*J. Agr. Sci. Tech. (2014) Vol. 16: 1253-1266*

# Modeling the Process of Drip Irrigation System Adoption by Apple Orchardists in the Barandooz River Basin of Urmia Lake Catchment, Iran

S. Mohammadzadeh[1], H. Sadighi[1*], and Gh. Pezeshki Rad[1]

## ABSTRACT

**The extensive use of traditional irrigation systems has led to overexploitation of groundwater and overuse of surface water in the Urmia Lake Catchment (ULC) area of Iran. The purpose of this study was to model the adoption process of drip irrigation system (DIS) by apple orchardists (AOs) using the five stages of Roger's model for Innovation Decision Process (IDP). Survey method of applying questionnaire and interview technique was used to collect data from 136 AOs. The results of the study indicated that, first, AOs' knowledge level was "relatively low" and the majority of them were in the early stages of IDP. Secondly, applying an ordinal logistic regression, up to 36.3% of knowledge level variability, could be explained by variables consisting of: the contact level with extension agents, educational level, rural-urban commuting and information sources. Thirdly, using binary logistic regression, up to 74.1% of probability of adoption, could be explained by variables consisting of source of irrigation, knowledge scores, and orchard size. Fourthly, the main barriers for adoption were high costs, lack of license for semi deep wells, need to grow alfalfa, poor knowledge, and low surface area, respectively. Fifthly, about 0.5% of AOs had already implemented DIS. These findings were instrumental for localizing a model and developing the needed policy and institutional interventions.**

**Keywords:** Innovation Decision Process (IDP), Logistic Regression, Pressured Irrigation, Urmia Lale.

## INTRODUCTION

Like many countries in the world, Iran's agriculture is the main consumer of water. Urmia Lake Catchment (ULC) is one of the major agricultural producing areas where approximately one million hectares are currently devoted to horticulture and field crops production (Iran's Ministry of Agriculture, 2012). According to West Azarbayejan Regional Water Authority (2012), agriculture consumes an average of 87% of water sources in the ULC. Therefore, this issue has led to over-exploitation of groundwater and over-use of surface water. Consequently, the annual volume of water received in the Urmia Lake as well as the groundwater table has significantly decreased. According to Foreign Agricultural Services of the USDA (2012), water depth of Urmia Lake decreased about six meters from 1998 to 2012. If the drying process continues, the entire lake, as the third largest salt-water lake on earth, will dry up and, as a result, horrible environmental problems will occur at both regional and national scales (IWRM, 2011).

Despite water shortage in the ULC zone, a great amount of water used in agriculture is lost because of low water use efficiency

[1] Department of Agricultural Extension and Education, College of Agriculture, Tarbiat Modares University, Tehran, Islamic Republic of Iran.
[*] Corresponding author: e-mail: Sadighi_h@modares.ac.ir

(WUE) (about 38%) that derived from using traditional irrigation systems, namely, basin and furrow (Kohansal and Rafiei, 2009; Abbasi *et al.*, 2006). Based on some researches, WUE obtained in DIS and sprinkler irrigation system (SIS) reached as high as 90 and 70%, respectively (Mirjat *et al.*, 2006; Soccol *et al.*, 2002). Hence, converting traditional irrigation systems to pressurized irrigation systems is being seriously considered.

In spite of converting to DIS, which can increase production costs, there is an economical advantage that makes it worthwhile for adoption. The higher profitability may be due to one or more of the following factors: saving of water per unit of land; saving in other costs (fertilization, weed control, and insecticides); saving energy; introduction of marginal land and water; and improvement in the quantity and quality of the yield (Fishelson and Rymon, 1989; Douh, and Boujelben, 2011). Thus, considerable government efforts have been made to facilitate the adoption of DIS by providing needed equipment, credit and extension services. Nevertheless, the adoption of DIS as an *innovation* is lagging behind.

Diffusion scholars have long recognized that an individual's decision about an innovation is not an instantaneous act, rather, it is a process that occurs over time and consists of a series of different choices and actions through which an individual evaluates a new idea and decides whether or not to incorporate it into his or her ongoing practices (Ruttan, 1996; Rogers, 2003). Rogers (2003) characterized a five-stage model for Innovation Decision Process (IDP) that consists of prior conditions and factors affecting each stage (Figure1). He noted that each stage in the IDP is a potential rejection point, and rejection can occur even after a prior decision to adopt, which is called *discontinuance*.

Caswell and Zilberman (1986) examined the effects of well depth and land quality on

