Agriculture, Environment & Society

Journal homepage: www.aes.uoz.ac.ir

# Identification of effective factors on acceptance of new irrigation systems for optimum agricultural water management in the Torshiz area

Somayeh Galdavi [*a], Fateme Ghomanjani [a], Hadi Dehghan [a]

[a] Department of Water Sciences and Engineering, Kashmar Higher Education Institute, Kashmar, Iran

ARTICLE INFO

*Article history:*
Received: 13 April 2024
Accepted: 16 May 2024
Available online: 1 June 2024

*Keywords:*
Adoption of NISs
Structural modeling
Sustainable agriculture
Water scarcity

ABSTRACT

The aim of this research was to identify the factors contributing to the adoption of New Irrigation Systems (NIS) by farmers in the Torshiz region. After gaining a comprehensive knowledge of the study area, a questionnaire was prepared to gather the opinions and views of farmers on the use of these systems. After determining the validity of the questionnaire through expert opinions and its reliability by calculating Cronbach's alpha (0.93), the questionnaire was distributed among 100 farmers and filled out by them in the region. The analysis of the questionnaires was done in SPSS 21 software, and the structural modeling of the effective factors in the acceptance of the systems was done in Smart PLS software. The analysis showed that all of the investigated factors had a significant impact on the acceptance of irrigation systems (T-index greater than 1.96 and significant level less than 0.05). Attitudinal factors were found to be the most influential, followed by economic factors. According to the results, the most significant educational factor was found to be the "suitable cultivation pattern for the region", while the most important economic factor was "various cultivation abilities". In terms of social factors, "using the positive experiences of others in connection with NIS" was identified as the most crucial. Lastly, among the attitudinal factors, it was found that believing that it causes more success in farm management is of the highest importance. Therefore, according to the location of this region, which is located in a hot and dry climate, farmers should be encouraged to accept the use of technology. They can do this by identifying the most suitable cultivation pattern for the region and holding scientific and practical training courses. In this case, it is possible to increase agricultural production and improve water consumption efficiency in the area.

## Highlights

- Identify factors influencing farmers' adoption of NIS for better water management in Torshiz, a hot and dry region.
- All investigated factors (educational, economic, social, attitudinal) significantly influence NIS adoption.
- Attitudinal factors have the strongest influence, followed by economic factors.
- Farmers value NIS' potential for success in farm management and efficient water use.

## 1. Introduction

Water is a valuable and finite resource that plays a crucial role in agricultural production across the world (Martinez-Arteaga et al., 2023). In countries with low average rainfall, agricultural irrigation is a key factor in food and fiber production, and it can consume up to 60% of the available freshwater resources (Koech et al., 2021). The water shortage is currently one of the most pressing issues of the 21st century. This problem is caused by a combination of factors, including climate change and population growth. It poses a threat not only to food security but also to the income security, livelihoods, and overall well-being of rural populations. Furthermore, it endangers regional prosperity and development (Yazdanpanah et al., 2023; Castillo et al., 2021). It is predicted that global water demand will increase by 20–

* Corresponding author.
E-mail address: s.galdavi@kashmar.ac.ir, s.galdavi@yahoo.com
https://doi.org/10.22034/jelsa.2024.452224.1060

30% in the industrial, domestic, and agricultural sectors by 2050, and agriculture will remain the main consumer of fresh water (Martinez-Arteaga et al., 2023). On the other hand, it is expected that the allocation of water resources to different economic sectors and the need to increase the efficiency of water consumption will intensify (Iskandar et al., 2018).

Iran is currently facing a serious water crisis. Water demand has risen substantially, while water resources have decreased significantly across most regions of Iran. This is largely due to prolonged periods of drought. As a result, Iran has earned the fourth position in the Middle East and North Africa region for severe water stress (Rouzaneh et al., 2021). For example, it has been reported that 16 out of 30 river basins in Iran have experienced a drastic decrease in water levels (Ashraf et al., 2019). This can be attributed to climate change, which is expected to reduce water supply and access by 50% by 2050 (Boazar et al., 2019). At the same time, the efficiency of agricultural water consumption in Iran (35%) is very low compared to developed countries, which is more than 70%. Due to the gradual deterioration of the water situation, some methods have been used to reduce this crisis in Iran, among which improving water productivity in the agricultural sector is a vital goal to conserve water and reduce the water crisis (Rahimi-Feyzabad et al. 2020). In addition, due to the increase in demand, limited resources, variation of water level in time and place, and soil pollution, it is necessary to optimize the management of water resources in the agriculture section (Nejadrezaei et al., 2018). In the meantime, new irrigation technologies provide the possibility of controlling and distributing water to meet agricultural water needs (Chuchird et al., 2017). Efficient irrigation practices are responsible for reducing the effects of climate change and creating a positive impact on crop yield, food production, food security, and economic development (Piwowar et al., 2020). For example, technologies such as drip and rain irrigation are a type of agricultural water management that can reduce water shortages by 19% and save up to 35% of agricultural water (Koech and Langat, 2018).

In this context, the studies of the Water and Soil Research Institute and the Agricultural Engineering Research Institute of Iran show that replacing traditional irrigation methods with NIS by improving the efficiency of water consumption can save between 3000 and 6000 cubic meters per hectare (Yazdanpanah et al., 2022). However, irrigation technologies are usually rarely used, especially when a high initial investment is required. Also, a lack of awareness amongst farmers and the public about the different types of irrigation methods is one of the most important and effective issues in the consumption and management of water resources in agriculture. In fact, only 14% of the world's 275 million hectares of irrigated land currently use efficient irrigation methods (Martinez-Arteaga et al., 2023).

