Factors affecting the implementation of soil conservation practices among Iranian farmers

Moslem Savari*1, Masoud Yazdanpanah & Davoud Rouzaneh

As soil is the basis for agriculture, soil erosion is one of the major threats to food security in arid and semi-arid regions across the world. Therefore, soil conservation is an important step to increase productivity and ensure sustainability in agriculture. To implement soil conservation measures, farmers must voluntarily adopt soil conservation behaviors. Therefore, it may be important to understand the psychological and social factors that influence farmers’ environmental sustainability. Thus, in this study, social cognitive theory (SCT) was used as a theoretical framework to investigate the factors influencing Iranian farmers’ soil conservation behaviors (SCBs). The results showed that SCT was a successful theory in this area as it could explain 0.662 and 0.537 percent of behavioral intentions (BI) and SCBs, respectively. Moreover, the two components of self-efficacy (SE) and outcome expectancies (OE) were the strongest SCT variables that influenced SCBs. Overall, our results may provide new insights for policymakers in the agricultural sector to reduce soil erosion.

Today, human beings confront unprecedented challenges due to increasing demand for food and environmental sustainability1,2, primarily because agriculture is suffering from a variety of climatic stresses3–6 and on the other hand, recently increasing pressure on farmland to food production for the growing population has led to improper land use and severe ecological damage7,8. In conventional agriculture, tillage practices are inappropriately carried out without regard to the negative consequences on the environment to maximize production and income4. In contrast, soil erosion and land degradation negatively affect the economic, social, and environmental development of agriculture9–12. To increase productivity and maintain the sustainability of natural resources13, a paradigm shift in agriculture is essential by eliminating unstable elements of conventional agriculture (plowing and tillage, depletion of soil organic matter, monocultures, etc.)14.

There is no doubt that soil is the most important source of production for meeting basic human needs, especially food and wood15,16. Although soil produces food and wood, it forms so slowly that it is practically non-renewable17. Therefore, a wide range of sustainable farming methods has been proposed to address the problems of food security and sustainability in agriculture across all regions of the world18. In other words, the application of conservation agriculture methods due to its sustainable principles such as permanent ground cover, planned crop rotation, maintenance of agricultural soil structure, integrated weed management15,19 as an agroecological approach has been introduced and promoted worldwide to address the concerns of sustainable agriculture20,21. This agricultural system leads farmers to tend to apply crop rotations, maintain soil fertility by preserving crop residues, and perform minimum tillage, which ultimately leads to economic and sustainable production22,23.

A significant proportion (70–80%) of the world’s agricultural land is affected by soil erosion, according to international studies21. Statistics and data confirm that Asia has the highest rate of soil erosion among all continents. Moreover, among all Asian countries, Iran is at the top of the list of countries suffering from soil erosion, as about 94% of its agricultural land is affected by soil degradation24. This country has a large desert area and its soils are not well covered. As a result, soil erosion in Iran reaches 16.6 tons per hectare annually, with an increasing trend24. Due to soil and climatic conditions, there is no appropriate situation for agricultural fields in this region25. Moreover, low rainfall, lack of soil organic matter, erosion, and poor soil quality are other factors that limit the possibilities of agricultural land in Iran26. Since soil erosion irreversibly damages agricultural land, it is one of the main causes of agricultural land destruction27. This negative impact can be considered a vital problem as it not only reduces agricultural productivity but also contributes to desertification and more poverty in rural areas28.

Department of Agricultural Extension and Education, Agricultural Sciences and Natural Resources University of Khuzestan, Mollasani, Iran. *email: Savari@asnrukh.ac.ir
The three main factors destroying soil are climatic, soil physical properties, and management factors, the last of which can play a significant role. This is because although farmers use conventional methods that increase the level of soil degradation, there are no measures to protect the soil from erosion. Moreover, growers use inputs to increase productivity, which ultimately increases soil degradation. Therefore, the adoption of soil conservation technologies can be one of the most important measures to combat erosion and soil degradation.

The adoption of agricultural technologies is influenced by several factors, and in many cases, soil conservation measures are not used by farmers. New soil conservation technologies can be applied through rules and regulations, financial incentives, and voluntary behavior. Incentive programs and regulations are short-term solutions, while voluntary behaviors have long-term effects. Applying voluntary behaviors to soil conservation requires understanding farmers’ perceptions and perspectives. Scientists have also paid great attention to the importance of farmers’ role in controlling soil erosion and protecting soil, which is necessary to study and recognize the cognitive and behavioral characteristics of farmers and rural communities.

Although most studies on the application of soil conservation technologies have focused on economic factors, relatively little research has been conducted on the psychological factors influencing farmers’ conservation behavior. Researchers have found that focusing on economic factors alone cannot fully explain people's conservation behavior because people’s decisions are not always driven by economic factors. According to studies on the adoption of new soil conservation technologies, changing farmers’ perceptions is the most important factor influencing the adoption of these technologies. Consequently, we need to change farmers' behavior to adopt the technology at the farm level so that they accept voluntary behaviors, because studies have shown that one of the major obstacles to the adoption of conservation agriculture at the field level is to convince farmers to engage in conservation behaviors.