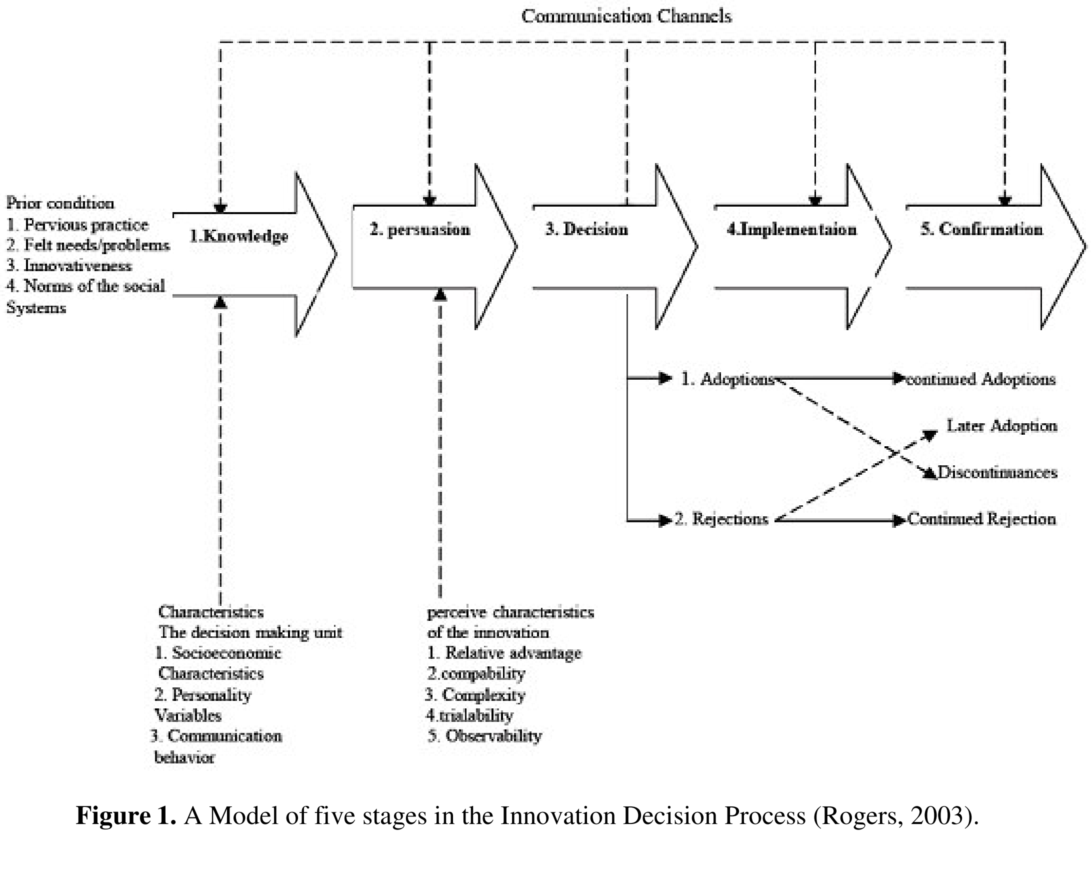


**Figure 1.** A Model of five stages in the Innovation Decision Process (Rogers, 2003).

a farmer's choice of irrigation system using a production function approach. The adoption and diffusion of drip irrigation technology in Hawaii were examined by Shrestha and Gopalakrishnan (1993). Skaggs (2001) studied current high-tech irrigation system usage, drip irrigation usage, and plans for future drip irrigation adoption by Chile Pepper producers in New Mexico. Kumar (2012) addressed the factors limiting or enhancing the adoption of DIS, and policy actions needed at different levels to speed it up. Kulecho and Weatherhead (2006) examined the factors affecting adoption of small-scale low-cost drip irrigation in Kenya, using the Rogers' (1995) model for IDP as the framework of the study. Bagheri and Ghorbani (2011) compared the adoption, discontinuance, and non adoption of SIS among 3 groups of farmers who were trained to apply those in Iran.

Given this backdrop and considering Rogers' model as theoretical framework, the purpose of this study was to model the decision making process in adoption of DIS by AOs in the Barandooz River Basin (BRB) of ULC area. The objectives were to:

Describe the current practices of AOs;

Determine AO's positions in the DIS decision process;

Assess their knowledge regarding DIS, and

Examine factors that affect their adoption process.

## MATERIALS AND METHODS

### Research Area

ULC lies in northwest of Iran at an altitude of about 1300-3000 m above sea level, among three provinces as West Azerbaijan, East Azerbaijan and Kurdistan (Figure 1). The total ULC area is about 51,876 square kilometers, which is 3.15% of the entire country (out of the 165 million ha), and includes 7% of the total surface water in Iran (IWRM, 2011). ULC has semi arid climate with annual average precipitation of around 340 mm. There are fourteen perennial streams and seven intermittent streams in the lake basin. Barandooz River is one of perennial streams with 70 kilometer length, 1,318 $km^2$ basin surface area and a total annual discharge value of about 265×106 $m^3$ (WARWA, 2012). BRB was the research area for this study and is considered to be one of the main apple producing areas in Iran (Figure 2). The main reasons for selecting ULC in general and BRB in

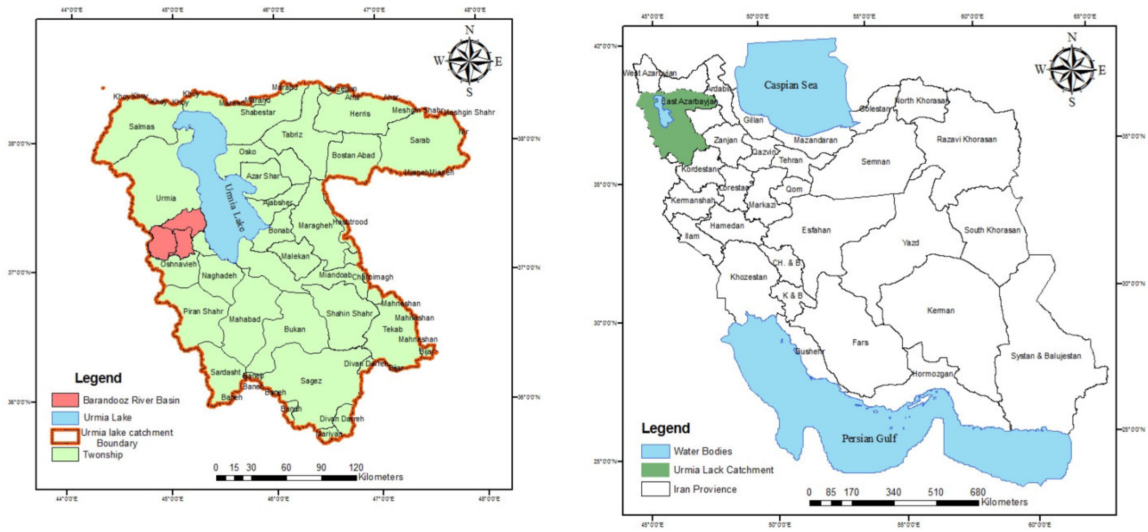


**Figure 2.** The location of ULC in Iran (right) and the location of Barandooz River Basin BRB in ULC (left).

particular as research areas were its problematic situation regarding expansion of apple orchards in recent years, thereby increasing demand for surface and ground water. Of course, the ULC zone is considered to be one of the main apple producing areas in Iran, which produces about 40 percent (one million tons) of national apple production (Iran's Ministry of Agriculture, 2008). Therefore, adoption and implementation of the DIS in this area is considered as one of the best solutions to increase WUE. Particularly, BRB is the main apple producing area in ULC and the top national apple producers are usually chosen from this region. Similarly, the AOs in BRB zone are considered as leaders for other AOs in ULC area, therefore, the probability of adoption of DIS in this region is very high and the results of this study could be adapted to other regions.