The Iranian government is actively taking steps to manage the water shortage challenge in the country. One of them involves encouraging farmers to use new irrigation technology. so, it is investing approximately USD 300 million to support their adoption. According to this plan, the government pays 85% of the total cost of implementing NIS, and the farmer's share remains only 15% (Yazdanpanah et al., 2022). Therefore, with the provision of such government facilities and these conditions of water scarcity and climate change, the cooperation of farmers is necessary for more efficient and sustainable use of water resources due to the relationship between agricultural activities and their environment. Despite the government's efforts to provide appropriate facilities to farmers, the acceptance rate of these systems remains low. Therefore, it is necessary to encourage farmers to adopt these systems and promote the sustainable use of water resources. As a result, the investigation of factors affecting the adoption of new irrigation methods in agriculture has attracted considerable attention among researchers. some researchers, such as Movahedi et al. (2017), Taheri et al. (2018), Menatizadeh and Zamani (2017), Chuchird et al. (2017), Feizabadi and Gorji (2018), Saleh et al. (2022), and Sabbagh and Gutierrez (2023), have conducted research in this field to investigate the factors that influence the adoption of new irrigation methods in agriculture. For example, A study conducted by Saleh et al. (2022) analyzed the factors that influence the adoption of education and irrigation technologies for sustainable food production in the state of Nigeria. The results showed that most of the farmers had a low level of education, which indicates that agriculture in the study area is heavily dominated by the traditional farming system and leads to lower crop yields. Also, the results showed that poor service to farmers was directly related to the acceptance of education and the adoption of irrigation technologies by farmers. Also, Sabbagh and Gutierrez (2023) investigated the factors influencing the adoption of NIS by farmers in Lebanon. By preparing a questionnaire, they used various economic, social, and educational factors to determine the effective factors. The results showed that the hope of farmers to grant facilities to use these systems, the hope of producing more products (higher yield), and the need for less work on the farm are effective in the acceptance of these irrigation systems**.**

The review of research showed that knowledge of the effective factors in accepting new irrigation methods plays an important role in the use of these methods by the target community (farmers). Therefore, due to the great importance of preserving water resources and preventing the wastage of this valuable resource, the current research has been carried out in the Torshiz region of Khorasan Razavi province**.** Considering that the two categories of aridity and desertification caused by climate change will definitely cause serious damage to agricultural and horticultural products, national wealth, and people in arid and semi-arid areas such as the Torshiz region, the use of these methods can play an effective role in making optimal use of available water resources.

To address this issue, the use of NIS can be highly effective in making optimal use of available water resources and increasing yield, quality, and quantity of products while reducing costs and saving water consumption. Moreover, it can also help control the income fluctuations of users, protect and maintain agricultural

lands, and prevent and control desertification and wind/erosion crises in the region.

This can also increase the job satisfaction of farmers and their motivation for sustainability. The acceptance of new irrigation technology by farmers depends on various environmental conditions and factors. So, the farmer's level of awareness, income, and profit from the implementation of new irrigation methods can play an important role in their acceptance and development. Therefore, by considering the significant differences that exist in the rural communities of the country in terms of economic, social, and cultural points of view, it is important to examine the effects and reasons for accepting and not accepting new irrigation technology regionally, and the results of this study can be derived from this. The direction is more important**.**

## 2. Materials and methods

### 2.1. Study area

The current research is focused on the Torshiz region in Khorasan Razavi province. The region includes four cities, namely Kashmar, Bardaskan, Khalilabad, and Kouhsorkh (Figure 1). The Torshiz region is situated in a dry area located in the north of the Namak Desert. According to the climate classification, the area has a dry and mildly hot desert climate. The average annual rainfall is reported to be 190 mm. The average maximum temperature is 22.5 degrees Celsius, while the average minimum temperature is 11 degrees Celsius. The potential of evaporation and transpiration at the Kashmar synoptic station is 1701 mm per year. Rainfall is limited to the winter and spring seasons. There are no permanent rivers in the plain, and the most important seasonal river is Sheshtaraz. Due to the poverty of water resources, renewable natural resources are very sensitive and fragile, and a lack of attention and unplanned and unprincipled exploitation could lead to the destruction of these resources. Therefore, conducting research on the optimal management of water resources in the region is crucial to ensure their sustainability.

