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FULL LENGTH ARTICLE

Determinants of Iranian agricultural consultants' intentions toward precision agriculture: Integrating innovativeness to the technology acceptance model

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Precision agriculture;
Behavioral attitude;
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Iran

Abstract Environmental crises and global concerns toward the consequences and side impacts of conventional agricultural systems and agricultural activities on environment resulted in the viewpoint of the necessity of changing mental patterns regarding sustainable farming systems. Different agricultural methods such as precision agriculture have been presented to respond to environmental problems in recent years. The purpose of this research was to investigate factors influencing agricultural personnel and consultants' attitude and behavioral intention to use precision agricultural technologies. The survey research and multistage random sampling were used to collect data from 183 agricultural consultants in Agricultural Engineering and Technical Consulting Services Companies. The results of structural equation modeling indicated that agricultural personnel and consultants in Fars Province intended to use precision agricultural technologies. Based on the results the behavioral attitude is the most important determinant of experts' intention toward the use of the precision agriculture technologies. Also individual innovativeness, attitude of confidence, perceived ease of use and perceived usefulness of precision agricultural technologies affected on the behavioral attitude and behavioral intention to use. According to the results, practical suggestions have presented to use these technologies in Iran.
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1. Introduction

There are three steps in technology development, and three strategies for precision agriculture (PA). Step one is based on conventional farming technology, with intensive mechanization to reduce the labor input. Step two involves the development of mapping techniques, variable-rate technology machines, and introductory decision support system on the basis of information technology. Step three implies the maturity of wisdom-oriented technologies. Scenario 1 is based

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on a "high-input and high-output" conventional strategy. Scenario 2 has a strategy for "low-input but constant output", and scenario 3 aims at "optimized input–output" as the goal of precision farming (Shibusawa, 2002). Through the advent of environmental crises and global concerns toward the consequences and side impacts of some agricultural activities on environment most of the researches and experts brought up a huge global challenge, i.e. a motion toward environmentally friendly agriculture due to observing an agriculture profoundly as a national independence focus and an effective basis on the environmental balance. Taking action to an environmentally friendly agriculture requires that sustainability and sustainable agriculture as successful management of agricultural resources to satisfy changing human needs along with the environmental conservation and biologic resources increase would be taken into consideration (Chikwendu and Arokoyo, 1997). Sustainable agriculture is conceptually a system for successful management in taking advantage of resources for providing human foods as well as increasing the environmental quality conservation and natural resources. In a general concept the sustainable agriculture is an insight which depends on human goals and his recognition of the effects of agricultural activities on the environment. In fact, the sustainable agriculture emphasizes that not only nature should be regarded but also agricultural products should be developed along with environment. Thus, production process will last in the future. There is a general consensus among agricultural development practitioners in Iran that the goals of sustainable agriculture should include increasing production (for an ever increasing population), preventing soil erosion, reducing pesticide and fertilizers contamination, protecting biodiversity, preserving natural resources and improving well-being (Rezaei-Moghaddam et al., 2005).

Why precision agriculture is needed? In recent studies the formal reports of Iran's natural resources and environment are frustrating. It should be noted that after Australia, Iran has the second global rank in erosion and destruction of fertilized lands and natural resources. This is to say that 33 tons of soil has been destructed and eroded in each hectare. One of the major reasons is the excessive consumption of fertilizers and chemical pesticides in agricultural sector. In addition, the reports show that pesticides and chemical fertilizers (nearly 3 tons in each hectare) are used too much in Iran. Developing and modernizing agriculture in Iran has resulted in primary costs including water pollution by pesticides and transfer to the soil and livestocks, foodstuff and feedstuff contaminations, air pollution and excessive use of natural resources. Tendency toward modernizing agriculture has led to remove livestock and plant traditional procedures, hygiene risks and loss of job (Kashani, 2001). Also Iran is located in an arid and semi-arid region. Having an average annual precipitation of 250 mm, Iran receives less than one third of global average precipitation (750 mm). Bearing in mind such a climatic condition, many severe or mild droughts are inevitable. In recent years, Iran has experienced several droughts. The current severe, prolonged and extensive drought in Iran has not only affected agricultural productivity but also threatened water resource sustainability (Keshavarz et al., 2010). This crisis in agricultural development of Iran has demonstrated that conventional development strategies are fundamentally limited in their ability to promote sustainable agricultural development. Therefore, it emphasizes on forming a new agricultural model for achieving sustainable agricultural development (Rezaei-Moghaddam et al., 2005). Hence, it seems that the conceptual pattern dominating conventional agricultural systems should be changed and we should move toward the design of sustainable farming systems.

