023a; Yegbemey et al., 2024). The use of climate information in agriculture and the selection of appropriate strategies in this field is a kind of individual and social decision-making process that is a function of various issues (e.g., Qi et al., 2022; Zhang et al., 2022; Kreft et al., 2023) at the individual and environmental levels (Zang et al., 2022; Teng et al., 2022). Differences in the living environment and how people make decisions affect how they make decisions about their environment. These differences and decision-making abilities are very important when people are faced with a particular issue like application of meteorological information. Each issue has multiple dimensions that add to its complexity in interaction with individual and environmental conditions. These complexities in decision making become more crystallized when it is less studied in people with thematic knowledge and problem-solving ability (Valizadeh et al., 2021; Savari et al., 2023b). The use of meteorological information and predictions by farmers is no exception to this rule. The behavior and responses of farmers in relation to this information for reasons such as doubts about the favorable consequences of applying these results in agricultural activities and negative attitudes differs impressively. This has caused farmers' responses to this information and predictions to change from non-acceptance to full acceptance (Onyango et al., 2022).

One of the easiest ways to improve the use of climate forecast results in agricultural communities is to identify and analyze the determinants of the willingness to use this information (Ncoyini et al., 2022; Andati et al., 2022; Giua et al., 2022). This can help the successful implementation of intervention programs addressing behavioral changes. Furthermore, it facilitates farmers' decisions to use meteorological information, especially in countries such as Iran. Studies (e.g., Valizadeh et al., 2021; Savari et al., 2023c) show that what has caused great damages to the various sectors of the Iranian economy, including agriculture, are extreme weather and climate events (which occur more frequently under climate change). For example, the reports of the Agricultural Jihad Organization of West Azerbaijan Province show that the lack of proper and optimal use of meteorological information in 2020, has caused the agricultural sector of West Azerbaijan Province to suffer a loss of $ 62 million (Ministry of Agriculture-Jahad, 2022). These damages are generally caused by events such as floods, hail, drought, and frost. Studies (such as Ncoyini et al., 2022; Andati et al., 2022; Giua et al., 2022; Savari et al., 2023a) emphasize that the correct and timely use of meteorological information and forecasts can have a significant impact on reducing these damages.

In Iran, providing meteorological information and climate services to farmers is done in two methods. The first and more comprehensive method is done by using Islamic Republic of Iran Broadcasting. In other words, Islamic Republic of Iran Broadcasting informs many farmers of different regions about the latest weather and climate events and forecasts every day. In this method, information such as air temperature, precipitation forecasts, location of precipitation systems, vulnerable areas against temperature stress (heat and cold), vulnerable agricultural areas against temperature stress, and general strategies to deal with the stresses are provided to farmers (Valizadeh et al., 2021). The second method is done by using virtual platforms such as Agroyar virtual meteorological station. The Agroyar virtual meteorological station and the rest of the platforms are generally robots that collect the weather and climate information of the desired GPS point for farmers using satellite information and weather stations in the region and provide them after analysis. This information is analyzed specifically for agriculture and may have differences with the meteorological information provided by Islamic Republic of Iran Broadcasting. However, these platforms use farm weather information and weather stations in precision agriculture, more accurate pest and disease warning services, water conservation management and growth regulation, helping to carry out scientific and efficient agricultural production management and achieve sustainable agricultural development (Agricultural Jihad Organization of West Azerbaijan Province, 2024). However, it should be noted that the concentration of information provided by these sources does not mean that the traditional and local methods used by farmers to predict the weather and climatic changes are not effective. For example, Iranian farmers can, in many cases, use the data and information they obtain in the field of wind intensity and direction, wind blowing time, air temperature, cloud color and density, and rainfall in different seasons, predict the weather and its changes. However, Iranian farmers in general and West Azerbaijan Province in particular are reluctant to use this modern information and predictions. Identifying the determinants of farmers' willingness to use meteorological information and predictions and using them in the agricultural development programs can play an important role in reducing the vulnerability of the agricultural sector to weather and climate hazards and increase agricultural productivity. In this regard, the study of farmers' willingness to use meteorological information and predictions in Iran through the lens of theory of planned behavior (TPB) was selected as the main purpose of the study. The main research questions to address this purpose were as follows:

1. Can the TPB serve as a basis for explaining farmers' willingness to use meteorological information?
2. According to the TPB, what factors affect farmers' willingness to use meteorological information?
3. If the TPB is used to explain farmers' willingness to use meteorological information, what constructs can help to increase the predictive power of this theory?
4. Using the TPB to explain their willingness to use meteorological information, what practical suggestions can be made to create positive behavioral changes in this field?

2 Theory of planned behavior (TPB)

TPB was first proposed by Ajzen (1991) to predict the future and actual behavior of individuals. This theory is actually based on Reasoned Action Theory (RAT). TPB predicts the occurrence of a particular behavior, provided that the individual is willing to do so (Ajzen, 1991). RAT, which is the basis of TPB, is used in situations where the individual has considerable voluntary control over the behavior. In other words, the success of RAT depends on the degree to which the individual voluntarily controls his/her behavior. When voluntary control over a behavior decreases (or the person is unable to perform the behavior despite his/her intent), the applicability of the model decreases (Ajzen and Fishbein, 2004). In RAT, there is a construct which is called perceived behavioral control (PBC). When attitudes and subjective norms are fixed, the ease or difficulty of performing a behavior will have a strong effect on the willingness/intention towards that behavior. The relative weights of these three constructs are different in different societies and behaviors. Given this difference, Ajzen (1991) established a new model, called TPB. Ajzen (1991) states that a person who has a high sense of control over his/her behavior and intends to do that behavior is more likely to do so. PBC depends on the presence or absence of facilitators, barriers to a behavior, and perceived ability. If there are control beliefs about the facilitators of a behavior, one's perceived power over the behavior increases (Ajzen, 1991).