The theory of planned behavior (TPB) describes SE as a constructive force through which human cognitive, social, emotional, and behavioral abilities are effectively organized to achieve goals. SE refers to a person’s sense of empowerment and confidence to use behavior change techniques. Facilitators and obstacles are socio-structural factors (SSFs) that are part of the human behavior area because it accounts for the dynamic nature of individuals’ behavior and explains a higher degree of variance in protective behavior. Furthermore, because the variables in this theory are good at predicting changes in behavior, it is more important than other theories. However, there is no attempt to evaluate the effect of SCT on the adoption of SCBs. To fill this gap, we focused on this theory. Therefore, this study aimed at two objectives: (i) to determine the explanatory power and efficiency of SCT in explaining SCBs, and (ii) to understand the determinants in the use of SCBs, and to determine the applicable strategies in this area.

**Theoretical framework**

**Social cognitive theory (SCT).** Social cognitive theory (SCT) was first proposed by Bandura. Its application dates back to the 1970s. Initially, this theory was widely used in the field of health behavior prediction and obtaining medical information systems to understand the psychological mechanisms of individuals. SCT is one of the most widely used theories of behavior change, as it discusses how to establish and maintain patterns of behavior. According to this theory, an individual’s self-confidence plays a crucial role in his ability to perform a behavior. Moreover, it assumes that human behavior is the result of a threefold reciprocal and dynamic interaction between the individual, their behavior, and the environment in which they exist. Personal beliefs relate to the self-efficacy (SE) of the individual, behavioral factors include long-term goals, whereas environmental factors are obstacles and supporting factors. According to this theory, behavior is influenced not only by experience but also by the observation of others. Key constructs in SCT include Aim, SE, Outcome Expectancies (OE), Environmental Factors (EF), Perception of Others’ Behavior (POB), and Behavioral Intentions (BI).

Kinetic and reciprocal effects on the environment are key components of SCT theory. Bandura describes SE as a constructive force through which human cognitive, social, emotional, and behavioral abilities are effectively organized to achieve goals. SE refers to a person’s sense of empowerment and confidence to use certain behaviors to achieve a goal. Situations in which people have confidence in their abilities, behavior, perceptions, and feelings are markedly different from situations in which the person feels incapable, insecure, or incompetent. A strong sense of SE enhances personal well-being and ability. A person with a high SE attempts to accomplish difficult tasks and sets higher goals. Conversely, people with low SE avoid challenging issues and problems. These people are weakly committed to their goals, and when faced with obstacles, they focus on their failures and negative outcomes instead of finding solutions. Research shows that SE plays a significant role in influencing individual behavior and goal achievement. There are two main categories of EF that influence behavior: Behavioral barriers and Social support. Social support refers to how the behavior of others influences an individual's adoption of a behavior. Behavioral change is facilitated by this factor, which provides a positive foundation for other predictors or key elements of SCT. Environmental obstacles are personal and social factors that directly or indirectly hinder behavior change. The more obstacles present, the less likely people are to use behavior change techniques. Facilitators and obstacles are socio-structural factors (SSFs) that are part of the environmental aspects of SCT and can predict goal attainment and behavior. Thus, the environment influences the behavior of others and provides a framework for understanding behavior. OE is another important construct of this theory that influences BI, which can be viewed as positive and negative expectations. A more positive OE provides a higher probability of adopting a particular behavior, while a lower OE is a barrier to the use of the behavior. The main difference between SE and OE is that SE defines self-confidence in one's ability to perform important tasks, whereas OE defines beliefs about the consequences of such behavior. Another SCT variable that directly affects behavioral choice is BI, which refers to mental tendency along with desire and conscious tendency to act that is the strongest influencing variable on behavior. Figure 1 shows the used version of SCT in this study. The research hypotheses are formed based on this version.
Layer (1): Outcome expectancies (H1), self-efficacy (H2), perception of others’ behavior (H3), and socio-structural factors (H4) have significant effects on behavioral intentions.

Layer (2): Behavioral intentions (H5), outcome expectancies (H6), self-efficacy (H7), perception of others’ behavior (H8), and socio-structural factors (H9) significantly affect behaviors.

Methodology

Study type. This practical study was a quantitative type. The data collection was conducted as a field survey that was performed as a single-cross study.

Study area. This study was conducted in Behbahan city of Khuzestan province (southwest of Iran) (Fig. 2). The average annual precipitation and evaporation in this city are less than 255 and 2100 mm, respectively. In Khuzestan province, there are about 2.3 million hectares of fertile land, of which only a small part (20%) is cultivable. On average, nearly 18 tons of soil per hectare are eroded annually. Khuzestan province (including Behbahan) ranks first in Iran due to this increasing trend of soil erosion. This adverse effect caused by climatic and human factors has limited opportunities for agricultural activities. In some cases, this soil degradation has even led to increased dust pollution in the region, which has ultimately affected the livability of rural households. Since climatic factors are difficult to control, they can only help reduce soil erosion by changing the behavior of farmers in an environmentally friendly way.

Statistical population and sample size. This study included all farmers in Behbahan city, Khuzestan province. Using the table of Krejcie and Morgan, 300 participants were selected by multistage stratified random sampling method with proportional allocation. Most farmers were in the middle age group with average age of 43.68 years and they had agricultural work experience of 19.36 years. The average number of their family members was 5.16 ± 3.55. A considerable proportion of them (62.7%) had attended soil conservation courses. A considerable percentage of them (37%) were also members of agricultural cooperatives. The annual income of farmers was 95.28 ± 37.53 million tomans per year (Descriptive statistics and classification of these variables are available in Table S1).