In recent years different agricultural methods have been presented in response to environmental problems and reach to sustainable agricultural development such as precision agriculture. The concept of precision agriculture, based on information technology, is becoming an attractive idea for managing natural resources and realizing modern sustainable agricultural development (Maohua, 2001). Precision agriculture is a management strategy that uses information technology to bring data from multiple sources to bear on decisions associated with crop production (National research Council, 1997). PA is conceptualized by a system approach to re-organize the total system of agriculture toward a low-input, high-efficiency sustainable agriculture. PA provides an ideal tool for agricultural risk assessment and rational farm-work scheduling (Zhang et al., 2002). In fact, precision agriculture is a management concept which combines information and communication technologies for management of temporal and spatial variability in agriculture (Fountas et al., 2005). The basic goal of PA to optimize yield with minimum input and reduced environmental pollution is highly required for developing countries to face the challenge of sustainability (Mondal and Basu, 2009). Precision agriculture techniques are enforceable in all aspects of production cycle of farming products, from pre-cultivation operation to harvest.

According to studies, various models and theories have been presented in the field of information technology acceptance including Theory of Reasoned Action (TRA), Theory of Planned Behavior (TPB), Theory of Planned Demand (TPD), Innovation Diffusion Theory (IDT), the Unified Theory of Acceptance and Use of Technology (UTAUT) and Technology Acceptance Model (TAM). Technology acceptance model is considered as the most widely accepted model among information researches for studying users' system acceptance behavior (Yi et al., 2006). This model was developed by Davis (1989) based on the theory of reasoned action as the most effective and fundamental human behaviors theory. It provides a basis for tracing the impact of external factors on internal beliefs, attitudes and intentions (Ghamatrasa, 2006). TAM posits two particular beliefs "Perceived ease of use" – it refers to the degree to which the prospective user expects the target system to be free of effort – and "Perceived usefulness" that is defined as the prospective user's subjective probability that using a specific application system will increase his or her job performance (Davis et al., 1989).

Different researches were carried out based on technology acceptance model for predicting individual behaviors, intentions, and attitudes toward information technology acceptance. The results of Davis et al. (1989) study indicated that perceived usefulness affected on information technologies acceptance while perceived ease of use had less effect on making decision to use those kinds of technologies. Different researches confirmed TAM needs to be given additional variables to provide an even stronger model. Adrian et al. (2005) noted that there was a significant relationship between attitude of confidence, perceived net benefit, farm size and education level with behavioral intention. Moreover, there was a significant relationship between perceived usefulness and perceived net benefit, also there was a significant relationship between attitude of confidence and perceived ease of use and attitude of confidence and perceived usefulness. Lee et al. (2007) investigated the relationship between perceived usefulness, perceived ease of use, attitude to use and intention to use of information technology (IT). Yi et al. (2006) discovered that there was a significant and positive relationship between personal innovativeness (PI) and perceived ease of use, result demonstrability, perceived behavioral control and subjective norm.