Since RAT was limited to behavior in which individuals had imperfect voluntary control, TPB was developed to address the implications of this theory (Ajzen, 2003; Lavuri, 2022; Seddig et al., 2022). TPB is a developed theory that has overcome the basic problems by including the third predictor of behavioral intention (PBC) (Hagger et al., 2022; Kurata et al., 2022). However, the essence of RAT and TPB is the willingness of the individual to perform a certain behavior, such as the willingness to use meteorological information and predictions. According to this theory, the intention to perform a behavior is anticipated by three factors of attitude towards the use of meteorological information and predictions, subjective norms in the use of meteorological information and predictions, and perceived behavioral control in the use of meteorological information and predictions (Shanka and Gebremariam Kotecho, 2023; Gansser and Reich, 2023; Li and Zhang, 2023). In short, attitudes toward behavior, subjective norms, and perceived behavioral control all together lead to the formation of willingness (future behavior) and actual behavior. According to Ajzen (2003) in this theory, behavior is a central factor that is determined by one's intentions, and behavioral intentions, in turn, are predicted by attitudes, subjective norms, and perceived behavioral control.

Attitude is the positive or negative assessment of specific behaviors such as the use of meteorological information and predictions (Pino et al., 2017). In TPB, attitude cannot directly determine behavior, but indirectly determines it through behavioral intentions (Mankad, 2016; Waris et al., 2023). Subjective norm (perceived social norm or perceived social pressure in the context of the desired behavior) is another variable of TPB (Heriyati et al., 2023; Ong et al., 2023). In some cases, this variable refers to individuals' perceptions of the extent to which others approve or disapprove of their behavior (Ding et al., 2023).

The third variable in TPB is PBC, which indicates an individual's ability to succeed in performing a particular behavior (Abid and Jie, 2023; Amare and Darr, 2023). In fact, PBC is the perceived ease or difficulty of the behavior (Mu et al., 2023). Although the success of TPB has been proven in terms of predicting behavior (Savari et al., 2023c), there is evidence (Yazdanpanah et al., 2015; Faisal et al., 2020; Zhang et al., 2020; Valois et al., 2020; Wu et al., 2022; Cahigas et al., 2023; Huang et al., 2023; Daiyabu et al., 2023; Li et al., 2024; Gutierrez et al., 2024; Zhu et al., 2024; Wang et al., 2024; Hwang et al., 2024) demonstrating that incorporating some variables to this theory can increase its explanatory power. As a result, in this study, moral norm variables regarding the use of meteorological information and predictions and perceived behavioral control and self-identity in the use of meteorological information and prediction were added to TPB.

There are many justifications for incorporating the moral norms into TPB (Ajzen, 1991; Savari et al., 2023b; Canova et al., 2023). Adding moral norms is important for understanding behaviors that

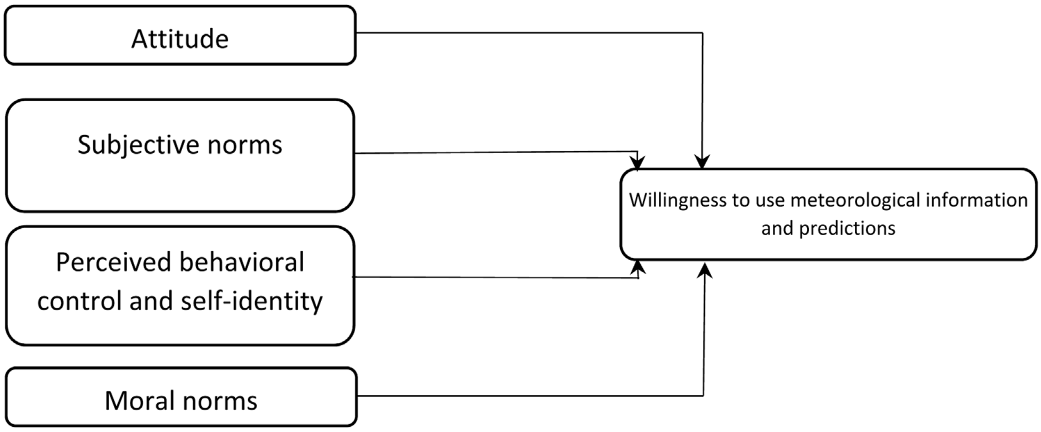

FIGURE 1
Theoretical framework.

