Agro-Economic Factors Determining on Adoption of Rice-Fish Farming: An Application for Artificial Neural Networks

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Abstract—**This study was carried out to identify agro-economic factors on adoption integrated rice-fish farming by farmers. A survey was conducted using a stratified random sampling to collect data from farmers of selected villages in Guilan province, north of Iran. The questionnaire validity and reliability ware also determined to enhance the dependability of the result. Data were collected from 184 respondents (61 adopters and 123 non-adopters) randomly sampled from selected villages and was analyzed using the Artificial Neural Networks. Results for agronomic independent variables showed correctly that 78.2% were classified from training samples and 71.7% from testing samples. In addition, results for economic independent variables showed correctly that 72.7% were classified from training samples and 71.2% from testing samples. On this basis, agro-economic factors influencing the adoption of integrated rice-fish farming were application of chemical fertilizers, application of herbicides, especially quantity using Diazinon, yearly income from agricultural activities, number animals and accessibility to agricultural organs.**

Index Terms—**artificial neural networks, rice-fish farming, agro-economic, farmers, north of Iran**

I. Introduction

Rice culture has been practiced in Asia for 5000-6000 years, and the harvesting of wild fish from rice-fields can be considered as a prelude to fish culture [1]. The earliest records of fish culture in rice-fields originate from Asia, circa 2000 years ago [2], [3]. Integrated rice-fish farming offers a solution to economic problem of farmers by contributing to food, income and nutrition [4]-[6]. Many reports suggest that integrated rice-fish farming is ecologically sound because fish improve soil fertility by increasing the availability of nitrogen and phosphorus [7]-[9]. The feeding behavior of fish in rice fields causes aeration of the water. Integrated rice-fish farming is also being regarded as an important element of integrated pest management (IPM) in rice crops [10]-[13]. At the farm level rice-fish integration reduces use of fertilizer, pesticides and herbicides in the field. Such reduction of costs lowers farmer's economic load and increases their additional income from fish sale [14]-[17]. Also, integrated rice-fish farming gave higher rice yields and fetched higher gross margin than sole rice cropping system [18], [19], [7]. Although, problems of fish farming in paddy fields were about economic, fish food, losses of fish, fish fingerlings, water, wildlife, knowledge and expertise, insurance, oxygen, Azolla, transportation and market [20], [21]. However, rice-fish farming remains marginal in countries because of socioeconomic, environmental, technological, and institutional in many countries. Although rice-fish technology has been demonstrated successfully and a considerable number of farmers have been trained through various projects, this integration has yet to be widely [22], [23]. In Iran, four species of warm-water fish (common carp, grass carp, silver carp, and bighead) are of production potential in paddy fields [24], [25]. Accordingly, much research was performed on the factors of ecologic, biologic, environmental, agronomic, economic and social influencing adoption of rice-fish farming. Results of all this research was reported by using observation, review and various statistical methods. In this studies, descriptive statistic, Chi square, Mann-Whitney test, t-test, Logistic regression, Discriminant analysis, Multi-response analysis and fuzzy analysis were the important statistical methods used [26]-[35]. Nowadays, application of artificial neural network analysis as a better model has been considered in study of technology adoption and factors predictors. In this respect, there are studies such as Morris et al. [36]; Qi and Yan [37]; Allahyari and Noorhosseini [38], [39]; Smith et al. [40]. The main purpose of this study was to identification the agro-economic factors influencing adoption of rice-fish farming in north of Iran by use artificial neural network analysis.

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II. Materials and Methods Hints

A. *Studied Location and Survey*

This study was carried out by survey design. Studied area including *Talesh*, *Rezvanshahr* and *Masal* set in *Tavalesh* region of *Guilan* province near to Caspian Sea, north of Iran (Fig. 1). Respondents were selected from rural area and categorized into adopters and non-adopters of integrated rice-fish farming. Totally 184 farmers were selected by stratified random sampling technique using the table for determining the sample from given population developed by Bartlett et al. [41] that including 61 (33.15%) adopters and 123 (66.85%) non-adopters (Table I). This survey was conducted in using a questionnaire with open-ended questions. The questionnaire was pre-tested by interviewing three farmers (not included in the study). After some modifications, it was tested again with 10 other respondents.

