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Determinants of Eco-Innovations in Agricultural Production Cooperatives in Iran

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ABSTRACT

The purpose of this study was to identify determinants of Eco-Innovations (EI) in agricultural production cooperatives in Iran. Qualitative and quantitative methods were applied to the research. The qualitative section included semi-structured interviews, face-to-face interviews, and brainstorming sessions, and the quantitative section included descriptive statistical and spatial and Bayesian probit models to estimate the model of research. SPSS and MATLAB software was used in this study. SPSS software was used to describe the variables, explain the types of EIs and their effects and comparison of adopters and non- adopters, and MATLAB software was used for the estimation of the model. The data of 300 members of agricultural production cooperatives in Khouzestan Province, Iran, were collected based on random sampling, in 2020 summer. The research examined the different types of EIs. For comparison of adopter and non-adopter characteristics, a t-test and Mann-Whitney test (MW) were used. The results of the t-test showed that there was a significant difference between age, income, crop yield, and farm size for adopters and non-adopters of EI. The Mann Whitney U test (MW) showed significant difference between farmers' education level, EI awareness, attitude toward EI, EI knowledge, willingness to creativity, being risk oriented, and access to information of adopters and non-adopters of EI. Based on the results obtained from the spatial models, with a probability of 99%, both models were significant. Based on the results of the estimation of spatial models, the independent variables and the spatial autoregressive coefficient had significant role on adoption of EI. For practical implications, it can be said that cooperative members, when adopting the EIs, can use the proposed model that is appropriate to their field of work. This study conducted a critical review before specifically recommending how cooperatives become eco-innovators.

Keywords: Eco-innovation adopters, Innovative pathways, Mann Whitney U test, Spatial models.

INTRODUCTION

The three most important disciplines in sustainable development are attention to economic, social and environmental development (Dudek and Wrzaszcz, 2020). The emergence of sustainability as a major driver of innovation highlights a number of important issues that merit investigation, such as potential avenues for sustainable innovation and sustainable product innovation and factors underlying differences between firms in their commitment to a sustainable innovations orientation (Varadarajan, 2017). In recent years, the search for innovative pathways towards sustainability has been brought to the forefront of international agenda settings (Colombo *et al*., 2019).

Environmental challenges such as pollution, climate change, water and natural resources depletion and dwindling bio-diversity are true threats to the survival of our civilization, forcing us to learn how to act now (Azevedo *et al*., 2014). By considering the eco-friendly products and requiring organizations and firms to this issue, it enables them to take into account

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environmental needs and create competitive advantages and be on the path of increasing development and growth (Nidumolu *et al*., 2009), sustainable product development and eco-friendly activities are expected to become more important in the future (Varadarajan, 2017). Increased awareness on sustainability has influenced business organizations to improve their environmental performance and efficiency (García-Granero *et al*., 2018).

Bosshagh *et al.* (2014) concluded about adoption of Eco-Innovation (EI) activities in Iran, that 10.8 percent of farmers were in a highly unsustainable group, 32 percent in an unsustainable, 30.4 percent in somewhat sustainable, 15.2 percent in the sustainable group and the rest were in a highly sustainable group. in the sustainable group. Fatemi *et al.* (2018) revealed that despite the different environmental rules and regulations, there was no improvement or progress in EI achievement in Iran. Returning to the condition in which ecological footprint equals biocapacity is the least action required to decrease the pressure on nature. Effective and suitable environmental policies are needed in order to address the policy gap as well as reduce the ecological footprint level to the balance point by appropriate executive activities covering the implementation gap. Thus, the purpose of this study was to identify factors influencing the adoption of eco-innovations by members of agricultural production cooperatives.