are interpreted morally (not logically) (Bagheri and Teymouri, 2022). Because in some cases, farmers may not perform behaviors such as the use of meteorological information and forecasts for logical reasons and have moral justifications for it. For example, farmers may use meteorological information because they believe that using this information will prevent their food security from being compromised. There is also evidence (Valizadeh et al., 2020; Cao et al., 2021; Cao et al., 2023) that the inclusion of the self-identity variable in TPB (as another predictor) can improve the predictive power of behavioral intention. The concept of identity is derived from Stryker's theory of identity. According to Stricker theory, identity is a set of social roles. In other words, the extent to which an individual sees himself/herself as a representative for specific social role reflects his/her self-identity (Lambert, 2019; Rahimi-Feyzabad et al., 2020). In fact, self-identity is a label that people use to describe themselves and is expected to have a significant impact on behavioral intention (Cao et al., 2021; Cao et al., 2023). Self-identity is influenced by social structure and social structure in turn builds the behavior. Therefore, it can be argued that self-identity is perceived conceptually and functionally somewhat similar to PBC. In other words, some functions of self-identity reflect the functions of PBC. In this regard, in the present study, these two variables were combined and presented in the form of perceived behavioral control and self-identity. Therefore, self-identity along with PBC in the present study are regarded as "one" of the predictors of farmers' willingness to use meteorological information (Stryker, 1968). Based on this theoretical background, the basic version of TPB was articulated in the form an extended TPB (Figure 1) in which attitude, subjective norms, moral norms, and perceived behavioral control predict willingness to use meteorological information and predictions. Therefore, the main hypotheses which will be tested are as follows:

H1: Attitude positively and significantly affects willingness to use meteorological information and predictions;

H2: Subjective norms positively and significantly affects willingness to use meteorological information and predictions;

H3: Moral norms positively and significantly affects willingness to use meteorological information and predictions; and

H4: Perceived behavioral control positively and significantly affects willingness to use meteorological information and predictions.

It is important to note that the predictors are not independent from one another.

3 Methodological considerations

3.1 Research design

The current research is a deductive study because its hypotheses are theory-oriented. It should also be mentioned that this research is a quantitative and applied study that was done using the survey technique. The results of the study can be used by farmers, agricultural managers, meteorologists, and agricultural policymakers. Figure 2 illustrates the flowchart of the research procedure.

3.2 Study area

This research was conducted in Naghadeh County, West Azerbaijan province of Iran (Figure 3). The region is located in the northwest of the country, where in the last decade its agricultural community has been exposed to various impacts of extreme weather and climate events such as long periods of drought. West Azerbaijan province has a generally cold and dry climate with an average annual total precipitation of 300–400 mm. This province has an important role in the production of agricultural products such as wheat, barley, sugar beet, sunflower, pumpkin, apple, and grape in the country (Agricultural Jihad Organization of West Azerbaijan Province, 2019). However, climate change induced events such as floods, hail, drought, and frost have caused great damage to the agricultural sector of West Azerbaijan Province and Naqadeh County. According to the Agricultural Jihad Organization of West Azerbaijan Province (2019), in 2019, more than 560 ha of lands in Naghadeh County were damaged by

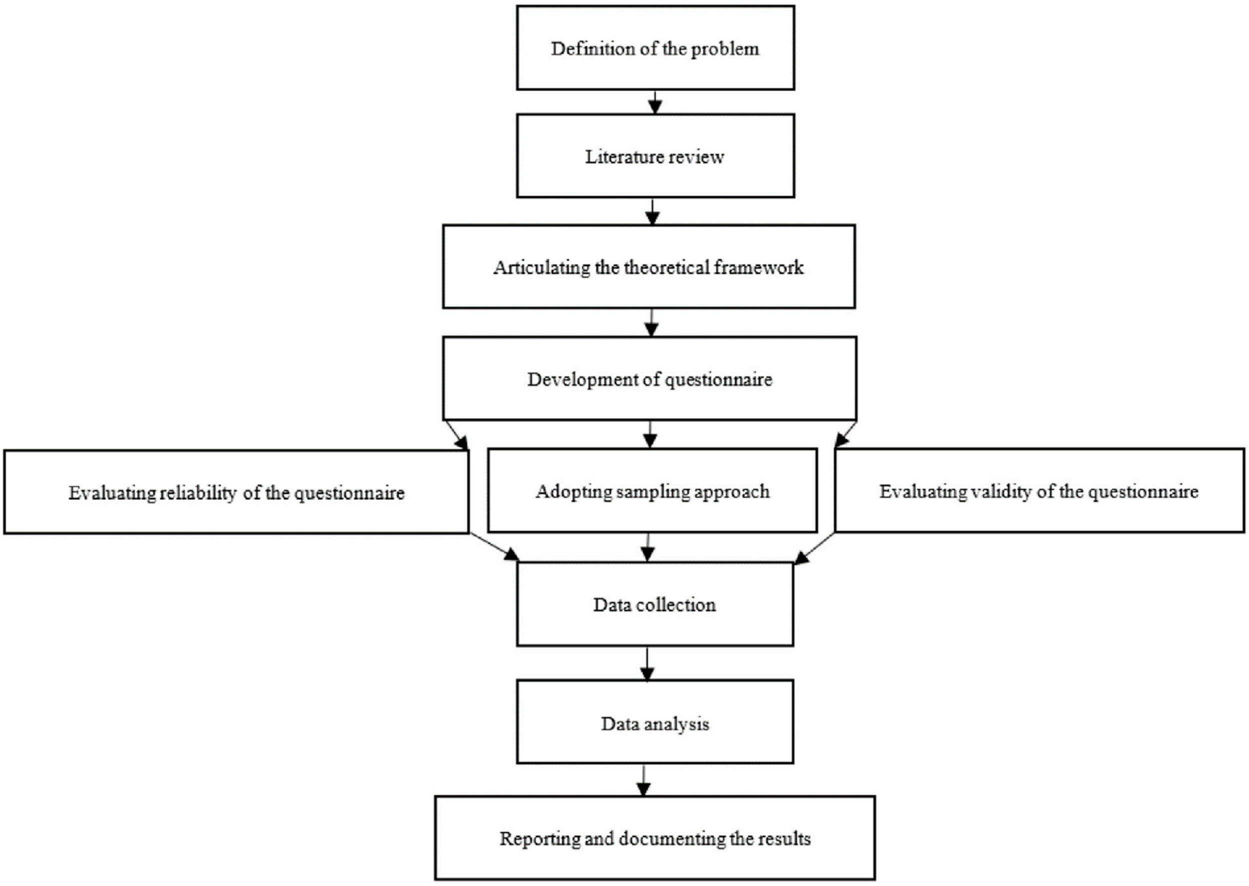

FIGURE 2
Research procedure.