TABLE I. Total Sample Size Used in the Study Area

	Talesh	*Masal*	*Rezvanshahr*	Total
IRFF Adopters Population	31	31	17	79
IRFF Adopters Sample Size	19	28	14	61
IRFF Non-adopters Sample Size	38	56	29	123

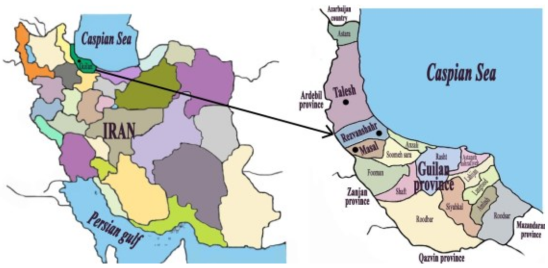

Figure 1. Site of study

B. *Statistical Analysis*

In this study, artificial neural networks were used for statistical analysis. Data analysis was conducted with statistical package for social sciences (SPSS18).

C. *Artificial Neural Networks Analysis*

Using neural networks was started since early twentieth century, and it has expanded recently. Artificial neural network or neural network is a computational tool inspire by human brain. Characteristics such as learning and conformity ability, generalization power data basic processing, error tolerance and uniformity of analysis and design causes the neural networks to have high processing ability and are able to successfully perform tasks such as estimation of nonlinear complex functions and recognizing and classifying the patterns. The structure of neural networks is generally a multilayer networks or graph with simple relations between the layers. In each layer, there is one or several computational unit calling node or artificial neurons which in fact are a simple pattern of human brains neurons. The role of neurons in neural networks is data processing; this is performed in artificial neural networks through a mathematical processor which is the activating function. An artificial neural network in simplest form has an input and an output layer. But a network with hidden layers has greater abilities. It can be affirmed that a progressive neural network having a hidden layer, sigmoid activating function in the hidden layer, linear activating function in the output layer and adequate number of neurons in the hidden layer is able to approximate each function with desire precision. This network performs like an input-output system and used input neurons value to calculate the output neurons value. Each link between the neurons in various layers has its own specific weight which affects the network by adjusting these weights during the training stage, learners' pattern present in- between the output and input variables. Generally, neural network can be divided into two; the supervised learning and un- supervised learning depending on the learning techniques. In the supervised learning, correct response (output) is given to the network for each input pattern. Weights are defined such that network produced responses near to the correct well-known responses. During the repeated correction of the weights, a network is trained. By repeated learning process, the network can identify the correct values of the weights and will decrease the errors rate. In this learning, basic structure of data and correlation between the patterns present in data are discovered by the network and the patterns will be organized in suitable classes. According to the structure also, artificial neural network are divided to progressive and regression networks. In progressive networks, there is no feedback loop and regressive networks have feedback loop where neurons in each layers, receive data both from previous layers and subsequent layers. In present study, multilayer Perception model was used to construct a prediction model where it will predicts one or more dependent (target) variable [38], [39]. In this study, the network was trained with 70% of data and cross validation was used to define the training pause condition to prevent extra training. A final network was evaluated and tested using 30% of data. To exclude any uncontrollable influencing factor and providing the maximum similarity in the test samples, training and cross validation of these samples was selected as completely randomized among the data and were utilized to develop the networks.

Dependent Variable: the dependent variable was the adoption of rice-fish farming. The dependent variable was dichotomized with a value 1 if a farmer was an adopter of integrated rice-fish farming and 0 if non-adopter.

Agronomic Independent Variables: The agronomic variables for the two groups were examined using artificial neural networks model. The definitions and measurement of variables are present in Table II. AF, AH, AP, BP and WI were entered in the model as dummy variables. The other variables namely QF, QD and NP were entered as continuous variables.

The model was specified as follows;

$$Y = f(AF, QF, AH, AP, BP, QD, NP, WI)$$

Economic Independent Variables: The economic variables for the two groups were examined using artificial neural networks model. The definitions and measurement of variables are present in Table II. US, FW, IN and FI were entered in the model as dummy variables. The other variables namely PR, INC, RC, NF, AN and AN were entered as continuous variables.

The model was specified as follows;

Y= f (PR, INC, RC, NF, AN, US, FW, IN, FI)

TABLE II. DEFINITION OF VARIABLES INCLUDED IN THE ARTIFICIAL NEURAL NETWORKS MODEL

Dependent Variable		
Y = Adoption		Adopters = 1, Non adopters = 0
Agronomic Independent Variables		
AF	= Application of Chemical Fertilizers	Yes = 1, No = 0
QF	= Quantity Using Chemical Fertilizers	Kg/ha
AH	= Application of Herbicides	Yes = 1, No = 0
AP	= Application of Pesticides	Yes = 1, No = 0
BP	= Biological Control of Pests	Yes = 1, No = 0
QD	= Quantity Using Diazinon	Kg/ha
NP	= Number of Plows	Number in year
WI	= Accessibility to Water Supply for Irrigation	Very mach = 5, Much = 4, Intermediate = 3, Little = 2, Very little = 1
Economics Independent Variables		
PR	= Amount of farm ownership	Farm area (ha)
INC	= Yearly income from agricultural activities	Rls
RC	= Yearly expenditure in rice farming	Rls
NF	= Farm patches	Number of patches
AN	= Domestic animals	Number of animal
US	= Utilization system	Ownership = 1, otherwise = 0
FW	= Farm workers	Family members = 1, otherwise = 0
IN	= Accessibility to agricultural inputs (fertilizers, pesticides, machinery equipment, …)	Very much = 5, Much = 4, Intermediate = 3, Little = 2, Very little = 1
FI	= Accessibility to financial resources/ credits/ investment	Very much = 5, Much = 4, Intermediate = 3, Little = 2, Very little = 1

