Agricultural Marketing and Commercialization Journal
7(2), 156-170, 2023, ISSN Print: 2676640X, ISSN online: 2676-7570

Factors affecting the use of climate-smart agricultural technologies among wheat farmers in Alborz province with a planned behavior approach

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Received: 03 July 2023/ Revised: 19 August 2023/ Accepted: 27 September 2023/ Published: 31 December 2023

Abstract

The increase of greenhouse gases such as methane and carbon dioxide in the earth's atmosphere has caused global warming and climate change. The effects of climate change, such as increasing temperatures and changes in rainfall, have threatened food security and reduced crop production. Therefore, it is necessary to use climate smart agricultural (CSA) technologies for adaptation and resilience with these effects. The purpose of this study was to investigate the factors influencing the intention to use CSA technologies for climate-smart crop production using the theory of planned behavior. The method of this research was quantitative and research data has been collected through a questionnaire. Path analysis method was used to test the model. The statistical population of this research was 800 wheat farmers of Nazarabad city in Alborz province. The sample size was determined by Cochran's formula of 260 people and the sampling method was proportional stratified random. The results showed that the variables of attitude, subjective norms and perceived behavioral control could predict 25.3% of the variance of the intention to use CSA technologies. The importance of these variables on the intention variable was respectively: subjective norms (0.340), perceived behavioral control (0.188) and attitude (0.148).

Keywords: climate change, climate-smart agriculture, theory of planned behavior

Introduction:

With the beginning of the industrial revolution in the 18th century and the increase in the combustion of fossil fuels, the amount of greenhouse gases in the earth's atmosphere increased (Reboita et al., 2022). These greenhouse gases such as methane and carbon dioxide in the atmosphere have caused global warming. The average global surface temperature has increased by 0.9°C from 1880 to 2015 (Safaeian et al., 2023). According to the fifth assessment report of the IPCC (Intergovernmental Panel on Climate Change), the global average surface temperature will probably increase from 2.6 to 4.8°C by the end of the 21st century (2081-2100) compared to (1986-2005) under the RCP8.5 scenario (IPCC, 2014). The effects of climate change, such as increasing temperature, changes in rainfall, increasing the intensity and frequency of storms, and increasing droughts, will reduce food security and the yield of agricultural products in the next 20 years.

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Climate change refers to expected changes in long-term weather patterns in a specific region or for the entire global climate (Narimisa & Narimisa, 2018; Rahimi et al., 2019). The significant increase in the frequency and intensity of extreme weather events due to climate change creates an important challenge for the production of agricultural crops (Asrari et al., 2022). Climatic variables have changed in the Middle East over the past 10 years, and as a result, the increase in temperature and decrease in rainfall have also occurred in Iran. Due to the fact that 85% of Iran's parts are located in the dry and desert belt, it is considered one of the least rainy regions in the world. Forecasts show that by 2050, the average rainfall in Iran will decrease by 20-25% and the temperature will increase by 2.6°C. Therefore, climatic phenomena such as severe and long-term droughts and floods will occur. For these reasons, climate change has occurred in Iran. Climate changes in Iran have created many problems for the agricultural sector, such as reducing production and productivity (Abdollahzadeh et al., 2023).

The impact of climate change on agricultural systems, along with population growth, threatens the response to the growing need for food. To reduce the effects of climate change, climate smart agriculture (CSA) has been proposed as a key strategy (Mutengwa et al., 2023). CSA as defined by FAO in 2010 helps to achieve the Sustainable Development Goals. This concept combines the three dimensions of sustainable development (economic, social and environmental) by considering the issue of food security and climate challenges. Conceptually, CSA is an approach to change agricultural systems to support food security under the new realities of climate change (Palombi & Sessa, 2013). CSA is not a specific agricultural technology, but rather the identification of appropriate agricultural methods for each specific location. Its goals are: (1) Sustainable increase in agricultural productivity, food security and development (2) adaptation and resilience of agriculture to climate change (3) reducing greenhouse gases emission from agriculture (Dunnett et al., 2018). CSA technologies are broad and include water management, soils, energy, genetic resources, livestock, forestry, fisheries and climate-smart crop production. The climate- smart crop production methods investigated in this study are: (1) irrigation management (2) conservation agriculture (3) integrated pests and diseases management (4) integrated weed management (5) farm management (6) Using from improved` seeds (Lipper et al., 2017; Palombi and Sessa, 2013; Aryal et al., 2018; Brüssow et al., 2017). In various researches, the theory of planned behavior (TPB: Ajzen, 1999) has been widely used to investigate factors affecting environmental behaviors such as water conservation (Chaudhary et al., 2017), air pollution control (Yao et al., 2022), soil conservation (Gao et al., 2022), energy conservation (Macovei, 2015), recycling (Moradnezhadi et al., 2023; Ma et al., 2021) and organic food purchase (Teixeira et al., 2022; Saputra et al., 2023). TPB is one of the most effective models for predicting human social behavior (Xu et al., 2020). For these reasons, the theory of planned behavior was chosen as the theoretical model of this research.

