

## Article

# Why Have Economic Incentives Failed to Convince Farmers to Adopt Drip Irrigation in Southwestern Iran?

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**Abstract:** Sustainable water usage is an important global concern and an urgent priority, especially in dryland regions such as Iran. The Iranian government is actively addressing the challenge of water scarcity by encouraging farmers to adopt new water application technology. Its main element to decrease water consumption is to encourage new irrigation systems, in particular drip irrigation. However, despite the benefits of drip irrigation technologies and the availability of generous government subsidies, adoption rates of the improved irrigation technology remain critically low among Iranian farmers. Therefore, this study seeks to determine what is limiting the uptake of improved irrigation technology in Iran. While it is well known that acceptance of new technology ultimately depends on multiple and interrelated factors, we examine those factors affecting farmers' adoption from three theoretical perspectives in the adoption literature: farmers' socio-economic characteristics, social capital, and technology characteristics. A cross-sectional survey was undertaken in Behbahan district in Khuzestan province in southwest Iran. The sample comprises 174 farmers who adopted drip irrigation in that region and 100 non-adopters who were located in the same region. Discriminant analysis reveals that a socio-economic approach is the strongest model to predict adoption of drip irrigation technology in the study area, followed by models of technical characteristics, and social capital. These results can help agricultural extension agents and policy-makers design appropriate and effective strategies that facilitate the adoption of drip irrigation at an increasing rate.



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**Keywords:** water scarcity; irrigation system; social capital; socio-economic characteristics; adoption technology

## 1. Introduction

Sustainable water use is an important global concern and an urgent priority, especially in dryland regions such as Iran. Acknowledging the impending crisis, the Iranian water authority announced that the government had started a scheme that aimed to increase water protection. Based on this project, water consumption in the agricultural sector, which is about 90 billion cubic meters, should be almost halved [1].

If the current rate of water use is not diminished, economic development might be hampered, reducing food security while increasing poverty, hunger, conflicts, mass immigration, and the possibility of war [2–5]. Combined with predictions about population growth, urbanization, industrialization, and climate change, this situation could be much worse in the near future [6–9]. Policymakers, researchers, NGOs, and farmers are increasingly

pursing various innovative technical, institutional, and policy interventions that will enable more efficient, equitable, and sustainable utilization of scarce water resources [6,10,11].

Consuming more than 90% of Iranian water, the agriculture sector is the primary target of the government's plan. Mostly focusing on the reduction of water demand, a wide range of initiatives have been proposed, including, but not limited to, growing of tolerant-crops, application of new irrigation systems, water pricing, and water rationing [6,12]. Water use efficiency of irrigation is very low in Iran—about 15% to 36% through conventional irrigation methods [13,14]—not just far lower than the 70–90% irrigation system efficiency typically found in developed countries [15,16], but also lower than the water efficiency in some developing countries, such as India [17].

This low water-use efficiency in Iranian agriculture calls for initiatives to increase the effective use of available water resources [14,16,18]. In short, modern irrigation is seen as a basic solution to water scarcity [10]. In this regard, drip irrigation is proposed by the Iranian government as a panacea that could sustainably provide farmers with improved yields, higher water-use efficiency, and reduced use of water for irrigation [19,20]. Studies by the Soil and Water Research Institute and Agricultural Engineering and Engineering Research in Iran show that replacing traditional irrigation methods with new and improved irrigation systems can improve water use efficiency, saving an average of 3000 to 6000 cubic meters per hectare. Scaling this reduced water usage over 350,000 hectares of irrigated agricultural lands could potentially save about 2.1 billion cubic meters of water annually.

The Iranian government is actively addressing the challenge of water scarcity by encouraging farmers to adopt new water application technology [21]. A key part of the Iranian policy to decrease water usage is to encourage farmers and other stakeholders to implement water-new irrigation systems. According to Article 35 of the Sixth Iranian Development Plan, about \$300 million is budgeted for investments in new and improved irrigation schemes by farmers. Based on this plan, the government pays 85% of all costs for implementing a new irrigation system, leaving the farmer's share at only 15% [22]. However, notwithstanding the benefits of new irrigation technologies and the availability of the generous government subsidy, adoption rates of improved irrigation technology remain critically low among Iranian farmers [23]. The question is why?

The goal of this study is to determine what is limiting the uptake of the improved irrigation technology in Iranian agriculture. Financial incentives offered by the government in the form of a huge subsidy have failed to convince farmers to adopt the improved technology. What is restricting adoption? Is it because particular characteristics of the new and improved irrigation system have little or no compatibility with farmers' existing systems? Are there certain socio-economic characteristics that inhibit or prevent acceptance at the farm level? An empirical analysis is required to determine the factors that underlie growers' decisions to accept or not drip irrigation systems on their land.