III. RESULTS AND DISCUSSION

A. Artificial Neural Networks for Agronomic Factors

In results for agronomic independent variables, case processing summary showed that 124 samples and 60 samples were in two groups of training samples and testing samples, respectively (Table III). Based on the results of network analysis, total number of units contained in the input layer equals to the total number of auxiliary variables and causal variable. According to the fact that in present study 8 variables of agronomic factors were studied as independent (auxiliary) variables and there was no cause variable, 8 neurons were placed in the input layer of this study. The number of output layers was 2 units. In this analysis, number of adopters and non-adopters were 2 output layers of this study.

Results for agronomic independent variables showed correctly that 78.2% were classified from training samples and 71.7% from testing samples (Table IV). Table V, also indicates the importance of agronomic independent variables influencing on adoption of integrated rice-fish farming. Importance of agronomic independent variables is in defining the point that how much the amounts predicted by the network will change with variation of independent variable values. Normalizing this importance is very simple; and is achieved through dividing the importance value on its larger value and is expressed as percent. It seems that variables including the quantity using Diazinon (QD), application of chemical fertilizers (AF) and application of herbicides (AH) had the greatest effect on the system that will classify the subjects.

TABLE III. CASE PROCESSING SUMMARY FOR AGRONOMIC VARIABLES

Sample	N	Percent
Training	124	67.4%
Testing	60	32.6%
Total	184	100.0%

TABLE IV. CLASSIFICATION OF CASES FOR AGRONOMIC VARIABLES

Sample	Observed	Predicted		
		Non-Adopters	Adopters	Percent Correct
Training	Non-Adopters	78	8	90.7%
	Adopters	19	19	50.0%
	Overall Percent	78.2%	21.8%	78.2%
Testing	Non-Adopters	31	6	83.8%
	Adopters	11	12	52.2%
	Overall Percent	70.0%	30.0%	71.7%

Dependent Variable: Adoption

TABLE V. INDEPENDENT AGRONOMIC VARIABLES IMPORTANCE IN DETERMINING THE NEURAL NETWORK

Independent Agronomic Variables	Importa nce	Normalized Importance
Application of Chemical Fertilizers (AF)	0.217	77.0%
Quantity Using Chemical Fertilizers (QF)	0.062	22.2%
Application of Herbicides (AH)	0.202	71.5%
Application of Pesticides (AP)	0.053	18.9%
Biological Control of Pests (BP)	0.073	26.0%
Quantity Using Diazinon (QD)	0.282	100.0%
Number of Plows (NP)	0.039	13.8%
Accessibility to Water Supply for Irrigation (WI)	0.071	25.3%

B. Artificial Neural Networks for Economic Factors

In results for economic independent variables, case processing summary showed that 132 samples and 52 samples were in two groups of training samples and testing samples, respectively (Table VI). Based on the results of network analysis, total number of units contained in the input layer equals to the total number of auxiliary variables and causal variable. According to the fact that in present study 9 variables of economic factors were studied as independent (auxiliary) variables and there was no cause variable, 9 neurons were placed in the input layer of this study. The number of output layers was 2 units. In this analysis, number of adopters and non-adopters were 2 output layers of this study.

Results for economic independent variables showed correctly that 72.7% were classified from training samples and 71.2% from testing samples (Table VII). Table VIII, also indicates the importance of economic independent variables influencing on adoption of integrated rice-fish farming. Importance of economic independent variables is in defining the point of how much the amounts predicted by the network will change with variation of independent variable values. Normalizing this importance is very simple, and is achieved through dividing the importance value on its larger value and is expressed as percent. It seems that variables including the yearly income from agricultural activities, number animals and accessibility to agricultural organs (fertilizers, poisons, machinery etc.) had the greatest effect on how the system will classify the subjects.