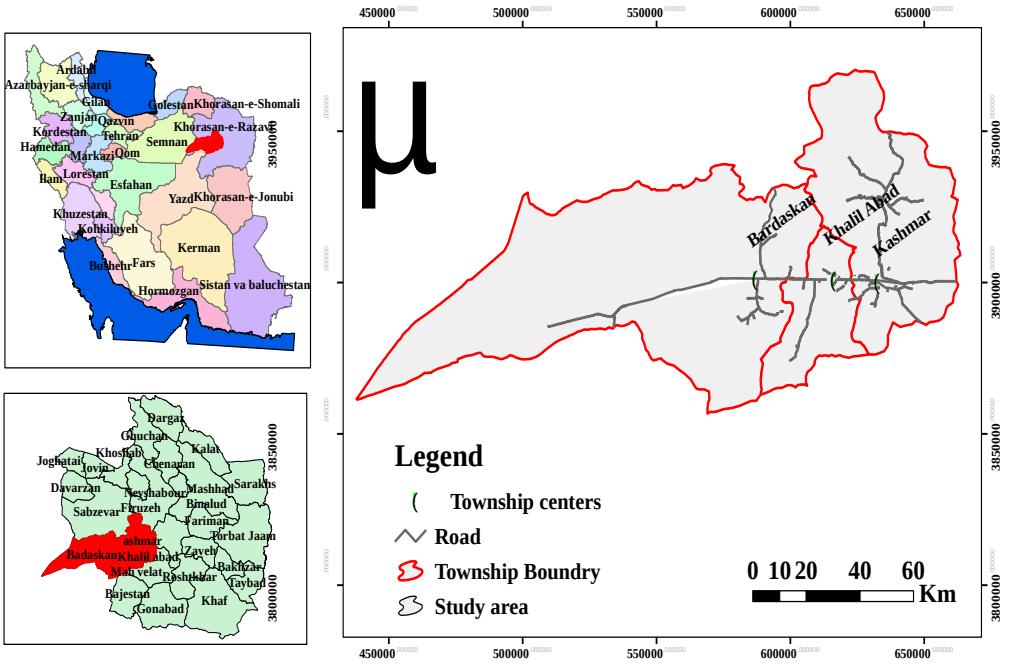


**Figure 1. The location of the study area of the Torshiz region**

### 2.2. Method

The purpose of this study was to identify the factors that affect the adoption of NIS for optimal use of agricultural water in the Torshiz region of Khorasan Razavi province. The acceptance of new irrigation technologies varies greatly and is influenced by several factors. Among the factors reported by researchers, household characteristics, farm size, age, education level, farmer's experience, assurance of more income, farmer's investment ability, educational and promotional factors, awareness of the effects of climate change, Government subsidies, cropping patterns, reliability, and risk-taking influence the adoption of irrigation systems for crops (Oyetunde-Usman, Z.; Olagunju, 2021; Martinez-Arteaga et al., 2023)**.** Therefore, in conducting this research, it was tried to investigate different types of influencing factors on the adoption of new irrigation methods and use them in preparing a questionnaire. So, the current research is of the quantitative research type, and in terms of research method, it is descriptive-analytical along with fieldwork. To conduct this research, at the beginning, the previous related research was investigated. The dependent variable of this research is the factors influencing the adoption of NIS, and the theoretical framework and independent variables include economic, social, educational-promotional, and farmers'

attitude factors. Descriptive, analytical, and correlation methods have been used to identify the influencing factors in the acceptance of new systems**.**

A questionnaire was used to collect information to identify the influencing factors distributed and filled out by farmers in the Torshiz region of Khorasan Razavi province as water stakeholders. In order to check the validity of the questionnaire, experts in the field were consulted, and the questionnaire's reliability was tested by distributing 30 questionnaires among the target population. These questionnaires were completed and collected, and Cronbach's alpha coefficient was calculated to measure their reliability. Generally, 100 questionnaires were filled out by the target society. SPSS software was used to analyze the data, and Smart PLS was used to prepare the structural model. The questionnaire includes individual social variables (including age, education, main job, place of residence, advertising and promotion, and personal interests) and economic variables (including the scale of farms, ownership of machinery, government credits, provision of cheap electricity, government support, and cooperation in the implementation and limitation of water resources) that have a significant effect on the adoption of NIS. Figure 2 illustrates the steps of the research.

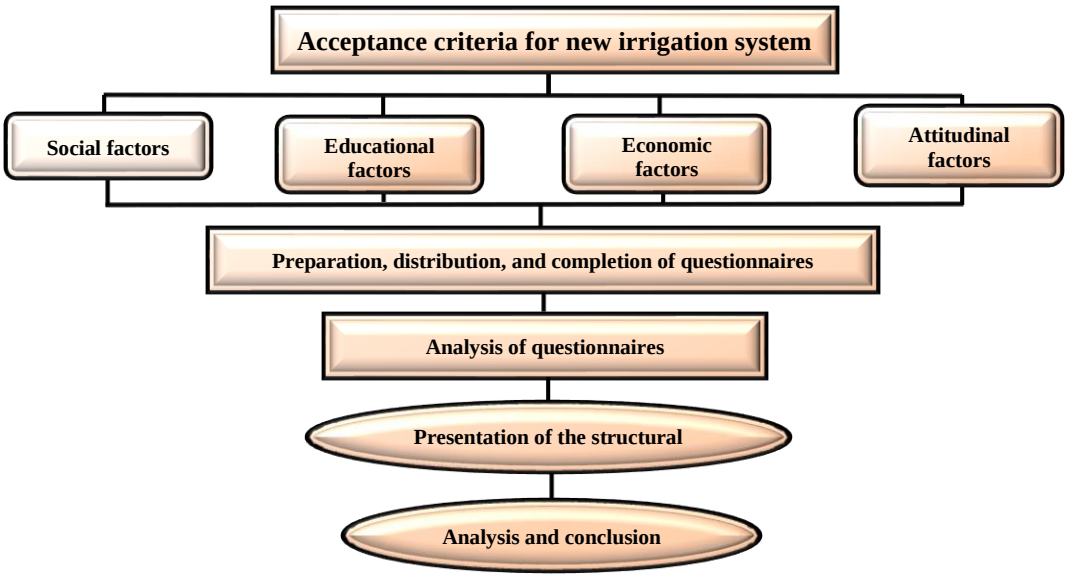


**Figure 2. Flowchart of research steps**

## 3. Results and discussion

The aim of the current research was to identify the factors that influence the adoption of these systems by farmers in the Torshiz region. Therefore, decision-makers should identify why farmers' desire for these systems has not been successful despite strong financial and political support. So, this issue was investigated in the present study. In this way, a questionnaire was prepared and completed by the farmers to investigate and identify the factors affecting the acceptance of these systems. Also, in this context, it should be noted that some researchers, such as Lopolito et al. (2022), believe that improving the methods of using water resources in the agricultural sector and innovations such as water-saving techniques are vital strategies to promote economic development (Lopolito et al., 2022).

In this research, a questionnaire was utilized to collect the necessary information. Experts confirmed the validity of the questionnaire, and its reliability was assessed by calculating Cronbach's alpha. The coefficient was calculated at 0.93, indicating that the questionnaire is reliable. In the following, the results of the analysis of the questionnaires are presented.

### 3.1. Characteristics of farmers

The survey results indicate that the majority of the participants, accounting for 45 percent of the sample, were aged between 30 and 45 years. Most of the respondents had attained a diploma (33 percent), followed by a sub-diploma (24 percent), a post-diploma (23 percent), and a bachelor's degree (20 percent). The survey also revealed that 95% of the land ownership was private, while only 5% was leased. the type of product is mostly in the garden category (73%), followed by agriculture (27%). Most of the farmers produce grapes, pistachios, and wheat**.**

In the next step, the importance and priority of each of the examined items were determined based on the opinion of the farmers. Then, the structural model was prepared based on the results. The results of the investigation are presented below.

### 3.2. Prioritizing items in each factor

Friedman's test was used to check the same importance of the items in each factor to prioritize the items of each of the educational, economic, attitudinal, and social factors according to the item scale (5-point Likert scale). the results showed that the significant level of Friedman's test is less than 0.05 and the items are not equally important. The ranking of items based on the average of each item is presented in Tables 1 to 4:

According to the results, the most critical educational factor in the region is the item "cultivation pattern suitable

for the region", while the least significant is the item "protection technology of productive resources"(Table 1).

