IMPACT OF AGRICULTURAL TRAINING COURSES ON APPLYING MODERN AND EFFICIENT IRRIGATION METHODS AMONG FARMERS IN TABRIZ, IRAN (TREATMENT EFFECT APPROACH)

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Abstract
Purpose: *Many experts believe that the lack of an efficient water management system in agriculture has made it essential to redesign new irrigation models adopted in many successful countries across the world. Improving water productivity in the agriculture sector is undoubtedly one of the crucial measures taken to improve water resource management. Water productivity in Iran's agriculture is about one-fifth of the global standard. Many assume that accurate training courses for farmers or granting production facilities and loans for agriculturists are beneficial steps to use efficient and effective irrigation methods and a subsequent considerable saving in water consumption.*
Design/methodology/approach: *This study aims to apply the Treatment Effect Approach to examine the impact of academic or promotional training courses for irrigation efficiency on the application of modern and efficient irrigation methods, by farmers. To do this, 132 trained farmers were assigned to the treatment or test groups, and 212 untrained farmers in Tabriz were assigned to the control group in the crop year 2020.*
Findings: *Results indicated a positive and significant impact of agriculture education and training courses on the probability of using efficient irrigation techniques. In other words, agriculture knowledge increases the probability of using modern irrigation methods up to 344.25.*
Originality: *It is suggested that agricultural policies must grant loans and facilities to agriculturists or those farmers who have received purposeful training courses about the application of efficient irrigation methods.*
Keywords: *Agricultural Water, Agricultural Training Courses, Treatment Effect, Improving Water Efficiency*

INTRODUCTION

Water is the main factor that limits agricultural products qualitatively and quantitatively so accurate water use is the major restrictive factor that prevents increasing crops (Sergun, V., et al., 2022). Hence, correct water-use efficiency is an underlying reason that affects the quality and quantity of agricultural products. Therefore, accurate water use and increased water-use efficiency in the farm are fundamental solutions used to overcome this constraint (Kondratenko, E. P., et al., 2021). We are dealing with a water crisis in Iran, so the inherent limitations of water and water use are the main challenges for water management in this country. Water resources play a vital role in the development process of the country. This role is intensified in Iran due to ascending rise in urbanization and the necessary development of the agriculture sector along with reduced underground resources. This case has been worsened due to low available water resources in addition to dried climates with low precipitation. Water resource projects, especially dams and irrigation networks plus the use of wells and manholes can solve the mentioned problems and develop the regions (Pérez-Nava, J., et al., 2021; Sule, I.F et al. 2021). Different water use systems and economic and social issues are substantial issues in this field. The highest water exploitation (i.e., 81 billion m^3 or more than 90%) is allocated to the agriculture sector's consumption (Jafari, 2000).

Water management simply means optimal water use by consideration of physical, social, financial, regional, and political constraints that are categorized as follows (Goodman *et al.*, 1988).

Direct Economic Values

These objectives are well-known and include water supply for urban, rural, and industrial consumption,