Eco-innovation has been widely accepted as a method for improving the environmental performance of enterprises and for supporting them to improve their products; as well as to advance to more sustainable business models, and as a driver of business success and competitive advantage at the firm level (Szilagyi *et al*., 2018). Rammell (2003) explained that this competitive environment encourages companies to change their methods and actions from different dimensions such as processes, technologies, products to new and sustainable forms. Effective management is crucial for obtaining high returns from a production system on a sustained basis (Chizari and Ommani, 2009). The term eco-innovation was introduced as explicitly three kinds of changes towards sustainable development: technological, social, and institutional innovation (Rennings, 2000). The results of Arranz *et al*. (2019) highlighted that the complexity of the EI process affects the decision to develop EI. The concept of "eco-innovation" in essence is rather recent, since it first appeared in the innovation literature in a book by Fussler and James (1996). These authors defined EI as "new products and processes which provide customer and business value, but significantly decrease environmental impacts". Kesidou and Demirel (2012) suggested that firms must initiate EIs in order to satisfy the minimum customer and societal requirements, yet, increased investments in EIs are stimulated by other factors such as cost savings, firms' organizational capabilities, and stricter regulations. Ociepa-Kubicka and Pachura (2017) explained serious barriers of EI, including uncertain demand from the market, uncertain return on investment or a too-long payback period for EI, lack of funds within the enterprise, insufficient access to existing subsidies and fiscal incentive. Also, Ozusaglam (2012) quoted ITRE (2009) that considered the following barriers to eco-innovation: (i) Informational barriers arise from an asymmetric distribution of knowledge about material and resource efficiency among various actors, such as users and producers; (ii) Financial barriers are generally the result of a splitting of financial incentives between actors e.g. between user and investor, with contrasting interests as regards the introduction of EI; (iii) A gap between R&D and market launch often occurs when the risks associated with R&D expenditures are high, in which case a firm will only accept to act as a "first mover", i.e. to introduce an EI if it can benefit from a sufficient patent protection. Organization for Economic Co-operation and Development (OECD) (2005) measured

EI with four group factors such as cost, knowledge, market, and institutional factor. Also, Horbach (2008) developed a new framework for EI measurement with demand, supply, and institutional policy.

Sehnem *et al.* (2016) categorizes EI into five categories: Further EI (pollution and manipulation of technological resources and services), integrated EI (technological processes and clean products), EI alternative product (new technological paths), macro-organizational EI (new organizational structures), and EI for general purposes. Also, Hojnik and Ruzzier (2016) categorized EI into four types includeing product EI, process EI, organizational EI, and environmental R&D investments.

Based on the Dudek and Wrzaszcz (2020), the significance of EIs in agriculture is particularly important because it emphasizes the close dependence of agriculture on natural conditions and resources, including the state of the soil and water and the provision of ecosystem services. Costantini *et al.* (2017) concluded that direct and indirect effects of EI have positive effects on environmental performance. Marin (2014) showed that innovation efforts of polluting firms is significantly biased towards environmental innovations and that environmental innovations tend to crowd out other more profitable (at least in the short run) innovations. Cai and Li (2018) state that technological capabilities, environmental and organizational capabilities, a market-based instrument, competitive pressures, and customer green demand contribute to the development of EI.

The purpose of this study was to identify determinants of Eco-Innovations (EI) in agricultural production cooperatives in Iran.

MATERIALS AND METHODS

Qualitative and quantitative methods were applied to the present research. The qualitative section included semi-structured interviews, face-to-face interviews, and brainstorming sessions, and the quantitative section included descriptive statistical and spatial and Bayesian probit model to estimate the model of research. The qualitative study was carried out among the members of agricultural cooperatives who accepted and applied EI (50 members out of 300), and the type of EI and the effects of each were examined. The quantitative study was done by using a questionnaire for collecting all characteristics of the adopters and non-adopters. SPSS and MATLAB software was used in this study. SPSS software was used to describe the variables, explain the types of EIs and their effects and comparison of adopters and non-adopters, while MATLAB software was used for the estimation of the model. The data of 300 members of the agricultural production cooperatives in Khouzestan Province, Iran, were collected based on random sampling in 2020 summer. Agricultural cooperatives members were categorized as adopters or non-adopters. In this research, the adopters were those who had accepted and applied at least two EIs.