Based on the findings, the item "capability of diverse cultivation" is considered the most important economic factor, while the item "investment ability of the farmer" is considered the least important by the farmers (Table 2).

**Table 1. Prioritization of educational factors**

| Educational factors | Mean | Standard deviation | Score |
|---|---|---|---|
| Suitable Cropping pattern for the region | 3.4300 | 0.97706 | 1 |
| Irrigation calendar according to the cultivation pattern of the dominant crops | 3.3900 | 1.10914 | 2 |
| Suitable Irrigation Timing | 3.3400 | 1.08451 | 3 |
| Correct irrigation methods | 3.2700 | 1.06225 | 4 |
| Risk management in the agricultural sector | 3.1200 | 1.01782 | 5 |
| Planning for production activity | 3.0900 | 1.08334 | 6 |
| Production skills in the agricultural sector | 3.08 | 1.125 | 7 |
| Optimal use of production resources | 3.02 | 1.189 | 8 |
| Accounting skills in the production sector | 2.87 | 1.236 | 9 |
| Production resource protection technology | 2.86 | 1.172 | 10 |
| Friedman's test: 84.649 | freedom Degree: 9 | Significant level: 0.000 | |

**Table 2. Prioritization of Economic factors**

| Economic factors | Mean | Standard deviation | Score |
|---|---|---|---|
| Diverse cultivation capability | 4.16 | 5.16 | 1 |
| Reduction of total irrigation costs in the long term | 4.01 | 1.08 | 2 |
| Reducing water consumption and costs | 3.99 | 1.03 | 3 |
| possibility of using irrigation in agriculture and increasing income | 3.96 | 1.09 | 4 |
| Reduce weed and control costs | 3.88 | 1.09 | 5 |
| Development and increase of cultivated area | 3.81 | 1.09 | 6 |
| Increasing the amount of production per unit area | 3.74 | 1.10 | 7 |
| Reducing fertilizer costs | 3.55 | 1.18 | 8 |
| Reducing land leveling costs | 3.54 | 1.13 | 9 |
| Reducing spraying costs | 3.50 | 1.18 | 10 |
| Reducing labor costs | 3.49 | 1.17 | 11 |
| Low implementation costs of modern irrigation | 3.16 | 1.39 | 12 |
| Providing timely facilities and long-term repayment of loans | 3.07 | 1.42 | 13 |
| The possibility of benefiting from bank facilities | 3.06 | 1.35 | 14 |
| Sufficient amount of bank facilities | 3.05 | 1.42 | 15 |
| Low interest rate of bank facilities | 3.01 | 1.37 | 16 |
| Farmer's investment ability | 2.89 | 1.33 | 17 |
| Friedman's test: 84.649 | freedom Degree: 16 | Significant level: 0.000 | |

According to the results, the item "Using the positive experiences of others in connection with NIS" has the highest importance, and the item "Providing explanatory training in connection with NIS" has the least importance from the users' point of view (Table 3).

**Table 3. Prioritization of social factors**

| Social factors | Mean | Standard deviation | Score |
|---|---|---|---|
| Using the positive experiences of others with NIS | 3.08 | 1.10 | 1 |
| Appropriate treatment of companies implementing new irrigation methods | 3.06 | 1.11 | 2 |
| Easy access to after-sales service of spare parts related to NIS | 3.01 | 1.12 | 3 |
| Easy access to stores supplying spare parts for NIS | 2.95 | 1.18 | 4 |
| Ensuring security in the area | 2.85 | 1.40 | 5 |
| Advertisements of sellers and design companies of NIS | 2.83 | 1.11 | 6 |
| Introducing NIS on radio and television | 2.77 | 4.23 | 7 |
| Educational visits to areas where NIS have been implemented before | 2.65 | 1.23 | 8 |
| Participation in training courses related to water management | 2.59 | 1.16 | 9 |
| Introducing NIS in promotional publications | 2.58 | 1.25 | 10 |
| Advice of experts and technical specialists to implement NIS | 2.58 | 1.25 | 11 |
| Providing explanatory training related to NIS | 2.56 | 1.26 | 12 |
| Friedman's test: 130.73 | freedom Degree: 11 | Significant level: 0.000 | |

Based on the findings, the most important attitudinal factor is the one that the item "leads to more success in farm management", while the least important factor is the item "accessibility of farmers to facilities and credits increases", according to the users' perspective (Table 4).

**Table 4. Prioritization of attitudinal factors**

| Attitudinal factors | Mean | Standard deviation | Score |
|---|---|---|---|
| It leads to more success in farm management | 4.19 | 0.92 | 1 |
| It increases income and profit for the family | 4.13 | 0.92 | 2 |
| It increases product performance | 4.09 | 0.99 | 3 |
| It is a suitable method for the production process | 4.08 | 0.94 | 4 |
| It improves product quality | 4.08 | 0.95 | 5 |
| It is effective in protecting the environment | 4.00 | 1.12 | 6 |
| It has tangible results | 3.99 | 0.92 | 7 |
| It prevents waste of time and capital in agriculture | 3.99 | 1.05 | 8 |
| Economically, it is associated with cost reduction | 3.95 | 1.02 | 9 |
| It preserves productive resources | 3.82 | 1.05 | 10 |
| It creates self-confidence | 3.80 | 1.03 | 11 |
| It causes acceptance of responsibility | 3.77 | 0.98 | 12 |
| It causes struggle with traditional thoughts in agriculture | 3.71 | 1.18 | 13 |
| They are technically feasible | 3.71 | 1.21 | 14 |
| They are relatively consistent with traditional methods and local knowledge | 3.65 | 1.02 | 15 |
| It makes family members cooperate together | 3.60 | 1.02 | 16 |
| Farmers' access to facilities and credits increases | 3.53 | 1.17 | 17 |
| Friedman's test: 159.34 | freedom Degree: 16 | Significant level: 0.000 | |

### 3.3. Structural equation model

In this section, the validity of the content value of each of the indicators used to design the model is analyzed using the structural equation model method. A complete structural equation model includes path analysis and confirmatory factor analysis. This method is used in research, where the goal is to test a specific model of the relationship between variables. The structural equation model is divided into two phases: confirmatory factor analysis and path analysis. In the measurement part, the relationship between the indicators or the questions of the questionnaire and the factors is investigated, and in the structural part, the relationship of the studied factors with each other is considered to test the hypotheses**.**

There are various methods to implement the structural equation model. one of the newest approaches to the structural equation model is the partial least squares method, which is a method for the structural predictive model. This approach is considered the first option for estimating the model, especially when the number of indicators for each factor is large and there is multiple alignment between them. So, in designing the structural model of the current research, this approach was used to estimate factor loadings and path coefficients (Rezazadeh and Davari, 2013).