Previous studies mostly confirmed innovativeness variable because of its important role in innovations acceptance (Agarwal and Prasad, 1998). They showed that PI could affect the decision whether or not to adopt a certain technology in the domain of IT. Agarwal and Prasad (1998) have proposed a new construct that illuminates the relationships in technology acceptance models, i.e., personal innovativeness in the domain of information technology. They defined PI as the "willingness of an individual to try out any new information technology". A person is characterized as innovative, if he or she is early to adopt an innovation and individual with higher levels of PI is expected to have more positive intentions to use of new IT (Jeong et al., 2009). In general innovation diffusion research, it has long been recognized that highly innovative individuals are active information seekers about new ideas. They are able to cope with high levels of uncertainty and develop more positive intention toward acceptance. Individuals with higher personal innovativeness are expected to develop more positive beliefs about the target technology (Lu et al., 2005). Several authors agree that the PI influences their cognitive and decision-making processes (San Martin and Herrero, 2012).

Karahanna et al. (1999) state that perceived usefulness, visibility, result demonstrability and triability had direct, positive and significant effect on behavioral attitude, and behavioral attitude had direct, positive and significant effect on individual intention to use information technology. Hubona and Buton-Jones (2002), Wu and Wang (2005) and Liu et al. (2005) revealed that there were positive relationships between belief about ease of use and belief about usefulness. Phillips et al. (1994), Malhotra and Galletta (1999), Liu et al. (2005) and Rezaei-Moghaddam and Salehi (2010) cited that there was a positive and significant relationship between attitude to use and intention to use and perceived ease of use and attitude to use. Phillips et al. (1994), Malhotra and Galletta (1999), Hubona and Buton-Jones (2002), Liu et al. (2005) and Rezaei-Moghaddam and Salehi (2010) showed that there was a positive and significant relationship between perceived usefulness and attitude to use. The results of Malhotra and Galletta (1999), Wu and Wang (2005) and Liu et al. (2005) showed that there was positive and significant relationships between perceived usefulness and behavioral intention. The results of Rezaei-Moghaddam and Salehi (2010) demonstrated that attitude of confidence had direct and significant effect on attitude to use of experts.

It is required that Iran moves toward precision agriculture technologies seriously due to potential capacities and it cannot be actualized unless different agricultural operators involve in. Due to the key role of agricultural experts in innovation adoption by farmers this study considers proper strategies for adoption of these technologies through investigating agricultural experts and consultants' attitude and intention as water and soil connectors, farm managers and different products supervisors regarding precision agriculture technologies application. According to excessive use of chemical fertilizers and pesticides by farmers and the water crisis in Iran, among precision agriculture technologies the experts' attitude and intention toward the variable-rate technology of fertilizing, irrigating, and spraying were measured that these technologies are more tangible for them. So objectives in particular are as follows:

- Investigating factors affecting on agricultural experts and consultants' intention.
- Investigating factors affecting on agricultural experts and consultants' attitude.
- Integrating innovativeness to the technology acceptance model and measuring the Goodness-of-Fit of model.

2. Research model and hypotheses

The theoretical model of this study is based on Davis technology acceptance model and adding attitude of confidence variable developed by Adrian et al. (2005) and individual innovativeness developed by Yi et al. (2006) in order to investigate the agricultural personnel and consultants' attitude and intention toward the application of the precision agriculture technologies. Also while experts feel confident toward precision agriculture technologies and perceive their usefulness, the variable of perceived ease of use will affect on behavioral attitude and behavioral intention as one of the hypotheses of this study. In this regard, perceived ease of use and attitude of confidence were respectively considered as independent variables and moderator variables (Fig. 1). According to the presented model, the following hypotheses were suggested:

H_1 = perceived ease of use affects on perceived usefulness (H_{1a}), attitude of confidence (H_{1b}), behavioral attitude (H_{1c}) and behavioral intention (H_{1d}).
H_2 = individual innovativeness affects on perceived usefulness (H_{2a}), attitude of confidence (H_{2b}), behavioral attitude (H_{2c}) and behavioral intention (H_{2d}).
H_3 = attitude of confidence affects on perceived usefulness (H_{3a}), behavioral attitude (H_{3b}) and behavioral intention (H_{3c}).
H_4 = perceived usefulness affects on behavioral attitude (H_{4a}) and behavioral intention (H_{4b}).
H_5 = behavioral attitude affects on behavioral intention.