Statement. All interviewees were informed about data protection issues by the enumerators and gave their consent orally at the beginning of each interview. Informed consent was obtained from all individual participants included in the study. All materials and methods are performed in accordance with the instructions and regulations and this research has been approved by a committee at Agricultural Sciences and Natural Resources University of Khuzestan, Mollasani, Iran. This research has been approved by an institutional review board at Agricultural Sciences and Natural Resources University of Khuzestan, Mollasani, Iran. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Data availability. The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.
Measurements. The main instrument in this research was a questionnaire consisting of two major parts. The first one included the farmers’ characteristics and their farm features. The second part consisted of items assessing SCT, which included 24 items in seven subsections: (i) four OE items (ii) three POB items (iii) three BI items (iv) three SSF items (v) four SE items, and (vi) seven items measuring SCBs. Next, the respondents were asked to comment on the statements measuring the variables as they agree with them (Likert scale 1- very low to 5 very high). The Likert scale reduces statistical problems (Fornell, 1992). One of the most important points of this research is to measure the variables SCT based on previous studies. The questionnaire items are shown in Table 1. (Descriptive statistics and classification of these variables are available in Table S2).

Validity and reliability of the instrument. Before interviewing farmers, the draft questionnaire and questions were reviewed by a panel of experts, and based on their comments, desired changes were made to the questionnaire until it was eventually finalized. In addition, Cronbach’s alpha coefficient and combined reliability were used to assess the reliability of the research instrument (Table 2).

Data analysis. Data were collected and analyzed using SPSS23 and SmartPls software. SmartPls was developed because of the weaknesses of first-generation structural equation modeling (SEM) and was introduced as the second generation of component-based SEM methods. There are several reasons that researchers use SEM so frequently for data analysis. First, because of its ability to test theories in terms of equations between variables. Also, by considering measurement error, the researcher can analyze the data by describing the error. SEM consists of two steps, measurement and a structural model. Measurement is about how to explain the hidden variables by explicit variables. Namely, this step examines the validity of the explicit variables in measuring the hidden variables. Structural models, on the other hand, examine the relationship between the hidden variables to test the research hypotheses.

In addition, independent t-test and F-test were used to compare farmers’ SCB based on two-level and multilevel variables, respectively. These two types of tests are among the parametric tests that have high accuracy for comparing the means of groups. Independent t-test is used to compare the means of two groups and F-test is used to compare the means of several groups. The results of these tests have a higher validity than non-parametric tests.

Informed consent. Informed consent was obtained from all individual participants included in the study.
Results

Comparison of farmers’ SCBs based on individual and demographic variables. In order to compare farmers’ SCBs based on two variables, membership in cooperatives and soil conservation courses, t-test was used. Based on the results, it can be said that farmers who were members of agricultural cooperatives or participated in soil conservation training courses had higher SCBs (Table 2).

In order to compare farmers’ SCBs based on multilevel variables, age, agricultural work experience, number family members and incom, one-way ANOVA was used. Based on the results, it can be said that there was no significant difference between farmers based on these variables (Table 3).

Structural equation modeling. In this section, the Partial Least Squares (PLS) approach was used to examine the predicted relationships in the conceptual research model. The results of this section are presented in two sections: Measurement model and research structural model.
Assessment of the measurement model. The assessment of the measurement model was performed in three stages: unidimensionality, Validity and Reliability, and Discriminant Validity. The following are the results of the assessment steps for measuring research constructs.

Unidimensionality. This step was evaluated by the values of factor loading and t. According to the results (Table 4), it can be assumed that this factor value for the selected markers (above 0.603) was statistically significant at the error level of (P < 0.01). This result confirms the unidimensionality of the selected markers. Conse-
Consequently, the markers used to determine the research constructs were correctly selected and measured exactly the same component.

Validity and reliability. In this step, the values of combined reliability (CR), Cronbach’s alpha, and average variance extracted (AVE) were checked. As shown in Table 4, CR, Cronbach’s alpha coefficient, and AVE of all constructs in the proposed research model were greater than 0.60, 0.70, and 0.50, respectively; therefore, all latent variables in the proposed research model were reliable and valid. This result indicates that the items selected to measure the research constructs are carefully chosen and allow the experiment to be repeated.

Discriminant validity. Diagnostic validity occurs when questions measuring one variable differ from questions measuring other variables. If the AVE between the research variables is statistically greater than the correlation between them, the research variables have adequate diagnostic validity. According to Table 5, it was found that the AVE for the research constructs (0.76 < AVE < 0.89) was greater than their correlation (0.44 < r < 0.74). This result indicates that the diagnostic validity of the constructs in the proposed research model was confirmed.

Assessment of the research structural model. Various indicators were used in testing the fit of the structural research model (Table 6). Considering the proposed values of the indicators and the number of values given, it is obvious that the model fits well and can be used to test the research hypotheses.

After confirming the measurement and structural models of the research using confirmatory factor analysis, the method of path analysis (assessment of the structural model) was used to test the hypotheses in the proposed conceptual model of the research. The path model of the research, which shows standardized factor loadings and significance, is shown in Figs. 3 and 4.

Test of research hypotheses: this stage presents the final results of the variables related to the use of SCBs at the field level. Bootstrapping was used to assess the significance of the path coefficient or beta method. Thereby, it was used in two states, including 100 and 300 samples. The results showed that in both cases there was no change in the significance of the parameters and the results were significantly valid. Since the significance of the relationship between the variables was not affected by the sample size, while the t-statistic solely changed; therefore, hypotheses can be tested in the form of a regression model. The results showed that all the research hypotheses were confirmed based on the predicted relationships. Moreover, the research variables were able to explain 53.7% of the SCBs (Table 7).