The partial least squares method does not require any assumptions about the type of distribution of the measurement variables. Therefore, it is suitable and applicable for data with a non-normal or unknown distribution. In this study, the items to be measured are variables that have an unknown definition and distribution on the Likert scale, and due to their non-normality, the partial least squares method is superior to the covariance-based methods. Covariance-based methods are sensitive to sample size. Smaller samples decrease the statistical power of the method. Also, by reducing the sample size, the assumption of normality of the data cannot be shown well. The partial least squares method estimates the model parameters using the original sample. However, for the correct statistical estimation of the model, it uses the sample reproduction method to determine the confidence interval of the model parameters (Qanavati et al., 2013).

This is a statistical technique that does not require assumptions about the distribution of the measurement variables. This makes it suitable for analyzing data with non-normal or unknown distributions.

### 3.4. Measurement model

Before applying the structural equation model, it is important to ensure that the structures being studied are valid and that the chosen indicators accurately measure the desired structures. for this purpose, Confirmatory factor analysis (CFA) is used. If the factor load of each indicator with its structure has a T value higher than 1.96, then that indicator has the necessary accuracy to measure the existing structure or attribute. If the indicators of the studied structures have a value of T less than 1.96, they do not have the necessary importance for measurement and should be discarded from the analysis process. According to the review, none of the questions had any problems, and the validity of the constructs showed that the items provided suitable factorial structures to measure the variables studied in the research model.

In structural equation modeling, in addition to construct validity, criteria such as reliability and validity are also evaluated to check the variables. Reliability means that there was the same collection of questions among different respondents. To check reliability, a composite reliability index was used; values higher than 0.7 for each structure indicate its proper reliability (Table 5).

### 3.5. Structural model

At this stage, considering the completion of the variable refinement phase and the assurance of the accuracy of the indicators in the measurement of related variables, it is possible to test the research hypotheses, which were examined in the form of the structural equation model of the hypotheses, and the direction of the structural model was evaluated. Each path corresponds to one of the hypotheses of the model. Each hypothesis is tested by examining the sign, size, and statistical significance of the path coefficient (beta) between each independent variable and the dependent variable. The predictive effect of the dependent variable will be greater if the value of the path coefficient is higher. By considering the results of the study of the relationships between independent and dependent structures using the relevant coefficient, it is possible to study the significance of the effects between the research structures. The significance of the T-value for each path coefficient should be tested to investigate the significance of the path coefficient or beta; therefore, the bootstrap method was used (Table 6).

**Table 5. Examination of AVE values and reliability indices**

| Factors | Cronbach's alpha | rho_A | Composite reliability | AVE |
|---|---|---|---|---|
| Educational factors | 0.95 | 0.95 | 0.96 | 0.70 |
| Social factors | 0.94 | 0.95 | 0.95 | 0.60 |
| Economic factors | 0.94 | 0.95 | 0.95 | 0.54 |
| Attitudinal factors | 0.97 | 0.97 | 0.97 | 0.64 |
| Acceptance of irrigation systems | 0.98 | 0.98 | 0.98 | 0.51 |

**Table 6. Examining the relationships between variables and their significance**

| | Path coefficient | The standard deviation | T index | Significant level |
|---|---|---|---|---|
| Educational factors -> acceptance of irrigation systems | 0.22 | 0.02 | 15.19 | 0.000 |
| Social factors -> adoption of irrigation systems | 0.24 | 0.02 | 14.77 | 0.000 |
| Economic factors -> adoption of irrigation systems | 0.33 | 0.02 | 20.63 | 0.000 |
| Attitudinal factors -> acceptance of irrigation systems | 0.37 | 0.03 | 14.84 | 0.000 |

The results show that all the investigated factors have an impact on the acceptance of irrigation systems (T-value greater than 1.96 and a significant level less than 0.05), and the most influential are attitudinal factors and then economic factors. these results are consistent with the results of Movahedi et al. (2017), which investigated the factors influencing the acceptance of pressure irrigation by farmers in Asadabad city, Hamadan province. Their findings showed that attitudinal variables (including perceived usefulness, perceived ease of use, and attitude towards use) had a positive and significant effect on the acceptance of irrigation systems under pressure. Taheri et al. (2018) also investigated the factors influencing the acceptance of the water management plan for the restoration of Lake Urmia by the farmers of Naqdeh city and concluded that there is a significant relationship between the attitude toward the restoration of Lake Urmia and the water management plan. Their findings showed that the variables of knowledge about lake restoration, facilities for accepting the plan, attitude towards lake restoration, and attitude towards the water management plan are the most important factors that recognize the two groups of farmers who accept and do not accept the water management plan. Also, the results of this section are consistent with the results of Haji et al.'s (2020), which investigated and analyzed the factors affecting the acceptance of drip irrigation by sugar beet farmers using a questionnaire. The results showed that attitude variables, perceived ease of use, and perceived usefulness of using new irrigation methods have a significant positive effect on the adoption of drip irrigation technology.

Figures 3 and 4 of the research models are presented in two modes with T-values and path coefficients.

