

## Compare the accuracy of artificial neural network and regression models to estimate flood (Case Study: Urban area of Joghatay)

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**Abstract.** In this study, regression and neural network techniques is used to estimate the flood peak discharge moment in Joghatay urban basin with the use of physiographic and climatic stations surrounding the place. In order to assess the stations, Climatology and around the basin of the hydrometer, 8 stations that had at least 37 years of daily data selection were chosen and the following data were used for the input of the model: data area, the slope of the basin, average height, channel length, Gravylyus index, annual rainfall and also flood peak discharge was used as the output of the model. First the peak instantaneous flow rate was estimated by regression and then 63% of inputs were used for training neural network models, and 37% of the remaining data were used for testing the models. Finally, in order to compare the results and assess the efficiency of the method mentioned in the discharge peak moment, we used the correlation and root mean square error. The results showed that the technique of artificial neural network is superior to the regression method to estimate the flood peak discharge point. Based on these results, the problem of short period of peak discharge data in stations related to maximum flow rate can be solved by using artificial neural network, and predicting the watershed flood of the area.

**Keywords:** Flood peak discharge, artificial neural network, regression model, the coefficient of correlation, root mean square error minimum, Joghatay

### 1. INTRODUCTION

In recent decades, most researchers have used characterization of multiple linear regression models and geostatistical models for predicting and modeling the meteorological and hydrological processes and also in order to understand the characteristic of floods and droughts. (menhaj 1384, rezae1383, karamouz and araghinejad 1384)These model, in fact, make the parameters linear and bring them into the decision-making process and in most cases cannot properly analyze complex problems climate- hydraulic and it is essential to introduce models with more performance to predict nonlinear and complex Phenomenon.(kim and valdes 2003)For this reason, experts and scientists of science of hydrology and other related sciences seek to develop appropriate models, to predict these events. Appearance of capable theories like neural networks and fuzzy algorithm had great change in analysis and performance of dynamic systems of different sciences related to water. Today, the efficient methods used in the areas of air and water is the artificial neural network that According to the researchers, the main reason for its increasing popularity and use is the high power and speed for the simulation of processes that we don't have a good understanding on it, or Checking them other existing methods, it is very difficult and time consuming (karamouz and araghinejad 1384, khoshhal and hosseini 1389).

In general, it can be said that the artificial neural network model is a powerful and capable model that we can look at it in a positive approach for predicting climate-hydrologic problems. Especially because the network is capable of governing the data, even data that is confusing.(Dehghani and Ahmadi 1387) And it also doesn't have the need for clear explanation of the nature of the processes in a mathematical way.(Basher and others 2000).Today's, a lot of

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effort is done in effort of forecasting the stream flow and to simulate the rainfall-run off and to estimate the hydrological parameters, using a neural network. And we can say that in most cases, artificial neural networks is capable of predicting and simulating the hydrologic parameters in an acceptable way.(hosseini and borhani 2009)In this paper, the use of artificial neural network models and regression estimation of maximum flood in urban area Joghatay is assessed according to physiographic and climatic factors. So recognition of flood discharge factors and estimation of its flow rate can cause to reduce the damages to natural resources.

## 2. MATERIALS AND METHODS

### 2-1-The study area

The study area includes the subfields in the Watershed of Joghatay urban which locates in the south and southeast of Joghatay city. There is no village in urban areas of Joghatay, but zamand and Goft are the main villages outside of this field. The extent of urban areas Joghatay 91/28 square kilometers. Joghatay urban areas, includes 5 sub hydrological fields, 4 sub non-hydrological fields and 3 Cumulative subfields. The average height of Joghatay is 1912. Geographical coordinates of the studied area are listed in Table 1.

**Table 1.** The urban watershed of Joghatay.

Longitude (X)	Latitude (Y)	
497429	4044867	Positioning in the imaging system (UTM)
504913	4051688	
565817	363257	Position in Lat / lon
570318	363638	

### 2-2 Stats

To predict the maximum flood, stations nearby the urban area of Joghatay are considered that some of newly built stations were removed from the list due to the lack of having the adequate statistics. At last 8 stations was selected. In order to reach to accurate results, we used the statistics of hatiteh and other stations near the basin. These stations have the same altitude and same climate condition as the studied area and the also have a good condition of statistical period.(figure 2)Physiographic information of the basin is taken from the bureau of natural resource management and climate data of Khorasan Razavi.