## Data Sources

The target population was all the AOs in the BRB (3127) and the list of their names and addresses was accessible from West Azerbaijan Province Agriculture Organization. A simple random sampling method was used and sample size was determined through a pretest from 30 AOs according to Nyariki (2009) and Equation 1:

$$n = Z^2_{\alpha/2} \frac{p(1-p)}{d^2} \qquad (1)$$

Where, $n$ is sample size, $Z$ is the statistical certainty set at the 95% confidence level (Z= 1.96) for an error risk (α) of 5%, $p$ is the estimated level (65%), and $d$ is the precision (0.08). This test yielded a sample size of 136.

This research used a survey design and face to face interview technique as means of data collection. The instrument for data collection was a self-designed structured questionnaire. Face and content validity of the questionnaire were confirmed by a panel consisting of agricultural extension agents, horticulturists, and irrigation experts. A Cronbach alpha coefficient of 79% was calculated, indicating high reliability of the questionnaire (Carmines and Zeller, 1979).

## Analytical Models

Prior to modeling DIS decision process, the AOs' stages in the DIS decision process were identified by a 5-option question. Then, the knowledge scores, which were determined by testing technique, were calculated by sum of 12 True/False type questions for all of AOs. Thereafter, the scores were categorized into three levels, namely, low (0-4), moderate (5-8), and high (9-12).

Using SPSS 19, ordinal logistic regression was used for modeling knowledge level that was based on ordinal scale (Table1) and binary logistic regression was used for modeling of persuasion dichotomous variable (Tabachnich and Fidell, 2007). Due to the small number of adopters, modeling was not carried out in decision stage. None of AOs were into implementation or confirmation stage. Therefore, these stages were not applicable and not analyzed.

In modeling AO's knowledge level, it was assumed that $y^*$ denote a latent (unobserved) variable that represents the "levels of knowledge", $y$ the observable variable, and $\tau$ the thresholds for levels of knowledge ($\tau_1$ = 5 and $\tau_2$ = 8), such as Equation 2 must hold in an ordered model:

$$y_i = \begin{Bmatrix} low\ if\ y^* < \tau_1 \\ moderate\ if\ \tau_1 \le y^* \le \tau_2 \\ high\ if\ y^* > \tau_2 \end{Bmatrix} \qquad (2)$$

This latent variable $y^*$ can be estimated using the structural model:

$$y_i^* = x_i \beta + \varepsilon_i \qquad (3)$$

Where, $x$ is a vector of variables explaining $y^*$, $\beta$ is the associated vector of coefficients, and $\varepsilon$ is the error term for each farmer $i$. If the error terms of equation are

**Table 1.** Description of the variables used in modeling of DIS decision process.

| Acronym | Description | Type of measure |
|---|---|---|
| Dependent variables | | |
| Knowledge score | AO's [a] knowledge score regarding DIS [b] | Scores (0 to 12) |
| Knowledge level | AO's knowledge level regarding DIS | Scoring: Low (0-4); Moderate (5-8), and High (9-12) |
| Persuasion | Whether a AO like or dislike DIS | Dummy (1: If like, 0: If dislike) |
| Adoption | Whether a AO will or will not use DIS | Dummy (1: If will use, 0: If won't use) |
| Independent variables | | |
| - | AO' age | Years |
| EDUL | Educational levels | Number of years of formal education |
| EXPL | experience level | Years |
| RUCOM | Rural-urban commuting | Number times a month |
| MI | Monthly income | Rials |
| MAR | Marriage | Dummy (1: If married, 0: If single) |
| NCHLD | Number of children | Numbers |
| EDULCHLD | Educational levels of AO' children | Sum of years of formal education |
| MECL | Mechanization level | Number of orchard machinery of AO |
| TF | Type of farming: Orchardist; agronomy; animal husbandry; and non-agriculture | Dummy (1: If yes, 0: If no) |
| IRGWSOU | Irrigation water source: River; semi deep well; deep well; and spring | Dummy (1: If use; 0: If not use) |
| TIRGS | Type of irrigation systems used by AO | 1: If basin; 2: If furrow, 3: If DIS |
| NIRG | Number of irrigation | Number times a crop year |
| SFOW | Status of farm ownership | 1: If owned, 2: If rented |
| ORSI | Orchards size | Hectare (ha) |
| NORF | Number of orchards fragmentation | Numbers |
| CONLAEA | the contact level with agricultural extension's agents | 0= No; 1= Very low; 2= Low; 3=Moderate; 4= High, 5= Very high |
| FR, AEA, TV,RAD, SAT, INT, SUPIN, PUB | Communication channels: Friends and acquaintances ; agricultural extension' agent; TV; radio; Satellite; Internet; suppliers of inputs, and publication of extension service | Dummy (1: If use, 0: If not use) |

[a] Apple orchardists, [b] Drip irrigation system.

assumed to have a logistic distribution, the probability that a farmer $i$ will choose one of the categories $j$ (the levels of knowledge) can be expressed as an ordinal logit model:

$$p(y_i > j) = \frac{\exp(\alpha_j + x_i\beta)}{1+[\exp(\alpha_j + x_i\beta)]}, j = 1,2,3 \quad (4)$$

Where, $\alpha$ is the constant term, and $\beta$ corresponds to the coefficients of a vector of variables $X$. Since the ordered logit model estimates one equation over all levels of the response variable, the test for proportional odds examines whether our one-equation model is valid.