According to the results, various economic, social, educational, and attitudinal factors are effective in the acceptance of NIS by farmers. Detailed Identifying and investigating these factors can play a significant role in developing appropriate policies to promote the use of these methods among farmers. Developing NIS, which optimize and reduce water consumption, in these areas with a hot and dry climate and lands prone to desertification can cause the prosperity of agriculture in the region and the economic growth of local and rural communities. Therefore, it is also effective in protecting the soil and reducing the risks of desertification caused by the abandonment of villages and agricultural lands**.** According to Playan and Mateos (2006), the renovation and optimization of irrigation systems can improve the efficiency of water consumption in agriculture. This process can be particularly beneficial in desert areas and can contribute to the survival of people in rural areas. Also, the results of this section are consistent with the results of other researchers, including Farid et al. (2019), who studied the factors affecting the optimal adoption of irrigation systems among farmers in a region in Pakistan. The results showed that factors such as high economic efficiency, operator deployment, and farmer training are effective in the adoption of these systems by farmers.

Sabbagh and Gutierrez (2023) also investigated the effective factors in the adoption of NIS by farmers in Lebanon. Their results showed that it provides for and has a financial impact on the adoption of these methods by farmers. In this stage, the need for less work and achieving better performance and efficiency of products were also important factors.

According to the results, the factors of "cultivation pattern suitable for the region", "diversity cultivation ability", "using the positive experiences of others" and "more success in farm management" have the greatest impact on the acceptance of these systems by farmers. Therefore, these factors should be considered in planning to convince farmers to use NIS. In this context, Farid et al. (2019) stated that NIS has a suitable efficiency for saving water and increasing the yield of crops**.** However, the most important issue with these systems is their non-acceptance

or low acceptance by agricultural communities, despite their proven benefits. So, identifying the factors affecting the acceptance of these systems by farmers can play an important role in the development of these systems. They found out in research that factors such as high economic efficiency, the establishment of operators, and farmer training are effective in the acceptance of these systems by farmers.