Rainfall changes in Alborz province during the 2019-1400 crop year compared to the long term showed a decrease of 20.9%. The

average temperature of the province has also been above normal (Iran Meteorological Organization, 2022). Nazarabad city of Alborz province is located in an arid and semi-arid climate with an average annual rainfall of 238 mm and an average annual temperature of 14.2°C (Mirkhani et al., 2020). Researchers' interviews with wheat farmers in Nazarabad city of Alborz province show that the main reason for their concern about climate change is the decrease in rainfall and its increase in fluctuations, increase in temperature and drought, decrease in groundwater and dry winds, which have caused a decrease in wheat yield. Therefore, according to these conditions, it is necessary to use CSA technologies to climate-smart crop production in this region in order to achieve CSA goals. According to the government's policy on self-sufficiency in wheat production and creating sustainable food security in the country, wheat farmers were selected as the statistical population of this research. Despite the benefits of CSA methods (Arial et al., 2017), the use of these methods among wheat farmers in Nazarabad city of Alborz province is still very low. Therefore, it is very important to investigate the factors that affect the behavior of using CSA technologies by them. For these reasons, Nazarabad city of Alborz province was chosen as the main research site.

Literature review

Various studies have been conducted regarding the use of behavioral models to perform environmental behaviors. Research results Atta-Aidoo et al. (2022) show that farmers' attitude has a significant effect on their intention to adopt CSA methods. Subjective norms also have a significant effect on the acceptance behavior of farmers. In addition, the perceived behavioral control has a significant effect on the adoption intention and behavior of small farmers. Research results Li et al. (2023) shows that behavioral attitudes, subjective norms, and perceived behavioral control contribute to the willingness of cotton farmers to adopt smart agricultural technologies and can also directly or indirectly through intention affect behavior. The findings of Jiang et al. (2018) show that the attitude and perceived behavioral control of farmers have a positive and significant effect on their intention to reuse agricultural biomass waste. While their subjective norms do not have a significant effect on this intention. The results of studies Correia et al. (2022) show that students' environmental knowledge and attitude do not have a significant effect on the intention of environmentally friendly behaviors. While their subjective norms and perceived behavioral control have a positive effect on intention. In addition, students' perceived behavioral control and behavioral intention have a strong and positive effect on environmentally friendly behavior. Research results Ahmmadi et al. (2021) show that attitude, perceived behavioral control, and subjective norms positively affect consumers' intention of products irrigated with purified wastewater. In addition, risk perception has a negative and significant relationship with consumer behavior. The research results Soorani & Ahmadvand (2019) show the usefulness of using the extended model of planned behavior in predicting intention to reduce waste and food consumption management. In addition, attitude, perceived behavioral control, feeling of guilt, subjective norm