Binary logistic regression, which was used to link the probability of a dichotomous outcome (such as adoption or non adoption) to the set of explanatory variables, has been widely applied in adoption studies (Fishelson and Rymon, 1989; Skaggs, 2001; He *et al*., 2007; 2008; Jara-Rojas *et al.*, 2012). For modeling purposes, persuasion stage $y$ was assumed to be the decision to like DIS technology and $X$ was a vector of explanatory variables related to like. For the farmer $i$, $Z_i$ is an indirect utility derived from the adoption decision, which is a linear function of explanatory variables (X) that is expressed as:

$$Z_i = X_i\beta \quad (5)$$

Regarding the adoption, decision of farmers is specified as $Y= f (X, \varepsilon)$. If the error terms of equation are assumed to have a logistic distribution, the probability that a farmer i will like DIS can be expressed as a binary logit model:

$$P_i(Y_i = 1) = \frac{\exp^{x_i\beta}}{1+\exp^{x_i\beta}} \quad (6)$$

Where, $P_i$ denotes the probability of the farmer *i* like event, $Y_i$ is the dependent variable, which would be represented by "like", and takes on the value of 1 for the farmer *i* that persuaded to DIS, while 0 is the value if "dislike" occurred. The validity of both models was tested by Omnibus and Hosmer & Lemeshow Goodness-of-Fit tests (Hosmer and Lemesho, 2000).

## RESULTS

### Profile, Current Practices, and Felt Needs of AOs

The demographic, socioeconomic, and occupational characteristics of AOs are presented in Tables 1 and 2. Orchardists did not only grow orchards but also raised animals and crops. The information sources of AOs regarding agricultural issues were, respectively, friends and acquaintances (81.8%); TV (75%); extension agents (62%); radio (51%), suppliers of inputs (10.5%); publications of extension service (3.5%); and Internet (1.5%).

The majority of the AOs used groundwater extracted by semi-deep wells (66.7%) or deep wells (23%) and about 24% of them used surface water supplied by Barandooz River or its branches. 18% of AOs used both ground and surface water. Deep wells were used in cooperative manner with other users.

Considering the average number of irrigations (8 times a crop year), irrigation interval was about 15 days. Hence, deficit of irrigation water was the main problem for many of the AOs. The decline of ground water table was another major common problem among the AOs whose sources of irrigation water were groundwater being extracted through semi deep wells. Development of diseases such as Apple Black Spot and White Root Rot were the main problems of AOs using basin (flood) irrigation system.

### Determining AO's Statues in the DIS Decision Process

The distribution of respondents by their stages in the IDP is shown in Table 3. The majority (about 60%) of the AOs who were in persuasion or decision stages determined that they "like" DIS and the remaining (about 40%) "Dislike" it. Only nine people out of 30 AOs that were in decision stage adopted the DIS and were going to implement it; the rest rejected it.

### Measuring and Scoring of AO's Knowledge Regarding DIS

The average knowledge score achieved by AOs regarding "DIS" was

**Table 2.** Statistics of continuous variables used in the modeling of DIS decision process (n= 136).

| Variable | Minimum | Maximum | Mean | SD |
|---|---|---|---|---|
| CONLAEA | 0 | 5 | 1.8 | 0.8 |
| Number of children | 0 | 11 | 3. | 1.7 |
| Educational levels of AO' children | 0 | 15.2 | 7.8 | 3.4 |
| Number of irrigation | 4 | 13 | 8.3 | 1.9 |
| Orchards size | 0.2 | 12 | 1.8 | 1.6 |
| Number of orchards fragmentation | 1 | 9 | 2.16 | 1.26 |
| AO' age | 23 | 84 | 54.5 | 13.5 |
| Mechanization levels | 0 | 10 | 2.3 | 2.8 |
| experience level | 5 | 70 | 31 | 14 |
| Rural-urban commuting | 1 | 30 | 12.38 | 8.37 |
| Monthly income (Thousands Rial) | 1000 | 25000 | 6376.250 | 4481.107 |

**Table 3.** Respondents' profile of DIS decision stages.

| Stage in the Innovation-Decision | Items | Number | Frequency (%) |
|---|---|---|---|
| No knowledge | I had never heard of drip irrigation before hearing the description provided in this questionnaire. | 2 | 1.47 |
| Knowledge | I understand its purposes and features, but have not decided whether or not I like or dislike drip irrigation. | 18 | 13.24 |
| Persuasion | I have decided. I like or dislike drip irrigation. | 86 | 63.24 |
| Decision | I have decided. I will or will not use drip irrigation. | 30 | 22.06 |
| Implementation | I am using drip irrigation. | 0 | 0.00 |
| Confirmation | I have used drip irrigation long enough to evaluate whether or not will be it as part of my future in orchid. | 0 | 0.00 |
| | SUM | 136 | 100 |

approximately **5.5** out of 12, which is considered as “moderate to low”. Their knowledge levels were considered as “low” for 35 (about 26.1%), “moderate” for 68 (50%), and “high” for 33 (23.9%). The knowledge of AOs about DIS advantages were responsible for increased WUE; reduced labor cost; and decreased disease, respectively. As for the disadvantageous features of DIS, the required technical knowledge was pointed out as the most important variable (Table 4).

## Modeling Factors Influencing Decision Making Process in Adopting DIS

### Knowledge Stage

Based on the *Chi*-Square statistic (35.136) and $P< 0.01$, two estimated intercept-only and final regression models had convergence, hence were considered as suitable. According to goodness-of-fit statistic, *p*-values for both Pearson and Deviance *Chi*-squares were > 0.05, hence the models fit to data (Hosmer and

**Table 4.** Apple orchardists’ (AO’s) knowledge regarding “DIS”.

| | Items | Awareness N | Awareness % | Priority |
|---|---|---|---|---|
| Advantages | Drip irrigation can help to use water efficiently. | 134 | 98.18 | 1 |
| | Drip irrigation can reduce labor cost. | 116 | 84.04 | 2 |
| | Drip systems are adaptable to oddly shaped fields or those with uneven topography or soil texture. | 12 | 9.12 | 12 |
| | The application of drip irrigation system can control the weeds growth. | 59 | 43.43 | 6 |
| | Conditions may be less favorable for disease development. | 98 | 71.90 | 3 |
| | Precise application of nutrients is possible using drip irrigation. | 31 | 22.63 | 8 |
| | Holding the promise of increased yield and quality. | 62 | 45.62 | 5 |
| | Timely application of herbicides, insecticides, and fungicides is possible. | 25 | 18.38 | 10 |
| Disadvantages | Drip emitters are easily plugged by silt or other particles not filtered out of the irrigation water. | 53 | 38.69 | 7 |
| | Drip Irrigation causes concentration of salts on soil surfaces. | 18 | 13.14 | 11 |
| | Technical knowledge is required to use drip irrigation. | 91 | 66.79 | 4 |
| | Rodents may hurt drip irrigation system. | 26 | 19.34 | 9 |

Lemesho, 2000). The Pseudo *R*-squares showed that up to 36.3% of the knowledge level variations could be explained by four independent variables (Table5). Considering the significance of *Chi*-square statistic, the proportional odds assumption appears to have held, therefore, the ordinal logistic regression gives two parallel equations as equation7 in the below.

