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Presentation of ANFIS Model in Development of Agricultural Economy Programs through Energy Analysis

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ABSTRACT

Agriculture is one of the most important economic sectors in developing countries. Today, models become a standard tool for energy planning. In this paper, we introduce a Neuro-Fuzzy Inference System as well as present a model as an energy modeling tool for developing agricultural economy. Indicators were defined and used to determine the relationship between energy outputs and input to compare and assess various products energy and similar products in different cropping systems. First, modeling stages algorithm was designed to forecast product yield. The proposed model was a combination of the two models, in one model, the total amount of energy that had a greater proportion in the production included in a category and regarded as input variables of ANFIS network, in another model, the total amount of energy that had lower proportions in the production included in other category and considered as input variables of the second network. The output system of energy indicators would be an effective criterion in the production. Studies and analysis of research results showed that predicting product yield using ANFIS had a significant impact on policy-making and agriculture economic plans.

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INTRODUCTION

Economic development is a key objective of economic policy-makers. Numerous studies by researchers around the world showed that growth rate of energy consumption in the world depended largely on economic growth level. In the not so distant past, scientists and researchers had little faith on the role of energy in comprehensive and holistic economic development, but over time, the energy was considered not only as an important component in the communities development, but also as an essential pillar for achieving development and prosperity of a country, as energy is now one the important and vital data in human life and nearly in all productive and consuming activities in different economic sectors (Rahimi Zade *et al*., 2007). Agriculture is one of the most important economic sectors in developing countries. The agricultural sector is one of the energy consuming sectors. Energy is important as a consuming input. This sector has an effective role in economic development, employment and non-oil exports as well as supplying food security. Iran is not the exception and agricultural sector has a particular importance in Iran and has always a significant role in non-oil exports (Salimi Far *et al*., 2002, Mehrabi *et al*., 2009, and Najafi, & Tarazkar, 2005). Efficient use of energy has a critical role in production stability, system economic optimization, and fossil fuels reserves maintenance and air pollution reduction (Rahimi Zade *et al*., 2007). Energy analysis is essential for proper management of scarce resources to improve agricultural production, by which the efficient and economic productive activities are determined. Determining consumed energy in each stage of the production process and, in fact, determining the steps that require the lowest energy inputs, providing a basis for the conservation of resources as well as contributing in the sustainable management and relevant policies are other advantages of energy analysis (Hematian *et al*., 2010, . Chaudhary *et al*., 2006). Today, models become a standard tool for energy planning. In recent years, many efforts were done to formulate and implement strategies for energy planning in developing countries (Menhaj *et al*., 2009). Models are symbols of reality and state simply and generally the most important characteristics of real-world. Forecasting is one of the main goals of constructing economic models that unlike many major markets, agricultural products market stay away from predicting new research, as the studies are often based on econometric methods (Kohansal *et al*, 2012). Adaptive Neuro-Fuzzy Inference System (ANFIS) [1] was presented by a PhD student, Lotfizade, called Jang in 1993 (Jang, 1993). The application of neural networks

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in economics and econometrics began in the late 80s with White's study on financial markets and forecasting stock price of IBM Company in 1988. The aim of this paper is introducing ANFIS as well as presenting a model as an energy modeling tool for developing agricultural economy due to the role and importance of energy consuming in the process of economic growth and development. Table 1 showed the results of some researches.

Table 1: Describing some researches

Subject	Result	Researcher
Application of ANFIS for forecasting production through different input energies	ANFIS model was able to forecast well the wheat crop with high accuracy.	Naderloo *et al*., 2012
Application of ANFIS model in comparison with ARIMA[2] econometric model to forecast the retail price of agricultural products.	ANFIS model was more effective than the ARIMA model in forecasting retail prices of agricultural products.	Fahimi Fard *et al*., 2008
Egg price forecasts using ARIMA, artificial neural networks and Holt - Vintz smoothing	Forecasting results of the ANN method was closer to the truth than the other methods. And can provide the right decisions to help policymakers.	Kohansal *et al*., 2012
Forecasting the price of some crops in Fars Province: Application of Artificial Neural Networks	The results showed that the artificial neural network has the lower error for prediction of different product prices and are more accurate than other methods.	Najafi *et al*., 2007
Modeling and forecasting Iran agricultural exports using artificial neural networks	The results showed that the artificial neural networks have high capacity to forecast exports of agricultural products and are able to predict export this product more accurately than conventional methods	Mehrabi *et al*., 2009
Transportation energy demand forecasting using neural networks : A case study in Iran	The results of prediction by this method showed that the error is much less compared with multiple regression method.	Menhaj *et al*., 2009