Discussion
In this study, the decisions of Iranian farmers to use SCBs in the field were investigated using the psychological-social model of SCT. According to the authors’ knowledge and literature review, there has been no attempt to study SCT among farmers around the world. While most of the studies in agriculture have studied SCT to assess water conservation behavior and energy use in fields. Therefore, this research can fill the gap of many previous studies to some extent and provide new insights for policymakers in this area. In addition, the results of this study can assist other countries in arid and semi-arid regions of the world, as well as in tropical regions that suffer from soil erosion.

The results of comparing means showed that there is a significant difference between farmers’ SCBs based on two variables; membership in cooperatives and soil conservation courses. The results of this section are in line with the studies. Therefore, increasing farmers’ knowledge through training courses and cooperatives has a key role in using SCBs. Low levels of knowledge and skills may limit the adoption of conservation behaviors in agriculture, as the context of sustainable development activities is highly dependent on human resources.

| Constructs | 1 | 2 | 3 | 4 | 5 | 6 |
|------------|---|---|---|---|---|---|
| 1. BI | 0.89* |
| 2. SSF | −0.64** 0.76* |
| 3. OE | 0.63** −0.62** 0.79* |
| 4. POB | 0.52** −0.53** 0.44** 0.88* |
| 5. SE | 0.74** −0.58** 0.53** 0.47** 0.85* |
| 6. Behaviors | 0.59** −0.45** 0.63** 0.52** 0.50** 0.87* |

Table 5. Correlations with square roots of the AVE. *The square roots of AVE estimate. **Correlation is significant at the < 0.01 level.

| Fit index | SRMR | D-G1 | D-G2 | NFI | rms-theta |
|-----------|------|------|------|-----|----------|
| Suggested value | <0.1 | >0.05 | >0.05 | >0.90 | ≤0.12 |
| Estimated value | 0.08 | 0.775 | 0.452 | 0.98 | 0.08 |

Table 6. Summary of Goodness of Fit Indices for the Measurement Model.
In addition, the results of comparing farmers’ SCBs based on the studied variables (age, agricultural work experience, the number of family members, income) showed that there was no significant difference in this area.

SEM was used to examine the factors associated with the use of SCBs in this study, and the results showed that this theory was very successful. This can be explained by two reasons: (i) All relationships between the constructs of SCT were statistically significant, and all research hypotheses were verified; therefore, it can be argued that the SCT model was much more successful in SCBs than in other application domains. (ii) SCBs have greater explanatory variance than their use in areas such as water conservation51,52 and renewable energy64. The research hypotheses are discussed below.

The SEM results showed that OE had a direct influence on BI51,52,84–86 and protective behavior40. This finding confirmed the hypotheses of 1 and 6. The reason for this result lies in the fact that a positive OE will always motivate people to continue an activity. A negative OE, on the other hand, is always seen as a major obstacle to engaging in an activity21. According to Bandura’s49 theory, inhibitors and incentives can be effective in the adoption of a behavior. That is if an inappropriate behavior in the environment has positive or negative consequences for individuals, the likelihood that they will adopt the behavior changes9,40,87. It can be concluded that farmers who are aware of the positive consequences of using SCBs are more motivated to take action to protect the environment. According to the research of Shahangian et al.51 OE can take three forms: (1) a positive attitude and pleasant feeling toward participating in SCBs (expectation of a physical outcome), (2) an understanding of social support in participating in SCBs (expectation of social consequences), and (3) a sense of a moral norm in performing such behaviors (expectation of self-assessed consequences) that affect individuals’ intentions and behaviors.

SE was the most influential variable on BI and SCBs9,30,57,83,87. This result confirmed hypotheses 2 and 7. SE influences behavioral choice, effort, and goal pursuit, and determines how to deal with obstacles and challenges40. According to Bandura’s49 emotions, thoughts, and behavior in any situation depend on the person’s sense of ability. Therefore, the use of SCBs requires good skills and knowledge so that a simple understanding of the nature of soil conservation activities influences farmers’ behavior. This suggests that farmers who better understand soil conservation will be more engaged in such activities85,86. SE will lead farmers to believe that soil-conserving behaviors are possible. Indeed, SE creates a moral obligation among farmers to protect the soil. Therefore, it might be vital for farmers to attend seminars and workshops to become more familiar with soil conservation and understand more about the use of soil conservation measures and their effects.

According to the studies Valizadeh et al.40, Shahangian et al.51, Schunk and DiBenedett59, POB was also effective on BI and SCBs. Our results were consistent with hypotheses 3 and 8. Social learning through observation and imitation occurs unconsciously in many people, in both positive and negative ways, which can have
effective or destructive consequences. Other researchers state that the importance of observing the behavior of others influences personal behavior and believe that understanding the behavior of others is part of a person's behavior. The significance of POB to SCBs highlights the importance of the social environment and an individual's understanding of the consequences of others' behavior. In agrarian societies, conversion is usually difficult due to financial and professional inadequacies, so they usually wait to learn the attitude and consequences of behavior from others, then accept it when there is positive feedback. Similarly, Warner showed that observing the neighbors' behavior constantly impacts further on the acceptance of a friendly behavior in the neighborhood than when a person with a high social status promotes and spreads a behavior. However, when behavior is institutionalized in society as a value or norm, violating it may lead to social exclusion for others. Therefore, farmers imitate other people to avoid social isolation and accept the behavior. By doing so, people with higher social and economic status can influence the behaviors of farmers who are more inclined to conserve soil, since social pressure always influences the behavioral tendencies and actual behavior of individuals.