Where, $\gamma_i$ is the cumulative probability of , (*i* regarding DIS of i[th] level of knowledge and $a_1$ and $a_2$ (constant values) are given in the Table 5.

## Persuasion Stage

The results of Omnibus test, namely, the large *Chi*-square value (24.119) and the small p-value (P< 0.01), showed that the predictive power of the entire variables was acceptable. Furthermore, the results of Hosmer and Lemeshow statistic indicated a large P-value (sig = 0.628) in third step, which means that the predicted probabilities for a covariate equate the observed probabilities. Finally, Cox and Snell and Negelerke Pseudo *R*-squares showed that the model that includes the three variables of semi deep wells, knowledge score, and orchard size explained up to 74.1% of variation in "persuasion" variability (Table 6). The model correctly predicted 88.1% of persuaded and non-persuaded farmers. Thus, the binary logistic regression model is as equation 8 in the below.

Where, 1 is "like" status that is on the logit scale.

## AOs' Viewpoint about Barriers of Adoption of DIS

Based on the respondent's comments, most of the AOs faced various barriers for adopting the DIS. These barriers were the high cost of installation and maintenance of DIS (86% of farmers), lack of license for well (60%), the livestock need for alfalfa (40% of farmers), poor knowledge (33.3%), the small size and fragmentation of orchard holdings (15%), lack or high cost of electrical power (10%), sufficient water

$$y_i = \frac{\exp\{\alpha_i + 0.787CLAEA + 0.415EDUL - 0.095RUCOM - 1.399nonuseoffriends\}}{1+\exp\{\alpha_i + 0.787CLAEA + 0.415EDUL - 0.095RUCOM - 1.399nonuseoffriends\}} = 1, 2) \quad (7)$$

$$P(Y=1) = -9.098 + 0.655 * ORSI + 0.917 * knowledgescore + 2.432 * u\sin gsemideepwell + \varepsilon \quad (8)$$

**Table 6.** Parameter estimates of the binary logistic regression model for persuasion of DIS (n= 116).[a]

| | | B | SE | Wald | Sig | Exp(B) |
|---|---|---|---|---|---|---|
| Step 1 | Orchard size | .574 | .191 | 9.075 | .003** | 1.776 |
| | Constant | -2.973 | .960 | 9.587 | .002** | .051 |
| Step 2 | Orchard size | .726 | .249 | 8.502 | .004** | 2.066 |
| | Orchardists' knowledge score | .767 | .308 | 6.183 | .013* | 2.153 |
| | Constant | -7.571 | 2.458 | 9.482 | .002** | .001 |
| Step 3 | Orchard size | .655 | .240 | 7.411 | .006** | 1.924 |
| | Orchardists' knowledge score | .917 | .387 | 5.617 | .018* | 2.501 |
| | Using semi deep well for irrigation | 2.432 | 1.188 | 4.189 | .041* | 11.378 |
| | Constant | -9.098 | 2.972 | 9.369 | .002** | .000 |

[a] Observed Percentage of dependent variable: Like= 70 (60%), Dislike= 46 (40%). Omnibus Test: *Chi*-square= 24.119; *Sig*= 0.000, Hosmer and Lemeshow Test: *Chi*-square= 9.357; *df*= 7; *Sig*= 0.628; _2log likelihood= 53.785 (a); Cox and Snell $R^2$= 0.556, Nagelkerke $R^2$= 0.741. Overall Percentage of corrected predictions, 88.1%.

* Significance at 5%, ** Significance at 1%.

supply (12%), age of trees (8%), use of deep well in cooperative manner (6.7%), and problems with credit loans (3.3%), respectively.

## DISCUSSION

Based on the results, the theoretical model could be modified to generate a localized model for the AO's DIS decision making process in the BRB (Figure 3).

### Education and Adoption

Based on farmer's comments and according to modeling persuasion stage, one of the most important factors affecting adoption of DIS was knowledge score. *Exp(β)* showed that holding all the other independent variables constant, for every 1 unit increase in knowledge score, we expect a 2.5 times increase in the log odds of "like" (the probability of adoption). On the other hand, the results of ordinal logistic model in knowledge stage showed that one additional level of education (i.e., going from 0 to 1) results in a 51% increase in the odds of higher level of knowledge, controlling all of the other variables in the model. Therefore, more educated AOs were more likely to adopt DIS. This seems to be logical because formal education helps to get more and detailed information from the media and, so, it gives shape and direction to the thinking process of the individuals. Our results were also consistent with that of Kumar (2012), Jara-Rojas *et al.* (2012), Bagheri and Ghorbani (2011), Xue *et al.* (2007) and Albrecht and Ladewig (1985), which revealed that adopters were more educated.

