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The Role of Technical Knowledge and Technology Accessibility in Explaining Grain Farmers' Soil Conservation Behavior: The Use of Technology Acceptance Model

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ABSTRACT
Soil degradation caused by conventional agriculture is a growing problem on grain farms in the Bagherabad district of Mahallat County. This study sought to investigate grain farmers' soil conservation behavior (SCB) based on an extended technology acceptance model (TAM). A structural equation modeling technique was used to test this extended TAM based on the survey collected data from 243 grain farmers. Findings revealed that farmers poorly used soil conservation practices (SCPs). However, among SCPs, grain farmers have used organic manuring the most and cover cropping the least on their farms. The reason for this is they had more knowledge about organic manuring and also more access to organic manures. This study also supported the indirect effect of technical knowledge (TK) and Technology Accessibility (TA) on Perceived Usefulness (PU) by affecting Perceived Ease of Use (PEOU) directly. In addition, the present study pointed out that intention was the most important factor explaining SCB, and PEOU was the most important factor influencing intention. Therefore, to improve SCB, improving farmers' perceived ease of use (PEOU) should be considered through facilitating TA along with enhancing TK. In this regard, along with providing extension services, policymakers are advised to facilitate farmers' access to appropriate soil conservation (SC) technologies and inputs and also increase the purchasing power of farmers through granting cheap credit facilities and supplying technologies at affordable prices.

KEYWORDS
Grain Farmers, Soil Conservation Behavior, Technical Knowledge, Technology Acceptance Model, Technology Accessibility.

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نشریه علمی
آموزش محیط‌زیست و توسعه پایدار

«مقاله پژوهشی»

نقش دانش فنی و در دسترس بودن تکنولوژی در تبیین رفتار حفاظت خاک غلات‌کاران: کاربرد مدل پذیرش تکنولوژی

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چکیده

در مزارع غلات دهستان باقرآباد شهرستان محلات، تخریب خاک در نتیجه به کارگیری عملیات کشاورزی متعارف به عنوان یک چالش فزاینده مطرح می‌باشد. مطالعه حاضر به دنبال این بوده تا رفتار حفاظت خاک غلات‌کاران در این منطقه را با استفاده از مدل پذیرش تکنولوژی تبیین نماید. فرضیه‌های مبتنی بر این مدل، بر اساس داده‌های گردآوری شده از سطح ۲۴۳ کشاورز غلات‌کار و با استفاده از تکنیک مدل‌سازی معادلات ساختاری مورد تحلیل قرار گرفتند. نتایج نشان داد که سطح به کارگیری روش‌های حفاظت خاک در حد ضعیف بوده است. با این وجود، از میان روش‌های حفاظت خاک، غلات‌کاران کوددهی با کودآلی را بیشتر از دیگر روش‌ها به کار گرفته‌اند. دلیل این امر به دانش بیشتر آنها در خصوص استفاده از کودهای آلی و دسترسی بیشتر به این نهاده برمی‌گردد. همچنین، نتایج نشان داد که دانش فنی و دسترسی به تکنولوژی توانستند از طریق تأثیر مستقیم بر سهولت استفاده ادراک شده و تأثیر غیر مستقیم بر سودمندی ادراک شده بر رفتار حفاظت خاک اثرگذار باشند. لذا برای بهبود رفتار حفاظت خاک، در ابتدا بایستی میزان سهولت استفاده ادراک شده از طریق تسهیل دسترسی به تکنولوژی و افزایش دانش فنی ارتقا یابد. در این راستا، به سیاستگذاران توصیه می‌شود تا در درجه اول در کنار فراهم آوردن زمینه‌های ارائه آموزش‌های ترویجی در این خصوص، زمینه دسترسی کشاورزان به تکنولوژی‌ها و نهاده‌های حفاظت خاک را نیز فراهم نمایند و در گام بعدی از طریق ارائه تسهیلات اعتباری کم بهره و عرضه تکنولوژی‌ها در قیمت‌های مقرون به صرفه قدرت خرید کشاورزان را افزایش دهند.

واژه‌های کلیدی

غلات‌کاران، رفتار حفاظت خاک، دانش فنی، مدل پذیرش تکنولوژی، در دسترس بودن تکنولوژی.

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Introduction

This study was conducted in the Bagherabad district of Mahalat County, located in the southeast of the Markazi province of Iran. It has a temperate mountainous climate. Its altitude is 1775 meters above sea level with an average annual temperature of 13°C and mean annual precipitation of 240 mm yr^{-1}. This district has 26 inhabited villages with a population of 10,692 persons. Barley, wheat, and maize, respectively, with cultivated areas of 1200, 600 and 250 hectares are the main grain crops in this area. The predominant farming system on these grain farms is conventional farming. Conventional soil tillage system as a sub-system of it is chemical-and tillage-intense and leads to soil degradation physically, chemically and biologically (Arriaga et al., 2017). To cope with this problem, SCPs especially conservation tillage are considered to protect soil from erosion by leaving sufficient crop residue (at least 30% of the crop) on the field after harvest (Han et al., 2018; Pittelkow et al., 2015). In other words, SCPs including Mulching, minimum tillage, planting of cover crops, crop rotation, organic manuring, formula fertilization by soil testing and buffer strips were introduced to maintain and improve soil quality (Fantappiè et al., 2020; Yang et al., 2018). Despite the promotion of the benefits of SCPs by agricultural extension experts in the study area, soil degradation caused by conventional soil tillage (i.e., intensive and continuous soil tillage combined with low organic fertilizer, and crop residue removal or burning) is also a growing problem on grain farms in the study area. To explore this problem, the current study sought to investigate factors explaining grain farmers' SCB based on an extended TAM.