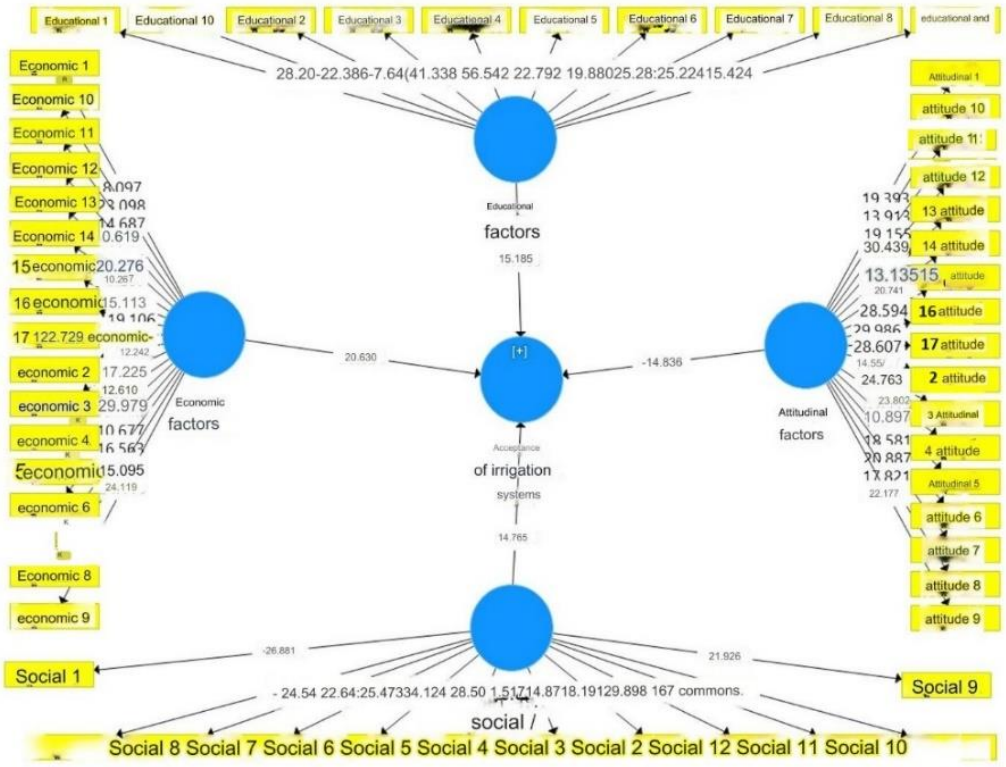


**Figure 3. Structural model with T-Values**

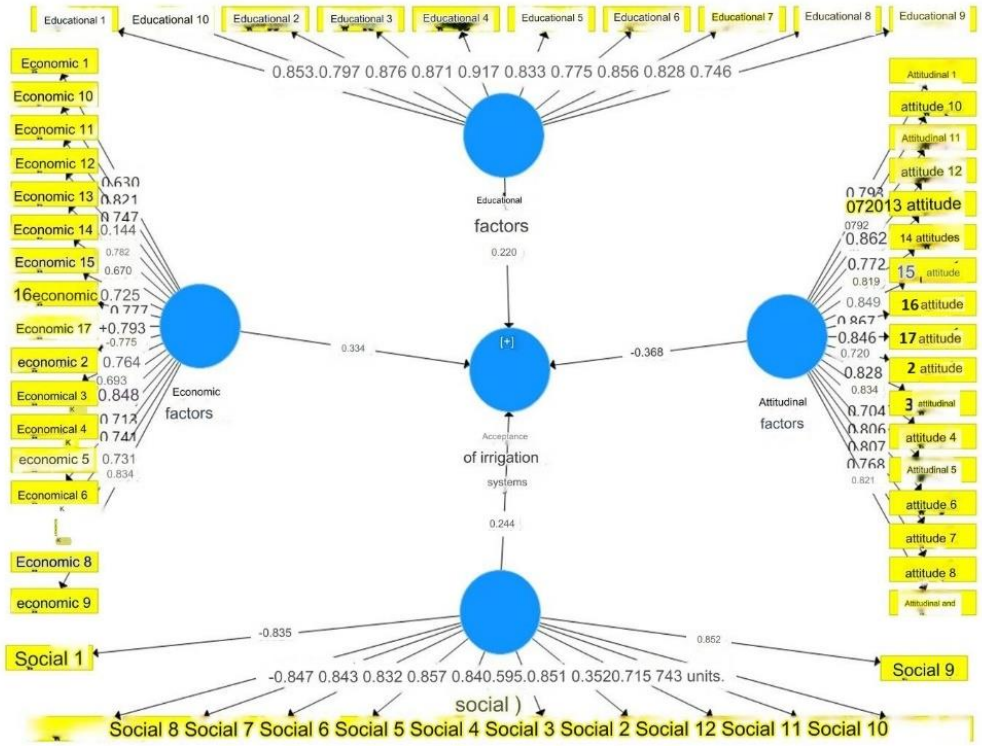


**Figure 4. Structural model with path coefficients on paths**

It is important to note that the study area has the potential to use renewable energy sources, such as solar energy, to power irrigation systems. This aligns with the principle of sustainable development, which focuses on supporting the economy, society, and environment in a way that meets the needs of the present population without compromising the natural resources and environment for future generations. Sustainable development emphasizes the need to balance the protection and sustainable use of natural resources in managing society. The goals of sustainable development in the water resources field aim to increase the efficiency of water consumption in all regions and at all levels. It also includes maintaining and revitalizing ecological systems related to water resources to optimize water use. In addition, it encourages community participation in the sustainable development of water resources. This issue has been emphasized by Chuchird et al. (2017) in their study. Their research aimed to identify the factors that affect the adoption of agricultural irrigation technologies. After identifying these factors, they also emphasized the importance of the sustainable development of water resources.

It is important to consider various factors when proposing an irrigation system for farmers. These factors include the amount of water available, climatic conditions, soil type, crop type, and water requirements, as well as economic and social conditions, especially the investment ability of farmers. This has been confirmed by Van de Zande et al. (2024) in their research on farmers' preferences for modern irrigation methods. Through questionnaires and interviews, they found out that the cultivation area, crop type, and investment capacity of farmers play a significant role in their acceptance of irrigation methods. Therefore, it is essential to consider these factors when proposing irrigation systems to farmers.

The results of this research can aid in developing effective approaches to increase farmers' positive attitudes towards NIS and encourage their acceptance. Additionally, the findings can provide valuable insights to planners and decision-makers in the agriculture and water sectors, including the Agricultural Jihad Organization, the Ministry of Energy, and the Environmental Protection Organization. The study identified the key factors and behavioral change strategies that can be used to promote the use of irrigation systems and encourage sustainable maintenance of the systems in the area. Thus, the research can be a guideline for justifying and encouraging farmers to adopt optimal agricultural water management technologies and efficient water allocation management.

## 4. Conclusion

The aim of the present study was to identify the key factors that affect the acceptance of NIS for optimal management of agricultural water resources in the Torshiz region. To achieve this, a questionnaire was developed to gather the opinions and views of farmers regarding the use of NIS after gaining extensive knowledge of the study area. The collected data was analyzed using SPSS 21 software, and the factors that influence the acceptance of these systems were modeled using Smart PLS software. The results of the analysis indicated that all the factors investigated had a significant impact on the acceptance of irrigation systems (T-values greater than 1.96 and significant level less than 0.05), and the most influential were attitudinal factors and then economic factors. The results indicate that farmers have a positive attitude towards NIS and agree that these systems can lead to optimal water management. Therefore, it is recommended to strengthen this positive attitude and provide banking facilities to encourage farmers to use NIS. The study found that among the educational factors, the "suitable cultivation pattern of the region" was the most important, while among the economic factors, "various cultivation ability" was the most significant. Therefore, it is crucial to determine the appropriate cultivation pattern of the region and inform farmers to encourage their participation in projects such as the use of modern irrigation methods. Regarding social factors, "using the positive experiences of others in connection with NIS" was found to be the most important, while among the attitudinal factors, "leads to more success in farm management" was given the highest importance. This shows that if NIS are implemented on trial fields and farmers observe an increase in crop yield, higher economic efficiency, and improved water resource efficiency, they would be more likely to use these methods. This action could be taken by providing suitable incentives, such as long-term bank facilities at low rates. Also, this issue shows the role of education in accepting these systems**.** Therefore, it is necessary to convince farmers to use NIS by holding educational and promotional courses. In fact, agricultural promotion and education are effective managerial strategies to improve agricultural water usage among farmers. These strategies create changes in people's behavior through cognitive, emotional, and psychological aspects. The cognitive aspect results in increased awareness and knowledge; the emotional aspect results in attitude changes; and the psychological aspect results in the development and improvement of people's skills. investigating and determining the behavioral aspects of the learners before each educational action is important to be successful in educational-promotional programs. Ultimately, the future of water depends on whether agriculture can manage and use water sustainably. This requires a series of actions, such as information and educational programs, that may not have clear results in the short term.

## Acknowledgements

This research is the result of the research project of the Kashmar Higher Education institude and the authors thank their support.

## Conflict of interest

No conflict of interest has been declared by the authors.

## References

Ashraf, S., AghaKouchak, A., Nazemi, A., Mirchi, A., Sadegh, M., Moftakhari, H.R., & Anjileli, H. (2019). Compounding effects of human activities and climatic changes on surface water availability in Iran. *Climate*

*Change*, 152 (3–4), 379–391. **doi: 10.1007/s10584-018-2336-6**

Boazar, M., Abdeshahi, A., & Yazdanpanah, M. (2020). Changing rice cropping patterns among farmers as a preventive policy to protect water resources. *Journal of Environmental Planning and Management*, *63*(14), 2484–2500. **doi: 10.1080/09640568.2020.1729705.**

Castillo, G.M.L., Engler, A., & Wollni, M. (2021). Planned Behavior and Social Capital: Understanding Farmers' Behavior toward Pressurized Irrigation Technologies. *Agricultural Water Management, 243*, 1-16. 106524. **doi: 10.1016/j.agwat.2020.106524**

Chuchird, R., Sasaki, N., & Abe, I. (2017). Influencing Factors of the Adoption of Agricultural Irrigation Technologies and the Economic Returns: A Case Study in Chaiyaphum Province, Thailand. *Sustainability*, *9*, 1524. **doi: 10.3390/su9091524.**

Feizabadi, Y., & Gorji, E. M. (2018). Analysis of effective factors on agricultural water management in Iran. *Water and land development*, *38*, 35-41. **doi: 10.2478/jwld-2018-0040.**

Haji, L., Valizadeh, N., Rezaei-Moghaddam, K., & Hayati, D. (2020). Analyzing Iranian farmers' behavioral intention towards acceptance of drip irrigation using extended technologyacceptance model. *Journal of Agricultural Science and Technology*, *22* (5), 1177-1190.