Khuzestan Province is one of the agricultural hubs of Iran and supplies 13.5% of the country's total agricultural production. It currently ranks first in the country in the production of 12 products including wheat, corn, sugar cane and beets. Khuzestan alone supplies 45 percent of the country's sugar needs, while rice consumption of 13 million people and wheat consumption of 11.5 million people are produced in this province. Indeed, 138 types of products are produced in Khuzestan, which has also 6.2 million livestock units and has gained the first place in aquaculture production with an annual production of 130,000 tons (Amirizadeh, 2020).

Spatial econometric methods are becoming part of the standard toolkit of applied researchers in agricultural, environmental and development economics (Holloway *et al*., 2002). A Bayesian probit model with individual effects that exhibit spatial dependencies is set forth. Since probit models are often used to explain variation in individual choices, these models may well exhibit spatial interaction effects due to the varying spatial location of the decision makers (Smith and LeSage, 2004). To calculate Bayesian coefficients, the Gibbs sampling and Metropolis–Hastings algorithm were used. Also, to extract the appropriate model the spatial error dependence [LM(err)] by Lagrange Multiplier test was implemented. In addition, for spatial lag dependence [LM(lag)] a Lagrange Multiplier test was conducted. Spatial econometrics is a subfield of econometrics that deals with spatial autocorrelation and spatial heterogeneity in regression models for cross-sectional and panel data (Ommani and Noorivandi, 2017; Paelinck and Klaassen, 1979; Anselin, 1988). The Bayesian method was used to estimate parameters in spatial probit models (Wooldridge, 2002; Ommani and Noorivandi, 2017). Based on the LeSage (2008), the spatial autoregressive process shown in Equation (1) and the implied data generating process in Equation (2) provide a parsimonious approach to representing the dependence structure.

$$y = \alpha i_n + \rho W y + \varepsilon \qquad (1)$$

$$(In - \rho W) y = \alpha i_n + \varepsilon$$

$$y = (I_n - \rho W)^{-1} i_n \alpha + (I_n - \rho W)^{-1} \varepsilon \qquad (2)$$

$$\varepsilon \sim N\,(0, \sigma^2 I_n)$$

LeSage (2008) introduced a constant term vector i_n and associated parameter α to accommodate situations where the vector y does not have a mean value of zero. The n by 1 vector y contains our dependent variable and ρ is a scalar parameter, with W representing an n by n spatial weight matrix. Also, ε follows a multivariate normal distribution, with zero mean and a constant scalar diagonal variance-covariance matrix σ2In.

LeSage (2008) used the spatial autoregressive process to construct an extension of the conventional regression model that shown in Equation (3), along with the associated data generating process in Equation (4). The model has been labeled the Spatial Auto-Regressive (SAR) model.

$$y = \rho W y + X\beta + \varepsilon \qquad (3)$$

$$y = (I_n - \rho W)^{-1} X\beta + (I_n - \rho W)^{-1} \varepsilon \qquad (4)$$

Another popular spatial model is the Spatial Error Model (SEM), which takes the following form (LeSage, 2008):

$$y = X\beta + u, u = \rho W u + \varepsilon, \quad \varepsilon \sim N\,(0, \sigma 2\, In) \qquad (5)$$

$$y = X\beta + (I_n - \rho W)^{-1} \varepsilon$$

In this model, there are additional explanatory variables in the matrix *X* that are used to explain the variations in *Y* over the spatial sample of observations.