Fred Davis introduced TAM first in 1985 to eliminate the shortcomings of the theory of reasonable action and the theory of planned behavior in explaining acceptance behavior. Then, he developed the first modified version of the TAM in 1989 (Davis et al., 1989; Marangunić & Granić, 2015). It soon became the most widely used model in predicting acceptance behavior (Marangunić & Granić, 2015). Over the past three decades, many studies applied the TAM to explain farmers' acceptance behavior (e.g. Bagheri et al. 2020; Khoza et al. 2020; Wang, Jin, and Mao 2019; Verma and Sinha 2018; Silva, Canavari, and Sidali 2018). Evidence from previous studies depicted that people's perceptions about the profitability of technology and its ease of use are influenced by the level of farmers' access to technology (Buah et al., 2011; Faruque-As-Sunny et al., 2018; Matuschke & Qaim, 2008; Pagliacci et al., 2020) and also their technical knowledge level (Werner et al., 2017). A review of the latest meta-analyzes showed that previous scholars ignored the effect of these two external factors in the extension and modification of the TAM (Al-Emran et al., 2018; Granić & Marangunić, 2019; Marangunić & Granić, 2015; Rahimi et al., 2018). Against this backdrop and given the critical role of these two important factors in shaping farmers' perceptions during the behavior change process, the current study sought to identify:

1. To what extent did grain farmers use SCPs on their farms?
2. Which contextual variables can explain farmers' SCB?
3. What are the most important variables influencing farmers' SCB?
4. How TK and TA can explain farmers' SCB?

Based on the above, the conceptual framework of the research is shown as follows (Figure 1).

As defined by Ajzen (1991), intention refers to what extent a person will or plans to perform a given behavior. Based on extended TAM, the intention had a direct effect on behavior. Bagheri et al. (2020) investigated grain farmers' intentions and behavior toward the use of biological inputs in the Ardabil Province of Iran using TAM. They indicated the intention had a positive impact on the adoption of biological inputs. Also, other studies demonstrated that intention had a direct and significant effect on the adoption of agro-environmental measures (van Dijk et al., 2016), smartphone apps in dairy herd management (Michels et al., 2019), and SCB (Wauters et al., 2010).

Martin Fishbein and Ajzen (1975) defined attitude as the positive or negative feelings toward doing a behavior. According to extended TAM, attitude has a direct impact on intention. In this regard, the results of studies conducted by Wauters et al. (2010) and Haghjou et al. (2014) showed that attitude was the most explaining factor in farmers' soil conservation behavior. Similarly other previous studies also indicated that there was a positive and significant relationship between the attitude and intention to use biological inputs (Bagheri et al., 2020), integrated pest management (Despotović et al., 2019), integrated production (Silva et al., 2018), mobile-based agricultural extension service (Verma & Sinha, 2018), and cover cropping (Werner et al., 2017).

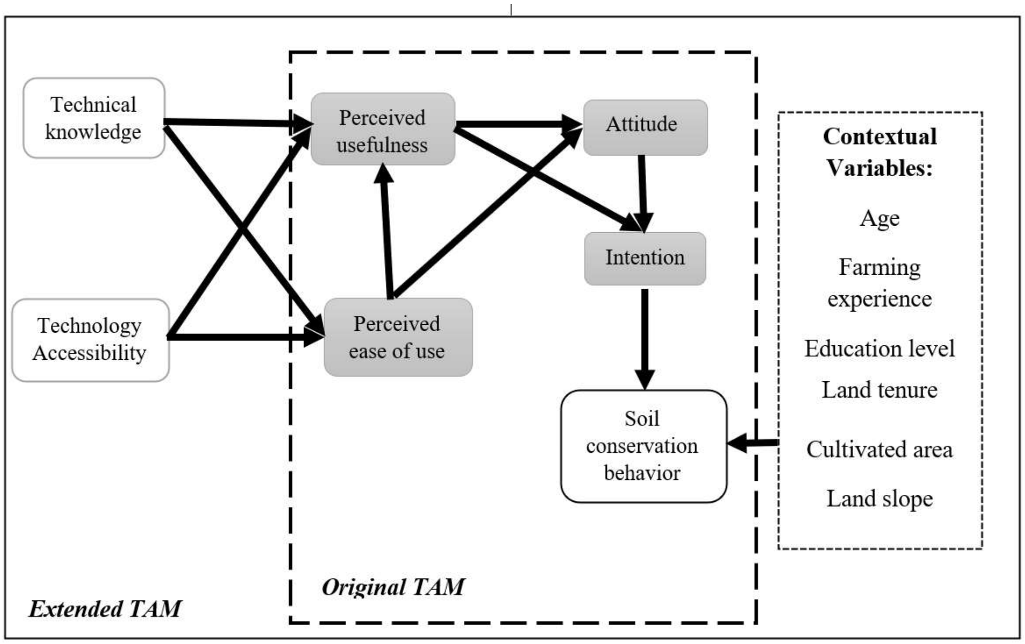

Figure 1. The Original TAM (Davis et al., 1989), and the Conceptual Framework of the Research (the Extended TAM)

PU is defined as the extent to which a person believes that the use of new technology would enhance her or his performance, efficiency, and effectiveness (Verma & Sinha, 2018). Fantappiè et al. (2020) revealed that farmers' perceptions of profitability have a relatively greater impact on the adoption of SCPs compared to environmental attitudes as well as the presence of subsidies. Based on the TAM, PU has a direct effect on attitude and intention. Many previous studies indicated that PU had a direct and significant effect on attitudes toward the use of conservation practices (Bagheri et al., 2020; Rezaei et al., 2020; Silva et al., 2018; Wang et al., 2019). Nevertheless, Verma and Sinha (2018) stated that PU had no significant and direct effect on attitude. Bagheri et al. (2020), Michels et al. (2019), and Verma and Sinha, (2018) also referred that PU significantly influenced the intention. In line with them, Naspetti et al. (2017) also found that PU is the main determinant of a farmer's intention to adopt an innovative sustainable production strategy. However, Wang et al. (2019) and Silva et al. (2018) depicted that PU had no significant direct effect on farmers' intentions, but an indirect effect by attitude.

According to Davis (1989), PEOU is defined as the extent to which a person believes that the usage of a specific technology will be free of effort. So, the PEOU of an innovation or technology goes back to its nature and inherent characteristics of it, such as complexity and flexibility level (Gangwar et al., 2015; Gefen & Straub, 2000). Investigation of the studies related to the adoption of agricultural technologies, revealed that in some studies PEOU had a positive significant impact on attitude and PU (Rezaei, Safa, and Ganjkhanloo 2020; Bagheri et al. 2020; Verma and Sinha 2018), but in certain studies PEOU had no significant direct effect on attitude and PU (e.g.

Silva, Canavari, and Sidali 2018).