3. Research method

The survey was used among agricultural experts and consultants in Fars Province, Iran. Three counties including Shiraz, Marvdasht and Fasa were randomly selected. Cochran formula (Hoseini, 2003) and multistage random sampling were used to collect data from 183 agricultural experts and consultants. Agricultural Engineering and Technical Consulting Services Companies is a structure with separate legal system that provides consulting and technical services for farmers in the form of NGOs (see Fig. 2).

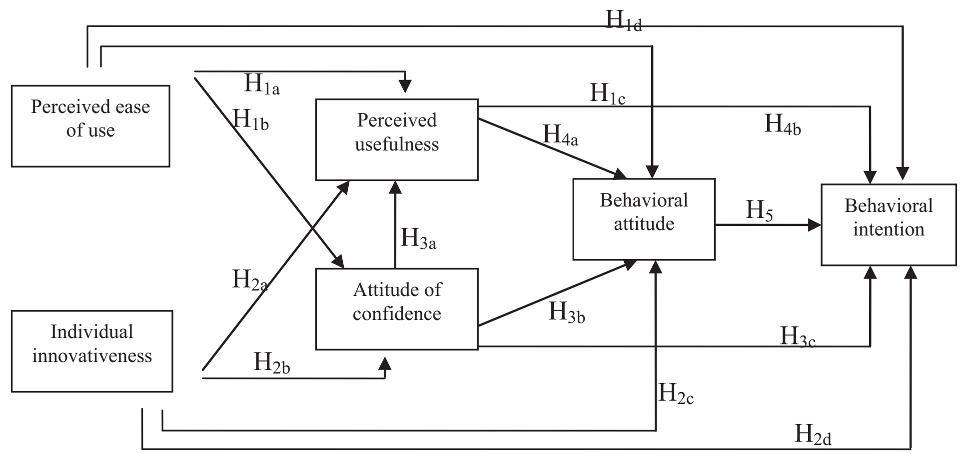

Figure 1 Theoretical framework.

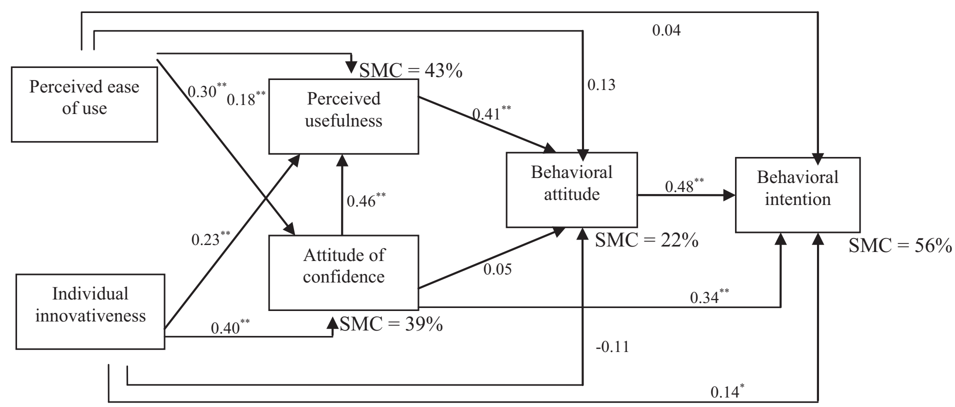

Figure 2 Structural equation modeling and path coefficients between variables.