natural disasters caused by extreme weather and climate events in a changing climate. This has not only posed a major challenge to the livelihoods of affected farmers, but has also led to a significant reduction in the province's agricultural exports. However, timely use of meteorological information and predictions by farmers could play an impressive role in reducing the negative impacts of these events. In this regard, the farmers of this county were selected as the target population of this study.

3.3 Sampling method

The data required for analysis in this study were collected through a close-ended questionnaire in June-July 2020. Data were collected to assess the level of willingness of farmers to use meteorological information and predictions regardless of their socio-economic status. However, this sample included respondents with a wide variety of socio-demographic backgrounds who participated in the data collection process. The population of interest included all farmers in Naghadeh county (N = 9006). The sample size of 368 farmers was estimated using the Krejcie and Morgan table (Krejcie and Morgan, 1970). Data were collected using face-to-face interviews. Samples were selected using stratified random sampling approach with proportional assignment. For sampling through stratified random sampling approach, Naghadeh County was divided into 4 categories (each category included some villages). From these four categories, 8 villages (two villages from each category) were selected. Then, within these eight villages, cases were randomly selected for interview. The differences in variances of the categories in terms of number of cases was one of the most important justifications for selecting samples using stratified random sampling method with proportional assignment. This difference in the size of the main population categories necessitated the use of a method that could select samples in proportion to size. The similarity of the samples within the four strata in terms of characteristics such as agricultural systems, methods of obtaining meteorological information, and etc. also strengthened the assumption of using stratified random sampling method with proportional assignment. Economic constraints on research funding and relatively high sampling accuracy were other reasons for using stratified random sampling with proportional assignment. In this method, classifying the population into different categories and selecting samples with respect to population sizes of strata reduces research costs (Mansourfar, 2020). Mansoufar (2020) also mentions that low variance within categories increases sampling accuracy. It should also be mentioned that the missing data in the data set were replaced with the means of variables in $SPSS_{25}$.

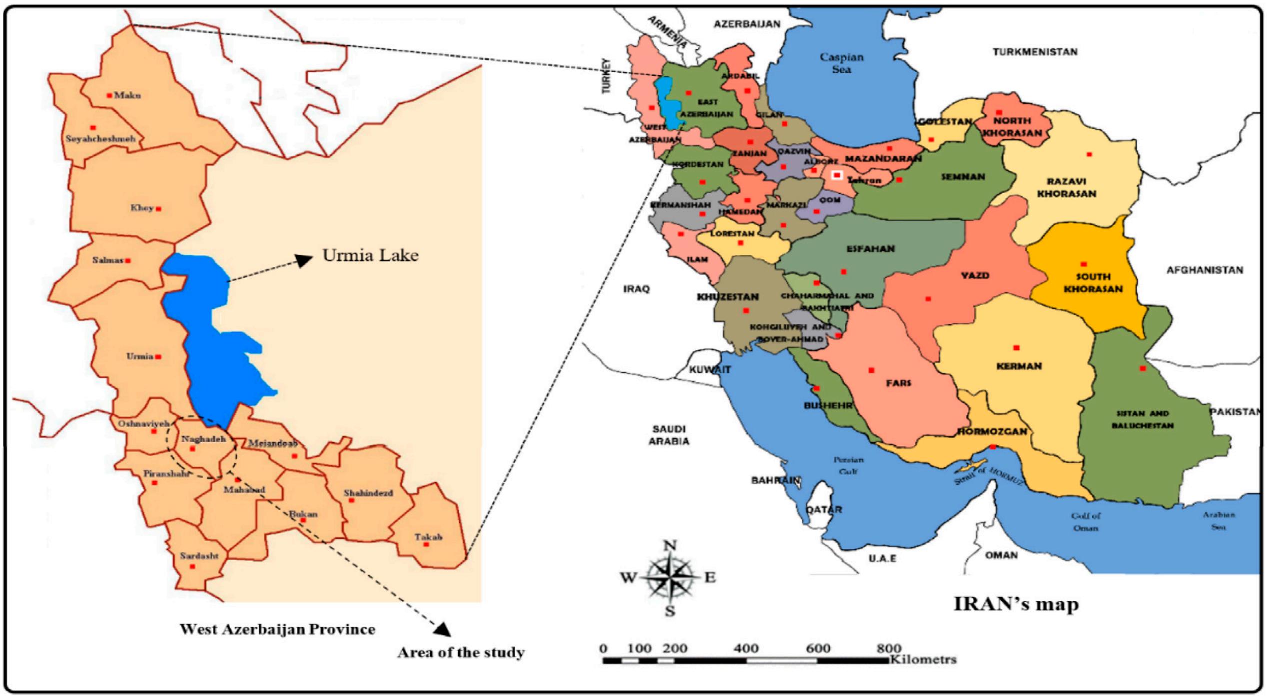

FIGURE 3
The map of study site.