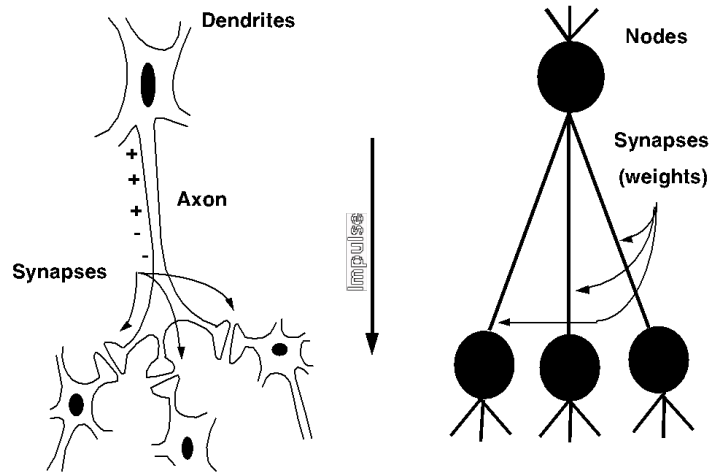
**Table 2.** Characteristics of stations near the urban areas of Joghatay.

Annual rainfall	Gravylus factor	Channel length	Average height	Slope Basin	Perimeter	Area	Stations
384	1.56	27.9	2254	29.7	59.9	115.6	arie
344	1.47	17.9	1935	3.1	53.9	106	nashib
333	1.27	20.7	1857	23.8	43.8	92.8	hatiteh
364	1.42	53.9	2094	26.3	115.2	519.7	Esfaraaien
340	1.97	24.6	1903	24.5	102.6	212.6	Iraqi
388	1.52	18.7	2291	39.7	55	102.7	taghon
329	1.57	40.7	1818	18.8	124.5	491.1	zarandeh
347	1.51	13.5	1958	20.5	35.1	42.3	Upper Chakaneh

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**3. THE ARTIFICIAL NEURAL NETWORK MODEL**

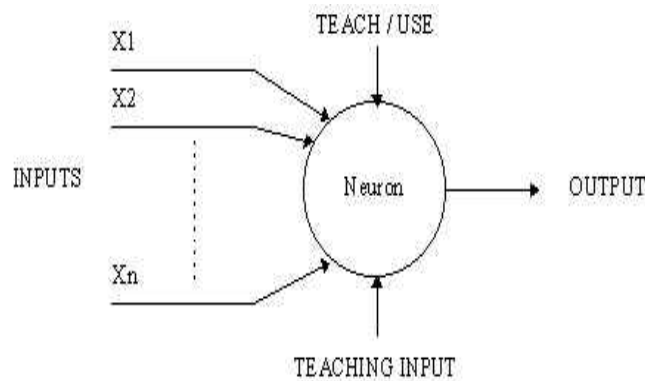
ANN-based is a method based on connecting multiple processing unit simply neural networks systems are new computational method for machine learning, knowledge representation, and finally apply the knowledge gained to predict output response of complex systems. The main ideas of these networks (partly) are inspired by the way biological nervous system function, to process data and learn information about it. A key element of this idea is to create new structures for information processing systems. Network is made of some arbitrary nodes or single cells that link inputs to outputs (bayazidi, 1392)



**Figure 1.** The structure of neural network

The study of artificial neural networks is greatly inspired by the natural learning systems in which a complex set of interconnected neurons are involved in learning.

It is assumed that the human brain is composed of  $10^{11}$  neurons, each neuron is connected with  $10^4$  other neurons. However, one can recognize the picture of another person in 0.1 seconds. This extra power should be reached with parallel processing of a large number of neurons.



**Figure 2.** Neural network components

Neural networks are the most used and most practical methods of modeling complex problems involving hundreds of variables. Neural networks can be used for classified issues (the output of a class), or regression issues (the output is a numeric value).ANN is a branch of artificial

intelligence, that transfer the laws behind the data to the network structure by processing of experimental data. That's why these systems are called intelligent systems.(Negarsh and others,1391).These networks are made of simple operating elements in a parallel way. These elements are inspired by biological nervous systems. In nature of the structure of neural networks is determined the connection between the components. And by adjusting the value of each connection as a connection weight, the relationship between its components are determined.(Kia,1387). The network has a close connection with the analysis of the input data and its similar results that maybe nonlinear, and then with the use of logical connection, the simulation for the similar events is done. (Kochakzadeh and Bahmani, 1384)

Network architecture consists of 9 inputs, 5 units in hidden layer and 1 output. The activation function used in the middle layer is hyperbolic tangent and error function used is the mean-square with error function in the output layer. The used model is MLP (multi-layer perception).It should be noted that 63% of data is used as training and 37% of data is used for testing. Squares mean value obtained from this model, as shown in Table 3 is 0.057 with the error of 0.028 on training samples and the mean square error in the sample tested is 1.22 with the error of 19.58.