TK is described as the extent to which a person knows how to apply technology in practice. Farmers' knowledge about conservation practices can affect their PEOU. For example, in a study performed by Werner et al. (2017), decreasing the farmers' perception of difficulty by providing information to farmers on how to overcome barriers was introduced as an effective way to implement conservation measures. Furthermore, farmers' knowledge of conservation practices has a significant effect on their conservation behavior. For instance, in a study conducted by Samiee and Rezaei-Moghaddam (2017), the results revealed that the knowledge of no-tillage technology was one of the most important variables classifying adopters and non-adopters. Faruque-As-Sunny, Huang, and Karimanzira (2018) also indicated that knowledge about soil testing and fertilizer recommendation facilities was found to have a significant effect on the adoption. Along the same lines, Timprasert, Datta, and Ranamukhaarachchi (2014) stated that the adopter of integrated pest management had more knowledge about natural enemies, plant extracts, and sticky traps because they received extension consulting services more than the other farmers. Consistent with these findings, Han et al. (2018) found farmer awareness of conservation tillage technology had significant negative impacts on acceptance of conservation tillage.

TA refers to a situation in which a particular technology can be successfully used by all persons with different economic and socio-psychological capabilities (Kulkarni, 2019). In the process of diffusion of new agricultural technologies among the farmers of a community, in addition to providing socio-psychological requirements, the desired technology must be accessible to all groups of farmers (e.g., rich and poor farmers or small-scale and large-scale). In this regard, farmers must have both economic and physical access to the new technology. Physical access to the technology means that the technology is available in the area, and economic access means that all farmers can afford it (Buah et al., 2011). In the present study, the term "technology accessibility" means access to inputs, tools and equipment needed to apply SCPs. Pagliacci et al. (2020) pointed out that the TA had a significant effect on the acceptance of conservation practices. Matuschke and Qaim (2008) revealed that a shorter distance to the input supplier might lead to farmers' better access to information on commercial seed technologies. Furthermore, increasing the role of the private sector in seed markets increased farmers' access to hybrids and subsequently acceptance rate. Nevertheless, limited access will slow the diffusion of new technologies. Buah et al. (2011) also indicated that among the challenges that national policies should address is access to and use of improved technologies. They also stated that improving farmers' access to improved varieties and mineral fertilizers can increase the adoption rate. Furthermore, in a study conducted in Bangladesh, the unavailability and unstable market price of fertilizers during crop seasons was introduced as one of the main constraints regarding the adaption of integrated soil fertility and nutrient management system practices (Farouque & Takeya, 2008). A review of these studies has shown that none of the researchers added the TA to TAM and did not investigate the direct impact of TA on PU and PEOU. Therefore, in the current study, the TA as a new construct was added to TAM.

Personal and professional characteristics of farmers (contextual variables in this study) can affect their adoption behavior. A review of a study conducted by Asfaw & Neka (2017) depicted that the age and education status of household heads had negative and positive impacts on the adoption of introduced soil conservation practices, respectively. In this regard, Ntshangase et al. (2018) indicated that the age and education status of farmers had a positive impact on their adopting no-till conservation agriculture. Furthermore, Han et al. (2018) also stated that an increased farmer's education level significantly increased the likelihood of the adoption of conservation tillage and the total cultivated area of land per household had a significant negative impact on it. Similar to this finding, Fantappiè et al. (2020) indicated farm size had the strongest influence on the choice of the SCPs. Ntshangase et al. (2018) also indicated that an increase in land size was negatively related to no-till conservation agriculture adoption.

Moreover, Haghjou et al. (2014) introduced the ownership of land and the slope of farms as important factors influencing the Adoption of SCPs.

Research Methodology

This study used a quantitative research design (a descriptive, correlational, and Causal-Comparative type) to determine factors affecting the SCB of 599 grain farmers in the Bagherabad District. It was carried out by field and cross-sectional survey methods. According to Krejcie and Morgan (1970), the statistical sample size was selected 234 farmers. The stratified sampling technique with proportional allocation was used to select participants. It was possible that there would be a non-response rate, so 260 questionnaires were distributed among selected participants (Table 1). Data was collected through in-person interviews with the participants. Finally, after collecting the questionnaires and removing the unanswered or incomplete questionnaires, the data from 243 questionnaires were analyzed (with a response rate of 93.46 %).

Table 1. Villages, Population Size, and Selected Participants

Villages	N_i	n_i	Villages	N_i	n_i
Arqadeh	26	11	Sabzkondor	12	5
Country side	18	8	Saadatabad	7	3
Afshjerd	8	4	Shoreh	4	2
Amirabad arazi	34	15	Aliabad	21	9
Amirabad bozijan	18	8	Qalavar	12	5
Atashkoh	7	3	KohSefid	9	4
Abgarm	5	2	GolCheshmeh	5	2
Bagherabad	38	17	Larijan	31	14
bozijan	20	9	Mohammadabad	27	12
Jordijan	27	11	Mezor	11	5
Jamalabad	35	15	Nakhjiravan	35	15
Jodan	28	12	Nimvar	128	55
Chahlarz	20	9	Yekkehchah	13	5
Total	-	-	-	599	260

Note: number of grain farmers in each village (N_i), number of participants in each village (n_i)

Instrument

Data was collected through a structured questionnaire. Five-point Likert scale (strongly disagree=1, disagree=2, undecided=3, agree=4, strongly agree=5) was used to measure all the items of the questionnaire except for SCB (never=1, seldom=2, sometimes=3, often=4, always=5) (Table 3). Structural equation modeling (SEM) using the Smart PLS software version 2 was used to test the extended model. Also, descriptive analysis was performed with IBM SPSS Statistics for Windows, Version 26.0. Armonk, NY: IBM Corp. To describe latent and observed variables, we classified them into three categories according to the following formula:

Interval length = (maximum score-1) ÷ Number of levels = (5-1) ÷ 3= 1.33 (1)

Classes: Poor = from 1 to 2.33; Fair = from 2.33 to 3.67 and good = above 3.67

To establish the face and content validity of the survey items, a comprehensive literature review and then the evaluation by expert judgement were conducted. Also, a pilot study was performed to test the reliability of the questionnaire items. In this regard, the questionnaire was distributed among 30 farmers similar to the main participants of the study in the Khorheh district (Fig. 2). Cronbach's alpha values for constructs were above 0.60 (Straub & Gefen, 2004) and for whole questionnaire items was 0.87 indicating high internal consistency reliability of the survey instrument (Hinton et al., 2004) (Table 2).