3.4 Data collection and analysis

The data collection tool containing the variables in the conceptual framework was a closed-ended and structured questionnaire that consisted of two parts. The first part was related to the demographic characteristics of the respondents and the second part was related to the dependent and independent variables in the conceptual framework. Willingness to use meteorological information and predictions, which was the dependent variable of this study, was measured using four items (Table 1). Also, attitude, subjective norms, perceived behavioral control and self-identity, and moral norm regarding the use of meteorological information and predictions were measured using four, three, four, and three items, respectively. These four variables were in fact the main independent variables that were considered as the predictors willingness to use meteorological information and predictions according to the extended PBT. The items of all these variables were assessed using a five-point Likert scale (1: strongly disagree, 2: disagree, 3: no Idea, 4: agree, and 5: strongly agree). The face and content validity of the questionnaire was confirmed by using the opinions of academic experts in social studies of the environment and meteorological information. Also, the construct validity was estimated at the desired level based on the results of the AVE index. Since this index was higher than the acceptable threshold of 0.5 for all constructs of the extended TPB. The reliability of constructs was assessed using Cronbach's alpha coefficients and composite reliability (CR). Cronbach's alpha values and composite reliability for all constructs were higher than the proposed threshold of 0.7, indicating an acceptable internal consistency and validity of the structures (Table 1).

Data analysis was performed in two phases using $SPSS_{25}$ and $LISREL8_{.80}$ software. In the first phase, descriptive statistics were used. Pearson correlation coefficients and structural equation modeling (SEM) were applied in inferential statistics phase.

4 Results

4.1 Descriptive results

Examination of the demographic characteristics of the respondents showed that the majority of respondents (86%) were male. 79.7% of the respondents lived in the village permanently and the rest came to the village temporarily for agricultural work. The average income of each farmer at the time of this research in 2020 was approximately $30882. Most respondents (50%) were 25–35 years old. In terms of education, most respondents (about 46%) had a diploma or bachelor degree. Agricultural activity of 64% of the respondents focused on planting products such as wheat, barley, alfalfa, and corn. About 25% of the respondents were gardeners. Therefore, apples, plums, peaches, nectarines, etc. were their main products. The other 11% of farmers were more engaged in planting summer crops. 12% of respondents rented their farmlands. It should also be mentioned that about 45% of participants earned between $ 1700–2500 a year.

4.2 Correlation analysis

Pearson correlation test was used to examine the relationship between research variables (Table 2). It should be mentioned that

TABLE 1 Items used to measure the variables, Cronbach's alpha values, composite reliability, and discriminant validity.

Construct/variable	Num	Item
Willingness to use meteorological information and predictions		α = 0.81, CR = 0.83, and AVE = 0.56
	1	I intend to use meteorological information and predictions
	2	I would like to refer to various and reliable sources for meteorological information and predictions
	3	I will try to use meteorological information and predictions in the future
	4	I will try to continue using meteorological information and predictions
Attitude towards the use of meteorological information and predictions		α = 0.78, CR = 0.85, and AVE = 0.59
	1	The use of meteorological information and predictions helps to reduce the damage caused by climatic phenomena
	2	Because of the many benefits of using meteorological information and predictions, I try to encourage other farmers to use this information
	3	In my opinion, using meteorological information and predictions is a wise and logical task
	4	We must strive to use meteorological information and predictions as an integral part of the country's agriculture
Moral norm variables regarding the use of meteorological information and predictions		α = 0.79, CR = 0.86, and AVE = 0.67
	1	I am committed to using meteorological information and predictions
	2	If I use meteorological information and predictions, I feel that I am helping to achieve a good goal
	3	Using meteorological information and predictions makes me feel like a good person
Subjective norms in the use of meteorological information and predictions		α = 0.83, CR = 0.77, and AVE = 0.53
	1	My friends and acquaintances think that I should use meteorological information and predictions
	2	If I use meteorological information and predictions, my family and acquaintances think I'm a good person
	3	People around me expect me to use meteorological information and predictions
Perceived behavioral control and self-identity in the use of meteorological information and prediction		α = 0.75, CR = 0.86, and AVE = 0.61
	1	I think it is easy to use meteorological information and predictions
	2	Whether or not to use meteorological information and predictions is up to me
	3	Using meteorological information and predictions is an important part of who I am
	4	I have the necessary financial and intellectual skills to use meteorological information and predictions

Source: Results of present study.

the data meet all requirements for Pearson correlation (the results of normality indices have been presented in 4.3). The results of Pearson correlation analysis demonstrated that willingness to use meteorological information and predictions was significantly associated with attitude, subjective norms, perceived behavioral control and self-identity, and moral norm regarding the use of meteorological information and predictions. According to the results, attitude ($r = 0.518$; $p < 0.01$), subjective norms ($r = 0.366$; $p < 0.01$), perceived behavioral control and self-identity ($r = 0.427$; $p < 0.01$) and moral norm regarding the use of meteorological information and predictions ($r = 0.330$; $p < 0.01$) have positive and significant correlations with willingness to use meteorological information and predictions.

4.3 Measurement model

Confirmatory factor analysis (CFA) was used to evaluate the measurement model. For CFA, first, the normality of the survey data was examined. All kurtosis values for items used to measure variables were less than 5. In addition, squared Mahalanobis Distance values are one of the most important criteria used to detect and evaluate multivariate outliers (Alsufyani et al., 2022). The Mahalanobis Distance test was all lower than the chi-square values. Therefore, there was no outlier in this study. Also, fit indices and their expected values were examined. According to the value reported for each of the model fit indices in Table 3, the value of chi-square normalized by the degree of freedom is less than 5 and,

TABLE 2 Correlation matrix of research variables.