Existing studies on the acceptance of innovation in agriculture largely focus on economic incentives. Robalino [24] finds that subsidies or other incentives often are necessary to accelerate the diffusion of new technology.

To date, the prevailing approach to understand the drivers of farmers' decisions regarding the adoption of water saving technologies and practices is economic rationality, whereby the individual is motivated by the objective of maximizing their utility, subject to a series of constraints related to farm size, low levels of education, and limited financial resources [25]. However, the success of economic motivations depends mainly on the level of social capital [26–28]. Hence, there is a research gap, thus demonstrating that it is necessary to consider all economic and socio-economic factors along with social capital factors.

In this study, we examine those factors that affect farmers' adoption of improved irrigation methods from a multi-dimensional perspective. Since it is well known that acceptance of new technology ultimately depends on multiple and interrelated factors [29], we examine those factors affecting farmers' adoption from three theoretical perspectives simultaneously. All three are already considered in the adoption literature: farmers' socio-

economic characteristics, their technology characteristics, and their social capital. Our study examines how social capital variables, farmers' socio-economic characteristics, and technology characteristics affect the adoption decision of farms in the Behbahan district in Khuzestan province in southwest Iran.

## 2. Conceptual Framework

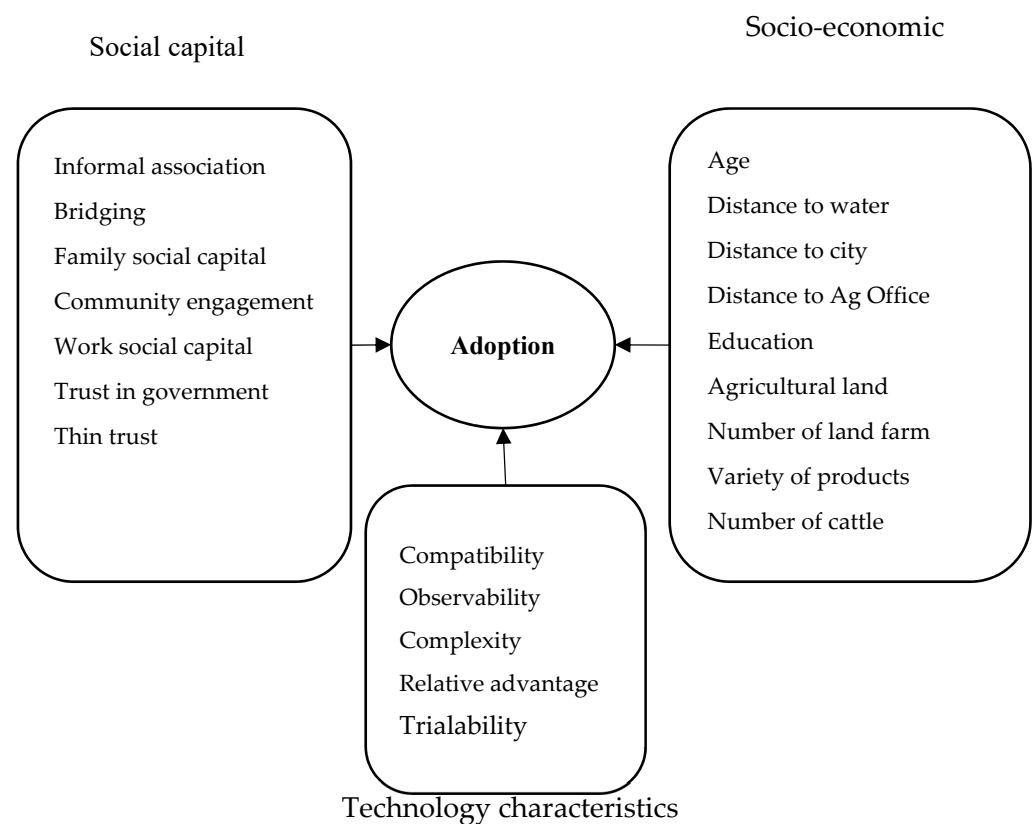
### 2.1. Socio-Economic Factors

The importance of socioeconomic factors in the acceptance of innovation in agriculture is long known. A large number of socio-economic factors are considered in the literature of innovation adoption [30–33]. Socio-economic factors refer to the personal characteristics of the main decision-maker on the farm [34]. Stephenson [35] finds that farmers who accept new technology early tend to be younger, more educated, and more cosmopolitan; have higher incomes and larger farm sizes; and are more reliant on primary sources of information. Feder et al. [36] argue that personal factors, such as education, farm size, and experience, are important causes of innovation acceptance in developing countries. Chandran and Surendran [37] argue that socioeconomic features, such as age, education, farming experience, and farm size, have a positive influence on drip irrigation adoption by farmers in India. Zhang et al. [19] find that Chinese farmers' level of education plays a pivotal role in the adoption of new irrigation technology: those who possess more education have a greater ability to navigate around constraints, thereby facilitating the adoption process vis-à-vis for farmers with less education. Farm size is another important factor in the adoption of new irrigation systems. Mottaleb et al. [38] in Bangladesh and Zhang et al. [19] in China find that farm ownership is significantly and positively related to the acceptance of innovations, such as new irrigation systems. Furthermore, researchers find that this effect is not limited to land size: other assets such as the size of livestock enterprise also can affect adoption. Feike et al. [39] find that farm size, crop types, and cropping intensity influence the adoption of drip irrigation in China. Namara et al. [11] find that family size, education, and type of crop influence the adoption of micro-irrigation systems in India. Mirzaei et al. [40] and Torkamani and Shajari [41] find that age is significant in the acceptance of new irrigation systems in Iran. Abdulai et al. [42] find that