Figure 4. Path model with t-values.

Table 7. Results of research structural models.

| Hypothesis | β  | t    | Result | R²    |
|------------|----|------|--------|-------|
| H1: OE → BI | 0.239 | 4.190 | Confirm | 0.662 |
| H2: SE → BI | 0.503 | 9.398 | Confirm |       |
| H3: POB → BI | 0.110 | 2.003 | Confirm |       |
| H4: SSF → BI | -0.129 | 2.300 | Confirm |       |
| H5: BI → behaviors | 0.253 | 3.497 | Confirm |       |
| H6: OE → behaviors | 0.348 | 4.800 | Confirm |       |
| H7: SE → behaviors | 0.151 | 2.334 | Confirm |       |
| H8: POB → behaviors | 0.238 | 4.333 | Confirm |       |
| H9: SSF → behaviors | -0.122 | 2.190 | Confirm |       |
the existing educational and economic barriers must be overcome. In other words, the use of soil conservation practices may initially reduce farmers’ income even if it brings them long-term benefits. It can also cause a lot of wasted time for farmers, as they are not familiar with these behaviors. To solve this problem, two measures can be recommended, including (1) providing information through farmer cooperatives to familiarize farmers with a particular measure and (2) commitment of the government to cover part of the soil conservation measures cost in the early years or providing agricultural subsidies to farmers, especially to those with less financial capacity. There are numerous studies showing that increasing incentives can always improve environmental performance. Finally, the results showed that BI positively and significantly affected farmers’ SCBs, confirming hypothesis 5. According to SCT and TPB theory, psychosocial factors influencing behavior are mainly achieved through BI. Earlier studies demonstrated that the intention variable is continuously the strongest and most direct factor influencing actual behavior. According to previous studies, a possible explanation could be that people with high BI in their protective behavior, consistently perform the actual behavior more than others. Therefore, policymakers in this field are generally recommended to pay special attention to the psychosocial factors mentioned in this study to create sustainable behavior, because incentives and restrictions alone cannot produce sustainable behavior in the agricultural environment (Four policy implication on SCBs among farmers are presented in text S1).

Conclusions and limitations
This study is one of the first attempts to investigate SCBs in Iran using SCT theory. The results demonstrated that SCT was a successful theory in this area because it was able to explain 0.662 and 0.537% of BI and SCBs, respectively. Our findings could provide new insights to policymakers to increase farmers’ SCBs. Moreover, according to our results, SE and OE were the strongest SCT variables in SCBs. Finally, despite the important results, three important limitations must be noted in this study. First, some variances in soil conservation behavior have not yet been explained. Therefore, it is necessary to improve the power of the model in explaining SCBs by reviewing the literature and identifying the most important variables, and including them in the SCT. Second, only SCT was used to study soil conservation behavior. Therefore, it is necessary to use other behavioral models in this area to determine their explanatory power. Third, only social and psychological factors were examined in this study. Although these factors are important components of sustainable behavior, it seems necessary to assess the economic factors outside the scope of this study.

Received: 28 February 2022; Accepted: 12 May 2022
Published online: 19 May 2022

References
1. Komarek, A. M., Thierfelder, C. & Steward, P. R. Conservation agriculture improves adaptive capacity of cropping systems to climate stress in Malawi. Agric. Syst. 190, 103117 (2021).
2. Charles, H., Godfray, H. & Garnett, T. Food security and sustainable intensification. Philos. Trans. R. Soc. B Biol. Sci. 369, 1 (2014).
3. Challinor, A. J. et al. A meta-analysis of crop yield under climate change and adaptation. Nat. Clim. Chang. 4, 287–291 (2014).
4. Challinor, A. I., Koehler, A. K., Ramirez-Villegas, J., Whitfield, S. & Das, B. Current warming will reduce yields unless maize breeding and seed systems adapt immediately. Nat. Clim. Chang. 6, 954–958 (2016).
5. Savari, M. & Shokati Amghani, M. SWOT-FAHP-TOWS analysis for adaptation strategies development among small-scale farmers in drought conditions. Int. J. Disaster Risk Reduct. 67, 1 (2022).
6. Savari, M. & Shokati Amghani, M. Factors influencing farmers’ adaptation strategies in confronting the drought in Iran. Environ. Dev. Sustain. 23, 4949–4972 (2020).
7. Savari, M., Eskandari Damanhe, H. & Eskandari Damanhe, H. Drought vulnerability assessment: Solution for risk alleviation and drought management among Iranian farmers. Int. J. Disaster Risk Reduct. 67, (2022).
8. Savari, M. & Zhololdeh, M. The role of climate change adaptation of small-scale farmers on the households food security level in the west of Iran. Dev. Pract. 31, 650–664 (2021).
9. Eder, A., Salhofer, K. & Scheichel, E. Land tenure, soil conservation, and farm performance: An eco-efficiency analysis of Austrian crop farms. Ecol. Econ. 180, 106861 (2021).
10. Keesstra, S. et al. Soil-related sustainable development goals: Four concepts to make land degradation neutrality and restoration work. 7, 133 (2018).
11. Savari, M., Naghbeiranzad, F. & Asadi, Z. Modeling environmentally responsible behaviors among rural women in the forested regions in Iran. Glob. Ecol. Conserv. 35, e01202 (2022).
12. Savari, M., Damanhe, H. E. & Damanhe, H. E. Factors involved in the degradation of mangrove forests in Iran: A mixed study for the management of this ecosystem. J. Nat. Conserv. 66, 1 (2022).
13. Bhan, S. & Behera, U. K. Conservation agriculture in India—Problems, prospects and policy issues. Int. Soil Water Conserv. Res. 2, 1–12 (2014).
14. Savari, M., Ebrahim-Maymand, R. & Mohammad-M-Kanigolzar, F. The factors influencing the application of organic farming operations by farmers in iran. Agris On-line Pap. Pop. Econ. Informatics 5, 179–187 (2013).
15. FAO. Conservation agriculture in Central Asia: Status, Policy, Institutional Support, and Strategic Framework for its Promotion. 57 pp (2013).
16. Eskandari Damanhe, H., Khosravi, H., Habashi, K., Eskandari Damanhe, H. & Tiefenbacher, J. P. The impact of land use and land cover changes on soil erosion in western Iran. Nat. Hazards 110, 2185–2205 (2022).
17. Dougill, A. J. et al. Mainstreaming conservation agriculture in Malawi: Knowledge gaps and institutional barriers. J. Environ. Manage. 195, 25–34 (2017).
18. Pannell, D. J., Llewellyn, R. S. & Corbeels, M. The farm-level economics of conservation agriculture for resource-poor farmers. Agric. Ecosyst. Environ. 187, 52–64 (2014).
19. Rajwa, A. A. Sustainable weed management in conservation agriculture. Crop Prot. 65, 105–113 (2014).
20. Lalan, B., Dorward, P., Holloway, G. & Wauters, E. Smallholder farmers’ motivations for using Conservation Agriculture and the roles of yield, labour and soil fertility in decision making. Agric. Syst. 146, 80–90 (2016).
21. Faridi, A. A., Kavosi-Kalashami, M. & Bilahi, H. E. Attitude components affecting adoption of soil and water conservation measures by paddy farmers in Rasht County. Northern Iran. Land Use Policy 99, 1 (2020).
22. Thierfelder, C. et al. Conservation agriculture in Southern Africa: Advances in knowledge. Renew. Agric. Food Syst. 30, 328–348 (2015).