The agricultural production cooperatives members in Khouzestan Province were considered as the statistical population (N= 3823). According to the Cochran formula, the sample size was 300. The required information was collected through a questionnaire. The spatial probit model was used to evaluate the adoption of EI in agricultural production cooperatives in the following two situations:

Spatial Autoregressive Model-Mixed Regression or Spatial Lag Model: This model is similar to the dependent variable model of the latent time series (Ommani and Noorivandi, 2017). In this model, there are additional explanatory variables in the X matrix that are used to explain the variations in y over the spatial sample of observations (Table 1).

$$y=\rho W_1 y+X\beta+ \varepsilon \qquad (6)$$

$$y=\beta_0+\rho Wy+\beta_1 ATT+\beta_2 TEKN+\beta_3 EXT+\beta_4 WtC+\beta_5 RO+\beta_6 INC+\beta_7 LoE+\beta_8 8EAw+\beta_9 AIS +\varepsilon$$

$$\varepsilon \sim N(0, \sigma^2 I_n) \qquad (7)$$

Spatial Error Model: Results are presented in a regression model with spatial autocorrelation in disorders.

$$y = \beta X + \mu \qquad (8)$$

$$y=\beta_0+ \beta_1 ATT+\beta_2 TEKN+\beta_3 EXT+\beta_4 WtC+\beta_5 RO+\beta_6 INC+\beta_7 LoE+\beta_8 8EAw+\beta_8 AIS+\mu$$

$$\mu = \lambda Wu + \varepsilon \quad \varepsilon \sim N(0, \sigma^2 I_n) \qquad (9)$$

Table 1. Characteristics of agricultural cooperatives members.

Personal and economic characteristics		Mean	SD
Age (Year)		44.5	9.845
Level of education[a]		2.9	0.95
Farm size (Hectares)		6.8	1.53
Income (Million Rials per year= 4.3 Dollar per year)		831	28.46
Personality and cognitive characteristics	Items	Mean of total items	SD
Eco-innovation awareness[b]	12	32.53	8.65
Attitude toward eco-innovation[c]	10	35.69	9.32
Eco-innovation knowledge[b]	10	38.71	8.38
Access to information sources[b]	5	13.49	3.56
Willingness to creativity[b]	8	25.32	7.76
Risk oriented[b]	8	27.84	8.29

[a] 0= Illiterate, 1= Preliminary, 2= Guidance school, 3= High school, 4= Diploma and above.
[b] The Domain of Each Item: 0= None; 1= Very low; 2= Low; 3= Average; 4= High, 5= Very High.
[c] The Domain of Each Item: 1= Strongly disagree, 2= Disagree, 3= Unsure, 4= Agree, 5= Strongly agree. Source: Research findings (2020).

Where, y= Adoption of EI in agricultural production cooperatives is a dependent variable. Here, EI refers to use of bio-fertilizers, bio-control, conservation tillage, crop rotation with legumes, water conservation, waste management, organic production, product in ecological packing, and Social media for the production of organic products. If the beneficiary is adopted, the corresponding number is 1, and if it is not adopted, the number is zero.

ρ= Includes spatial autoregressive-mixed regression coefficient in the spatial lag model.

λ= Autoregressive coefficient in spatial error model.

ε = Error

W= Spatial Weight matrix.

ATT= Attitude of beneficiaries to eco-innovations.

TEKN= Technical knowledge about eco-innovations.

EXT= Participation in Extension and education classes about EI. If the beneficiary participated, the number 1, and if not participated, zero is allocated to it.

WtC= Willingness to Creativity.

RO= Being Risk Oriented.

INC= Income.

LoE= Level of Education

EAw= Eco-innovation Awareness

AIS= Access to Information Sources.

The above variables are independent variables that have been determined based on literature review, previous researches, and researchers' opinions.

RESULTS AND DISCUSSION

Demographic Characteristics of Agricultural Cooperatives Members

As shown in Table 1, the average age of selected agricultural cooperatives members in the study areas was 44.5 and the standard deviation was 9.84. The average level of education was 2.9. Also, the average farm size was 6.8 hectares. The main occupation of all of them was agriculture and 45 people had a second job in addition to agriculture. Their average attendance at training classes was 10 courses and their average income from agricultural activities was 831 million Rials per year. The mean rank of EI awareness, attitude toward EI, EI knowledge, access to information sources, willingness to creativity and risk oriented were, respectively, 32.53, 35.69, 38.71, 13.49, 25.32 and 27.84. Also, 285 (95%) members were male and the remaining 15 (5%) were female (Table1).