Table 2. Survey Instrument Constructs and Items

Construct	Item Wording and Item Code	Literature sources
Soil Conservation Behavior (SCB), Cronbach's α = 0.82	To what extent do you use Minimum tillage (SCB1) Organic manuring (SCB2) Planting of cover crops (SCB3) Mulching (SCB4) Crop rotation (SCB5)	(Fantappiè et al. 2020; Yang et al. 2018)
Intention to use (Intention), Cronbach's α = 0.74	It is possible that I would use SCP in the next 5 years (Intention1).	(Michels et al., 2019; Silva et al., 2018)
	I would use SCP if the neighbors adopt (Intention2).	(Silva et al., 2018)
	I want to use SCP continuously (Intention3).	(Haji et al., 2020)
	I advise other farmers to use SCP (Intention4).	(Wang et al., 2019)
Technology Accessibility (TA), Cronbach's α = 0.89	Required SC inputs and technologies are sufficiently available in supply centers in our area (TA1).	(Buah et al., 2011)
	I can easily procure required SC inputs and technologies from the nearest supply center whenever I want (TA2).	(Matuschke & Qaim, 2008)
	I can easily afford the cost of providing required SC inputs and technologies (TA3).	(Buah et al., 2011)
Attitude, Cronbach's α = 0.71	I feel good about using SCP (Attitude1).	(Fishbein & Ajzen, 1975)
	Using SCP is valuable to me (Attitude2).	(Rezaei et al., 2020)
	I am satisfied with the use of SCP (Attitude3).	(Rezaei et al., 2020)
Perceived usefulness (PU), Cronbach's α = 0.73	I believe that using SCP will improve the crop yield (PU1). I believe that Using SCP will lead to healthier products (PU2). I believe that using SCP is profitable in the long run (PU3). I believe that using SCP has few adverse impacts on the environment (PU4).	(Gefen and Straub, 2000; Chismar and Wiley-Patton, 2003)
Perceived Ease of Use (PEOU), Cronbach's α = 0.86	I think I would find it easy to acquire the necessary skills to use SCP (PEOU1).	(Michels et al., 2019)
	I think that I could easily learn how to use SCP (PEOU2).	(Michels et al., 2019)
	I think the use of SCP is not too complicated and difficult (PEOU3).	(Gefen and Straub, 2000; Gangwar et al., 2015)
	I believe the use of SCP is not more troublesome than conventional practices (PEOU4).	(Dutot, 2015)
Technical knowledge (TK), Cronbach's α = 0.83	I know how to use Minimum tillage (TK1) Organic manuring (TK2) Planting of cover crops (TK3) Mulching (TK4) Crop rotation (TK5)	(Kader et al., 2017; Z. Yang et al., 2018; Ward et al., 2018; Nielsen, 2018; Fantappiè et al., 2020; Han et al., 2018)

Assessing the Measurement Model Reliability and Validity

Factor loading and average variance extracted (AVE) values were used to assess the validity of the measurement model. The results showed that all values of factor loading were higher than 0.4 (Hulland, 1999) and also, all values of AVE were above 0.5 (Fornell & Larcker, 2016; Pappa et al., 2018). This result indicates that all the indicators related to the latent variables were able to measure the relevant structure well and had the necessary and sufficient accuracy to measure it (see Table 3). To examine the reliability of the items, composite reliability (CR) and Cronbach's alpha tests (CRA) were conducted. The results indicated all CR values were higher than 0.708 (Fornell & Larcker, 2016; Pappa et al., 2018) and all Cronbach's alpha values were above the recommended cut-off point of 0.60 (Fornell & Larcker, 1981). Thus, the items related to constructs were reliable and respondents had the same perception of the indicators (Table 3).

Table 3. Assessment of the Measurement and Structural Model

Latent variables	Observed variables	Measurement model					Structural model	
		Loading	T-value	CRA	CR	AVE	R^2	Communality
SCB				0.80	0.88	0.61	0.41	0.61
	SCB1	0.75	19.04					
	SCB2	0.84	34.84					
	SCB3	0.59	8.63					
	SCB4	0.77	18.98					
	SCB5	0.91	115.72					
Intention				0.87	0.91	0.72	0.71	0.72
	Intention1	0.70	15.76					
	Intention 2	0.86	37.90					
	Intention 3	0.92	86.85					
	Intention 4	0.90	53.07					
Attitude				0.89	0.67	0.82	0.67	0.82
	Attitude1	0.89	65.13					
	Attitude2	0.92	67.66					
	Attitude3	0.91	65.61					
PEOU				0.86	0.91	0.71	0.59	0.71
	PEOU1	0.88	16.93					
	PEOU2	0.83	74.01					
	PEOU3	0.80	27.38					
	PEOU4	0.86	54.78					
PU				0.81	0.87	0.64	0.68	0.64
	PU1	0.67	16.94					
	PU2	0.90	74.01					
	PU3	0.81	27.38					
	PU4	0.80	25.69					
TA				0.60	0.79	0.56	-	0.56
	TA1	0.67	12.37					
	TA2	0.74	14.46					
	TA3	0.81	22.71					
TK	TK1	0.60	9.45	0.85	0.89	0.63	-	0.63
	TK2	0.84	38.95					
	TK3	0.85	65.92					
	TK4	0.85	29.42					
	Tk5	0.80	23.54					

Note: all contextual variables (age, farming experience, education level, land tenure, cultivated area and land slope) were single item and their related values were equal to 1.

Discriminant Validity

Discriminant validity indicates a weak correlation between questions of one domain to other domains. In other words, the correlation coefficient of a question with other domains should be less than the correlation coefficient of that question with its own domain. As depicted in Table 4, the square roots of the AVE of each structure were larger than their highest correlation with other structures (Fornell-Lacker criterion) and this indicates the scales have discriminant validity.