**Table 3.** Error values in neural network

Training	The mean-square	0.057	Error value	0.028
Tested		1.22		19.58

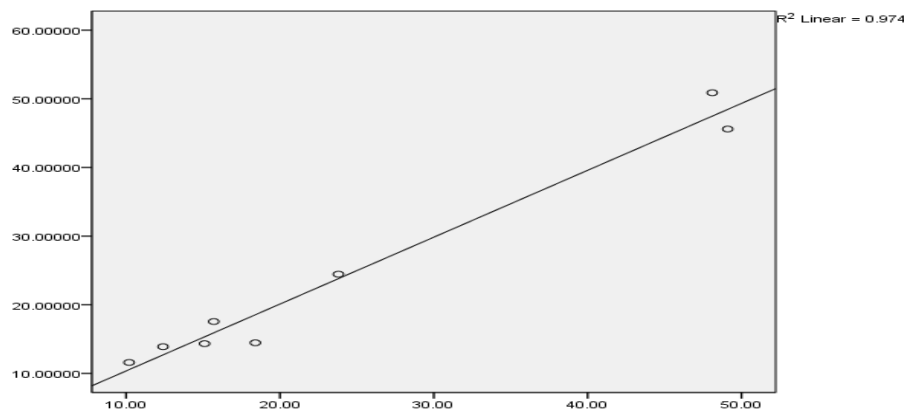
The importance of independent variables in the ANN structure model is like Table 4.

**Table 4.** The importance of independent variables in the ANN model.

Percent of the model	Variables
The length of the main stream	100.0%
Perimeter	62.1%
Area	56.4%
Gravylyus	52.5%
Slope Basin	46.6%
Annual rainfall	24.8%
Average height	22.8%

The main stream length, Perimeter and area have the highest positive impact on the flood peak discharge. And also the line equation fitted between the predicted values and the dependent variables by the factor of 0.97 are shown in figure 3.

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**Figure 3.** The correlation values estimated using neural networks and observed flood with return period of 2 years from the adjacent stations.

### 4. REGRESSION MODELS TO ESTIMATE FLOOD

With the same parameters as artificial neural network parameters, regression relations between these parameters were obtained for the specified return period. The precision of Regression equations extracted was less than the artificial neural network models. The  $R^2$  coefficients for the best Regression relation were calculated 0.92 for the return period of 2 years which contained the following variables: Area, Perimeter, basin slope, average height, channel length, Gravylyus index and annual rainfall.

### 5. CONCLUSION

Design an artificial neural network, includes selecting the number of hidden layers and processing elements for hidden layers that the process of Trial and error is the best way for creating output. (Alborzi, 1381)

In this study Multilayer Perceptron network and multiple regression was used to simulate and predict floods. Parameters of area, the slope of the basin, average height, channel length, Gravylyus index, and annual rainfall were used as inputs in the neural network. Output parameter in the network as the amount of water with the return period of 2 years. The performance function in the neural network was mean square error.

**Table 5.** Structure of neural network models and comparing the results for predicting floods by neural network models for and regression in stations adjacent to Joghatay urban area

Name basin	Network Type	Data percent	The number of neurons	Transfer function	$R^2$	Network training		The network test		Regression
						RMSE	MAE	RMSE	MAE	
joghatay	MLP	63 to 37	15	Hyperbolic tangent	0.97	0.057	0.028	1.22	19.58	0.92