and intention not to waste food are the drivers of food consumption management and food waste avoidance. Also, the intention to reduce household food waste can be predicted by the constructs of attitude, subjective norm and feelings of guilt. Research results Ali et al. (2021) show that attitude, perceived behavioral control, policy information campaigns, and past purchase experiences significantly affect consumers' behavioral intention to purchase energy efficient appliances, while subjective and moral norms are not significant in shaping behavioral intention. The findings of Rahman & Noor (2016) show that attitude and subjective norms significantly determine the purchase intention of organic food, while perceived behavioral control is not significant. Research results Macovei (2015) show the positive effect of attitude towards energy conservation behavior on energy conservation intention, perceived behavioral control on energy conservation intention, intention on environmental conservation behavior, awareness of results and need for energy conservation on intention and behavior, while perceived behavioral control on behavior and subjective norms on intention have no significant effect. Research results Basir et al. (2023) show that Marketing through social media has a significant effect on purchase intention of domestic products like Iranian tea and brand attitude. In addition, Brand attitude has a significant effect on customers' purchase intention. The results of studies Yadav & Pathak (2017) indicate a significant effect of behavioral beliefs on the attitude towards green products, normative beliefs on subjective norms, control beliefs on perceived behavioral control. In addition, attitude, subjective norms, perceived behavioral control and perceived value have a significant effect on the intention of consumers to buy green products, and the intention also has a significant effect on the actual buying behavior of consumers. While willingness to pay premium has no significant effect on intention. Research results Park & Ha (2014) show that attitude, personal norms and perceived behavioral control have a significant effect on recycling intention. While the direct effect of subjective norms on intention was not significant. Awareness of consequences has a significant effect on attitude, personal norms and subjective norms. Furthermore, subjective norms have a significant effect on attitude, personal norms and perceived behavioral control. The question of this research is posed as what factors are effective on the intention of wheat farmers to use CSA technologies for climate-smart crop production. The purpose of this study is to investigate the effective factors on the intention to use CSA technologies for climate-smart crop production using the theory of planned behavior (Figure. 1).

Agricultural Marketing and Commercialization Journal
7(2), 156-170, 2023, ISSN Print: 2676640X, ISSN online: 2676-7570

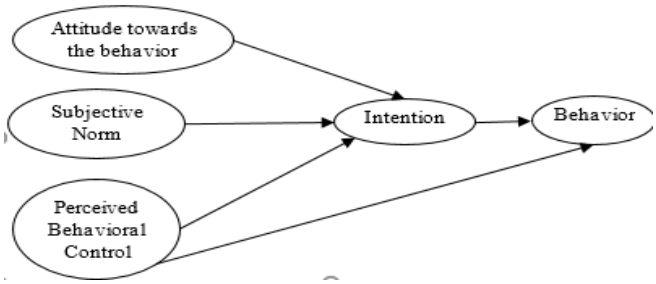

Figure 1. The theory of planned behavior

Methods and Materials

The current research method is quantitative. It is non-experimental in relation to control variables and applied in terms of purpose. Research data has been collected through cross-sectional survey and questionnaire. Alborz province with an area of about 5182.03 km^2, consists of six cities (Eshtehard, Savojbalagh, Taleghan, Fardis, Karaj, and Nazarabad) and has a population of 2,712,400 people. (Iran Statistical Center website, 2022). The research area is Nazarabad city, with an area of 587 km^2 and a population of 152437 people located in two central regions (including Nazarabad city and three rural districts of Ahmadabad, Jamaleddin and Najmabad) and Tankaman regions (including Tankaman city, southern Tankaman, and northern Tankaman rural districts) with 53 villages (Alborz Agricultural Jihad Organization, 2022). The statistical population of this research was 800 wheat farmers of Nazarabad city in Alborz province. The 260 participant sample size was determined using the Cochran formula. Appropriate Stratified sampling was selected as the sampling method. A researcher-made questionnaire including six sections was prepared to measure the research variables. The variables, the number of items, and their resources (Section 1-5) of the questionnaire are as follows: Attitude with six items (Ajzen, 2002; Madden et al., 1992; Sheeran et al., 2001), Subjective norms with five items (Ajzen, 1991, 2002; Venkatesh et al., 2003; Davis et al., 1989; Thompson et al., 1991), Perceived behavioral control with five items (Ajzen, 1991, 2002; Venkatesh et al., 2003), Intention with six items (Ajzen 2002), behavior with six items (Ajzen 2002). Intention is the intermediate dependent variable and behavior is the final dependent variable. Other variables are independent. Section 6 of the questionnaire measures personal and professional characteristics of wheat farmers. All items were measured using a Likert 7-point scale (ranging from fully disagree = 1 to fully agree = 7). The opinions of supervisors and advisors and agricultural extension and education experts were used to confirm the validity of the questionnaire. To determine the reliability of the questionnaire, a pilot test was conducted in Hashtgerd city (an area outside the main location of the research). Thirty questionnaires completed by wheat farmers were analyzed to calculate Cronbach's alpha. The total Cronbach's alpha coefficient of the questionnaire was calculated 0.785.