Table 4. Fornell-Lacker Criterion for Assessment of Discriminant Validity

No	1	2	3	4	5	6	7	8	9	10	11	12	13
1	1.00												
2	0.96	1.00											
3	-0.40	-0.38	1.00										
4	0.05	0.04	0.19	1.00									
5	-0.33	-0.32	0.02	-0.03	1.00								
6	0.02	0.04	0.06	-0.04	-0.09	1.00							
7	-0.02	-0.03	-0.05	0.02	0.05	-0.04	0.75						
8	0.02	0.01	-0.04	0.08	0.03	-0.01	0.53	0.79					
9	0.10	0.10	-0.14	0.06	-0.02	-0.07	0.50	0.57	0.80				
10	0.08	0.08	-0.08	0.08	-0.02	0.02	0.62	0.71	0.82	0.84			
11	0.11	0.11	-0.07	0.06	0.02	0.03	0.48	0.57	0.79	0.77	0.90		
12	0.09	0.10	-0.09	0.03	-0.01	0.05	0.57	0.58	0.77	0.81	0.82	0.85	
13	-0.02	-0.03	-0.03	0.06	0.02	-0.02	0.61	0.93	0.62	0.76	0.59	0.63	0.78

Note: 1) Age; 2) Farm experience; 3) Education level; 4) Cultivation area; 5) Land tenure
; 6) Land slope; 7) TA; 8) TK; 9) PU; 10) PEOU; 11) Attitude; 12) Intention; 13) SCB
* Values on the diagonal (bolded) are square root of the AVE while the off-diagonals are latent variable correlations

Assessment of Structural Model

Coefficient of determination (R^2) values were used to assess the structural model. This criterion is used to connect the measurement part and the structural part of the model in structural equation modeling. It shows how much an exogenous latent variable affects an endogenous latent variable. According to Chin (1998), R^2 values around 0.67, 0.33, and 0.19 and lower are considered as substantial, moderate, and weak respectively. According to the values obtained in the model, the value of R^2 was substantial for the attitude (R^2=0.67), intention to use (R^2=0.71), PEOU (R^2=0.59) and PU (R^2=0.56) and above moderate for SCB (R^2=0.41) (Table 3).

Assessing the Overall Fit of the Model

The goodness-of-fit (GOF) index is used to assess the overall fit of the SEM (Tenenhaus et al., 2004). The value of GOF is between zero and one, and the closer it is to one, the better the fit of the model (Henseler & Sarstedt, 2013). The values of 0.01, 0.25, and 0.35 GOF index refer to the weak, moderate, and strong fit of the model, respectively (Wetzels et al., 2009). According to the values depicted in Table 3 and its replacement in the Equation (2), the overall fit of the research model was strong (GOF=0.71). The formula of GOF is as follows:

$$(2)\quad GOF = \sqrt{\overline{R^2} * \overline{\text{Communality}}} = 0.71$$

Research Findings

The Farm and Farmers' Characteristics

As depicted in Table 5, a high percentage (63.37%) of grain farmers were in the middle age group (from 40 to 60 years) and a significant percentage of them (66.26%) had farming experience from 10 and 30 years. Only 10.70% of farmers had a university education. Irrigated wheat and irrigated barley respectively with an area of 642 and 516 hectares, had the highest cultivated area in the study area. Maize also came next with a cultivated area of 200 hectares. Border irrigation (46.21%) and flood irrigation (22.41%) were the most important irrigation method in the study area. A notable percentage

(64.19 %) of the grain farms were owner operated. 55.56% of arable land had low slopes and 32.92% of them had moderate slopes.

Table 5. Farm and Farmers Characteristics (n=243)

Farmers characteristics			Farm characteristics		
Variables	**Classes**	**Frequency (%)**	**Variables**	**Classes/types**	**Frequency (%)/ Area (%)**
Age (Year) Mean = 49.76; SD= 10.85	<30	10 (4.12)	Cultivated Area (ha) Mean = 5.77; SD= 8.99	Irrigated wheat Mean = 2.64; SD= 5.23	642 (45.76)
	From 30 to 40	37 (15.23)		Rainfed wheat Mean = 0.11; SD= 0.59	27 (1.92)
	From 40 to 50	82 (33.74)		Irrigated barley Mean = 2.12; SD= 3.57	516 (36.78)
	From 50 to 60	72 (29.63)		Rainfed barley Mean = 0.07; SD= 0.48	18 (1.28)
	>60	42 (17.28)		Maize Mean = 0.82; SD= 2.92	200 (14.26)
Farming experience (Years) Mean = 20.32; SD= 10.12	<10	48 (19.75)	Land Slope (%)		
	From 10 to 20	84 (34.57)			
	From 20 to 30	77 (31.69)		Nearly level (0-2%)	19 (7.82)
	From 30 to 40	27 (11.11)		Low (2-10%)	135 (55.56)
	>40	7 (2.88)		Moderate (10-15%)	80 (32.92)
				Strongly (15-25%)	9 (3.70)
Education level	Illiterate	20 (8.23)	Land tenure		
	Primary	80 (32.92)			
	Secondary	57 (23.46)		owner operated	156 (64.19)
	Higher secondary	60 (24.69)		cash rent	50 (20.58)
	Graduate	26 (10.70)		crop-share rent	37 (15.23)

Grain Farmers' SCB related to Contextual Variables

The results from Table 6 depicted that farmers poorly used SCPs on grain farms (mean = 1.74, SD = 0.63). They used organic manuring more (mean = 2.26, SD = 0.97) and cover cropping less (mean = 1.19, SD = 0.46) than the other SCPs. Similar to this finding, Fantappiè et al. (2020) also indicated that organic manuring was the most adopted among SCPs. Results from Figures 2 to 7 depicted that there were no significant differences between the level of grain farmers' SCB regard to age, farming experience, education level, land tenure type, cultivated area, and land slope (P-value > 0.05). Also, the data from the study area couldn't support the significant effect of contextual variables on the farmers' SCB (Table 7). In other words, variables namely age, farming experience, education level, land tenure, cultivation area, and land slope had no significant impact on farmers' SCB (t-value < 1.96). In this regard, a study conducted by Ntshangase et al. (2018) revealed that in contrast with our result, an increase in age and education significantly increased the likelihood of a farmer adopting no-till conservation agriculture and also, an increase in land size was negatively related to no-till conservation agriculture adoption. Furthermore, Han et al. (2018) also indicated that Farmer's education level had significant positive effects on the adoption of conservation tillage and the total cultivated area of land per household had a significant negative impact on it. Asfaw & Neka (2017) also revealed that there was a significant relationship between the age and education status of household heads with the adoption of introduced soil conservation practices. A study performed by Haghjou et al. (2014) depicted that contrary to the results of our study, ownership of land and slope of farms had a significant effect on the adoption of SCPs.