Similarly, one additional contact level with

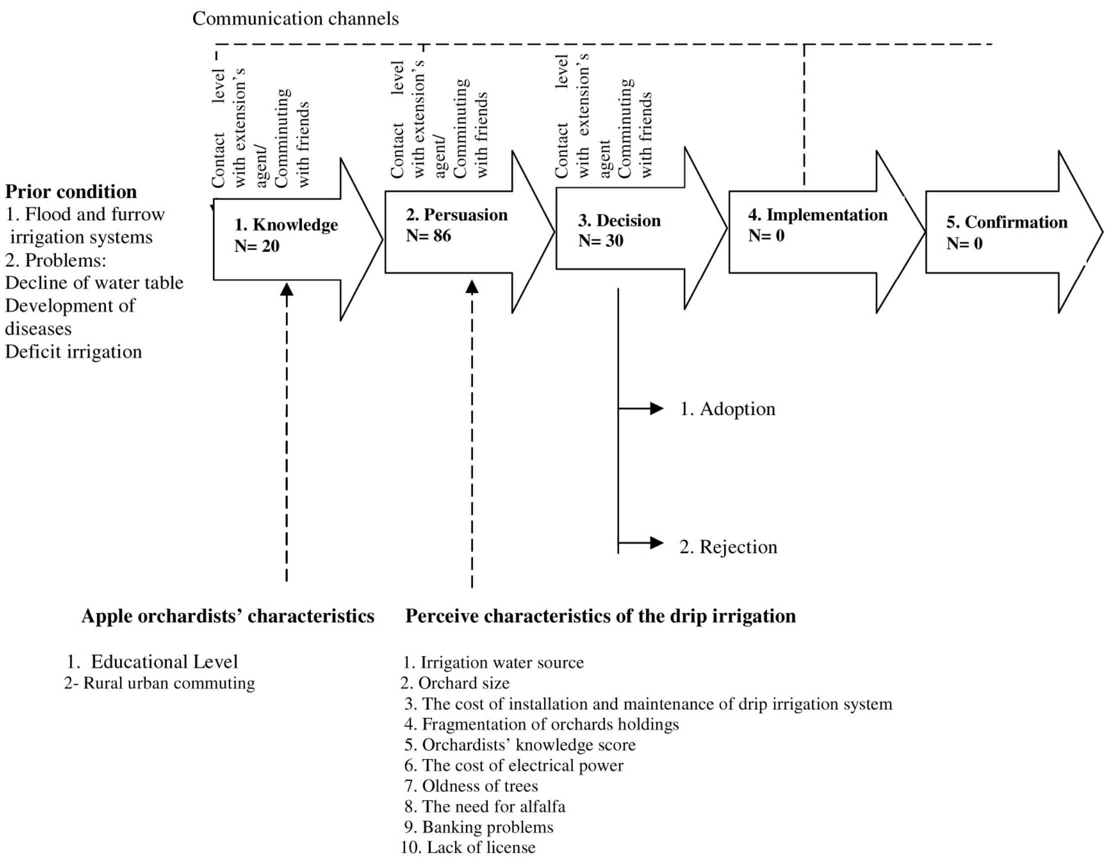


**Figure 3.** A localized model for Drip Irrigation Decision Process by apple orchardists.

agricultural extension agents results in a 120% increase in those same odds. This may probably be due to the fact that more contact with them leads to getting more information about farm and related activities such as irrigation. This finding is similar to findings of Alcon *et al.* (2011), Bagheri and Ghorbani (2011), Xue *et al.* (2007), Kulecho and Weatherhead (2006), and Skaggs (2001).

Likewise, farmers who did not use friends and acquaintances (other farmers) as information source were 75% less likely than those who used them to have higher level of knowledge, controlling all of the other variables. This might be due to the fact that interaction with other farmers might help them to exchange their experience and promote knowledge about new technologies. The other result of modeling that is consistent with this result is that one additional rural-urban commute per month results in a 9.1% decrease in the odds of having higher level of knowledge, given that all of the other variables in the model are held constant. The logic for this finding is likely that the more communication with urban areas leads to longer distance from rural community and other farmers and, therefore, decrease in knowledge level. Our results were also consistent with findings of Kumar (2012), Bagheri and Ghorbani (2011), Xue *et al.* (2007), Kulecho and Weatherhead (2006) and Skaggs (2001) and Albrecht and Ladewig (1985).

## Persuasion and Adoption

Perceived attributes of an innovation such as its relative advantage, compatibility, complexity, trial ability, and observability are especially important at persuasion stage (Rogers, 2003).

*Exp(β)* in persuasion modeling showed that holding all the other independent variables constant, for every 1 unit increase in orchard size, we expect a 1.924 times increase in the log odds of "like" (the probability of adoption). These findings prove to be logical because, as respondents indicated, the AOs who had bigger size orchards were resourceful financially to install and maintain the DIS. Furthermore, fragmentation of orchard holdings can reduce adoption rate, especially if number of holdings is high and far from each other. The reason is that fragmentation increases the cost of DIS. These factors are related to relative advantage attribute of DIS that the initial cost of DIS can affect its rate of adoption. This finding is in conformity with Kumar (2012), Alcon *et al.* (2011), Jara-Rojas *et al.* (2012), Bagheri and Ghorbani (2011), Skaggs (2001), Fishelson and Rymon (1989), and Albrecht and Ladewig (1985).

Another important barrier to adoption of DIS which related to compatibility attribute of DIS was the need for alfalfa. This need was vital for about one half of AOs because livestock raising was an income source for them. In addition, the manure produced by animals was used as organic fertilizer. Furthermore, some of AOs who disliked DIS had old apple trees. They believed that high need of old trees to water made the installation of DIS risky and, further, they feared that their trees might dry up. This finding was related to compatibility attribute of DIS and was in conformity with the finding of Shrestha and Gopalakrishnan (1993) that revealed plant cycle could affect adoption of DIS.

According to modeling persuasion stage as well as farmer's comments, the most important factor influencing adoption of DIS was "water source" that related to compatibility attribute of DIS. *Exp(β)* showed that the odds of AOs using semi deep well were 11.378 times the odds of AOs not using it. The results implied that by using semi deep well, conditions were suitable and affordable for installing DIS (the majority of farmers had water pumps and other equipment that were generally used in the semi deep wells for pumping water). Thus, it fits more closely with the AO's situation. On the other hand, because of high cost of electricity in pumping semi deep well, as well as decline of the water table in recent years, AOs preferred to use DIS. Alcon *et al.* (2012) reported similar result indicating that the farmers with access to groundwater had a conditional probability of adoption which was greater than those who did not use groundwater. The AOs who used deep well have had suitable conditions for installing DIS as participatory manner if they are forced to installing DIS as a requirement for using well license. Due to availability of water in using river, AOs who used this source disliked DIS because it was not compatible with felt needs. These findings were in conformity with those of Skaggs (2001), Shrestha and Gopalakrishnan (1993), and Caswell and Zilberman (1986).