According to TPB, there are three independent factors that determine the

behavioral intention, after which the behavior is performed: (1) Attitude towards the behavior: It is a person's overall positive or negative evaluation of performing a certain behavior. (2) Subjective norms: perceived social pressures to perform or not perform a behavior. (3) Perceived behavioral control: refers to the perceived ease or difficulty of performing the behavior (Ajzen, 1991). Therefore, according to the theory of planned behavior, the following five hypotheses were tested in this research:

H1: Attitude towards the behavior of using CSA technologies has a positive and significant effect on the intention to use these technologies.

H2: Subjective norms related to the behavior of using CSA technologies have a positive and significant effect on the intention to use these technologies.

H3: Perceived behavioral control in relation to the behavior of using CSA technologies has a positive and significant effect on the intention to use these technologies.

H4: Perceived behavioral control in relation to the behavior of using CSA technologies has a positive and significant effect on the behavior of using these technologies.

H5: The intention related to the behavior of using CSA technologies has a positive and significant effect on the behavior of using these technologies.

Data analysis

Descriptive and inferential statistics were used to analyze the data. Mean, median and mode were used in descriptive statistics and path analysis method was used in inferential statistics. Statistical data was analyzed using SPSS software version 26.

Results

Demographic characteristics of wheat farmers

Regarding the sample population, all wheat farmers were male with an average age of 52. Most of them were between 51 and 60 years old (73 people - 28.7%). Their minimum and maximum ages were 28 and 75 years, respectively. 36% of the sample population (95 people) have university degrees, and 35.7% (90 people) have high school degrees. The average wheat crop area was 14 hectares, and most farms have a crop area of fewer than 10 hectares (100 people-39.5%). The minimum and maximum wheat crop area was 2 and 100 hectares, respectively. The average experience of wheat farmers was 29 years and most of them had 21-30 years of experience (78 people - 30.6%). The minimum and maximum experience was 7 and 50 years, respectively.

The relationship between research variables

Pearson's correlation coefficient was used to examine the relationship between the variables of the theory of planned behavior. According to table 1, the intention variable in relation to the behavior of using CSA technologies has a significant relationship with attitude (r=0.345), subjective norm (r=0.460), and perceived behavioral control (r=0.286). In addition, the behavior of using CSA technologies has a significant relationship with attitude (r=0.259), subjective norm (r=0.332), perceived behavioral control (r=0.216) and intention to use these technologies (r=0.353). There is a stronger correlation between intention

Agricultural Marketing and Commercialization Journal
7(2), 156-170, 2023, ISSN Print: 2676640X, ISSN online: 2676-7570

and subjective norms than other variables (r=0.460). In addition, there is a stronger correlation between behavior and intention than other variables (r=0.353)

Table 1. Pearson correlation coefficients between variables of the theory of planned behavior

		Attitude	**Subjective norms**	**Perceived behavioral control**	**Intention**	**Behavior**
Attitude	correlation coefficient	1				
	Sig					
Subjective norms	correlation coefficient	0/513**	1			
	Sig	0/000				
Perceived behavioral control	correlation coefficient	0/121	0/234**	1		
	Sig	0/051	0/000			
Intention	correlation coefficient	0/345**	0/460**	0/286**	1	
	Sig	0/000	0/000	0/000		
Behavior	correlation coefficient	0/259**	0/332**	0/216**	0/353**	1
	Sig	0/000	0/000	0/000	0/000	

Correlation is significant at the 0.01 level**

Path analysis of influencing factors on the intention to use CSA technologies

In order to predict the dependent variable of the intention to use CSA technologies, and in addition to identify the importance and impact of each of the independent variables of attitude, subjective norms and perceived behavioral control in this dependent variable, path analysis was performed using the Enter method (Table 2).

The multiple correlation coefficient (R=0.511) shows the intensity of correlation between the set of attitude variables, subjective norms and perceived behavioral control with the intention of using CSA technologies. The adjusted R-square value (Adjusted R^2 = 0.253) shows that the set of variables of attitude, subjective norms and perceived behavioral control have been able to predict 25.3% of the variance of the variable of intention to use CSA technologies. Considering the significance of the F value at the 99% level (sig=0.000), the set of independent variables of attitude, subjective norms and perceived behavioral control are well able to explain the changes of the dependent variable of the intention to use CSA technologies (F=30/189).