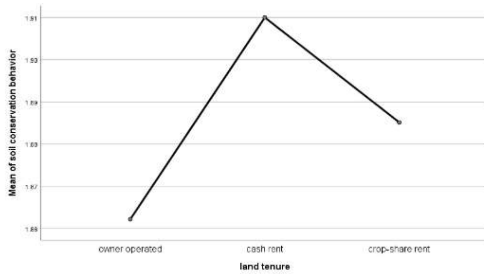

Figure 2. Mean of Conservation Behavior Regard to Land Tenure; F = 0.09 (P-Value = 0.92)

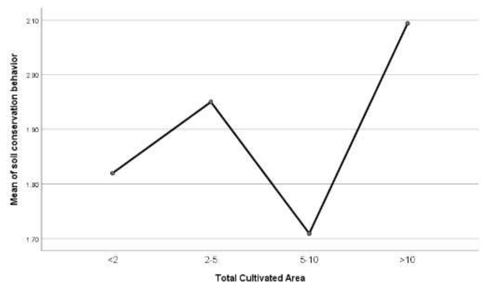

Figure 3. Mean of Conservation Behavior Regard to Total Cultivated Area (ha); F = 1.98 (P-Value = 0.12)

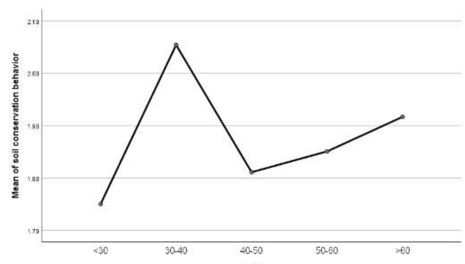

Figure 4. Mean of Conservation Behavior Regard to Age (Year); F = 0.85 (P-Value = 0.49)

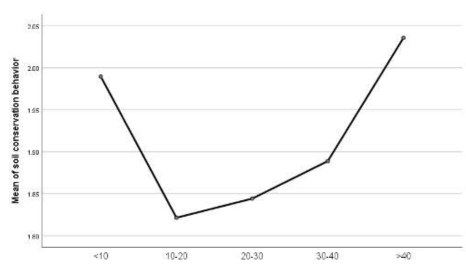

Figure 5. Mean of Conservation Behavior Regard to Farming Experience (Year); F = 0.53 (P-Value = 0.71)

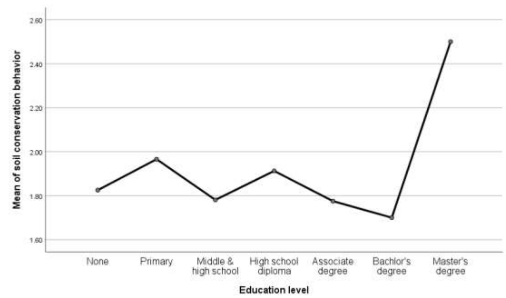

Figure 6. Mean of Conservation Behavior Regard to Education level; F = 0.71 (P-Value = 0.64)

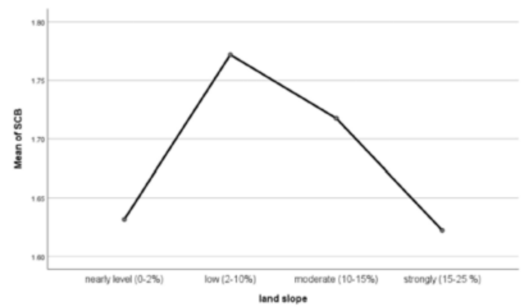

Figure 7. Mean of Conservation Behavior Regard to Land Slope; F = 0.44 (P-Value = 0.72)

Grain Farmers' Intention, Attitude, PU, PEOU, TK, and TA regard to SCB

Grain farmers stated that they had a relatively low intention to use SCPs (mean = 2.31, SD = 0.90). In other word, they pointed out that they poorly want to use SCPs in the near future (mean = 1.98, SD = 0.87) and continuously (mean = 2.01, SD = 0.84). Also, they stated that they poorly advise other farmers to use SCPs (mean = 2.04, SD = 0.86). Farmers had a fairly good feel toward SCB (mean = 2.80, SD = 1.13). However, SCB had a relatively low value for them (mean = 2.18, SD = 0.97) and they had low satisfaction toward SCB (mean = 1.96, SD = 0.89) (Table 6).

Grain farmers had relatively poor perceptions of the efficiency and effectiveness of SCB (mean = 2.20, SD = 0.78). However, they fairly believed that SCB would lead to healthier products (mean = 2.88, SD = 1.26) and have fewer adverse effects on the environment (mean = 2.52, SD = 1.05). The remarkable finding is that they poorly believed that SCB is profitable in the long run and will improve the crop yield. Grain farmers believed using SCPs is not easy and needs a lot of effort (mean = 2.05, SD = 0.80). In other word, they think it is not easy to acquire the skills needed to use SCPs (mean = 1.61, SD = 0.66) and they couldn't easily learn how to use SCPs (mean = 1.73, SD = 0.78).

They think they would find it easy to acquire the necessary skills to use SCPs. Nevertheless, they believed SCB is fairly complicated and difficult (mean = 2.38, SD = 1.15) and fairly troublesome than conventional farming behavior (mean = 2.49, SD = 1.21).

The result further revealed that grain farmers had poor access to required SC inputs and technologies (mean = 1.71, SD = 0.56). The respondents stated that they primarily could not easily afford the cost of providing these inputs and technologies (mean = 1.50, SD = 0.68). Moreover, they could not easily get them from the nearest supply center whenever they wanted (mean = 1.65, SD = 0.72). In addition, these inputs and technologies weren't sufficiently available in supply centers in their area (mean = 1.98, SD = 0.85). The current study also indicated that grain farmers had low TK with regard to SCB (mean = 2.00, SD = 0.70). They knew more about how to use organic manure (mean = 2.42, SD = 0.95) and less about how to planting of the cover crops (mean = 1.76, SD = 0.75) rather than the other SCPs (Table 6).