23. Eskandari Damanesh, H. et al. Testing possible scenario-based responses of vegetation under expected climatic changes in Khuzestan province. https://doi.org/10.1177/117862211101333214 (2021).

24. Ateei, P., Sadighi, H., Chiari, M. & Abbasi, E. Discriminant analysis of the participated farmers’ characteristics in the conservation agriculture project based on the learning transfer system. Environ. Dev. Sustain. 23, 291–307 (2021).

25. Izadi, M., Ateei, P., Karimi-Goughi, H. & Norouzi, A. Environmental impacts of Assessment of construction of water pumping station in Bacheh Bazar Plain: A case from Iran. EQA - Int. J. Environ. Qual. 35, 13–32 (2019).

26. Megaran, M. B., Madani, K., Hashemi, H. & Azadi, P. Iran’s Land Suitability for Agriculture. Sci. Rep. 7, 1–12 (2017).

27. Jia, L. et al. Regional differences in the soil and water conservation efficiency of conservation tillage in China. CATENA 175, 18–26 (2019).

28. Kuyvenhoven, A., Ruben, R. & Pender, J. Development strategies for less-favoured areas. Food Policy 29, 295–302 (2004).

29. Hoque, R. & Sorwar, G. Understanding factors influencing the adoption of mHealth by the elderly: An extension of the UTAUT model. Int. J. Med. Inform. 101, 75–84 (2017).

30. Gupta, K. P., Manrai, R. & Goel, U. Factors influencing adoption of payments bank by Indian customers: extending UTAUT with perceived credibility. J. Asia Bus. Stud. 13, 173–195 (2019).

31. Solis, D. & Bravo-Ureta, B. E. Technical efficiency among peasant farmers participating in natural resource management programmes in Central America. J. Agric. Econ. 60, 202–219 (2009).

32. Amsalu, A. & de Graaff, J. Determinants of adoption and continued use of stone terraces for soil and water conservation in an Ethiopian highland watershed. Ecol. Econ. 61, 294–302 (2007).

33. Solis, D. & Bravo-Ureta, B. E. Economic and Financial Sustainability of Private Agricultural Extension in El Salvador. https://doi.org/10.1300/j464v26n02_0726,81-102 (2008).

34. Bagheri, A. & Teymouri, A. Farmers’ intended and actual adoption of soil and water conservation practices. Agric. Water Manag. 259, 1 (2022).

35. Rodrigo-Comino, J. et al. The potential of straw mulch as a nature-based solution for soil erosion in olive plantation treated with glyphosate: A biophysical and socioeconomic assessment. L. Degrad. Dev. 31, 1877–1889 (2020).

36. Klik, A. & Rosner, J. Long-term experience with conservation tillage practices in Austria: Impacts on soil erosion processes. Soil Tillage Res. 203, 1 (2020).

37. Singh, R. K., Singh, A. & Pandey, C. B. Agro-biodiversity in rice–wheat-based agroecosystems of eastern Uttar Pradesh, India: implications for conservation and sustainable management. 21, 46–59. https://doi.org/10.1080/13504509.2013.869272 (2014).

38. Bijani, M., Ghazani, E., Valizadeh, N. & Fallah Haghghi, N. Pro-environmental analysis of farmers’ concerns and behaviors towards soil conservation in central district of Sari County, Iran. Int. Soil Water Conserv. Res. 5, 43–49 (2017).