age, education, and distance of irrigation water sources are significant predictors of innovation in Ghana. Dimara and Skuras [43] find that the farm's distance from main urban centers in Greece can influence technology adoption by farmers. Based on findings in the literature, we selected age, education, farmland, number of farmland parts, farming experience, distance to water resource, distance to city, and number of products (diversification), as well as the number of big and small livestock, as independent socio-economic variables that might explain the adoption of drip irrigation in southern Iran (Figure 1).

### 2.2. Social Capital

Although social capital was introduced by Hanifan about a century ago, its relationship to development and growth remained unknown until 1980, after which there was a significant expansion in this field of research and academic debate e.g., [27,44]. Putnam defines social capital as a relationship within a social organization within which trust is most important [44]. Social capital is normally clarified in the literature as being considered by networks, reciprocity of norms, and trust [45,46], which enable cooperation and coordination of people to attain anticipated objectives and joint benefits [27]. Social capital and innovation are naturally linked [47]. Many studies [e.g., Rijn et al. [47] in Sub-Saharan Africa; Micheels and Nolan, [26] in Canada; Hunecke et al. [27] in central Chile; Lambrecht et al. [28] in Congo; Michelini, [48] in Argentina; Sanginga et al. [49] in Uganda; Chirwa, [50] in southern Malawi; Isham, [51] in Tanzania] find that social capital acts as a valuable asset and might lead to greater levels of acceptance of innovation. Hunecke et al. [27] argue that social capital mechanisms play an appropriate role in the acceptance decision-making process. Narayan and Pritchett [52] observe that farmers in Tanzania who have higher levels of social capital use more modern agricultural inputs.

Nyangena [53] reveals that the likelihood of acceptance of innovation in Kenya increases with more social capital. Tiwari et al. [54] in Nepal reveal that membership in a farmers' group, which represents social capital, amplifies self-confidence among its members to accept innovative soil conservation techniques. Furthermore, they find that the level of awareness by an individual farmer of opportunities for adoption of new technology might be predisposed by their social relations with memberships of both the agricultural and broader communities. Lambrecht et al. [28] find that the charge of searching for information in Congo might be cheaper for farmers who have a larger network [55]. Manda et al. [56] initiate that cooperative membership increased the innovation acceptance by 11–24 percent due to their social networks [57]. In this study, the role played by farmers' social capital in accepting and adopting new irrigation systems is investigated. We quantify social capital of farmers through a scale developed by Woodhouse [58]. This 35-item scale captures elements of social association, bridging social capital, family social capital, community engagement, thin trust, and work social capital.



**Figure 1.** Theoretical framework.

### 2.3. Technology Characteristics

A large number of studies (e.g., Franceschinis et al. [59] in Italy; Micheels and Nolan, [26] in Canada; Aubert et al. [60] in Canada; Pannell et al. [61] in Australia; Warren et al. [62] in Scotland; Sattler and Nagel, [63] in Germany; Batz et al. [64] in Kenya) find that characteristics of the technological innovation itself can significantly affect adoption rates. These relate to the attributes of an innovation: (1) relative advantage, (2) compatibility, (3) complexity, (4) trialability, and (5) observability [65].