Table 2. Types of Eco-Innovations (EI) and their effects.[a]

Innovation introduced	Type of innovation	Effects of innovation	Repetitions	Farm size (Hectares)	products
Bio-fertilizers	process	Reduces costs	29	320	Wheat, corn, dates, oranges, tomatoes
		Easier to use	26		
		Marketability	15		
Bio-control	process	Protects soil microorganisms	37	545	Rice, dates, corn, wheat, oranges
		Increases crop yield	32		
		Increases the profit	21		
Conservation tillage	process	Increases fertility	41	650	Dates, corn, wheat, barley, alfalfa, citrus
		Save water	40		
		Reduces costs	31		
Crop rotation with legumes	process	Increases fertility	39	575	Vegetables, legumes, wheat, rice, corn
		Increases income	32		
		Increases the quality of the product	23		
Water conservation	process	Saves water usage	47	1100	Wheat, dates, citrus fruits, corn
		Reduces costs	41		
		Makes irrigation easier	27		
Waste management	marketing	Increases profits	48	950	Wheat, barley, corn
		Product marketability	45		
Organic production	product	improve the health of the community	36	460	Vegetables, citrus, dates
		Increases income in the long time	28		
Product in ecological packing	marketing	Desire to buy	27	370	Vegetables, dates
		Increases profit	22		
		Waste limiting	18		
Social media for the production of organic products	organizational	Increases knowledge and information	23	430	Vegetables, citrus, dates
		Development of organic products production	17		

[a] Source: Research findings (2020).

Eco-innovations Adoption

Types of Eco-Innovations and Their Effects

In the qualitative study, by using semi-structured interviews, face-to-face interviews, and brainstorming sessions among the members of agricultural cooperatives who accepted and applied EI, the type of EI and the effects of each were examined (Table 2).

The first EI examined was bio-fertilizers. A bio-fertilizer is a substance that contains living micro-organisms which, when applied to seeds, plant surfaces, or soil, colonize the rhizosphere or the interior of the plant and promotes growth by increasing the supply or availability of primary nutrients to the host plant (Vessey, 2003). Due to the widespread use of chemical inputs, the use of bio-fertilizers plays an important role in protecting the environment. According to the results, out of 300 farmers, 48 said they were using bio-fertilizers to prepare agricultural land. In answer to the question concerning the effects of using bio-fertilizers, 29 farmers stated that it reduces costs.

Bio-control is a technique of controlling pests, that is, mites, insects, weeds, and plant diseases by using other microorganisms (Nazir *et al.*, 2019). The use of bio-control methods for pests has an effective role in reducing the use of chemical pesticides. According to the results, 42 farmers said they used bio-control for pests and insects. In response to the question on the effects of bio-control, 37 stated that this protects soil microorganisms.

The third EI explored was conservation tillage for soil conservation. The use of conservation tillage methods plays an important role in reducing soil erosion and increasing fertility. According to the results, 52 farmers said that they used the conservation tillage method to prepare the land. In response to the question on the effects of conservation tillage, 41 farmers stated that this would increase fertility and protect soil microorganisms.

The fourth EI studied was crop rotation with legumes for soil fertility and biological nitrogen fixation. The use of crop rotation with legumes plays an important role in increasing soil fertility and reducing the use of nitrogen fertilizers. According to the results, 43 people said that they used crop rotation with legumes for soil fertility. In response to the question, what are the effects of crop rotation with legumes, 39 farmers stated that it increases fertility and reduces the use of chemical fertilizers.

The fifth EI studied was water conservation for the quantitative and qualitative protection of water resources. The use of water conservation methods such as drip irrigation plays an important role in reducing water use in the field. According to the results, 56 farmers said that they used water conservation method to reduce the use of water resources. In response to the question on the effects of water conservation, 47 farmers stated that it saves water usage. The sixth EI was waste management. The use of waste management methods such as modern harvesting machines, adjusting the harvesting machine and paying attention to the appropriate harvesting time plays an important role in increasing farm income. According to the results, 61 farmers said they used waste management methods. In response to the question on the effects of waste management, 48 farmers stated that it increases profits.