Iskandar, M. J., Baharum, A., Anuar, F. H., & Othaman, R. (2018). Palm oil industry in south east asia and the effluent treatment technology -a review. *Environmental Technology & Innovation*, *9*, 169–185. **doi: 10.1016/j.eti.2017.11.003.**

Koech, R., Haase, M., Grima, B., & Taylor, B. (2021). Barriers and measures to improve adoption of irrigation technologies: A case study from the Bundaberg region in Queensland, Australia. *Irrigation and drainage*, *70* (4), 909-923. **doi: https://doi.org/10.1002/ird.2583.**

Koech, R., & Langat, P. (2018). Improving irrigation water use efficiency: A review of advances, challenges and opportunities in the Australian context. *Water*, *10*, 1771. **doi: 10.3390/w10121771.**

Lopolito, A., Barbuto, A., & Santeramo, F. G. (2022). The role of network characteristics of the innovation spreaders in agriculture. *Bio-based and Applied Economics*, *11*(3), 219-230. **doi: 10.36253/bae-9932 .**

Martinez-Arteaga, D., Arias Arias, N.A., Darghan, A.E., & Barrios, D. (2023). Identification of influential factors in the adoption of irrigation technologies through neural network analysis: A case study with oil palm growers. *Agriculture*, *13*, 827. **doi: 10.3390/agriculture13040827.**

Menatizadeh, M., & Zamani, G. (2017). Causal analysis of water conservation behaviors of the studied farmers: Khorram Abad city. *Water resources research of Iran*. *14* (3), 80-91. [In Persian].

Movahedi, R., Izadi, N., & Vahdat Adab, R. (2017). Investigating factors affecting farmers'adoption of pressurized irrigation technology in Asadabad county, Hamedan province. *Water Research in Agriculture*, *31* (2), 287-300. [In Persian]. **doi: 10.22092/jwra.2017.113172**

Nejadrezaei, N., Allahyari, M. S., Sadeghzadeh, M., Michailidis, A., & El Bilali, H. (2018). Factors affecting the adoption of pressurized irrigation technology among olive farmers in Northern Iran. *Applied Water Science*, *8*, 190-199. **doi:10.1007/s13201-018-0819-2**

Oyetunde-Usman, Z., & Olagunju, K.O., Ogunpaimo, O.R. (2021). Determinants of adoption of multiple sustainable agricultural practices among smallholder farmers in Nigeria. *International Soil and Water Conservation Research*, *9*, 241–248. **doi: 10.1016/j.iswcr.2020.10.007**

Piwowar, A., Dziku, M., & Dziku, M. (2021). Water management in poland in terms of reducing the emissions from agricultural sources—current status and challenges. *Cleaner Engineering and Technology*, *2*, 100082. **doi: 10.1016/j.clet.2021.100082**

Playan, E., & Mateos, L. (2006). Modernization and optimization of irrigation systems to increase water productivity. *Agricultural Water Management*, *80*, 100-116. **doi: 10.1016/j.agwat.2005.07.007**

Qanavati, M., Azar, A., & Gholamzadeh, R. (2013). Path-structural modeling in management: application of SmartPLS Software. Tehran: *Negah Danesh Publications*. [In Persian].

Rahimi-Feyzabad, F., Yazdanpanah, M., Burton, R. J., Forouzani, M., & Mohammadzadeh, S. (2020). The use of a bourdieusian "capitals" model for understanding farmer's irrigation behavior in Iran. *Journal of Hydrology*, *591*, 125442. **doi: 10.1016/j.jhydrol.2020.125442**

Rezazadeh, A., & Davari, A. (2012). Structural equation modeling with PLS software. Tehran: Academic Jihad. [In Persian].

Rouzaneh, D., Yazdanpanah, M., & Bakhshi Jahromi, A. (2021). Evaluating micro-irrigation system performance through assessment of farmers' satisfaction: implications for adoption, longevity, and water use efficiency. *Agricultural Water Management*, *246*, 106655. **doi: 10.1016/j.agwat.2020.106655**

Sabbagh, M., & Gutierrez, L. (2023). Farmers' acceptance of a micro-irrigation system: A focus group study.*Bio-based and Applied Economics, 12*(3), 221-242. **doi: 10.36253/bae-13464.**

Saleh, A., Bako, R.B., & Suleiman, M.L. (2021). Factors influencing acceptance of farmer education and irrigation technology for sustainable food production in kwanar are dam – katsina state. *FUDMA Journal of Sciences (FJS)*, 5 (4), 142 – 148. **doi: 10.33003/fjs-2021-0504-797**

Taheri, H., Maleksaeidi, H., & Jalali, M. (2019). Factors affecting adoption of water management project for reclamation of lake Urmia by farmers in naghadeh township. *Iran-Water Resources Research*, *15*(2), 265-277. [In Persian]. **doi: 20.1001.1.17352347.1398.15.2.20.9**

Van de Zande, G. D., Amrose, S., Donlon, E., Shamshery, P., & Winter V, A. G. (2024). Identifying opportunities for irrigation systems to meet the specific needs of

farmers in East Africa. *Water*, *16*(1), 75. **doi:10.3390/w16010075**

Yazdanpanah, M., Zobeidi, T., Mirzaei, A, Lohr, K., Warner, L. A., Lamm, A., Rouzaneh, D., & Sieber, S. (2023). Comparison of different modern irrigation system adopters through socio-economic, innovation characteristics, and social capital values. *Regional Environmental Change*, *23*, (152). **doi: 10.1007/s10113-023-02147-7**

Yazdanpanah, M., Klein, K., Zobeidi, T., Sieber, S., & Lohr, K. (2022). Why have economic incentives failed to convince farmers to adopt drip irrigation in southwestern Iran? *Sustainability*, *14*, 2055. **doi: 10.3390/su14042055.**