4. Instrumentation

The structure of questionnaire consists of individual traits, two independent variables (perceived ease of use and individual innovativeness), three moderator variables (attitude of confidence, perceived usefulness and behavioral attitude) and behavioral intention as dependent variable. The variables were measured through 66 items by Likert scales ranging from strongly disagree to strongly agree. The definitions of variables have been provided in Table 1. The validity of questionnaire was tested by university professors' opinions. The questionnaire was pilot-tested with 30 randomly selected agricultural specialists out of the sample. The Cronbach's Alpha was measured to determine the reliability of the instrument and the variables. Based on the pilot test, the questionnaire was revised. Table 2 demonstrates that the reliability of question-

Table 1 Definition of the research variables.

Variable	Definition	References
Behavioral intention	Specialist's tendency to extension precision agriculture technologies among farmers	Phillips et al. (1994)
Behavioral attitude	The prospective specialist's positive or negative feeling about the adopting precision agriculture technologies	Taylor and Todd (1995)
Perceived usefulness	Defined as the prospective user's subjective probability that using a specific application system will increase his or her job performance	Davis et al. (1989)
Attitude of confidence	The confidence of a producer to learn and use precision agriculture technologies	Adrian et al. (2005)
Perceived ease of use	It refers to the degree to which the prospective user expects the target system to be free of effort	Davis et al. (1989)
Individual innovativeness	Defined as "the willingness of an individual to try out any new technology"	Agarwal and Prasad (1998)

Table 2 Cronbach's alpha coefficients for research variables.

Variable	Cronbach's alpha coefficient
Behavioral intention	0.78
Behavioral attitude	0.75
Perceived usefulness	0.72
Attitude of confidence	0.79
Perceived ease of use	0.83
Individual innovativeness	0.71

naire was acceptable. After collecting filled-in questionnaires the data were analyzed by LISREL software, version 8.54. Descriptive statistic and structural equations modeling were used to analyze data.

5. Results and discussion

5.1. Descriptive statistic

Descriptive statistics related to the variables have shown in Table 3. The mean of all variables were higher than average (3); thus, it may be concluded that experts' opinions regarding each examined index are higher than the average, in fact they are strongly agree or agree with each specification of the precision agriculture technologies.

5.2. Correlation between variables

Table 4 demonstrated the correlation coefficients among research variables. According to the results, there is positive and significant relationship among individual innovativeness, perceived ease of use, perceived usefulness, attitude of confidence, behavioral attitude and behavioral intention. As we see there was a significant correlation between behavioral attitude and behavioral intention ($p < 0.01$, $r = 0.54$). Different studies confirmed the role of attitude in changing intention and behavior. It can be noted that positive or negative feelings of a person can be an effective factor on accepting the precision agriculture technology. The correlation coefficients among perceived usefulness, attitude of confidence, perceived ease of use and individual innovativeness with behavioral intention were 0.40, 0.49, 0.44 and 0.40, respectively. The significant association between perceived usefulness and behavioral intention could be attributed to experts' pragmatism. Also, the correlation between behavioral attitude and perceived usefulness, attitude of confidence, perceived ease of use and individual innovativeness were computed. Based on the results there was positive and significant relationships between behavioral attitude and perceived usefulness ($p < 0.01$, $r = 0.38$), attitude of confidence ($p < 0.01$, $r = 0.29$), perceived ease of use ($p < 0.01$, $r = 0.44$) and individual innovativeness ($p < 0.01$, $r = 0.22$). Also, there are significant relationships between attitude of confidence, perceived ease of use and individual innovativeness with perceived usefulness at the level of significance 0.01. There was positive and significant correlations between attitude of confidence with perceived ease of use ($p < 0.01$, $r = 0.39$) and individual innovativeness ($p < 0.01$, $r = 0.57$). The relationship between attitude of confidence and perceived ease of use indicated the experts' confidence toward these technologies. In addition, the results showed that there was a positive and significant relationship between individual innovativeness and perceived ease of use ($p < 0.01$, $r = 0.45$). The results of correlation tests showed that the variables of the model are associated with each other.