Table 6. Descriptive Statistic of Latent and Observed Variables

Latent variables	Observed variables	Frequency (%)					Mean	SD
SCB		Never	Seldom	Sometimes	Usually	Always	1.74	0.63
	SCB1	110 (45.27)	98 (40.33)	29 (11.93)	6 (2.47)	0 (0.00)	1.72	0.77
	SCB2	58 (23.87)	93 (38.27)	67 (27.57)	21 (8.64)	4 (1.65)	2.26	0.97
	SCB3	205 (74.36)	31 (12.76)	7 (2.88)	0 (0.00)	0 (0.00)	1.19	0.46
	SCB4	115 (47.32)	60 (24.69)	50 (20.58)	17 (7.00)	1 (0.41)	1.88	0.99
	SCB5	118 (48.56)	100 (41.15)	19 (7.82)	6 (2.50)	0 (0.00)	1.64	0.73
Intention		S. D. Agree**	D. Agree	Undecided	Agree	S. Agree	2.31	0.90
	Intention1	88 (36.21)	78 (32.10)	71 (29.22)	6 (2.47)	0 (0.00)	1.98	0.87
	Intention 2	77 (31.69)	93 (38.27)	67 (27.57)	5 (2.06)	1 (0.41)	2.01	0.84
	Intention 3	72 (29.63)	95 (39.09)	72 (29.63)	4 (1.65)	0 (0.00)	2.03	0.81
	Intention 4	77 (31.69)	86 (35.39)	74 (30.45)	5 (2.06)	1 (0.41)	2.04	0.86
Attitude							2.02	0.71
	Attitude1	42 (17.28)	39 (16.05)	106 (43.62)	38 (15.64)	18 (7.41)	2.80	1.13
	Attitude2	69 (28.40)	82 (33.74)	79 (32.51)	6 (2.47)	7 (2.88)	2.18	0.97
	Attitude3	85 (34.98)	95 (39.09)	53 (21.81)	7 (2.88)	3 (1.24)	1.96	0.89
PEOU							2.05	0.80
	PEOU1	119 (48.97)	100 (41.15)	24 (9.88)	0 (0.00)	0 (0.00)	1.61	0.66
	PEOU2	115 (47.32)	78 (32.10)	50 (20.58)	0 (0.00)	0 (0.00)	1.73	0.78
	PEOU3	66 (27.16)	68 (27.99)	74 (30.45)	20 (8.23)	15 (6.17)	2.38	1.15
	PEOU4	67 (27.57)	54 (22.22)	73 (30.04)	33 (13.58)	16 (6.59)	2.49	1.21
PU							2.20	0.78
	PU1	159 (65.43)	68 (27.98)	15 (6.17)	1 (0.41)	0 (0.00)	1.42	0.63
	PU2	39 (16.05)	68 (27.98)	44 (18.11)	68 (27.98)	24 (9.88)	2.88	1.26
	PU3	77 (31.69)	104 (42.80)	52 (21.40)	5 (2.06)	5 (2.06)	2.00	0.90
	PU4	55 (22.63)	49 (20.16)	102 (41.98)	31 (12.76)	6 (2.47)	2.52	1.05
TA							1.71	0.56
	TA1	89 (36.63)	72 (29.63)	81 (33.33)	1 (0.41)	0 (0.00)	1.98	0.85
	TA2	119 (48.97)	90 (37.04)	33 (13.58)	1 (0.41)	0 (0.00)	1.65	0.72
	TA3	145 (59.67)	75 (30.87)	22 (9.05)	1 (0.41)	0 (0.00)	1.50	0.68
TK							2.00	0.70
	TK1	86 (35.39)	110 (45.27)	39 (16.05)	8 (3.29)	0 (0.00)	1.87	0.80
	TK2	41 (16.87)	92 (37.86)	81 (33.33)	24 (9.88)	5 (2.06)	2.42	0.95
	TK3	98 (40.33)	112 (46.09)	27 (11.11)	6 (2.47)	0 (0.00)	1.76	0.75
	TK4	103 (42.38)	71 (29.22)	51 (20.99)	17 (7.00)	1 (0.41)	1.94	0.98
	TK5	90 (37.04)	75 (30.86)	64 (26.34)	14 (5.76)	0 (0.00)	2.01	0.93

***** 5-point scale for measuring SCB

5-point scale:** Strongly Disagree (S. D. Agree); Disagree (D. Agree); Undecided; Agree; Strongly Agree (S. Agree)

Factors Explaining Grain Farmers' SCB based on Original TAM

The results from Table 7 confirmed the significant impact of all predicting factors of SCB in the original TAM (t-value > 1.96). In more detail, intention had a direct and significant effect on SCB (β = 0.64; t-value = 17.88) that is similar to the results of studies by Bagheri et al. (2020), Michels et al. (2019), van Dijk et al. (2016), and Wauters et al. (2010).

Attitude influenced intention to use SCPs (β = 0.55; t-value = 8.66). As similar results, previous studies revealed there was a positive and significant relationship between attitude and intention to use (Bagheri et al., 2020; Despotović et al., 2019; Silva et al., 2018; Verma & Sinha, 2018; Werner et al., 2017). For example, Werner et al. (2017) concluded that farmers' attitude toward growing cover crops significantly affected their intention to use them. PU affected attitude significantly (β = 0.49; t-value = 7.99) which is in line with the results of previous studies (Bagheri et al., 2020; Fantappiè et al., 2020; Rezaei et al., 2020; Silva et al., 2018; Wang et al., 2019). Unlike to this finding, Verma and Sinha (2018) revealed that PU had no significant and direct effect on attitude. PU positively influenced farmers' intention to use (β = 0.38; t-value = 6.01). This result is consistent with the findings from studies by Bagheri et al. (2020), Naspetti et al. (2017), Michels, Bonke, and Musshoff (2019), and Verma and Sinha, (2018) indicating PU had a positive and significant effect on intention to accept. In contrast to this, Wang, Jin, and Mao (2019) and Silva, Canavari, and Sidali (2018) depicted that PU had no direct effect on the intention to use. PEOU had a significant direct effect on PU (β = 0.86; t-value = 17.38), which is consistent with findings by Rezaei, Safa, and Ganjkhanloo (2020), Bagheri et al. (2020), and Verma and Sinha (2018) explaining PEOU had a significant effect on PU. This result is in contrast with a study by Silva, Canavari, and Sidali (2018) which indicated PEOU had no significant direct effect on PU. PEOU is positively associated with farmers' attitudes (β = 0.37; t-value = 6.26). This result is in accordance with the studies by Rezaei, Safa, and Ganjkhanloo (2020), Bagheri et al. (2020), and Verma and Sinha (2018) displaying PEOU had a direct and significant effect on attitude. In contrary with this finding, Silva, Canavari, and Sidali (2018) revealed that PEOU had no significant direct effect on attitude.