The seventh EI was organic production. Using organic production plays an important role in producing a healthy product. According to the results, 38 people said that their product was organic production and had a certificate of a healthy product. In response to the question on the effects of organic production, 36 farmers stated that it would improve the health of the community.

The eighth EI studied was ecological packing of the product. Using product in ecological packing increases marketing. According to the results, 41 farmers said that they used ecological packing. In response to the question on the effects of product in ecological packing, 27 farmers stated that it increases the desire to buy.

The ninth EI examined was use of social media for the production of organic products, which increases the interaction of producers with others about of organic products. According to the results, 35 farmers said they used social media for the production of organic products. In response to the question on the effects of social media for the production of organic products, 23 farmers stated that it increases knowledge and information in the field of organic production.

Comparison of Adopter and Non-Adopter Characteristics

Agricultural cooperatives members were categorized as adopters or non-adopters. In this research, the adopters are those who have accepted and applied at least two EIs.

Table 3. Comparison of adopter and non-adopter characteristics.

	Adopters		Non-adopter			
Variables	M	SD	M	SD	Test	P value
Age (Year)	41.2	8.43	54.3	10.63	T= 4.967	0.0001**
Income per year (Million Rials)	945.8	29.8	701.4	25.6	T= 5.501	0.0000**
Crop yield (Ton per hectare)	5.3	1.01	3.6	0.98	T= 6.727	0.0000**
Farm size (Hectare)	9.8	1.12	5.3	0.94	T= 4.143	0.0005**
Education level	3.5	0.81	1.8	0.89	U= 6.318	0.0000**
Eco-innovation awareness	42.35	7.03	28.02	8.98	U= 5.803	0.0002**
Attitude toward eco-innovation	45.08	9.09	32.89	8.96	U= 4.907	0.0001**
Eco-innovation knowledge	44.12	8.99	35.09	90.89	U= 5.391	0.0003**
Access to information sources	18.46	4.11	11.21	4.91	U= 3.941	0.0008**
Willingness to creativity	36.29	8.41	21.39	7.01	U= 4.823	0.0004**
Risk oriented	38.09	9.81	24.58	8.09	U= 5.107	0.0002**

The results are presented in Table 3. For comparison of adopter and non-adopter characteristics, SPSS software, a t-test, and Mann-Whitney test (MW) were used. The results of the t-test showed that there was a significant difference between age, income, crop yield, and farm size for adopters and non-adopters of EI. The Mann Whitney U test (MW) showed significant difference between farmers' education level, EI awareness, attitude toward EI, EI knowledge, willingness to creativity, being risk oriented, and access to information of adopters and non-adopters of eco-innovations.

Estimation of the Model:

In this study, to extract the appropriate model based on the lag or spatial error, the Lagrange coefficient was used. In addition, to computing the Bayesian coefficients, the Metropolis-Hastings algorithm and the Gibbs sampling method were used. Based on the results obtained from the two mentioned models, with a probability of 99%, both models were significant. Therefore, both models can be used to interpret the results regarding the adoption of EIs (Table 4).

Based on the results of the estimation of spatial models, the variables of attitude to EI, technical knowledge about EI, participation in extension and education classes about EI, willingness to creativity, being risk oriented, income, level of education, EI awareness, access to information sources, and the spatial autoregressive coefficient had significant role in adoption of EI (Table 5).

The variable of the attitude to EI with coefficients of 0.812 in the spatial lag model and 0.708 in the spatial error model has a significant role in adoption of EI at 1% level.

The variable of technical knowledge about EI with coefficients of 0.498 in the spatial lag model and 0.432 in the spatial error model has a significant role in adoption of EI at 5% level.

The variable of participation in extension and education classes about EI with coefficients of 0.501 in the spatial lag model and 0.542 in the spatial error model has a significant role in adoption of EI at 5% level.