irrigation and drainage, flood control, hydroelectric power supply, water quality management, and sedimentation and corrosion control.
Indirect Economic Values
Protecting water and soil resources of ecological systems, reducing entropy in a region, developing regional economy, improving income distribution and quality of life, health, and wellness, and preparing the field to cope with emergency conditions (Sotnikov, B. A et al., 2021; Gautam, P. et al., 2023).
The most important factor in planning for sustainable water resource development is our ability to consider the goals of the group (B).
Side issues of development must receive attention to accept ethical and philanthropic responsibilities and consider the life of future generations also to take some responsibilities that strengthen the economic dimensions of a society. Therefore, this measure is necessary for creating a sustainable economy in each region of the world. Comprehensive water resource management means creating a system that interacts with the environment, and social and economic development benefiting from its feedback. This process is required to create a management culture in water affairs and optimization of water resource management (Goodman *et al.*, 1988; Jafari, 2006). Because education has been an influential factor or treatment for the improvement of a situation, this study aims to address the role of academic or promotional training courses in using modern and efficient irrigation methods based on the novel and distinguished Treatment Effect approach.
Abdollahzadeh *et al.* (2018) studied the impact of participatory management on optimal water use and their results showed that the highest impact on the dependent variable of optimal water management was related to awareness of the present situation of the irrigation system. The variables of participation level and satisfaction with project implementation, the background of membership in the cooperative, road access to the farm, type of irrigation method, and education were in the next ranks, respectively. However, the second job had a reverse effect on optimal water management. Pishbahar *et al.* (2014) address the impact of agricultural knowledge background on the willingness to pay for healthy food products in Tabriz. To do this, they used Treatment Effect Approach. The treatment effect approach is a specific type of "sample selection" that measures the impact of a training program or educational curse called "treatment" on a certain dependent variable considered by the researcher. The results of this study showed that the agricultural knowledge background of individuals has a positive and significant effect on their willingness to pay for healthy food products rather than other conventional foods. Aryal and Rajouria (2007) concluded that water distribution method and income level of the farmer, network use and maintenance costs, knowledge level of users, sense of responsibility of farmer for use and protect irrigation network, and cooperation morale between government and agriculture sector can ensure the accurate water resource management. Tanaka and Sato (2005) studied water resource management and concluded that farmers' views on social justice can affect water resource management. This study found the important role of traditional beliefs and feelings in accurate water resource management. Moreover, Brewer *et al.* (1999) concluded that some factors, such as exploitation level, cultivation density, and farmers' views play a vital role in water resource management.
According to the abovementioned points, sustainability goals in agricultural water consumption can be achieved by answering the questions about factors used to optimize water use in agriculture or assigning agriculture production to productive forces. Therefore, this study aims to find whether education can be emphasized as a key factor for increasing agricultural water productivity. To answer this question, this study used a treatment-effect approach that has been explained herein.

MATERIALS AND METHODS
Treatment effect points to the impact of a specific treatment (including behavior, education, course, etc.) on an outcome variable and specific return. The treatment effect is indeed a specific type of sample selection. For instance, the present study addresses the impact of agriculture-related academic education on the use of modern and efficient irrigation methods. The treatment-effect approach was used for drug tests before its application in economics. The nominal variable represents medical treatment that equals 1 if the individual is treated, while equals 0 if the individual is assigned to the control group. The main difference between the use of treatment effect in drug tests and economic computation is that subjects in

drug tests are randomly selected and assigned to treatment or control groups, while a decision made on attending an educational course is not a stochastic variable. Individuals indeed decide by themselves whether to attend a course or not. Therefore, a new approach was developed to estimate the treatment effects focusing on the self-selection problem. Moreover, this effect is different among various individuals and the choice for attending an educational program can be a non-random action; hence, the estimation of treatment effect has received great attention from econometrics (Heckman, 1992, 1997; Rosenbaum and Rubin, 1983).

In the simplest case, the treatment effect is the coefficient of the dummy variable in a general regression model. Since these kinds of studies tend to find the random effect of treatment, the potential endogenous aspect of the nominal variable of treatment must be considered. In other words, the author must pay attention to "selection" in the treatment process (endogenous means that the researcher cannot identify other variables that affect the treatment effect; in this case, the researcher faces a correlation between the error term and explanatory variables or missing data problem). Treatment effect estimation has been discussed herein. In this estimation, the treatment affects individuals differently influencing the probability of treatment selection by individuals.[1]

The process begins by defining two potential results for a person: y_{0i} and y_{1i} which indicate the value of the outcome variable (accepting and implementing modern irrigation methods in this study) without and with treatment (having agriculture education or training in promotional courses), respectively. Therefore, the specific outcome of a person having agriculture education or training courses is specified through ($y_{1i-}y_{0i}$). However, other important points exist in treatment effect estimation. First, one of the potential results can be observed based on the decision a person made to receive agriculture education or training courses or not. Accordingly, the researcher faces missing data problems under such circumstances. In this case, we assume that have a certain independent sample (iid). This assumption makes the author eliminate the effect of the treatment of one group on another. It means that the treatment provided for group i only affects the results of group i. This assumption is known Stable Unit Treatment Value Assumption (SUTVA). Random sampling realizes SUTVA (Wooldridge, 2002). If r_i is a nominal variable that represents treatment (agriculture-related education or training courses), equation 1 can be observed:

$$y_i = (1 - r_i)y_{0i} + r_i y_{1i} \qquad (1)$$

The second point is that individuals achieve different results from the treatment; hence, various demographic parameters summarize the treatment effect on a specific group of individuals. Average Treatment Effect is a kind of standard for measurement parameters, which is defined as follows:

$$ATE = E\{\, y_{1i-}y_{0i}\} \qquad (2)$$

Or can be defined as a conditional average based on some covariates (conditional average treatment effect):

$$ATE|x_i = E\{\, y_{1i-}y_{0i}|x_i\} \qquad (3)$$

Equation (3) indeed describes the expected treatment effect on an arbitrary person with characteristics x_i. In other words, it measures the effect of randomly assigning a person in society to treatment (having agriculture education or attending agriculture training courses herein). Heckman (1997) criticized this theory. He used an idea entitled “a millionaire at random to participate in a training program for low-skilled work.” In his opinion, such selection is not associated with political and eligible conditions so it is useful to define the studied society better (Wooldridge, 2002; Verbeek, 2004).

ATE for the treated (ATT) is another metric studied in this case, which is defined as:

$$ATT = E\{\, y_{1i-}y_{0i}|r_{i=}1\} \qquad (4)$$

Equation (4) can be written as a conditional average based on one or more covariates (conditional ATT):

$$ATT|x_i = E\{\, y_{1i-}y_{0i}|x_i, r_{i=}1\} \qquad (5)$$

Therefore, ATT indicates the average treatment effect on those who are selected to receive agriculture education or training courses. Under specific circumstances, ATE equals ATT but are different in general because the choice of attending such education or training courses is non-random and depends on the

[1] If the treatment effect (TE) is equal for different individuals, it is called homogeneous; TE is considered heterogeneous, otherwise.

expected outcome of this kind of education or training called treatment. It may be expected that ATE is greater for those who select to receive such education or training courses rather the ATE for the whole society. On the other hand, no difference exists between ATE and ATT if individuals have chosen the case randomly.

The decision for receiving treatment (agriculture education or training courses) can be modelled using a probit model. It is assumed:

$$r_i^* = x_i'\beta + \eta_i \quad (6)$$

Where $r_i = 1$ if $r_i^* > 0$ and $r_i = 0$, otherwise. It has been also assumed that η_i has a normal distribution with mean value 1 and variance 1 (NID(0,1)) and is not correlated with explanatory variables x_i'. It is assumed that equations 6 and 7 have normal error terms with variances σ_0^2 and σ_1^2 and covariances σ_{02} and σ_{12} with error term η_i. In this case, we have:

$$E\{\varepsilon_{0i}|\mathrm{x_i}, \mathrm{r_i} = 0\} = \sigma_{02}\, E\{\eta_i|\mathrm{x_i}, \eta_i \leq -x_i'\beta\} = \sigma_{02}\lambda_i(x_i'\beta) \quad (7)$$

$$E\{\varepsilon_{1i}|\mathrm{x_i}, \mathrm{r_i} = 1\} = \sigma_{12}\, E\{\eta_i|\mathrm{x_i}, \eta_i > -x_i'\beta\} = \sigma_{12}\lambda_i(x_i'\beta) \quad (8)$$

Where:

$$\lambda_i(x_i'\beta) = E\{\eta_i|x_i, r_i\} = \frac{r_i - \emptyset(x_i'\beta)}{\emptyset(x_i'\beta)(1-\emptyset(x_i'\beta))}\emptyset(x_i'\beta) \quad (9)$$

This equation was designed to modify the error term of the probit model. Equation (9) defines Heckman's Landai (inverse Mills coefficient) for $r_i = 1$. In a general mode where σ_{02} and σ_{12} may not be zero, these results indicate that equations 6 and 7 can be estimated through a two-stage method that includes $\lambda_i(x_i'\beta)$ as the extra term. According to these conditions, ATE for the treated group is measured as follows:

$$ATT(x_i) = \delta + x_i'\gamma + (\sigma_{02} - \sigma_{12})\lambda_i(x_i'\beta) \quad (10)$$