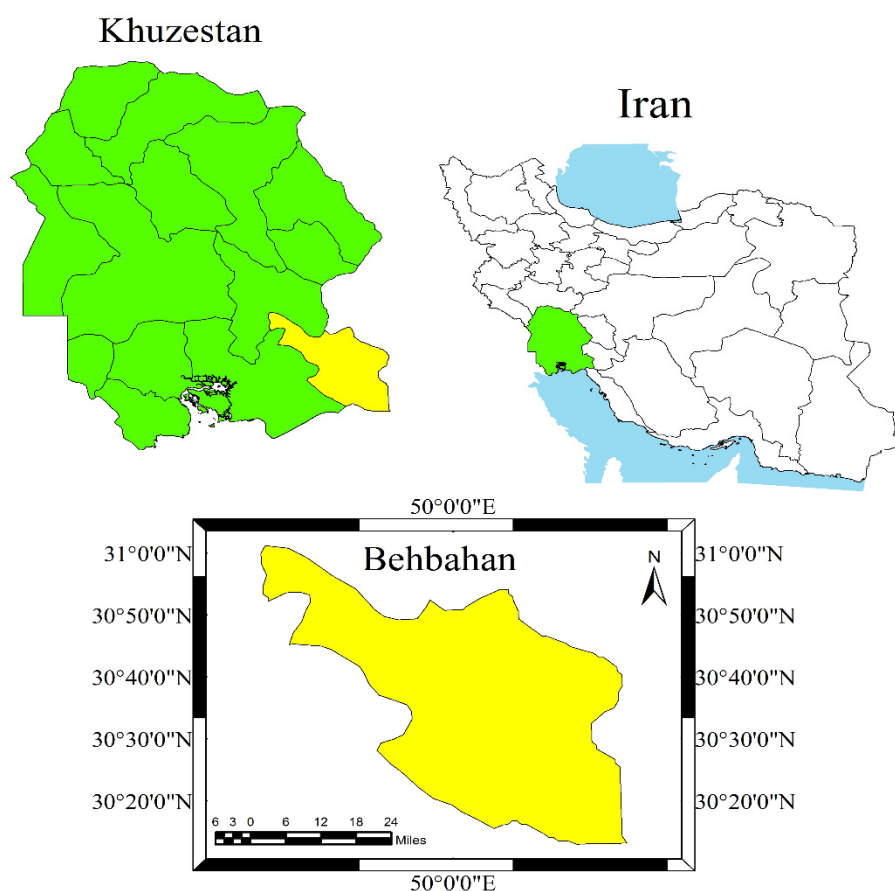
Rogers [65] defines relative advantage as the degree to which an innovation is seen as better than the idea it replaces or supersedes. Compatibility refers to the degree to which the innovation is consistent with socio-cultural values, past experience, and/or perceived need. In other words, if an innovation is to be accepted by a farmer, that technology must be compatible with the conditions facing the farmer [66,67]. Complexity refers to the degree to which an innovation is difficult to use or understand [65]. Trialability is the degree to which

an innovation may be experimented with on a limited basis. Observability refers to the ability to observe an innovation and its results, which directly relates to visual perception and other sensory perception [68].

Aubert et al. [60] find that adoption of precision agriculture in Canada was affected by the complexity of the technology components. Dai et al. [69] in China and Simin and Janković [70] in Serbia highlight the importance of technical complexity in the adoption of agricultural water-saving technologies and organic farming, respectively. Eder et al. [71] point out the importance of different relative advantages on the adoption of renewable energy in Uganda.

### 3. Materials and Methods

A cross-sectional survey was undertaken in Behbahan district in Khuzestan province in southwest Iran. Behbahan is located in the southeastern corner of Khuzestan province and has an arid climate (Figure 2).



**Figure 2.** Area under study.

The district agriculture office provided a list of 174 farmers who had adopted drip irrigation in that region. We interviewed all 174 in their home, by phone, or in the agriculture office (whichever was most convenient to them). We then selected randomly 100 non-adopters who were located in the same region and asked them the same questions. In total, our data consist of 274 observations. The questionnaire was divided into three sections including questions on socio-economic characteristics, technology characteristics, and social capital items. Respondents were asked to indicate on a five-point Likert scale their answers to questions pertaining to technology and social capital, from (1) strongly disagree to (5) strongly agree. Each questionnaire required approximately 40 min to complete. We assessed questionnaire validity and reliability through two distinct processes. First, the questionnaire was vetted and amended based on advice from a panel of experts (with

backgrounds and credentials in agriculture extension, sociology, and economics). They assessed the content validity in terms of relevance and clarity of items.

Second, a pilot study was undertaken with 30 farmers to investigate the questionnaire's reliability. Cronbach's alpha coefficient was used to evaluate internal consistency reliability. A generally accepted rule of thumb is that  $\alpha$  0.6–0.7 indicates a satisfactory level of reliability, and  $\alpha$  0.8 or higher is a very good level [72]. The results revealed that the reliability of the questionnaire variables (0.60–0.91) was acceptable to very good (Table 1).