Table 3 Descriptive statistics of research variables.

Variable	Min	Max	Mean	SD
Behavioral intention	2.33	5.00	4.33	0.55
Behavioral attitude	2.25	5.00	4.52	0.60
Perceived usefulness	2.00	5.00	4.12	0.43
Attitude of confidence	2.00	5.00	3.62	0.37
Perceived ease of use	2.00	5.00	4.32	0.66
Individual innovativeness	2.00	5.00	3.51	0.31

The score range for all variables is from 1 to 5.

5.3. Measurement model

The causal effects among research variables were measured by structural equation modeling (SEM) using LISREL software. The results of measured model have been presented in Table 5. The indices in experimental studies for measurement model include Chi-Square/Degree of freedom, Normed Fit Index, Non-Normed Fit Index, Comparative Fit Index, Goodness-of-Fit Index, Adjust Goodness-of-Fit Index, Root Mean Square Residual and Root Mean Square Error of Approximation. By taking the proposed criteria into account it can be said that the variables in the research present an appropriate model for defining behavioral attitude and behavioral intention toward the precision agriculture technologies.

5.4. Structural model

Based on the results of analyzing the expert's opinions in Fars Province demonstrated that external variables including perceived ease of use ($p < 0.01$, $\gamma = 0.18$) and individual innovativeness ($p < 0.01$, $\gamma = 0.23$) and internal variable of attitude of confidence ($p < 0.01$, $\beta = 0.46$) had direct and significant effects on perceived usefulness of precision technologies. Attitude of confidence had the most effect on perceived usefulness. The results were consistent with H1a, H2a and H3a respectively. The same finding was reported by Wu and Wang (2005) and Liu et al. (2005). These external variables predict 43% of variances in dependent variable of perceived usefulness (SMC = 0.43).

Findings regarding the causal effects between individual innovativeness and perceived ease of use with attitude of confidence showed that perceived ease of use had direct and positive effect on attitude of confidence ($p < 0.01$, $\gamma = 0.30$). This is in accord with H1b. In addition, individual innovativeness had direct effect on attitude of confidence and the coefficient of this variable was positive and significant ($p < 0.01$, $\gamma = 0.40$). The finding was consistent with hypothesis H2b. These two variables predicted 39 percent of the experts' attitude of confidence.

The results indicated that perceived usefulness was the only variable that had direct and significant effect on behavioral attitude ($p < 0.01$, $\beta = 0.41$). Significant causal effect between perceived usefulness and behavioral attitude confirmed

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Table 4 Correlation coefficients matrices between variables.

Variables	Behavioral intention	Behavioral attitude	Perceived usefulness	Attitude of confidence	Perceived ease of use	Individual innovativeness
Behavioral intention	1					
Behavioral attitude	0.54**	1				
Perceived usefulness	0.40**	0.38**	1			
Attitude of confidence	0.49**	0.29**	0.59**	1		
Perceived ease of use	0.44**	0.44**	0.49**	0.39**	1	
Individual innovativeness	0.40**	0.22**	0.50**	0.57**	0.45**	1

** .001 level.

Table 5 Models evaluation overall fit measurements.

Goodness of fit measure	Measure recommended	Results in this survey
Chi-square/degree of freedom (X^2/df)	⩽3	0.18
p-value	⩾0.05	0.73
Normed fit index (NFI)	⩾0.90	1.00
Non-normed fit index (NNFI)	⩾0.90	1.02
Comparative fit index (CFI)	⩾0.90	1.00
Goodness-of-Fit (GFI)	⩾0.90	1.00
Adjust goodness-of-fit (AGFI)	⩾0.90	0.99
Root mean square residual (RMSR)	⩽0.05	0.005
Root mean square error of approximation (RMSEA)	⩽0.1	0.000

Source: Gefen et al., 2000 and Markland, 2006.

previous findings of Rezaei-Moghaddam and Salehi (2010), Karahanna et al. (1999), Malhotra and Galletta (1999) and Phillips et al. (1994). The result is in accord with H4a. Therefore, this variable played an important role in making individual attitude toward the precision agriculture technologies. The results revealed that perceived ease of use and individual innovativeness had indirect effect on behavioral attitude through perceived usefulness. Besides, attitude of confidence affected behavioral attitude by perceived usefulness. These variables could predict 22% of variability of behavioral attitude toward the precision agriculture technologies.