Variable	Mean[1]	S.D.	Willingness	Attitude	Subjective norms	Perceived behavioral control and self-identity	Moral norms
Willingness	3.39	0.47	1				
Attitude	3.35	0.31	0.518**	1			
Subjective norms	3.30	0.41	0.366**	0.514**	1		
Perceived behavioral control and self-identity	3.24	0.21	0.427**	0.619**	0.218**	1	
Moral norms	3.34	0.45	0.330*	0.470**	0.560**	0.351**	1

**: Significance at the level of one percent error.
*: Significance at the level of five percent error.
1. Mean values ranged between 1 and 5.
Source: Results of present study.

TABLE 3 Fit indexes of measurement and structural models.

Model name and cut off value	RMSEA	IFI	NNFI	NFI	GFI	CFI	χ2/df
Acceptable cut off	≤0.08	≥0.90	≥0.90	≥0.90	≥0.90	≥0.90	1≤ χ^2/df ≤ 3
Measurement model	0.062	0.92	0.94	0.91	0.90	0.93	2.4
Structural model	0.073	0.93	0.92	0.91	0.91	0.93	2.8

X2, Chi-Square; Df, Degree of freedom; RMSEA, Root mean square error of approximation fit index; CFI, Comparative fit index; GFI, Goodness of fit index; NFI, Normed fit index; NNFI, Non-normed fit index; IFI, incremental fit index.
Source: Results of present study.

TABLE 4 The results of testing hypotheses, standardized effects of latent variables on willingness to use meteorological information and predictions, and predictive power of the model.

Dependent variable	Independent variable	Standardized effect	t-Value	Standard error	Result of testing hypothesis	R^2
Willingness to use meteorological information and predictions	Attitude	0.47	5.17**	0.09	Confirmed	0.46
	Subjective norms	0.32	3.76**	0.08	Confirmed	
	Perceived behavioral control and self-identity	0.38	4.24**	0.08	Confirmed	
	Moral norms	0.26	3.31**	0.07	Confirmed	

Source: Results of present study.

therefore, was at the desired level. The values of Goodness of fit index (GFI), Non-normed fit index (NNFI), incremental fit index (IFI), and Comparative fit index (CFI) were higher than 0.90. These values indicate the fitness of the extended TPB measurement model. One of the most important indices used in evaluating the extended TPB fitness was the Root mean square error of approximation fit index (RMSEA) for which the observed value is less than 0.08. These results indicate that the extended TPB measurement model has a good convergent structure and validity. In other words, the data-model fit is at a desirable level and the research hypotheses can be tested in the extended TPB measurement model. Therefore, the results of the hypothesis test can be considered reliable. The results of Table 4 show the optimal fit of the model.

AVE and CR indices are other indicators to assess the validity of the extended TPB measurement model, the results of which were described in detail in the methodology section. However, evaluating the values of loading factors or the correlation of items related to latent variables is also a very good strategy to check the fit in SEM. In a well-fitting model, the values of the loading factors are usually higher than 0.4 (Kahveci et al., 2016; Waqas et al., 2018). Based on the results of testing the extended TPB measurement model, all estimated loading factors were in an acceptable range. This result shows that the research tool had a satisfactory convergent validity. Thus, all constructs/variables had relatively high validity and reliability. These results justified these constructs/variables to be maintained within the research framework. In other words, the