If the condition $[\beta_1 = \beta_0 = \beta]$ applied then we have:

$$\begin{aligned} \mathrm{E}\{y_i|\mathrm{x_i}, \mathrm{r_i}\} &= \alpha_0 + \mathrm{x_i'}\beta + \delta\mathrm{r_i} + E\{\varepsilon_i|\mathrm{x_i}, r_i\} \quad (11) \\ &= \alpha_0 + \mathrm{x_i'}\beta + \delta\mathrm{r_i} + \sigma_{12}r_i\lambda_i(x_i'\beta) + \sigma_{02}(1-r_i)\lambda_i(\mathrm{x_i'}\beta) \end{aligned}$$

This equation indicates that parameters α_0, β, and δ can be estimated through a single regression provided that error terms' effect and nominal variable of TE are incorporated in the model. If it is assumed that $\sigma_{02} = \sigma_{12}$ then $ATT(x_i)$ and $ATE(x_i)$ become equal (Wooldridge, 2002; Verbeek, 2004).

According to the mentioned points, this study uses the TE approach to investigate the impact of agriculture-associated education and training courses to encourage farmers in Tabriz to use efficient irrigation methods. The required data were collected through simple random sampling in 2020. In this case, 212 farmers in Tabriz were assigned to the control group, while 132 farmers were assigned to the group in which they received agriculture-associated education or training courses to know efficient irrigation systems. The experimental model of study is specified within a two-step method as shown in Equation (12) because the effect of agriculture education or training courses (regarding the different orientations in agriculture disciplines, different universities, and educational levels) cannot be considered homogenous:

$$Y_i = \beta_0 + \beta_1\, Fext + \beta_2 income + \beta_3 ENV + \beta_3 Know + \beta_4 exp + \beta_5 EDU + \delta AGRI(= Exp + ENV + Rural + sat) \quad (12)$$

Where Y_i represents the use of productive and efficient irrigation techniques, exp indicates work experience (year), Fext is the number of household members, income indicates the individual's income level, ENV represents environmental tendencies, which are assessed based on 5 items such as ignoring some amenities to protect the environment and current irrigation methods that are hazardous for the environment. The variable of Know indicated the knowledge level of a person about modern irrigation methods and different types of such techniques and their efficiency rates. All of the mentioned indicators are of multiple Likert scale type scored based on the codes from 1 (completely unimportant) to 5 (completely important). The size of each index is measured based on the average score of answers given by an individual to the questions. Variable EDU represents the education level of respondents coded from 1 (illiterate) to 8 (Ph.D.). Finally, the variable Sat indicates satisfaction with agriculture (satisfied=1, unsatisfied=0), AGRI is the treatment effect of agriculture-associated education or training courses (effective=1, no effect=0), and δ measures the TE rate of agricultural knowledge of respondents in accepting modern irrigation techniques. The following variables affected the significance of the TE function: work experience (Exp) based on year, environmental protection tendencies and willingness (ENV), rural family (rural=1 not rural=0), and job satisfaction (Sat) (satisfied=1 unsatisfied=0). The econometric models were estimated through Stata12.00 software.

RESULTS AND DISCUSSION

According to a descriptive assessment of studied variables, most sample members were men with an average household of 4.1 members and an average age of 44.2; 38% of the sample size comprise individuals who had agriculture education or were trained and 315 were from rural families. Moreover, the average level of knowledge of individuals about efficient irrigation methods equalled 3.7 units, ordinal variable of education level had a mean value of 5.2 indicating an associate degree. According to the results of environmental protection willingness (mean value of 3.9), sample members were relatively willing to protect the environment.

[Insert Table I near here]

Table I reports the frequency distribution of using efficient irrigation techniques in production by treated and control groups. As seen in this table, over 60% of members in the treated group implement modern efficient irrigation techniques, while 60% of members in the control group do not apply these methods. Moreover, 35.5% of members in the treated group use inefficient irrigation techniques, while this rate equals 63% in the control group.