Table 2. Model summary and variance analysis of intention to use CSA technologies based on attitude, subjective norms and perceived behavioral control

(R) multiple correlation coefficient	**(R^2) coefficient of determination**	**Adjusted R^2 adjusted R-square**	**calculated F value**	**Sig F**
0/511	0/261	0/253	30/189	0/000

The relative importance and role of the independent variables of attitude, subjective norms and perceived behavioral control on the dependent variable of intention to use CSA technologies according to the obtained beta value are as follows: subjective norms (0.340), perceived behavioral control (0.188) and attitude (0.148) (Table 3). An increase of one standard deviation unit of the attitude towards the behavior of using CSA technologies causes an increase of 0.148 in the standard deviation of the intention to use CSA technologies. An increase of one standard deviation unit of subjective norms in relation to the behavior of using CSA technologies causes an increase of 0.340 in the standard deviation of the intention to use CSA technologies. An increase of one standard deviation unit of perceived behavioral control in relation to the behavior of using CSA technologies causes an increase of 0.188 in the intention to use CSA technologies. Considering that the calculated t value for attitude, subjective norms and perceived behavioral control is greater than 2.33, their error level is also smaller than 0.01 and 0.05, as a result, these variables have a significant impact in explaining the intention to use CSA technologies

Table 3. Path coefficients of intention to use CSA technologies based on attitude, subjective norms and perceived behavioral control

Model	**Unstandardized Coefficient**		**standardized Coefficient β (Beta)**	**t**	**Sig**
	B	standard error			
Constant	0/421	1/415		3/359	0/001
Attitude	0/064	0/152	0/148	2/358	0/019
Subjective norms	0/066	0/352	0/340	5/327	0/000
Perceived behavioral control	0/056	0/192	0/188	3/411	0/001

Path analysis of factors affecting the behavior of using CSA technologies.

In order to predict the dependent variable of the behavior to use CSA technologies, and in addition to identify the importance and impact of each of the independent variables of, intention and perceived behavioral control in this dependent variable, path analysis was performed using the Enter method (Table 4). The multiple correlation coefficient (R=0.373) shows the intensity of correlation between perceived behavioral control variables and the

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intention to use CSA technologies with the behavior of using CSA technologies. The adjusted R-square value (Adjusted R^2=0.133) shows that the variables of perceived behavioral control and the intention to use CSA technologies have been able to predict 13.3% of the variance of the variable of the behavior of using CSA technologies. Considering the significance of the F value at the 99% level (sig=0.000), the independent variables of the intention to use CSA technologies and perceived behavioral control are well able to explain the changes in the dependent variable of the behavior of using CSA technologies (F=20.792).

Table 4. Model summary and variance analysis of the behavior of using CSA technologies based on intention and perceived behavioral control

(R) multiple correlation coefficient	(R^2) coefficient of determination	Adjusted R^2 adjusted R-square	calculated F value	Sig F
0/373	0/139	0/133	20/792	0/000

The relative importance and role of the independent variables of perceived behavioral control and the intention to use CSA technologies on the dependent variable of the behavior of using CSA technologies according to the obtained beta value are as follows: intention (0.317), perceived behavioral control (0.125) (Table 5). An increase of one standard deviation unit of the intention to use CSA technologies causes an increase of 0.317 in the standard deviation of the behavior of using CSA technologies. An increase of one standard deviation unit of perceived behavioral control in relation to the behavior of using CSA technologies causes an increase of 0.125 in the standard deviation of the behavior of using CSA technologies. Considering that the calculated t value for intention and perceived behavioral control is greater than 2.33, their error level is also smaller than 0.01 and 0.05, as a result, these variables have a significant effect in explaining the behavior of using CSA technologies.

Table 5. Path coefficients of the behavior of using CSA technologies based on intention and perceived behavioral control

Model	Unstandardized Coefficient		standardized Coefficient β (Beta)	t	Sig
	B	standard error			
Constant	2/275	0/364		6/252	0/000
Intention	0/301	0/057	0/317	5/257	0/000
Perceived behavioral control	0/121	0058	0/125	2/375	0/039

The field model of the behavior of using CSA technologies of wheat farmers in Nazarabad city of Alborz province was designed using path analysis as shown in Figure. 2.