Table 4. Identify the appropriate model of Spatial Lag or Spatial Error.

Model	Test	Coefficient	Sig
$y= \rho w_1 y+X\beta+\varepsilon$	[LM(lag)]	115.105**	0.000
$y= \beta X+\mu$	[LM(err)]	64.549**	0.000

Source: Research findings (2020).

Table 5. Estimated parameters for model of Spatial Lag or Spatial Error.

Variables	Parameters	Model of Spatial Lag			Model of Spatial Error		
		Coefficients	Standard error	Sig	Coefficients	Standard error	Sig
----	β_0	2.115	0.729	0.003	1.91	0.768	0.008
ATT	β_1	0.812	0.539	0.005	0.708	0.484	0.005
TEKN	β_2	0.498	0.528	0.011	0.432	0.365	0.012
EXT	β_3	0.501	0.428	0.008	0.542	0.474	0.007
WtC	β_4	0.493	0.319	0.012	0.443	0.381	0.014
RO	β_5	0.392	0.169	0.023	0.354	0.265	0.028
INC	β_6	0.482	0.181	0.011	0.389	0.328	0.019
LoE	β_7	0.396	0.318	0.017	0.398	0.363	0.018
EAw	β_8	0.495	0.381	0.011	0.415	0.384	0.014
AIS	β_9	0.438	0.194	0.016	0.403	0.419	0.018
	ρ	0.712	0.273	0.000			
	λ				0.792	0.218	0.000

Source: Research findings (2020).

The variable of willingness to creativity with coefficients of 0.493 in the spatial lag model and 0.443 in the spatial error model has a significant role in adoption of EI at 5% level.

The variable of being risk oriented with coefficients of 0.392 in the spatial lag model and 0.354 in the spatial error model has a significant role in adoption of EI at 5% level.

The variable of income with coefficients of 0.482 in the spatial lag model and 0.389 in the spatial error model has a significant role in adoption of EI at 5% level.

The variable of level of education with coefficients of 0.396 in the spatial lag model and 0.398 in the spatial error model has a significant role in adoption of EI at 5% level.

The variable of EI awareness with coefficients of 0.495 in the spatial lag model and 0.415 in the spatial error model has a significant role in adoption of EI at 1% level.

The variable of access to information sources with coefficients of 0.438 in the spatial lag model and 0.403 in the spatial error model has a significant role in adoption of EI at 1% level.

CONCLUSIONS

The application of Eco-Innovation (EI) in the agricultural sector of Iran is not very favorable. Based on the studies, observations have been made and according to the results of this research, a small percentage of farmers pay attention to the use of EI subsets in the agricultural sector.

Given the significant role of attitudes towards EI in their adoption in the spatial lag model and spatial error model, it is necessary for planners to make essential efforts to motivate and improve stakeholder attitudes in the field of EI. Different motivational programs through educational and extension classes and mass media and creating an optimal attitude towards eco-innovations will be effective in this field.

Based on the research results, it was found that technical knowledge about EI, participation in extension and education classes about EI, willingness to creativity, being risk oriented, income, educational level, EI awareness, and information sources has a significant role in the adoption of EI in the spatial lag model and spatial error model. These results are in line with finding of Szilagyi *et al*. (2018), Chizari and Ommani, (2009), Bosshagh *et al.* (2014), and Fatemi *et al.* (2018). Based on the results we can recommend the followings:

This requires planners and administrators to make an effort to increase users' technical knowledge. In-service training courses and holding training classes based on the needs of users and at the right time with the right content will play an important role in increasing EI technical knowledge.

It is essential that policymakers and planners of extension programs should provide a variety of extension programs in the field of EI in order to develop the knowledge and skills of the beneficiaries and work to motivate and improve their attitudes.

It is essential that managers of agricultural production cooperatives should provide the necessary conditions for the development of farmers' creativity. Developing creativity and creating innovation opportunities among farmers and increasing their awareness of environmental protection can play an effective role in accepting eco-innovations.