**Table 1.** Reliability analysis.

Framework	Scale Name	Number of Items	Alpha
Social capital	Informal association (friends and neighbors)	7	0.76
	Bridging	4	0.81
	Family social capital	2	0.66
	Community engagement	4	0.60
	Work social capital	3	0.64
	Trust in government	6	0.91
	Thin trust	2	0.60
Technology characteristics	Compatibility	3	0.71
	Observability	3	0.76
	Complexity	3	0.86
	Relative advantage	5	0.79
	Trialability	3	0.78

## 4. Results

### 4.1. Descriptive Statistics

The descriptive analyses of farmers' socio-demographic characteristics reveal that adopters of drip irrigation (mean age of 52.91 years) were older than non-adopters (45.29 years). Adopters, on average, had more farmland (19.05) than non-adopters (8.40), were closer to water resource (543 m) than non-adopters (1052 m), and produce fewer products (2.39) than non-adopters (2.61). Finally, adopters had more cattle (400) than non-adopters (1.57). Other variables, including the number of agricultural land parts, distance to the agricultural office, and distance to the city, had no significant differences between adopters and non-adopters (Table 2).

**Table 2.** Discriminant analysis results.

	Models			Mean	
	Standardized Coefficients	Canonical Correlation	Structural Matrix	Adopters N = 174	Non Adopters N = 100
Model 1			Socio-economic characteristics		
Age	0.780	0.081	0.502	52.919	45.290
Distance to Ag office	0.511	0.097	0.399	8.12	4.79
Distance to water resource	−0.388	0.000	−0.329	543.775	1052.720
Education	0.336	0.086	0.044	10.17	9.91
Agricultural land	0.326	0.021	0.430	19.05	8.40
Variety of products	−0.345	−0.51	−0.206	2.39	2.61
Distance to city	−0.260	−0.013	−0.038	19.614	20.840
Number of cattle	0.211	0.004	0.194	15.948	1.570

Table 2. Cont.

Models			Mean		
	Standardized Coefficients	Canonical Correlation	Structural Matrix	Adopters N = 174	Non Adopters N = 100
Constant			−4.154		
Canonical Correlation			0.606		
Wilks' Lambda = 0.632	sig = 0.0001		Chi-square = 122.8	Variance = 100	Eigenvalue = 0.58
Model 2			Social capital		
Family social capital	0.694	1.431	0.513	3.86	4.0
Community engagement	−0.957	−1.993	−0.305	3.93	3.85
Work social capital	0.824	1.911	0.427	3.91	4.01
Constant			−5.367		
Canonical Correlation			0.248		
Wilks' Lambda = 0.938	sig = 0.001		Chi-square = 17.23	Variance = 100	Eigenvalue = 0.06
Model 3			Technology characteristics		
Compatibility	1.076	2.517	0.76	3.95	3.74
Complex	−0.723	−1.00	−0.253	3.39	3.51
Constant			−6.309		
Canonical Correlation			0.299		
Wilks' Lambda = 0.911	sig = 0.000		Chi-square = 25.29	Variance = 100	Eigenvalue = 0.09
Model 4			Combination model		
Age	0.728	0.076	0.424		
Distance to Ag office	0.460	0.098	0.377		
Distance to water resource	−0.354	0.0	−0.310		
Education	0.315	0.081	0.041		
Compatibility	0.336	0.786	0.294		
Family social capital	−0.300	−0.619	−0.163		
Agricultural land	0.367	0.023	0.406		
Variety of products	−0.267	−0.413	−0.195		
Distance to city	−0.235	−0.011	−0.036		
Constant			−4.672		
Canonical Correlation			0.629		
Wilks' Lambda = 0.605	sig = 0.000		Chi-square = 134.5	Variance = 100	Eigenvalue = 0.65

Structural matrix = discriminant loading = correlation between discriminating and standardized canonical discriminating function.

#### 4.2. Discriminant Analysis

To determine which factors influence the adoption of drip irrigation by farmers in this region of Khuzestan province, we applied linear discriminant analysis (LDA). LDA is a correlational technique that, based on a set of metric independent variables, classifies objects into one of two or more mutually exclusive groups of a categorical dependent variable [73]. LDA is a multivariate statistical method used to determine which variables are distinct between two or more groups [74]. It can identify how independent variables can best disaggregate groups of adopters/non-adopters with quantitative values and identify variables that are appropriately distinct between groups. It has application and interpretation analogous to multiple linear regression, by predicting an outcome when the response property has categorical values and descriptors are continuous variables [75].