MATERIALS AND METHODS

Required data was gathered using questionnaire and a random sampling of one or more agricultural products in order to model. Then, the data was analyzed using MATLAB software and ANFIS toolbox after calculation of energy indicators. The algorithm in figure 1 showed different stages of modeling.

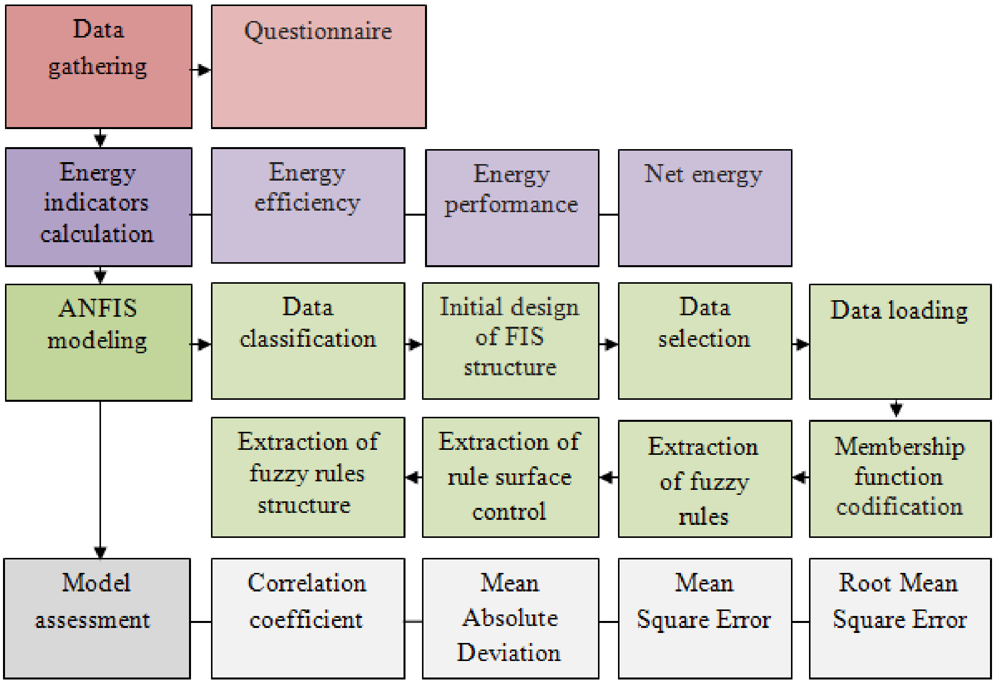

Fig. 1: Algorithm to forecast the yield with energy analysis using ANFIS

Analysis of energy in agriculture:

Energy is one of the topics of agricultural ecology and the ratio of input and output energy is calculated in different agricultural ecosystems around the world. Intended evaluations criteria include renewable and non-renewable energy and direct and indirect energy. Renewable energies are the energy in manpower and seeds. Non-renewable energies are petroleum products and the energy in fertilizers and machinery. Direct energies include the fuel consuming energy of tractors, motor pumps, and dryers, other machines and also electrical energy consumed in electromotor. Indirect energy was used in manufacturing farm machinery, fertilizers, pesticides as well as processing and nutrients delivery (Kouchaki *et al*., 1994, Basharabady *et al*., 2011). The indicators were defined and used to determine the relationship between energy output and input. Various products energy as well as similar products were compared and assessed in different cropping systems using these indicators.

2-1- energy efficiency: the ratio of output to input energy was used to calculate energy efficiency or the ratio of consumed energy. Thus, it is essential to calculate energy content of the final product as the output energy and the energy content of production inputs as input energy (Basharabady *et al*., 2011). The energy ratio does not have any unit and shows the effect of energy input unit in achieving the objectives of consumer (Equation 1).