Ultimately, the model of treatment effects of agriculture education on implementation and modern and efficient irrigation techniques in the production process was estimated based on a two-step method and mentioned assumption. Table II reports the results of the model estimation.

According to Table II, the parent statistic value (341.95) with a significance level<1% and negative significant Landa coefficient indicate proper specification of the two-step effect model. According to the results reported in this table, all variables, except for family or household members, in the model of implementing efficient irrigation methods had a positive and significant effect on the probability of implementation of these techniques. According to the results, the higher the education level, the more willing to implement modern irrigation techniques rather than conventional methods. The positive and significant effect of knowledge and environmental protection willingness indicated that individuals had much information about modern irrigation techniques. Moreover, those individuals with eco-friendly tendencies were more interested to implement efficient irrigation techniques compared to conventional methods.

[Insert Table II near here]

In terms of interpreting variables of the TE function, this function is estimated to remove the effects of these variables and purify the TE from the function of using efficient irrigation techniques. Therefore, it is enough to say that model's variables had a positive and significant effect on the agricultural education or training of individuals. According to the results of the two-step model, agriculture-related education or training courses had a positive and significant impact on the probability of accepting and using efficient irrigation techniques.

CONCLUSION AND APPLIED RECOMMENDATIONS

In general, the results of the estimated two-step model indicated a positive and significant impact of agriculture education and training courses on the probability of using efficient irrigation techniques. In other words, agriculture knowledge increases the probability of using modern irrigation methods up to 244.25. It is suggested that agriculture society's knowledge about modern agriculture science and irrigation techniques makes them aware of modern irrigation systems changing their attitudes towards these systems. This point is a critical key for policymakers to take an important step toward water-use efficiency in the agriculture sector which consumes a large volume of water. Accordingly, the field can be provided for using modern irrigation techniques and increase irrigation efficiency resulting from water-use efficiency by giving cultivation and farming opportunities to agriculturists, fostering the business environment of this sector, and designing more training courses for farmers (Askerov, P. F. et al., 2021).

According to the positive impact of knowledge level and environmental protection willingness, some measures can be taken to increase awareness and acknowledge of agriculture producers about traditional irrigation systems and make them familiar with modern systems. The mentioned measures include proving purposeful education for farmers due to insufficient knowledge about this sector in society, establishing and supporting non-governmental organizations (NGOs), protecting the environment, supporting sustainable agriculture, and encouraging them to do different activities, especially informing society about this case, and increasing environmental protection willingness.

Funding: None.

Conflict of interest: The authors declare that they have no conflict of interest.

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Table I. Frequency distribution of using efficient irrigation methods in production.

		Treated group		Control group	
Using efficient irrigation methods	**Code**	**Frequency (N)**	**Relative frequency (%)**	**Frequency (N)**	**Relative frequency (%)**
Implantation	0	85	64.5	78	37
Non-implementation	1	47	35.5	134	63
Sum		132	100	212	100

Table II. Results of estimated two-step TE model.

Tendency to pay Model				
Variable	**Coefficient**	**Std error**	**Z value**	**Sig.**
Constant value	-10.3	674.0	-27.7	000.0`
Number of household members	-1.75	12.92	-0.14	0.892
knowledge about efficient irrigation	0.311	2.92	3.02	0.002
Environmental protection willingness techniques	326.0	0.18	2.91	0.003
Work experience (year)	3.56	0.80	4.43	0.000
Education level	61.58	11.21	5.49	0.000
Agriculture education and job background	244.25	116.15	2.00	0.046
Treatment effect model				
Constant value	-2.28	0.789	-2.89	0.004
Work experience	0.002	0.005	3.100	0.002
Environmental protection willingness	15.0	086.0	70.1	09.0
Rural origin	0.11	0.31	73.2	0.009
Job satisfaction	0.375	0.121	3.10	0.002
Landa coefficient	-177.62	66.09	-2.69	0.007
Wald Chi-squared: 341.95 Prob[ChiSqd > value] = 0.0000				