The empirical model (1) was estimated using stepwise procedures. The dependent variable is binary (1 = adopter; 0 = non-adopter). LDA explicitly attempts to model the difference between the classes of data. The form of LDA equation is as follows:

$$DF = c_1 \times X_1 + c_2 \times X_2 + \dots + c_n \times X_n + a \quad (1)$$

where DF is the discriminate function—a linear combination (sum) of the discriminating factors;  $c$  is the discriminant coefficient or weight for that factor;  $X$  is the respondent's score for that factor;  $a$  is a constant; and  $n$  is the number of predictors variables. The standardized discriminant function coefficients in the table serve the same purpose as beta weights in multiple regression (partial coefficients): they indicate the relative importance of the independent variables in predicting the level of the dependent variable. They allow the comparison of variables measured on different scales. Coefficients with large absolute values correspond to variables with greater discriminating ability.

We estimated four LDA models to predict and differentiate between adopters and non-adopters of drip irrigation through three separate frameworks: socio-economic, social capital, and technical characteristics, as well as a combination of these three frameworks (results are presented in Tables 2 and 3). Wilk's Lambda was 0.632, 0.938, 0.911, and 0.605 in the four estimations, which are significant at  $p$ -value  $< 0.001$ . This means that the models can significantly differentiate between the two groups of farmers (Model 1:  $\lambda = 0.632$ ,  $\chi^2 = 122.875$ ; Model 2:  $\lambda = 0.938$ ,  $\chi^2 = 17.235$ ; Model 3:  $\lambda = 0.911$ ,  $\chi^2 = 25.293$ ; Model 4:  $\lambda = 0.605$ ,  $\chi^2 = 134.567$ ). Therefore, our null hypothesis ( $H_0$ ) of no differences is rejected. It is important to note that the smaller the Wilk's Lambda, the greater the power of that model to distinguish between two groups.

**Table 3.** Classification results.

		Predicted Group Membership			Total	Correctly Classify
		Adoption	Yes	No		
Model 1	Count	Yes	140	34	174	81.0%
		No	18	82	100	
	%	Yes	80.5	19.5	100	
		No	18.0	82.0	100	
Model 2	Count	Yes	117	57	174	57.7%
		No	59	41	100	
	%	Yes	67.2	32.8	100	
		No	59.0	41.0	100	
Model 3	Count	Yes	100	74	174	61.3%
		No	32	68	100	
	%	Yes	57.5	42.5	100	
		No	32.0	68.0	100	
Model 4	Count	Yes	142	32	174	82.5%
		No	16	84	100	
	%	Yes	81.6	18.4	100	
		No	16	84.0	100	

In model 1 (Socio-economic factors), the mean discriminant score (centroid) for the adopters' group is 0.576, which is significantly different from that of non-adopters who have a mean of  $-1.002$ . Thus, Model 1 can categorize the new irrigation adopters and non-adopters with an accuracy of 81.0% (Table 3). According to the results of LDA in model 1, variables such as age, distance to the agricultural office, distance to water resource, education, agricultural land, variety of products, distance to the city, and the number of cattle have a significant effect on the adoption of drip irrigation technology.

In Model 2 (Social Capital), the adopter's group has a mean score of  $-0.194$ , which is significantly different from that of non-adopters with 0.337 mean. Model 2 also is able to categorize 57.7% of the irrigation adopters' and non-adopters groups (Table 3). Three



factors (family social capital, community engagement, and work social capital) have a significant impact on the acceptance of drip irrigation technology.

In Model 3 (Technology Characteristics), the mean discriminant score for the adopters group is 0.236, which is significantly different from that of non-adopters, with a mean of  $-0.411$ . It was able to separate the two categories with 61.3% accuracy. Compatibility and complexity variables were significant in explaining differences between the groups in acceptance of the new irrigation system. Compatibility refers to the coordination of innovation with the conditions of the farmer from climatic, cultural, economic, and social points of view. Therefore, the more compatibility innovation has with these aspects, the more likely it is to be adopted. Complexity is another characteristic of innovation that negatively affects drip irrigation adoption. The more complex were farmers' perceptions of the new irrigation system in terms of the amount of knowledge required to apply it, the less likely it was to be adopted.

Model 4 is the strongest at distinguishing between adopters and non-adopters. The mean discriminant score for the adopters' group is 0.611, which is significantly different from that of the non-adopters group:  $-1.063$  mean. It is able to separate the two categories with 82.5% accuracy (Table 3). The sum of variables, such as age (+), distance to the agricultural office (+), distance to water resource (−), education (+), compatibility (+), family social capital (−), agricultural land (+), variety of products (−), and distance to city (−), also based on the results of Model 4, which is a combination of Models 1, 2, and 3, has a significant impact on the acceptance of drip irrigation system.