39. Raeisi, A., Bijani, M. & Chizari, M. The mediating role of environmental emotions in transition from knowledge to sustainable use of groundwater resources in Iran’s agriculture. Int. Soil Water Conserv. Res. 6, 143–152 (2018).

40. Valizadeh, N., Bijani, M., Hayati, D. & Fallah Haghghi, N. Social-cognitive conceptualization of Iranian farmers’ water conservation behavior. Hydrogeol. J. 27, 1131–1142 (2019).

41. Kassie, M., Jaleta, M., Shiferaw, B., Mimbando, F. & Mukuria, M. Adoption of interrelated sustainable agricultural practices in smallholder systems: Evidence from rural Tanzania. Technol. Forecast. Soc. Change 80, 525–540 (2013).

42. Teklewoeld, H., Kassie, M. & Shiferaw, B. Adoption of Multiple Sustainable Agricultural Practices in Rural Ethiopia. J. Agric. Econ. 64, 597–623 (2013).

43. Savari, M., Zholooldeh, M. & Khosravijou, B. Explaining pro-environmental behavior of farmers: A case of rural Iran. Curr. Psychol. 40, 1012–1022, https://doi.org/10.1007/s12144-021-00209-3 (2021).

44. Tej, Y. S. & Brindal, M. Factors influencing the adoption of precision agricultural technologies: A review for policy implications. Precis. Agric. 13, 713–730 (2012).

45. Savari, M., Abdeshahi, A., Gharechae, H. & Nasrollahian, O. Explaining farmers’ response to water crisis through theory of the norm activation model: Evidence from Iran. Int. J. Disaster Risk Reduct. 60, 1 (2021).

46. Ajzen, I. The theory of planned behavior. Organ. Behav. Hum. Decis. Process. 50, 179–211 (1991).

47. Davis, F. Perceived usefulness, perceived ease of use, and user acceptance of information technology. MIS Q. Manag. Inf. Syst. 13, 319–339 (1989).

48. Rogers W., R. Cognitive and physiological processes in fear appeals and attitude change: a revised theory of protection motivation. Heal. Educ. Behav. 34, 143–164 (2004).

49. Ratten, V., Ratten, H. Technological innovations and m-Commerce applications. Int. J. Innov. Technol. Manag. 4, 1–14 (2007).

50. Shahangian, S. A., Tabesh, M. & Yazdanpanah, M. Psychosocial determinants of household adoption of water-efficiency behaviors in Tehran capital, Iran: Application of the social cognitive theory. Urban Clim. 39, 1009 (2021).

51. Yazdanpanah, M., Feyzabad, F. R., Forouzani, M., Mohammadzadeh, S. & Burton, R. J. F. Predicting farmers’ water conservation goals and behavior in Iran: A test of social cognitive theory. Land Use Policy 47, 401–407 (2015).

52. Bahrami-Feyzabad, F., Yazdanpanah, M., Burton, R. J. F., Forouzani, M. & Mohammadzadeh, S. The use of a bourgeoisian “capitals” model for understanding farmer’s irrigation behavior in Iran. J. Hydrof. 591, 1 (2020).

53. Schwarzer, R. & Luszczynska, A. Predicting and changing health behavior. Heal. action Process approach 252–278 (2015).

54. Gothe, N. P. Correlates of physical activity in urban African American adults and older adults: Testing the social cognitive theory. Ann. Behav. Med. 52, 743–751 (2018).

55. Murphy, D. A., Stein, J. A., Schlinge, W. & Mailbach, E. Conceptualizing the multidimensional nature of self-efficacy: Assessment of situational context and level of behavioral challenge to maintain safer sex. Heal. Psychol. 20, 281–290 (2001).

56. Valois, R. F., Zullig, K. J. & Revels, A. A. Aggressive and violent behavior and emotional self-efficacy: Is there a relationship for adolescents? J. Sch. Health 87, 269–277 (2017).

57. Ramireez, E., Kulmina, P. H. & Cothran, D. Constructs of physical activity behaviour in children: The usefulness of Social Cognitive Theory. Psychol. Sport Exerc. 13, 303–310 (2012).

58. Schunk, D. H. & DiBenedetto, M. K. Motivation and social cognitive theory. Contemp. Educ. Psychol. 60, 101832 (2020).

59. Raskauskas, J., Rubiano, S., Offen, I. & Wayland, A. K. Do social self-efficacy and self-esteem moderate the relationship between peer victimization and academic performance?. Soc. Psychol. Educ. 18, 297–314 (2015).

60. Wang, S., Hung, K. & Huang, W.-J. Motivations for entrepreneurship in the tourism and hospitality sector: A social cognitive theory perspective. https://doi.org/10.1080/13689110.2018.11.018 (2018).

61. Zimmermann, B. J. Investigating self-regulation and motivation: Historical background, methodological developments, and future prospects. Am. Educ. Res. J. 45, 166–183 (2008).

62. Steere, S. et al. Understanding Girls’ Circle as an intervention on perceived social support, body image, self-efficacy, locus of control, and self-esteem. Adolescence 41, 55–74 (2006).