2-2- energy performance: An indicator of the amount of extracted product per unit of input energy (Equation 2). Energy performance varies depending on the type of crop, location and time and can be an indicator for the evaluation of how the energy is efficiently used in different production system of that specific product.

3-2 – Specific energy: Specific energy is the ratio of energy efficiency (Equation 3).

2-4 - Net energy: The difference between the input and output energy is called net energy (Equation 4). Acquired net energy or net added energy is depended on the unit of production (Ozkan *et al*., 2003).

The equations of the above-mentioned indicators are as follows (Mandal *et al*., 2002, Akbolta & Ekinci, 2006, and Naderloo *et al*., 2012):

$$ER(EUE) = \frac{E_O(MJ\ ha^{-1})}{E_i(MJ\ ha^{-1})} \quad (1)$$

$$EP\ (Kg\ MJ^{-1}) = \frac{Y(kg\ ha^{-1})}{E_i(MJ\ ha^{-1})} \quad (2)$$

$$SE\ (MJKg^{-1}) = \frac{1}{EP} \quad (3)$$

$$NE\ (MJKg^{-1}) = E_O(MJ\ ha^{-1}) - E_i(MJ\ ha^{-1}) \quad (4)$$

Where:

Energy input = Ei, energy output = Eo, energy ratio = ER, energy efficiency = EP, net energy efficiency = NE and specific energy = SE.

In various studies, the equivalent shown in Table 1 is used to calculate energy level and the energy equations are used to calculate the energy inputs and different agricultural operations. Furthermore, the energy equivalent of agricultural products is given in Table 2. For example, fertilizer or pesticide fuel energy (MJ/ha) is calculated by multiplying its value (liter or kg/ ha) by equivalent energy of each unit (MJ/l or kg). Moreover, tractors and machinery energy is estimated due to energy intensity weight onto MJ per kilogram year of life onto hour or year and its actual capacity is estimated onto hectare per hour. For calculating the amount of energy in tractors and machinery assumes that the energy spent for the production during its year of life is amortized. The total energy content of production inputs is considered as the total input energy in agriculture. The input energy is required to be calculated separately for each of the inputs to calculate the total energy content (Basharabady *et al*., 2011).

Table 1: Equivalent energies for main production inputs in agriculture sector (MJ ha)

Instance	Man-power	machinery	fuel	nitrogen	Phos-phorous	Potash	Grain	cereal	Oil seeds	Plant root seed
Unit	H	H	L	Kg	Kg	Kg	Kg	Kg	Kg	Kg
Equivalent Energy	1.96	62.70	56.31	66.14	12.44	6.7	25	25	3.6	14.7
Reference	(22,7)	(7)	(22,7)	(22,7)	(22,7)	(21,7)	(21,7)	(22,7)	(21)	(7)

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Table 2: Equivalent energies for agricultural products (MJ ha)

	products	Equivalent energies (MJ ha)		products	Equivalent energies (MJ ha)
vegetables	Grains	14.7	fruits	cereal	14.7
	Fruit vegetables	0.8		Nuts	11.8
	Melons and watermelons	1.9		Stone fruits	1.9
	Tuber and root vegetables	1.6		Grapes, etc.	11.8
	Leafy and edible vegetables	1.2		Seedy fruits	1.9
	Other	1.6		Citrus	1.9
	Sugar beet and sugar cane	5.04		potato	3.6
Industrial Plants	tea	0.8	Root plants		
	Tobacco	0.8		other	1.6
	other	11.8			
	oilseeds	25			
Reference:(19,7)					

Data Normalizing:

According to studies, it is better to standardize data between 0.1 and 0.9. Input data to the ANFIS network is normalized using the following equation.

$$X_i = 0.8\left(\frac{x - x_{min}}{x_{max} - x_{min}}\right) \quad (6)$$

Where X_i= the normalized value, x= the actual value and x_{min}, x_{max} = minimum and maximum data.