It is recommended that training programs be held for members of agricultural cooperatives on issues such as risk management, ways of recognizing risk, risk assessment, risk analysis, risks prioritization, and response to risks.

It is necessary to increase the income of beneficiaries through training programs on the optimal use of resources, reducing production costs, and application of the scientific principles in production.

It is necessary to provide conditions for the development of literacy and improving the level of education.

It is suggested that the necessary measures be taken to increase farmers' awareness through various information programs such as workshops, distribution of educational publications, news bulletins, implementation of radio and television programs and mass and social media.

It is recommended that the necessary information resources and appropriate communication channels be made available to the members of the cooperatives and that the necessary conditions be provided for adoption of EI.

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عوامل تعیین کننده نوآوری های زیست‌محیطی در تعاونی های تولید محصولات کشاورزی در ایران

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چکیده

هدف از این مطالعه شناسایی عوامل مؤثر در پذیرش نوآوری‌های زیست‌محیطی توسط اعضای تعاونی‌های تولید محصولات کشاورزی بود. از روش‌های کمی و کیفی برای تحقیق استفاده شد. بخش کیفی شامل مصاحبه‌های نیمه‌ساختاری، مصاحبه‌های حضوری و جلسات طوفان اندیشه، بخش کمی شامل مدل‌های توصیفی آماری و فضایی و مدل‌های بیزی برای تخمین مدل تحقیق می‌باشد. در این مطالعه از نرم افزار SPSS و MATLAB استفاده شده است. از نرم افزار SPSS برای توصیف متغیرها، توضیح انواع نوآوری های زیست‌محیطی و تأثیرات آنها و مقایسه پذیرنده‌ها و غیر پذیرنده‌ها و از نرم افزار MATLAB برای تخمین مدل استفاده شد. داده‌های ۳۰۰ نفر از اعضای تعاونی‌های تولید محصولات کشاورزی در استان خوزستان، ایران بر اساس نمونه‌گیری تصادفی در تابستان سال ۲۰۲۰ جمع‌آوری شد. این تحقیق انواع مختلفی از نوآوری‌های زیست‌محیطی را در تعاونی‌های کشاورزی ایران بررسی کرده است. برای مقایسه خصوصیات پذیرنده‌ها و غیر پذیرنده‌ها ، از آزمون t و آزمون من‌ویتنی (MW) استفاده شد. نتایج آزمون t نشان داد که بین سن، درآمد، عملکرد محصول و اندازه مزرعه برای پذیرندگان و غیر پذیرندگان نوآوری در محیط‌زیست تفاوت معنی‌داری وجود دارد. آزمون من‌ویتنی تفاوت معنی‌داری بین سطح تحصیلات کشاورزان، آگاهی از نوآوری های زیست محیطی، نگرش نسبت به نوآوری‌های زیست محیطی، دانش نوآوری‌های زیست‌محیطی، تمایل به خلاقیت، ریسک گرا بودن و دسترسی به اطلاعات پذیرندگان و غیرپذیرندگان نوآوری های زیست محیطی را مشخص نمود. براساس نتایج به دست آمده از مدل های فضایی ، با احتمال ۹۹٪ ، هر دو مدل معنی دار بودند. بنابراین، از هر دو مدل می‌توان برای تفسیر نتایج مربوط به پذیرش نوآوری‌های زیست‌محیطی استفاده کرد. بر اساس نتایج حاصل از برآورد مدل‌های فضایی، متغیرهای مستقل و ضریب خود رگرسیون فضایی نقش مهمی در اتخاذ نوآوری‌های زیست محیطی داشتند. برای مفاهیم عملی می‌توان گفت که اعضای تعاونی، هنگام اتخاذ نوآوری‌های زیست‌محیطی، می‌توانند از مدل پیشنهادی متناسب با حوزه کاری خود استفاده کنند. کار ما قبل از توصیه اینکه تعاونی‌ها در یک زمینه خاص خاص باید به نوآوری در محیط زیست تبدیل شوند ، یک بررسی مهم انجام می‌دهد.