63. Solís, D. & Bravo-Ureta, B. E. Economic and Financial Sustainability of Private Agricultural Extension in El Salvador. https://doi.org/10.1300/j464v26n02_0726,81-102 (2008).
66. Plotnikoff, R. C., Lippke, S., Courneya, K. S., Birkett, N. & Sigal, R. J. Physical activity and social cognitive theory: A test in a population sample of adults with type 1 or type 2 diabetes. Appl. Psychol. AN Int. Rev. 57, 628–643 (2008).
67. Thøgersen, J. & Gronhøj, A. Electricity saving in households–A social cognitive approach. Energy Policy 38, 7732–7743 (2010).
68. Kaye, S. A., Lewis, I., Forward, S. & Delhomme, P. A priori acceptance of highly automated cars in Australia, France, and Sweden: A theoretically-informed investigation guided by the TPB and UTAUT. Accid. Anal. Prev. 137, 3441 (2020).
69. Savari, M. & Gherechae, H. Application of the extended theory of planned behavior to predict Iranian farmers’ intention for safe use of chemical fertilizers. J. Clean. Prod. 263, 1 (2020).
70. Koohizadeh, M., Mohammad Akhoond-Ali, A. & Arsham, A. The Effect of Soil Moisture Levels on the Threshold Velocity of Wind Erosion in Dust Centers of South and Southeast of Khuzestan Province–Ahwaz. Iran. J. Soil Water Res. 52, 869–885 (2021).
71. Keshavarz, M. & Karami, E. Farmers’ decision-making process under drought. J. Arid Environ. 108, 43–56 (2014).
72. Wu, J. Urban sustainability: an inevitable goal of landscape research. Landsc. Ecol. 25, 1–4 (2009).
73. Ullman, J. B. & Bentler, P. M. Structural equation modeling. Handb. Psychol. Second Ed. https://doi.org/10.1002/9781118133880. HOP202023 (2012).
74. Serda, M. Synteza i aktywność biologiczna nowych analogów tiosemikarbazonowych chelatorów żelaza. Uniw. śląski 343–354 (2013).
75. Khoshmaram, M., Shiri, N., Shinnar, R. S. & Savari, M. Environmental support and entrepreneurial behavior among Iranian farmers: The mediating roles of social and human capital. https://doi.org/10.1111/jbshn.125015,1064-1088 (2020).
76. Kim, T. K. T test as a parametric statistic. Korean J. Anesthesiol. 68, 540–546 (2015).
77. The-T-test. Source: Adapted from Semenick, (96), p. 37. | Download Scientific Diagram. https://www.researchgate.net/figure/Thet-T-test-Source-Adapted-from-Semenick-96-p-37_fig2_274192999.
78. Yadav, R. & Pathak, G. S. Intention to purchase organic food among young consumers: Evidences from a developing nation. Appetite 96, 122–128 (2016).
79. Akkey, J. E., Rintamaki, L. S. & Kane, T. L. Health Belief Model deterrents of social support seeking among people coping with eating disorders. J. Affect. Disord. 145, 246–252 (2013).
80. Ahmmadi, P., Rahimian, M. & Movahed, R. G. Theory of planned behavior to predict consumer behavior in using products irrigated with purified wastewater in Iran consumer. J. Clean. Prod. 296, 6539 (2021).
81. Bagheri, A., Bondori, A., Allahyari, M. S. & Damalas, C. A. Modeling farmers’ intention to use pesticides: An expanded version of the theory of planned behavior. J. Environ. Manage. 248, 1 (2019).
82. Sarstedt, M., Ringle, C. M. & Hair, J. F. Partial least squares structural equation modeling. Handb. Mark. Res. 1, 1–47. https://doi.org/10.1007/978-3-319-05542-8_15-2 (2021).
83. Mogaka, B. O., Bett, H. K. & Nganga, S. K. Socioeconomic factors influencing the choice of climate-smart soil practices among farmers in western Kenya. J. Agric. Food Res. 5, 1 (2021).
84. Afshar, S., Sharif, A., Wasem, N. & Faroogh, R. Internet banking in Pakistan: An extended technology acceptance perspective. Int. J. Bus. Inf. Syst. 27, 383–410 (2018).
85. Pai, F. Y. & Huang, K. I. Applying the Technology Acceptance Model to the introduction of healthcare information systems. Technol. Forecast. Soc. Change 78, 650–660 (2011).
86. Venkatesh, V., Thong, J. Y. L. & Xu, X. Consumer acceptance and use of information technology: Extending the unified theory of acceptance and use of technology. MIS Q. Manag. Inf. Syst. 36, 157–178 (2012).
87. Ngoru, W. M., Gachene, C. K., Onyango, C. M., Nganga, S. K. & Girvetz, E. H. Factors constraining the adoption of soil organic carbon enhancing technologies among small-scale farmers in Ethiopia. Heliyon 7, 1 (2021).
88. Warner, L. A. Who conserves and who approves? Predicting water conservation intentions in urban landscapes with referent groups beyond the traditional ‘important others’. Urban For. Urban Green. 60, 1 (2021).

Acknowledgements
The current paper is adapted from a research assigned in Agricultural Sciences and Natural Resources University of Khuzestan, with a Grant Number of 981.54, and financially supported by the university, thereby we declare our appreciation for their help. This research has been approved by a institutional review board at Agricultural Sciences and Natural Resources University of Khuzestan, Mollasani, Iran.

Author contributions
All authors contributed to the study conception and design. Material preparation, data collection, and analysis were performed by M.S., M.Y., D.R. The first draft of the manuscript was written by M.S. All authors commented on the previous versions of the manuscript. All authors read and approved the final manuscript.

Competing interests
The authors declare no competing interests.

Additional information
Supplementary Information The online version contains supplementary material available at https://doi.org/10.1038/s41598-022-12541-6.

Correspondence and requests for materials should be addressed to M.S.

Reprints and permissions information is available at www.nature.com/reprints.

Publisher’s note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.