### Feasibility of Adoption and Implementing DIS in the BRB

The innovation decision process can just as logically lead to rejection decision as to adoption. It is possible for farmers to accept DIS only if they can get profit from its adoption. The AO's demographic and socioeconomic characteristics showed that they were mostly a population with weak socioeconomic status. Furthermore, considering the average orchard size, the majority of the AOs were categorized as small farmers and their orchards scattered in several holdings. Hence, two farm structure variables, namely, the small surface area and fragmentation of orchard holdings were the main barriers for adoption of DIS. In contrast, there is a potential that makes it worthwhile for adoption by about 60% of AOs using semi deep wells as irrigation water source. Of course, there are other barriers such as need to grow alfalfa, having aging trees, etc. that could be surmounted by education.

One way to cope with the inherent uncertainty about an innovation's consequences is to try out the new idea on a partial basis. The trial of new idea by a peer can substitute, at least in part, for the individual's own trial of an innovation. Therefore, establishment of DIS in demonstration farms can be quite effective in speeding up of the diffusion process, especially if the demonstrator is an opinion leader.

## CONCLUSIONS

Increasing WUE is a key point for many developing countries in arid and semiarid areas. Undoubtedly, the technology for water-saving is very important but the extension and practice also need more attention for implementation of water-saving technology. Using an opinion survey, this paper modeled the adoption process and key factors influencing the adoption of DIS. This would be helpful to adjust ULC water management policy to promote sustainable development. Hence, several useful conclusions that provide insight into pathways to increase the adoption of DIS in BRB are as follow:

Firstly, to overcome the problems due to shortage of water, decline of water table, deficit irrigation and development of diseases (such as Apple Black Spot and white Root Rot), the adoption and implementation of DIS is essential for AOs. Of course, the conditions are suitable for the majority of AOs to adopt and implement the DIS since they have semi deep well and the related equipment. Hence, suitable efforts should be made for adoption of DIS.

Secondly, since the AOs are in a range of socioeconomic status and farm conditions, the types of low-cost and commercialized micro-irrigation technologies to be used for AOs should fit their situation. Particularly, when it is considered that the majority of AOs are smallholder with their orchard holdings generally scattered in several fragments, DIS can be more elaborate and costly than necessary. For examples, growers who are new to drip irrigation might want to start with a simple system on a small acreage.

Thirdly, based on the results, the average knowledge level of AOs regarding DIS was relatively low, while that knowledge is essential for adoption of DIS. Hence, considering the majority of AOs were ageing with low educational levels, the promotion of AOs' knowledge level by extension activities i.e. training by extension agents, farmer-led extension, and establishment of demonstration farms, is essential for facilitation of adoption of DIS.

Forthly, the results also suggest the need for greater and comprehensive technical, political, and institutional support to facilitate adoption and use of DIS. Regarding the low economical status of many of farmers' households, the adoption of DIS must be accompanied with suitable incentives such as long-term and low-interest rate loans.

## REFERENCES


1. Abbasi, F., Heydari, N. and Sohrab, F. 2006. Water Use Efficiency in Iran Islamic Republic: Status, Challenges and Opportunities. In: "*AARINENA Water Use Efficiency Network*", (Eds.): Hamdan, I., Oweis, T. and Hamdallah, G.. *Proceedings of the Expert Consultation Meeting*, 26-27 November 2006, Aleppo, Syria, PP. 58-70.
2. Albrecht, E. and Ladewig, B. 1985. Adoption of Irrigation Technology: The Effects of Personal, Structural, and Environmental Variables. Department of Rural Sociology, Texas A & M University. Available at: http://www.ag.auburn.edu/auxiliary/srsa/pages/Articles/SRS%201985%203%2026-41.pdf
3. Alcon, F., de Miguel, M. and Burton, M. 2011. Duration Analysis of Adoption of Drip Irrigation Technology in Southeastern Spain. *Technol. Forecast. Soc. Chang.,* **(78):** 991–1001.
4. Bagheri, A. and Ghorbani, A. 2011. Adoption and Non-adoption of Sprinkler Irrigation Technology in Ardabil Province of Iran. *Afr. J. Agric. Res.,* **6(5):** 1085-1089.
5. Carmines, E. G. and Zeller, R. A. 1979. *Reliability and Validity Assessment*. Thousand Oaks, Sage, CA, PP.71.
6. Caswell, M. F. and Zilberman, D. 1986. The Effects of Well Depth and Land Quality on the Choice of Irrigation Technology. *Am. J. Agric. Econ.,* **68(4):** 798–811.
7. Douh, B. and Boujelben, A. 2011. A. Improving Water Use Efficiency for a Sustainable Productivity of Agricultural Systems Using Subsurface Drip Irrigation. *J. Agric. Sci. Technol.,* **B1:** 881-888
8. Fishelson, G. and Rymon, D. 1989. Adoption of Agricultural Innovations: The Case of Drip Irrigation of Cotton in Israel. *Technol. Forecast. Soc. Chang.,* **35(4):** 375–382.
9. He, X. F., Cao, H. H. and Li, F. M. 2007. Econometric Analysis of the Determinants of Adoption of Rainwater Harvesting and Supplementary Irrigation Technology (RHSIT) in the Semiarid Loess Plateau of China. *Agric. Water Manage.,* **(89):** 243–250.
10. He, X. F., Cao, H. H. and Li, F. M. 2008. Factors Influencing the Adoption of Pasture Crop Rotation in the Semiarid Area of China's Loess Plateau. *J. Sustain. Agr.,* **32:** 161-180
11. Hosmer, D. W. and Lemesho, S. 2000. *Applied Logistic Regression.* Second Edition, John Wiley and Sons, Hoboken, PP. 370.
12. Integrated Water Resources Management (IWRM), 2011. Urmia Lake Basin. Available at: http://www.wri.ac.ir/urmia/English/index.html
13. Irans' Ministry of Agriculture. 2008. *Results of Survey Sample Horticultural Products.* Available at: http://www.maj.ir/portal/File/ShowFile.aspx?ID=e9f5eb11-a6b6-43af-8fec-af236ae07c28
14. Jara-Rojas, R., Bravo-Ureta, B. E. and Diaz, J. 2012. Adoption of Water Conservation Practices: A Socio-economic Analysis of Small-scale Farmers in Central Chile. *Agric. Syst.,* **110:** 54–62.
15. Kohansal, M. R. and Rafeie, D. H. 2009. Choosing and Ranking Irrigation Methods and the Study of Effective Factors of Adoption in Khorasan Razavi Province in Iran. *Bulg. J. Agric. Sci.,* **15(1):** 67-76.
16. Kulecho, I. K. and Weatherhead, E. K. 2006. Adoption and Experience of Low-cost Drip Irrigation in Kenya. *Irrig. Drain.,* **(55):** 435–444.
17. Kumar, D. S. 2012. Adoption of Drip Irrigation System in India: Some Experience and Evidence. *Bangladesh Development Studies,* **35(1):** 61-78.
18. Mirjat, M. S., Brohi, A. D., Shah, A. and Chandio, A. S. 2006. Performance Evaluation and Adoption of Trickle Irrigation in Water Scare Areas. Water Management and Soil Conservation in Semi-