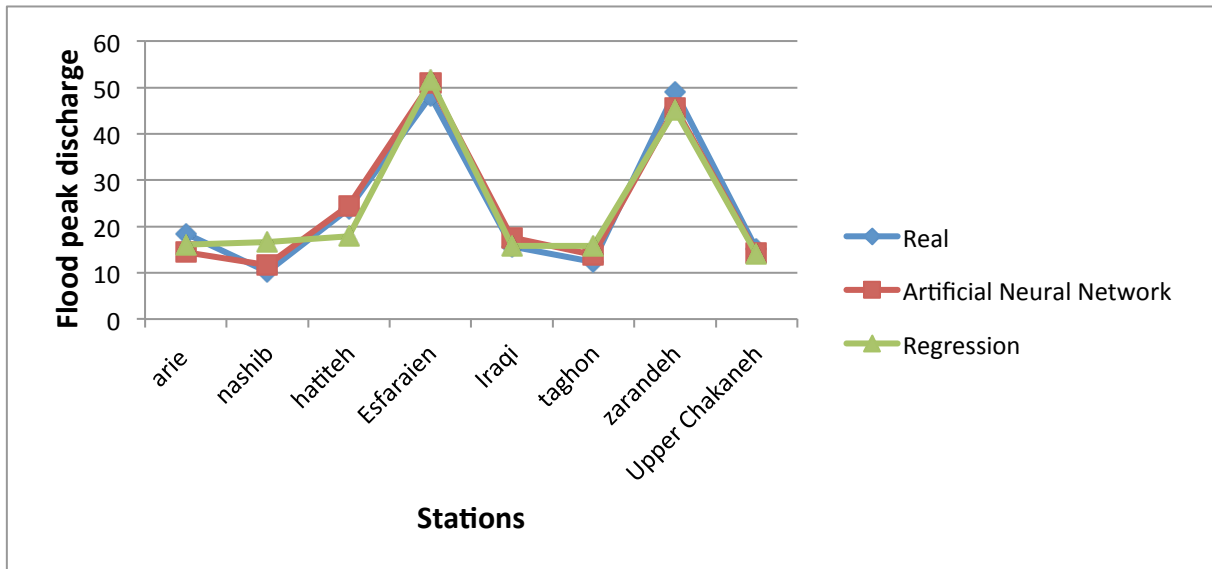
After the formation of many models from a variety of regression model, Table 6 was chosen as the best prediction of the flood.

**Table 6.** Top regression model

joghatay adjacent stations	$Debi2 = 79.368 + .134 A - .353 P$
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A: Area – P: Perimeter – debi2: flow rate with a two-year period

Variable a (area) has the most positive impact on neural network models and regression on the flood peak discharge. In general, the most effective entrance area of these models is the main channel.



**Figure 4.** Comparison of actual and estimated flood discharge with artificial neural network and the regression model of stations adjacent to urban area of Joghatay

Flood prediction using neural networks with different return periods adjacent to stations of Joghatay urban area are listed in Table 7.

**Table 7.** Estimated values of flood with different return periods stations adjacent to urban area of Joghatay.

Stations	2 years	5 years	5 years	20 years	50 years	100 years
arie	23.18	29.5	52.32	95.39	159.37	202
nashib	11	36.76	78.76	149.42	267.32	378.51
hatiteh	22.26	51.15	81.91	175.98	192.61	209.42
Esfaraieen	44.33	48.5	112.09	216.82	228.02	490.25
Iraqi	15.7	19.75	88.6	128.95	257.87	286.19
taghon	13.56	16.57	50.3	146.2	155.2	171.54
zarandeh	48.71	82.77	116.71	187.26	191.43	424.86
Upper Chakaneh	14.38	38.64	63.47	95.81	142.26	163.17

**6. SUJESTIONS**

- The development of neural networks and regression models in other watershed places of the country, in particular places that are statistically poor or don't have statistical reports.

## Compare the accuracy of artificial neural network and regression models to estimate flood (Case Study: Urban area of Joghatay)

- More researches on the different architectures of neural networks by changing the number and type of inputs.
- Compare and calibrate physical methods used in water resources and watershed development using neural network
- Comparing and calibrating physical methods used in water resources and watershed engineering using neural network
- Increasing the use of neural network techniques in hydrology simulation of different phenomena.
- Carry out more research to examine the issues of water using artificial neural networks in the following cases:
  - Simulate groundwater movement.
  - Evaluate earthquake and the consequences of that on water structures.
  - Preparing the model of movement and transportation of water wave.
  - Giving the model of sedimentation in channels and reservoirs
  - Short-term and long-term flood forecasting in rivers
  - Zoning the flood and determining the privacy of the river
  - Providing hydraulic models.
  - Predicting changes in sea levels.
  - Determining the characteristics of hydraulic jump
  - Determining the policy of exploitation of water resources
  - Generally flood is predictable and preventable and by studying the watershed, flood peak rates at different return periods can be determined.

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