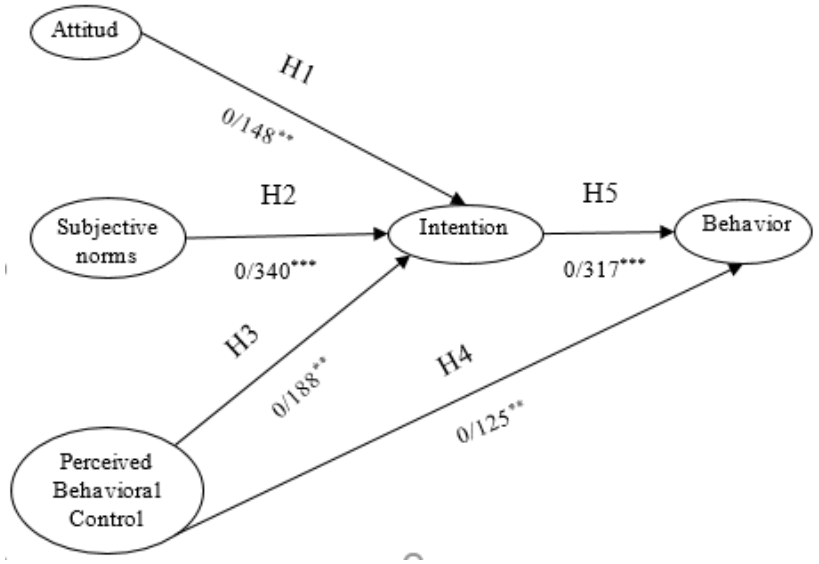

Figure. 2. The final diagram of the path analysis of the behavior of using CSA technologies

Discussion and Conclusion

The purpose of this study was to investigate the effective factors on the intention to use CSA technologies for climate-smart crop production using the theory of planned behavior in Nazarabad city of Alborz province. The results showed that there is a positive and significant relationship between attitude and intention to use CSA technologies in wheat farmers (H1). This shows that wheat farmers have a positive evaluation of using CSA technologies. In other words, they have the necessary knowledge regarding the use of these technologies to adapt to the effects of climate change. These results are consistent with the findings of (Bandari et al., 2019; Karami et al., 2019). In addition, there is a positive and significant relationship between subjective norms and the intention to use CSA technologies in wheat farmers (H2). Therefore, wheat farmers are influenced by other people and with their approval, their intention to use CSA technologies increases. This is consistent with research (Park & Ha, 2014; Correia et al., 2022). Perceived behavioral control also has a positive and significant relationship with the intention to use CSA technologies in wheat farmers (H3). The wheat farmers of the research area believe that CSA technologies can be used for adaptation and resilience to the effects of climate change. Therefore, their intention to use CSA increases. These results are consistent with research (Li et al., 2023; Macovei, 2015). On the other hand, perceived behavioral control has a positive and significant relationship with the behavior of using CSA technologies (H4). In other words, the belief of this issue by wheat farmers who have opportunities to use CSA technologies leads to the behavior of using CSA technologies. These results are consistent with the research of (Soorani & Ahmadvand, 2019). The results of this research show that the intention to use CSA technologies in wheat farmers has a positive and significant relationship with the behavior of using CSA technologies (H5). Increasing the knowledge and

awareness of wheat farmers about the benefits and usefulness of CSA methods will lead to the behavior of using CSA technologies in them. This issue is consistent with the results of research (Park & Ha, 2014).

Suggestions

It is suggested that soft or long-term loans be paid by policymakers to wheat farmers for the provision of CSA equipment. This issue has created the necessary ability and behavioral control to adapt to the effects of climate change, and the intention to use CSA technologies in wheat farmers increases. Stopping the import of wheat by the government leads to an increase in the intention of wheat farmers to use CSA technologies. Increasing intention causes the behavior of using these technologies. The government should consider the necessary incentives for the use of CSA technologies.

These incentives, such as the increase in subsidies for the sale of agricultural inputs, lead to a positive evaluation of wheat farmers for the use of CSA technologies. As a result, a positive attitude is created in them towards the use of these technologies. By creating a positive attitude, the intention to use CSA technologies in them increases. The establishment of sample farms by the management of agricultural jihad in the research area, where CSA technologies are used, will encourage wheat farmers and intensify social pressures on them. With the increase of subjective norms in them, the intention to use CSA technologies also increases.

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Agricultural Marketing and Commercialization Journal
7(2), 156-170, 2023, ISSN Print: 2676640X, ISSN online: 2676-7570