Architecture of Neuro-Fuzzy Inference System (ANFIS):

Neuro-fuzzy inference system (ANFIS) provides Fuzzy Inference System (FIS) using a collection of data input and output. Membership functions parameters of the system are adjusted by back-propagation algorithm or combining with the method of least squares. This operation allows the fuzzy systems to learn their structure from the data collection. Neuro-Fuzzy Inference System during the learning ability of neural network and the inference ability of fuzzy systems can find any kind of model or nonlinear mapping as well as learning capability of neural network and the inference ability of fuzzy systems to relate accurately the inputs with the predicted output. Thus, ANFIS multi-layer neural network is based on fuzzy system. Fuzzy inference system method has many applications in adaptive techniques for customizing membership functions due to being more compact, in terms of computing, than field method. Therefore, the fuzzy system can better model the data (6). We describe a fuzzy system with two inputs of x and y and one output of z for brevity and simplicity. Collection of law with two if - then rules is considered as follows for a Sugeno Fuzzy Model of degree one:

$$\begin{cases} \text{Rule 1 if } X = A_1 \text{ and } y = B_1 \Rightarrow f_1 = p_1 x + q_1 y + r_1 \\ \text{Rule 2 if } X = A_2 \text{ and } y = B_2 \Rightarrow f_2 = p_2 x + q_2 y + r_2 \end{cases}$$

(Basharabady *et al*., 2011) Where A and B are the input membership functions and r, p and q are output functions, figure 2 shows the fuzzy model.

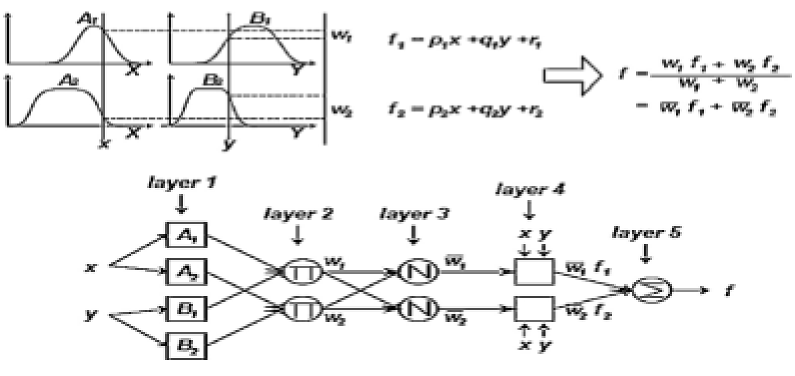

Fig. 2: A Sogno fuzzy model with two inputs and two rules and ANFIS structure of the presented model.

We continue to examine each layer separately (3):

First layer, input nodes: Every node in this layer is an adaptive node with an output that is defined as follows:

$$O_{1,i} = \mu_{A_i}(x) \qquad i = 1,2$$

(Fahimi Fard *et al*., 2008)

$$O_{1,i} = \mu_{B_{i-2}}(y) \qquad i = 3,4$$

(Moghaddam, 2009)

Where x and y are input nodes and Ai and Bi-2 are fuzzy sets associated respectively with the input that can take any provided shape of common membership functions. Parameters of each node determine the shape of membership function of the fuzzy set of that node. For example, A_i can be displayed as a bell- shaped function.

$$\mu_{A,i} = \frac{1}{1+\left[\left(\frac{x-c_i}{a_i}\right)\right]^{2b_i}}$$

(Menhaj *et al*., 2009)

Where {ai, bi, ci} are the set of parameters called the initial parameters and are, in fact, the nonlinear parameters in the network parameters set.

The second layer, rule node: Each node in this layer calculates the activity rule. Nodes yield is fixed in this layer and multiplies the input signals of previous layer and obtains output.

$$O_{2,i} = w_i = \mu_{A_1}(x) \times \mu_{B_1}(y) \qquad i = 1,2$$

(Najafi *et al*., 2007)

The third layer, the intermediate nodes: Nodes yield in this layer is fixed and displays by N. In fact, the potency of rules impact is normalized in this stage.

$$O_{3,i} = \overline{w_i} = \frac{w_i}{w_1+w_2} \qquad i = 1,2$$

(Najafi & Tarazkar, 2005)

The fourth layer, the result nodes: the nodes are adaptive in this layer and their yield is defined as follows:

$$O_{4,i} = \overline{w_i}\ f_i = \overline{w_i}\ (p_i\, x + q_i\, y + r_i) \qquad i = 1,2$$

(Hematian *et al*., 2010)

Where {pi, qi, ri} are the set of parameters called result parameters and are the linear parameters in the network parameters set.