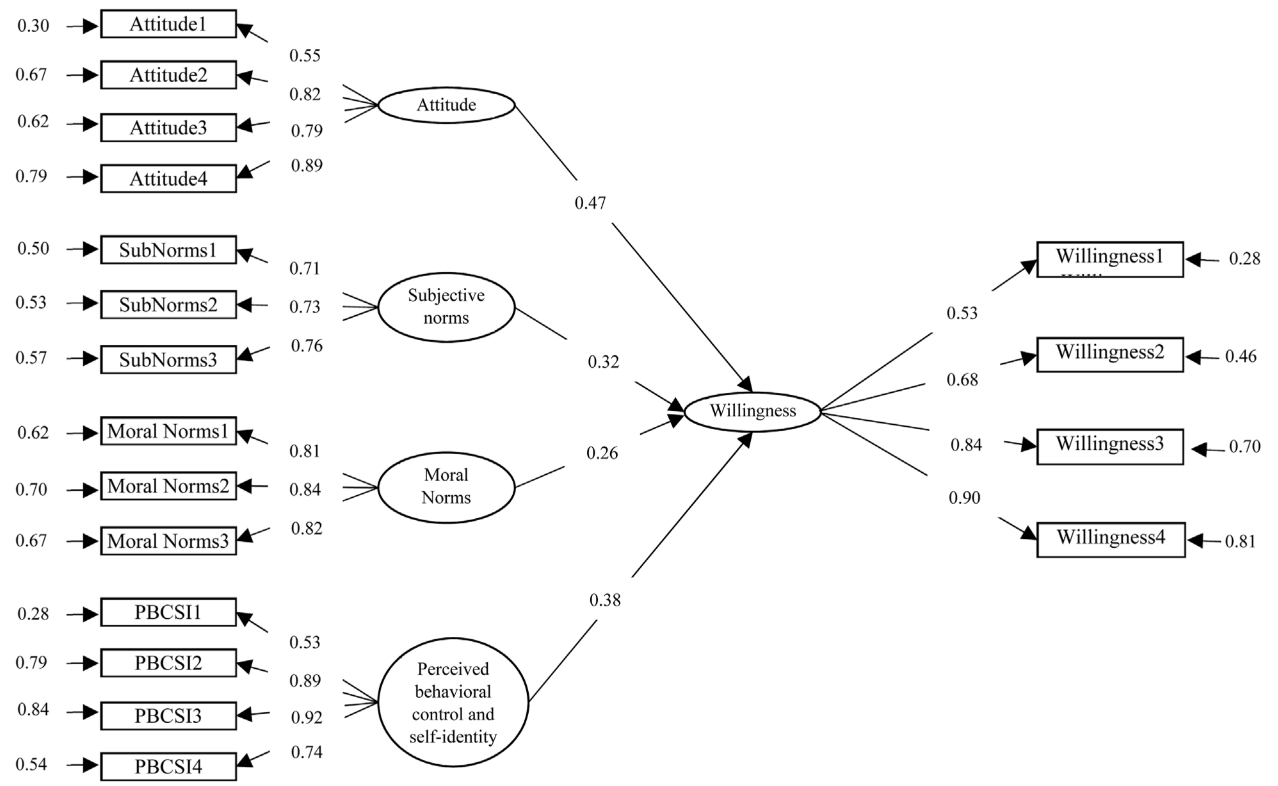

FIGURE 4
Structural model of the extended TBP with standardized path coefficients and loading factors.

measurement model was successfully validated and prepared for structural model analysis.

4.4 Structural model

Structural model analysis focuses on the appropriateness of the proposed model, hypothesis testing, and estimation of parameters related to relationships between latent variables (Pan and Truong, 2018). Accordingly, in the present study, a structural model was used to test the hypotheses and to investigate the relationships between latent constructs. In this section, the Maximum Likelihood Estimation strategy was used to run the model and then the covariance matrix was analyzed. Therefore, after examining the fit of the measurement and structural model and ensuring the fit of the extended TPB, the research hypotheses were tested. The evaluation criteria of structural model in SEM exactly follow the same rules as the CFA model fit. The fit indices of the extended TPB structural model indicated the fit of the model and its acceptability (Table 3). At this stage, willingness to use meteorological information and predictions, attitude, subjective norms, perceived behavioral control and self-identity, and moral norm regarding the use of meteorological information and predictions were entered into the analysis as latent variables. Considering the values of loading factors related to the indicators of each construct/variable and their significance level, it can be stated that the indicators are suitably adapted to the research theory. Table 4 summarizes the results for path coefficients and values of t. Besides, Figure 4 demonstrates the standardized path coefficients for the SEM model. The results presented in Table 4 show that the standardized path coefficients between the exogenous latent variables and the endogenous latent variable are significant at the level of $p < 0.01$ and their t-values are outside of the critical range (±1.96). From these results it can be inferred that the variables attitude (γ = 0.47), subjective norms (=0.32), perceived behavioral control and self-identity (γ = 0.38), and moral norm regarding the use of meteorological information and predictions (γ = 0.26) have direct and significant effects on willingness to use meteorological information and predictions. In other words, all the hypotheses presented in this study were confirmed.

5 Discussions and policy implications

Climate fluctuations are one of the most important current human hazards that have affected different aspects of human life with different intensities. In the coming years, agricultural productivity will decrease in many parts of the world and the lives of many people will be affected. This will be a response to the increase in the number of areas affected by temperature fluctuations, water stresses, and severe weather events that are the most important consequences of climate change. One of the best strategies to deal with these consequences and reduce their impacts is to use meteorological information and predictions in agricultural activities and farmers' decisions. Therefore, the aim of the study was to investigate the willingness to use meteorological information and predictions among Iranian farmers. Besides, the effects of attitude, subjective norms, perceived behavioral control and self-identity, and moral norm regarding the use of meteorological information and predictions on willingness to use meteorological information and predictions were investigated through structural equation modeling in this study.

Examination of the correlation coefficients of constructs affecting the willingness to use meteorological information with each other and with the dependent variable (willingness to use meteorological information and predictions) showed that the highest degrees of coefficients are related to the correlations between attitude with perceived behavioral control and self-identity, moral norm regarding the use of meteorological information and predictions with subjective norms, and attitude with willingness to use meteorological information and predictions. The correlation between these variables was assessed as moderate. It should be mentioned that the correlation of all the studied components with each other was direct and no inverse correlation was observed between them. This confirms that the constructs studied in this study are synergistic with each other. Therefore, with the improvement of the individuals in each of the variables, the cycle is intensified. As a result, the respondents tend to increase the use of meteorological information in their agricultural activities. This can lead to an increase in the agricultural community's resilience to the consequences of climate change, and as a result, farmers will suffer less in the face of these consequences.

Structural equation modeling demonstrated that the constructs influencing the willingness to use meteorological information were able to predict almost half of the willingness to use meteorological information and predictions variance changes. Among these constructs, attitude, perceived behavioral control and self-identity, subjective norms, and moral norm regarding the use of meteorological information and predictions had the most powerful impacts, respectively. Similar results can be found among the findings of Sharifzadeh et al. (2012) and Shi et al. (2017). These findings confirm that the psychological and social factors in the framework of this study have a significant ability to direct willingness to use meteorological information and predictions. In other words, by focusing and strengthening these factors, the desired results can effectively be achieved. The fact that a person is attentively accepted to use meteorological information and his/her subjective norms, self-identity, and moral norms are in the same direction, can guarantee that if this person has control over his/he decision-making process, he/she will use the meteorological information in agricultural activities. This brings climate change into a soft phase, one that is formed in people's minds regardless of technology and tools and can be implemented at a lower cost than technical solutions. This leaves great hope for planners and decision makers at the macro level of decision-making at the international and national levels.