How TK and TA can Explain Grain Farmers' SCB?

The result from Table 7 depicted that TK had an indirect effect on PU and a direct effect on PEOU (β = 0.54; t-value = 13.50), similarly Werner et al. (2017) revealed that enhancing farmers' knowledge can decrease their perception of difficulty to implement conservation measures. Samiee and Rezaei-Moghaddam (2017) and Faruque-As-Sunny, Huang, and Karimanzira (2018) indicated that farmers' knowledge about SCPs such as conservation tillage had a significant impact on their acceptance behavior. It is noteworthy that enhancing TK can be facilitated through farmers' access to extension services (Timprasert et al., 2014). In contrast with these results, Han et al. (2018) depicted farmer awareness of conservation tillage technology had significant negative effects on the adoption of conservation tillage. TA had no direct impact on PU (β = -0.02; t-value = 0.34) but direct impact on PEOU (β = 0.34; t-value = 7.60), which is in line with the studies by Pagliacci et al. (2020), Matuschke and Qaim (2008), and (Buah et al., 2011) concluding TA had a significant effect on the acceptance behavior and could increase the adoption rate. Moreover, Farouque & Takeya, (2008) introduced the unavailability and unstable market price of fertilizers during crop seasons as one of the main obstacles to the adoption of integrated soil fertility and nutrient management system practices. Based on the total effect of the predicting variables of SCB (Table 8), intention was the most important factor explaining SCB. PEOU was the most important factor influencing intention. To improve farmers' PEOU, enhancing TK and facilitating TA are important, correspondingly. In other word, for improving grain farmers' SCB, TA should be facilitated along with enhancing TK.

Table 7. Structural Estimates

Dependent variable	Independent variable	β*	t-value**	S. E	Decision
SCB	Age	0.21	1.15	0.190	Not supported
	Farming experience	-0.31	1.72	0.180	Not supported
	Education level	-0.01	0.21	0.052	Not supported
	Land tenure	-0.01	0.05	0.051	Not supported

Dependent variable	Independent variable	β*	t-value**	S. E	Decision
	Cultivation area	0.04	1.12	0.040	Not supported
	Land slope	-0.04	0.85	0.049	Not supported
	Intention	0.64	17.88	0.035	Supported
Intention	Attitude	0.55	8.66	0.065	Supported
	PU	0.34	5.37	0.064	Supported
Attitude	PU	0.49	7.99	0.062	Supported
	PEOU	0.37	6.26	0.060	Supported
PU	PEOU	0.86	17.38	0.049	Supported
	TK	-0.03	0.59	0.056	Not supported
	TA	-0.02	0.34	0.051	Not supported
PEOU	TK	0.54	13.50	0.039	Supported
	TA	0.34	7.60	0.044	Supported

* The path coefficients can be interpreted as standardized β coefficients (Hair et al., 2017)
** bootstrapping with 5,000 subsamples

Table 8. Standardized Direct Effect, Indirect Effect and Total Effect between Latent Variables

Dependent variables	Independent variables	Direct effect	Indirect effect	Total effect	t-value	S. E
SCB	Intention	0.64	-	0.64	17.88	0.036
	Attitude	-	0.35	0.35	7.96	0.045
	PU	-	0.39	0.39	9.48	0.041
	PEOU	-	0.46	0.46	12.67	0.037
	TK	-	0.24	0.24	7.29	0.032
	TA	-	0.15	0.15	5.26	0.028
Intention	Attitude	0.55	-	0.55	8.66	0.064
	PU	0.34	0.27	0.61	11.85	0.051
	PEOU	-	0.72	0.72	20.43	0.035
	TK	-	0.37	0.37	9.49	0.039
	TA	-	0.23	0.23	5.70	0.041
Attitude	PU	0.49	-	0.49	7.99	0.061
	PEOU	0.37	0.39	0.76	25.26	0.031
	TK	-	0.41	0.41	10.15	0.040
	TA	-	0.26	0.26	6.40	0.040
PU	PEOU	0.86	-	0.86	17.38	0.049
	TK	-0.03	0.46	0.43	8.36	0.051
	TA	-0.02	0.29	0.27	4.91	0.055
PEOU	TK	0.54	-	0.54	13.50	0.040
	TA	0.34	-	0.34	7.60	0.044

Conclusion

In this article, we have attempted to reveal those factors that are key to the grain farmers' SCB by emphasizing the role of TA and Tk in shaping grain farmers' PU and PEOU in TAM. It was found that farmers used organic manuring more and cover cropping less than the other SCPs because they had more knowledge about organic manuring and less knowledge about planting cover crops rather than the other SCPs. Farmers had poor access to SC technologies because they could not easily afford the cost of them and they could not get them from the nearest supply center. There was no significant impact of contextual variables such as age, farming experience, education level, land tenure type, cultivated area, and land slope on the farmers' SCB. The results confirmed that intention had a direct and significant effect on SCB; attitude influenced intention; PU and PEOU affected attitude significantly; PU positively influenced farmers' intention to use; and PEOU had a significant direct effect on PU. Based on the total effect of the predicting variables of SCB, intention was the most important factor explaining SCB and PEOU was the most important factor influencing intention. TK and TA were the most important variables influencing PEOU, respectively.

These findings guide us to the following recommendations towards the authorities, regional and local administrates and non-governmental organizations involved in improving farmers' conservation behavior. First, in order to reduce the soil degradation on the grain farms, assistance staff should change farmers' SCB through changing their intention to use SCPs. This is possible through improving farmers' PEOU. To improve farmers' PEOU, enhancing TK and facilitating TA are important, correspondingly. In other word, for improving grain farmers' SCB, TA should be facilitated along with enhancing TK. Enhancing farmers' TK could be possible by providing access to agricultural extension services. Taking a closer look, we found that among various SCPs, farmers' TK about using organic manure was higher than the other SCPs. One of the reasons was that more extensional activities had been done in this field because of farmers' more access to organic manuring technologies rather than the other SC technologies. With these interpretations, it can be said that in order to change the farmers' SCB, access to technology should be facilitated along with training and extension of SCPs. TA will be met by providing conditions for farmers to access SC technologies easily. Therefore, policymakers are advised to: 1) supply enough SC technologies in the studied area, and 2) increase the purchasing power of farmers through granting cheap credit facilities and supplying inputs and technologies at affordable prices.

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