The fifth layer, output nodes: the node yield is fixed in this layer and calculates the overall output from the input signals of the fourth layer.

$$O_{5,i} = Overall \quad output = \sum_i \overline{w_i}\ f_i = \frac{\sum_i w_i\, f_i}{\sum_i w_i}$$

(Akbolta & Ekinci, 2006)

Consequently, we have a network with the same yield as Sogno fuzzy model.

RESULTS AND DISCUSSION

The importance of energy analysis in different economic discussion was expressed in this study. Furthermore, different parameters needed to be identified, the required data needed to be gathered, various energy indicators needed to be calculated for modeling and the obtained data could be modeled and evaluated in the form of various models using Neuro-Fuzzy Inference System model. Neuro-fuzzy prediction model ANFIS was an effective approach in predicting the critical issues of Agricultural Economics based on this study and the results of previous researches. Investigation showed that energy modeling using Neuro-Fuzzy System under lied new researches and studies for researchers and policy-makers of efficient energy field. In this study, Neuro-Fuzzy System model was offered for predicting crop yield using energy analysis.

MATLAB software and ANFIS toolbox was used for modeling. Data would be included data on energy analysis of various agricultural products. Energy was determined by various indicators and data required would be obtained after determining the contribution of direct and indirect energy in crops and energy analysis, although there was not a general outline of how the data was divided, much of the data, typically 70 %, was assigned to training and the remaining was assigned to test. Network training continued until the minimum error was achieved. Number of training courses was appropriately considered proportional to the network error. Fuzzy rules could be deduced after loading data into ANFIS graphical interface. After obtaining the results, the model yield would be evaluated by different statistical criteria. Figure 2 showed the structure of the proposed model and the production forecast using energy analysis through ANFIS, for modeling in this research, the proposed model was a combination of both A and B Model, in model A, the total amount of energy that had a greater proportion in producing were in a category and were considered as input variables of ANFIS network. In model B, the total amount of energy that had lower proportions in production was in other category and was considered as input variables of the second network. And the output of this energy index system would be an effective criterion in production.

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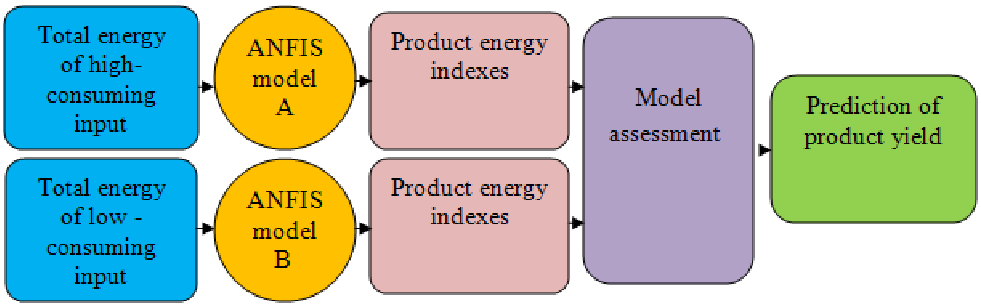

Fig. 2: The presented ANFIS model to forecast product yield

Conclusion:

In this paper, a model was developed to predict the product yield with energy analysis after introducing the fuzzy inference system. Furthermore, important factors in the operation, including energy efficiency, energy performance and net energy were considered as the objective function in the forecasting model using the fuzzy inference system. Moreover, the capability of forecasting econometric model promoted increasingly. Fuzzy inference systems models could be effectively used for all crops in different time. It was observed in this research that energy economy models based on fuzzy inference system could help in understanding planners econometric methods to predict and plan for future. Since the agricultural sector is important in terms of food security, prediction of product yield with accurate methods including of Neuro- Fuzzy System has a significant impact on policy-making and economic planning of this sector.

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