Due to the fact that attitude is the most effective construct influencing the willingness to use meteorological information among farmers, it is suggested that by creating multimedia programs, the agricultural community becomes aware of the benefits and consequences of using meteorological information in their activities. Because awareness is the first step in strengthening the desired attitude in the field of meteorological information and predictions. When people become aware of a topic, they begin to be curious about it and gain information about it, and this information forms the basis of their attitude.

The next influential element is perceived behavioral control and self-identity. This result is important because the farmer may want to use meteorological information and predictions but is not able to do so for any reason. Therefore, it is recommended that an in-depth analysis of perceived behavioral control and self-identity be conducted to determine what are the most important barriers to using meteorological information and predictions among farmers. By removing these barriers, we can hope for a more sustainable and resilient agricultural community in the face of climate change. It should be noted that farmers' self-identity about using meteorological information and predictions is also one of the main dimensions that was included in this study in the construct of perceived behavioral control. If this construct is not more effective than other variables, it is not less than them. One of the best strategies to increase people's self-identity and self-confidence in using meteorological information is to increase their knowledge in this field; because increasing knowledge will lead to increased ability and increasing ability will lead to increased self-identity. To achieve this goal, it is suggested that educational-extensional classes be held that focus on teaching the use of meteorological information in agricultural activities for farmers. By learning how to use meteorological information, farmers gain more confidence in themselves, and as a result, their self-identity is strengthened.

Subjective norms positively and significantly affected willingness to use meteorological information and predictions. Subjective norm is an individual-social construct that is generally influenced by the society in which the individual lives. In other words, the subjective norm of farmers is most affected by society and those around them. In this regard, it is suggested that social cooperation and research groups be formed on the use of meteorological information in agricultural activities. This can contribute to examine the various dimensions (strengths, weaknesses, threats, and opportunities) of using meteorological information from a collective perspective. Making a social decision in this regard can have a profound effect on a person's subjective norms and dramatically increase the speed of using meteorological information.

It is worth mentioning that the framework used in this study was a model that the findings have shown to be synergistic. As a result, each of these recommendations can have a significant impact on the application of meteorological information in agricultural activities and protect a significant part of the international agricultural community from the adverse consequences of climate change.

6 Conclusion, limitations, way forward

The most important conclusions of this study are summarized in the following. First of all, the variables attitude, subjective norms, perceived behavioral control and self-identity, and moral norms can positively affect farmers' willingness to use meteorological information. Therefore, by strengthening these factors among farmers, the vulnerability of farmers to agricultural meteorological hazards can be reduced. Second, farmers' moral evaluations, along with their logical evaluations, can be a good predictor for their willingness to use meteorological information. In other words, in order to create effective and positive changes in behavioral tendencies towards the use of meteorological information, in addition to paying attention to the logical aspects of farmers' behavior, it is also necessary to pay attention to its moral aspects. The results of this study also confirmed that the inclusion of moral norms in the TPB can improve its explanatory power. The third conclusion is that farmers' organizations and groups can play a key role in shaping their subjective norms, perceived behavioral control, self-identity and attitude. Because these variables had significant effects on the behavioral willingness of farmers, it can be expected that by forming these organizations and groups, positive behavioral willingness can be created in farmers towards the use of meteorological information and their vulnerability to the agro-meteorological hazards reduced.

Although this study contributes to the literature, it has some limitations. In this study, an attempt was made to use TPB to encourage the willingness to use meteorological information in order to reduce the vulnerability of farmers to agro-meteorological hazards. Nevertheless, it cannot be denied that this framework is only one of the known frameworks that can be used by policymakers and behavioral change practitioners to reduce the vulnerability of farmers to agro-meteorological hazards. In this regard, it is suggested that other behavioral change frameworks such as Norm Activation Theory or Value-Belief-Norm Theory be used in future research. These studies can prove the efficiency of using other models. The second limitation is related to the number of hypotheses tested in this study. The basic framework used in this study is TPB, and the number of hypotheses and the type of relationships in it are also limited. Although this study tried to develop this theory by adding the variables of moral norms and self-identity, future researchers can help to further develop this model by adding other variables. This can provide the basis for identifying more factors predicting the willingness and reducing the vulnerability of farmers against agro-meteorological hazards. The third limitation was related to the studied population. This study was conducted only in West Azarbaijan Province of Iran due to economic limitations. However, future researchers can replicate this research in other geographical areas. This can help the cross-validation of the results of present study. The fourth limitation is related to the behavioral willingness of farmers. In this study, we focused on the willingness of farmers to use meteorological information and tried to provide solutions to reduce the vulnerability of farmers to agro-meteorological hazards. Nevertheless, future researchers can focus in their research on the determinants of farmers' willingness to use climate-smart agricultural technologies, soil protection technologies, etc.

Data availability statement

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

Ethics statement

Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

NV: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing–original draft, Writing–review and editing. LH: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing–original draft, Writing–review and editing. SK: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing–original draft, Writing–review and editing. AA: Writing–original draft, Writing–review and editing. SJ: Writing–original draft, Writing–review and editing. HA: Writing–original draft, Writing–review and editing.

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