arid Environments. *14th International Soil Conservation Organization Conference*, May 14-19, 2006 (ISCO 2006), Marrakech, Morocco, PP.(1-6)

19. Nyariki, D. M. 2009. Household Data Collection for Socio-economic Research in Agriculture: Approaches and Challenges in Developing Countries. *J. Soc. Sci.,* **19(2):** 91-99
20. Rogers, E. M. 2003. *Diffusion of Innovations*. Fifth Edition, Free Press, NewYork, PP. 576.
21. Ruttan, V. W. 1996. What Happened to Technology Adoption–diffusion Research? *Sociol. Ruralis,* **36(1):** 51–73.
22. Shrestha, R. B. and Gopalakrishnan, C. 1993. Adoption and Diffusion of Drip Irrigation Technology: An Econometric Analysis. *Econ. Dev. Cult. Chang.,* **41(2):** 407–418.
23. Skaggs, R. K. 2001. Predicting Drip Irrigation Use and Adoption in a Desert Region. *Agric. Water Manage.,* **51:** 125–142.
24. Soccol, O. J., Ullmann, M. N. and Frizzone, J. A. 2002. Performance Analysis of a Trickle Irrigation Subunit Installed in an Apple Orchard. *Braz. Arch. Biol. Techn.,* **4:** 525-530.
25. Tabachnich, B. G. and Fidell, L. S. 2007. *Using Multivariate Statistics.* Fifth Edition, Allyn and Bacon, Boston, PP.1008.
26. U. S. Department of Agriculture, Foreign Agricultural Service (USDA-FAS). 2012. *Global Reservoirs and Lakes Elevation Database*. Available at: http://www.pecad.fas.usda.gov/cropexplorer/global_reservoir/gr_regional_chart.cfm?regionid=metu&reservoir_name=Urmia
27. West Azarbayejan Regional Water Authority (WARWA). 2012. Rivers Statistic. Available at: http://www.agrw.ir
28. Xue, F. H., Huhua C. and Feng, M. L. 2007. Econometric Analysis of the Determinants of Adoption of Rainwater Harvesting and Supplementary Irrigation Technology (RHSIT) in the Semiarid Loess Plateau of China. *Agric. Water Manage.,* **(89):** 243–250.

## مدل سازی فرایند پذیرش سیستم آبیاری قطره ای توسط باغداران سیب در حوضه آبریز رودخانه باراندوز دریاچه ارومیه

**س. محمد زاده، ح. صدیقی، غ. پزشکی راد**

### چکیده

استفاده گسترده از سیستمهای آبیاری سنتی در حوضه آبریز دریاجه ارومیه منجر به استفاده بیرویه از آبهای زیرزمینی و سطحی شده است. هدف این تحقیق مدلسازی فرایند پذیرش سیستم آبیاری قطره ای از سوی باغداران سیب با بهره گیری از مدل پنج مرحله ای فرایند تصمیم نوآوری راجرز می باشد. جمع آوری داده ها با استفاده از روش پیمایش و ابزار پرسشنامه و تکنیک مصاحبه با ۱۳۶ باغدار سیب صورت گرفته است. نتایج نشان داد که اولاً، سطح دانش باغداران سیب در زمینه آبیاری قطره ای نسبتاً پایین و اکثریت آنها در مراحل اولیه تصمیم نوآوری هستند. دوم، با بهره گیری از رگرسیون لجستیک ترتیبی تا ۳۶/۳ درصد تغییرات سطح دانش با متغیرهای سطح تماس با مروجین، میزان رفت و آمد به شهر و نوع منابع اطلاعاتی قابل تبیین است. سوم، با استفاده از رگرسیون لجستیک دو وجهی ۷۴/۱ درصد شانس پذیرش آبیاری قطره ای می تواند توسط متغیرهای نوع منبع آبیاری، نمرات دانش و اندازه

مزرعه تبیین شود. چهارم، موانع اصلی پذیرش آبیاری قطره ای به ترتیب عبارتند از: هزینه بالای نصب و نگهداری، نداشتن مجوز چاه، نیاز به یونجه، دانش ضعیف فنی و کوچکی و پراکندگی باغات. پنجم، حدود نیم درصد باغداران سیب منطقه این سیستم را پذیرفته و در باغات خود اجرا نموده اند. این یافته ها ابزاری برای ارائه مدل بومی و توسعه سیاستهای لازم و مداخلات سازمانی می باشد. مطالعه حاضر برای اولین بار یک مدل محلی پذیرش را با بکارگیری توأم مدل تئوریکی و تحلیل کمی و کیفی انجام داده است.