Based on the findings, the following functions were estimated for each of the models studied:

- $D1 = -4.154 + 0.081 \text{ Age} + 0.097 \text{ Distance to ag office} + 0.086 \text{ Education} + 0.021 \text{ Agricultural land} - 0.51 \text{ No product} - 0.013 \text{ Distance to city} + 0.004 \text{ No cattle}$
- $D2 = -5.367 + 1.431 \text{ Family social capital} - 1.993 \text{ Engagement} + 1.911 \text{ Work social capital}$
- $D3 = -6.309 + 2.517 \text{ Compatibility} - 1.00 \text{ Complexity}$
- $D4 = -4.672 + 0.076 \text{ Age} + 0.098 \text{ Distance to ag office} + 0.081 \text{ Education} + 0.786 \text{ Compatibility} - 0.619 \text{ Family social capital} + 0.023 \text{ Agricultural land} - 0.413 \text{ No product} - 0.011 \text{ Distance to city}$

## 5. Discussion

Discriminant analysis reveals that a socio-economic approach is the strongest model for predicting acceptance of new irrigation systems in the study area, followed by models of technical characteristics and social capital. In the first (socio-economic) model, the age of farmers was significantly different for adopters and non-adopters. Unexpectedly, age is the strongest predictor of adoption in this model.

Our study shows that as farmers get older they are more likely to accept an improved irrigation system. This finding contrasts with previous findings on age [76–78], which indicate that younger farmers are more likely to accept improved irrigation systems.

Distance to the agricultural office (extension) was another significant and positive variable between adopters and non-adopters. Despite prior expectations, the discriminant analysis reveals that the farther away farmers are from extension agents, the more likely they are to be an adopter. This is a surprising finding, running counter to the findings of other researchers [79–81]. A possible explanation lies in the findings of Ashoori et al. [82]: extension performance is evaluated by 80.8% of farmers in Iran to be not very useful.

Distance to water resources is another significant (negative) predictor. Farmers who have water resources close to their farm save time and money when transferring water to their farms as compared to those who spent more time and money moving water. Thus, they have less incentive to adopt the drip irrigation technology, which, despite the water-saving benefits and the large government subsidy, still requires extra expense and time to successfully implement.

Education is another important variable in the first model. Our consequences show that farmers who accepted the new irrigation system are relatively more educated. This conforms with findings by other researchers [41,79,83–85]. More highly educated farmers are better able to recognize the benefits of adopting new irrigation systems.

Farm size is another important indicator of adoption compared to non-adoption. Other studies [85–87] also report similar findings.

Distance to the city is another important factor that is significant (negatively) between adopters and non-adopters. Those further from a city were more likely to accept the improved technology. This finding is similar to results reported by Ashoori et al. [82] and Mengstie, [88]. This can be linked to inadequate access to inputs (market) required for irrigation systems.

Finally, in the first model, the number of cattle had a positive and significant effect on acceptance of the new irrigation system. Farmers with livestock are more likely to accept new irrigation systems than were farmers with no livestock. Those with larger livestock holdings likely have greater financial resources (and possibly less time) and, therefore, greater motivation to invest in a new irrigation system.

In the second (technology characteristics) model, compatibility is significant, explaining the difference between the groups. Iranians, in their long history, have often faced water shortages and they have learned to conserve water carefully. New, more efficient irrigation systems fit well with their long-standing concern about water. Therefore, this variable directly and positively influences adoption. However, complexity adversely (negatively) affected adoption. Complexity refers to the extent that new technology is difficult to use or understand [65]. Therefore, if farmers find new irrigation systems complex, they are less likely to adopt them.

In the third (social capital) model, only three variables are significant. While community engagement had a significant negative effect, work social capital and family social capital had significant positive effects on distinguishing between adopters and non-adopters. Community engagement refers to involvement in community projects, attending community events, and participation in local groups. In other words, the individual generally participates in social activities, spending energy and time on societal objectives. With that public involvement, the farmer spends less time on their farm. Therefore, this factor had a negative effect on accepting innovation. However, the other two variables in the third model, the person is constantly receiving different support from their family and peers. These two groups can provide personal, financial, and even emotional support. Additionally, they increase energy, time, and possibly even self-confidence, which are important factors in adopting innovations. In other words, those with stronger relationships with their colleagues on the farm and in the workplace might have learned more about the cost of installing new irrigation networks, how to use new irrigation networks, and how efficient they are. Getting more information about the innovation is considered a factor in its acceptance. Furthermore, family social capital refers to relationships and emotional relationships with family members and relatives. It seems that farmers who have more family social capital are more likely to be able to accept an innovation through their financial and emotional support.