Due to the causal effects among external variables, individual innovativeness and perceived ease of use and internal variables, attitude of confidence, perceived usefulness and behavioral attitude with dependent variable, behavioral intention toward the precision agriculture technologies, the findings demonstrated that behavioral attitude had the most direct and significant effect on the behavioral intention ($p < 0.01$, $\beta = 0.48$). The relationship between attitude and behavioral intention has been emphasized (Rezaei-Moghaddam et al., 2005). Significant causal effect between behavioral attitude and behavioral intention is compatible with the research of Karahanna et al. (1999), Malhotra and Galletta (1999) and Phillips et al. (1994). The finding is in accord with H5. The effect of attitude of confidence was significant ($p < 0.01$, $\beta = 0.34$), which was consistent with hypothesis H3c. The same finding was reported by Adrian et al. (2005). Individual innovativeness had direct, positive and significant effect on behavioral intention at the level of significance 0.05 ($\gamma = 0.14$). This is in accord with H2d. Based on the results, perceived ease of use and perceived usefulness had no direct effect on behavioral intention and this is in accord with the results of Adrian et al. (2005) and Rezaei-Moghaddam et al. (2012). But perceived usefulness indirectly affected behavioral intention by behavioral attitude. The aforementioned effective variables accounted for 56% of the variance in intention to use of precision agriculture technologies.

6. Conclusion and suggestions

Modernization of agriculture in Iran has led to the negative impacts, such as air pollution, contamination of water resources by pesticides and its transfer to soil and animals, contamination of food and animal forage, and unsustainable use of natural resources. The agricultural policy makers need to change their thinking regarding agricultural system in Iran. The application of precision agriculture technologies is an alternative to sustainable agriculture. This is one of the fastest growing alternative agricultural systems in the world. This study was conducted to identify the behavioral attitude and intention toward the precision agriculture technologies among the agricultural personnel and consultants in Fars Province, Iran. Then, it tries to test intention of Iranian experts based on the technology acceptance model. According to the results, the suggested model could determine the experts' behavioral intention strongly. Behavioral attitude was the most effective variable on behavioral intention. The role of attitude to increase behavioral intention has been emphasized. So improvement of positive attitude toward the precision agriculture technologies increases behavioral intention. This finding has policy implications for agricultural development policy makers so that it can help extension agents, agricultural educators and agricultural administrators to present suitable training and services to change attitude of clients. Establishing national workshops are useful for increasing capacity and perception of experts.

Perceived usefulness is important to change and reinforcement of behavioral attitude and behavioral intention. It has a significant role in the model so that perceived ease of use and attitude of confidence affect behavioral attitude through perceived usefulness. Thus, trainings should be planned in relation to justifying usefulness of these technologies for experts. It is suggested that a practical method instruction will be designed and implemented for raising knowledge and information based on method-demonstration and result-demonstration. Moreover,

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conducting training programs is necessary in agricultural sector for the personnel. Also, we found that agricultural personnel and consultants with higher individual innovativeness and who indicated confidence about using and learning precision agriculture technologies have greater intention to adopt these technologies. We should pay attention to these in planning for diffusion of this technology.

This study developed technology acceptance model adding individual innovativeness as an external variable to Davis technology acceptance model and constitution of attitude of confidence to replace perceived ease of use as a moderating variable. Therefore further development of the model with additional constructs such as environmental impacts of these technologies is proposed.

Conflict of interest

There is no conflict of interest.

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