TABLE VI. CASE PROCESSING SUMMARY FOR ECONOMIC VARIABLES

Sample	N	Percent
Training	132	71.7%
Testing	52	28.3%
Total	184	100.0%

TABLE VII. CLASSIFICATION OF CASES FOR ECONOMIC VARIABLES

Sample	Observed	Predicted		
		non-Adopters	Adopters	Percent Correct
Training	non-Adopters	76	12	86.4%
	Adopters	24	20	45.5%
	Overall Percent	75.8%	24.2%	72.7%
Testing	non-Adopters	32	3	91.4%
	Adopters	12	5	29.4%
	Overall Percent	84.6%	15.4%	71.2%

Dependent Variable: Adoption of Rice-Fish Farming

TABLE VIII. INDEPENDENT ECONOMIC VARIABLES IMPORTANCE IN DETERMINING THE NEURAL NETWORK

Independent Economic Variables	Importance	Normalized Importance
Amount of Farm Ownership (per Hectare)	0.058	16.8%
Yearly Income from Agricultural Activities (Rls)	0.345	100.0%
Yearly Expenditure in Rice Farming (Rls)	0.034	9.9%
Number of Farm Patches	0.067	19.4%
Number Animals	0.145	42.0%
Utilization System	0.085	24.6%
Farm Workers	0.056	16.3%
Accessibility to Agricultural Organs (fertilizers, Poisons, machinery…)	0.112	32.5%
Accessibility to Financial Resources/ Credits/ Investments	0.098	28.5%

Chi square, Mann-Whitney test and t-test in the results of Noorhosseini and Allahyari [28] indicated that the kind of fertilizers in the rice field, methods of weed control, methods of pest control, and the number of plows were the most important agronomic factors determining whether farmers would adopt rice-fish farming. Logistic regression in study of Noorhosseini and Allahyari [34] showed that biological control of pests in rice fields, quantity using Diazinon in rice fields, and numbers of plows in rice fields were the most important technical-agronomic factors impressible from fish farming in rice fields. Also, Chi square, Mann-Whitney test and t-test in results of Noorhosseini and Allahyari [32] showed that economic factors influencing the adoption of integrated rice-fish farming were farm ownership, yearly income from agricultural activities, average yield of rice, yearly expenditure in rice farming and farm workers. Noorhosseini and Allahyari [34] by Logistic regression reported that family size, number of contacts with an extension agent, participation in extension-education activities, membership in social institutions and the presence of farm workers were the most important socioeconomic factors for the adoption of rice-fish farming system. Similarly, Kapanda *et al*. [42] by Logit model reported that sex, age, wetland size, and livestock ownership were important parameters for the adoption of fish farming among farmers in Malawi. Wetengere [43] by probit model reported that sex, age, formal education, religious beliefs, extension education, land size, income, family size, risk, and profitability were important factors for the adoption of fish farming technology in Tanzania. Ahmed and Garnett [5] by production function model and using an ANOVA F-test reported that integrated rice-fish farming also provides various socioeconomic and environmental benefits. In addition, Ahmed *et al*. [44] by Tobit model reported that rice-fish farming is as production efficient as rice monoculture and that integrated performs better in terms of cost and technical efficiency compared with alternate rice-fish farming. Multi-response analysis in studies of Noorhosseini and Allahyari [20]; Noorhosseini [21] showed that economic problems, lack of access to appropriate fish food, losses, and lack of access to high quality fish fingerlings and dehydration and poor water quality were important issues in rice-fish farming. Karami *et al*. [26] noted that Discriminant function derived from integrated model could suitably categorize adopters and non- adopters of RFF. The most important variables, which differentiated RFF adopters and non-adopters, were access to information, knowledge of fish fingerlings, aquaculture management, and plot preparation for aquaculture and knowledge of fish harvesting. In addition, fuzzy analysis in study of Noorhoseini *et al*. [35] showed that most important agro-economics benefits of integrated rice-fish farming were more accessible to villagers to white meat through the production of fish, optimal and dual use of rice fields, pollution reduction and environmental sustainability by reducing the use of pesticides and chemical fertilizers, fish production as an additional product and increase revenue rice farmers, dual use from water irrigation resources, increase soil fertility of rice field by fish farming, biological control of weeds and pests

IV. Conclusions

In this study, important agro-economic factors influencing the adoption of integrated rice-fish farming were application of chemical fertilizers, application of herbicides, especially quantity using Diazinon, yearly income from agricultural activities, number animals and accessibility to agricultural organs. This result was recommend that the first agricultural extensional must display essential resources for adoption of integrated rice-fish farming among farmers. Second, developers of integrated rice-fish farming must increase benefit ably of fish farming. Secondly, the agronomic knowledge of using rice-fish farming should be disposed of farmers to adopt it more consciously and with a positive viewpoint. Finally the promotion of integrated rice-fish farming should be paid more attention for following enormous numbers of adopters of this technology.

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