## 6. Policy Implication

According to the results of significant variables, some important strategies are suggested to enhance the adoption of modern irrigation technologies by farmers.

The results of the five innovation characteristics show that two characteristics, compatibility and complex, affected the acceptance of drip irrigation technology.

It can be generally concluded that increased adoption of modern irrigation technologies is possible by showing farmers how these technologies are compatible, providing proper training and information that facilitates its implementation and provides practical solutions that generate a positive outlook for farmers to adopt these technologies.

The results confirm that one important reason for farmers' not adopting is the complexity of applying modern irrigation technologies. It is suggested that appropriate technical guidelines that reduce the complexity of drip irrigation systems be provided to farmers. Existing users can also be encouraged to guide their peers in maintaining equipment and optimizing the efficiency of drip irrigation technology.

The greater the distance between the farm and the water resources and the city the less likely that irrigation technology is adopted. Therefore, it is necessary to seriously consider an important recommendation in this regard. The large distance between farms and water resources and the city may indicate the poorer financial situation of the farmer, thus making it financially difficult for them to implement advanced irrigation systems. Therefore, it is suggested that different credits be considered for farms that are far away from water sources and cities. In addition, it is probably be more expensive to install irrigation systems on these farms, which will increase the need for government funding. In contrast, farmers with larger farmland are more likely to accept irrigation. On these lands, the installation of modern irrigation technologies is probably more cost-effective, and, instead of financial aid, it is necessary to increase people's knowledge and information about the importance of modern irrigation technology. The level of education affects the adoption of irrigation technology. The effect of education is probably due to the understanding of global water scarcity issues and the ability to calculate the benefits of reducing water consumption versus the cost of installing drip irrigation in the long term, as well as generally possessing better knowledge and awareness. Therefore, agricultural extension associations in the region should inform farmers in simple way about issues such as water shortages in Iran. It is also necessary to train farmers on the amount of water and the money saved after installing drip irrigation using simplified number and figures.

## 7. Conclusions

It is well documented that the adoption of innovations by farmers is a crucial factor for not only the growth and sustainability of agriculture, but also for reducing poverty in developing countries [89]. In this study, we focus on the adoption of a new irrigation system in a dry and water-scarce region of southwestern Iran. We consider an important intervention by the Iranian government to mitigate water shortages amid current and future climate change. The main reason for the water crisis in Iran is the low efficiency of water use in agriculture. Therefore, knowledge about the determinants of the adoption of new irrigation systems will provide important information for Iranian decision-makers to design appropriate and effective policies aimed at facilitating the acceptance of new irrigation systems. Globally, drip irrigation accounts for less than 5% of the total global irrigated area. Thus, the results of this study are also appropriate for other countries with similar conditions.

It is vital to note that the acceptance of innovations in agriculture, especially among smallholders in developing countries, is not only challenging but also seldom rapid [47]. In addition, it is often unsuccessful [47]. Knowledge about the determinants of new irrigation systems adoption gained from this study may help Iranian decision-makers design appropriate and effective policies aimed at facilitating an increased adoption of drip irrigation.

The approach of this study and its findings shed light on what might be done to inspire the positive acceptance of irrigation systems and why many earlier efforts have not been effective. The results reveal that the combination of different approaches (socio-economic factors, technology characteristics, and social capital) can predict the acceptance of new irrigation systems among Iranian farmers. Separately, socio-economic factors, technology characteristics, and social capital have great power in predicting the acceptance of new irrigation systems.

The results of this study provide insight into the diffusion of modern irrigation innovations in Iran. The results reveal different processes underlying the diffusion of water-saving technologies among adopters and non-adopters, demonstrating the importance of un-

understanding how innovations are perceived, how farmers use social networks, and their socio-economics characteristics. The combination model including different dimensions of socio-economic characteristics, social capital networks, and innovation characteristics best predicts those factors affecting the adoption of drip irrigation technology.

Finally, certain limitations of this study should be acknowledged. First, this study was conducted only in one of the counties of Khuzestan province and cannot be generalized to the whole of Iran. Therefore, similar studies should be undertaken in other parts of Iran as well. Additionally, this framework should be tested for other agricultural innovations. Since social capital is not previously used to explain the adoption of innovations in Iranian agriculture, further studies should be undertaken to determine the best and most accurate social capital framework for this type of analysis.

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