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Study of continental ingredients effect on River's Discharge Using Artificial Neural Network Method (Case study:Gharehsoo-Gorganrood basin)

Mahnaz Karami Jozani[1], Seyyed Ali Moasheri[2], Alireza Ildoromi[3], Hamid Nouri[4]

1. MSc student in Department of Natural Resources College, Malayer, Malayer University, Malayer,Iran
2. Agriculture Department, Payame Noor University, Zahedan, Iran
3,4. Assistant Professor Natural Resources College, Malayer University, Malayer,Iran

Corresponding Authors email: samoasheri@yahoo.com

ABSTRACT: Nowadays water supplies managing are one of the most important politics in human societies. In our country surface water resources count as the most important potential water supplies terrain. Plan and management of these resources requires fast and precise studies, because forecasting the flow of the river is one of the most important pillars in surface water supplies management, especially suitable planning on spate and drought occasions.In the present, research assessment of an artificial neural network in estimating and forecasting the discharge of Gharehsoo-Gorganrood basin's river is represented, which is modeled due to effective continental ingredients. The most suitable structure of neural network, including an MLP model with sigmoid transition function and a hidden layer is chosen. The Levenbeg-Marquadt algorithm is defined as the network training algorithm. The statistics characteristics MSE=0.01143 and R^2=0.95 indicate the neural network's exact estimation and forecast in evaluation of river's discharge using continental ingredients: maximum temperature, minimum temperature and rainfall. Thus the daily discharge of Gharehsoo-Gorganrood basin's river is predicted by the equation Y=0.9201X+0.0492 with the likelihood of 0.95 in the years 2011-2030. Eventually, sensitivity coefficient determination test showed that the effect of minimum temperature's digits on discharge factor forecasting is more than the other continental factors.
Key words: Discharge,forecasting, artificial neural network, sensitivity coefficient.

INTRODUCTION

Designing the water installations, erosion and river alluvium control, dam reservoir utilization, floodwater managing and rivers' inundation are as water manager's most important concerns in surface water resources management. Predicting the surface streams precisely, has become quite important due to the value of freshwater and shortage of these supplies in all around the world.

Hence, engineers and staffs at water department had an influenced effort on the case and they are always doing researches in order to find novel methods in this field. So far several complex equations and patterns such as rainfall-runoff consumption patterns, time series patterns and mixed algorithms (hybrid) are presented to predict river's discharge. However, in many cases the amounts calculated by various relations were not similar to observed amounts due to lack of precise knowledge and complexity of effective ingredients onRiver discharge.

In the last decades amazing advance and spread of computer models have the specialists taking growing trend in the fields of study and research. Among these models, Artificial Neural Network (ANN) model have been used in the field of water science, widely.

Soltani (2002) compared conceptual models and neural network in simulation of rainfall-runoff process. He expressed that in comparison to the other models, ANN requires less information and calibration and validation procedure is easier and faster. On the other hand ANN and conceptual models are more applicable during low water and high water periods respectively.

Kaviani and Asakereh studied the annual rainfall trend in Isfahan in the period 1894-1996, using Mann-Kendall test and parametric manners. The results showed that there isn't any meaningful trend in rainfall at this station.

Masahbavani and Morid (2005) studied the effects of climate changes on water resources and agriculture in Zayandeh rood of Isfahan's basin. They also scrutinized the ways of matching with it under theHADCM3model's data during 2010-2039 and 2070-2099. Information analyses show the rainfall decrease,

temperature increase and growth of consecutive droughty years up to the year 2100. Simulations of input discharge to Chadegan dam, using ANN technique and water allocation modeling by ZWAN model, also show the input current reduction to dam and decline in the water allocated to agriculture.

Dastoorani (2006) assessed the efficiency of ANNs on some fields related to rainfall and runoff, moreover, he stressed out the ability of this technique to estimate runoff in basins statistics, flood predicting at the right moment, hydrologic data reconstruction and also optimization of hydrodynamic models' results.

While studying the possibility of using the available continental parameters (rainfall and temperature) to estimate discharge in an annual period in the upper basin of the Bookan dam by multi variant regression and step by step models, Keirfam et.al. (2012) came to the conclusion that the prepared models were acceptable and step by step method had better results and also the effect of rainfall on discharge was more than temperature's effect.

Doosti (2012) studied the effect of climate changing on Tamar basin's rainfall located in Golestan state in the following decades. To do that, the data ofHADCM3's model was micro scaled for the location of interest using LARS-WG model under two scenarios: A2 and A1B and they have been used to simulate the rainfall parameters, minimum temperature, maximum temperature and solar radiation in the periods 2011-2030 and 2046-2065. The results showed rise in rainfall, temperature increase and sunny hours decrease in both periods. BTW minimum temperature changes are more than maximum temperature changes in both eras.

LalehSayyahet.al. (2012) simulated the temperature fluctuations, rainfall varieties and runoff changes in Karoon basin in the period 2010-2039 using simulated continental variants, by the coupled models "ocean atmosphere" and" General circulation of the atmosphere "under the greenhouse gases scenario. To study the effect of these changes on discharge and simulating the runoff for following periods of time, ANN was used. The results represent temperature increase and rainfall decrease in the region.

Lahlhem and Mania (2002) offered an appropriate method for problems with large scale and over a long period of time. They tried to compare ANN method with other ones and came to the conclusion that retroviral-type network with fewer middle layers has a better ability to estimate runoff current.

Yuo et.al. (2002) studied the effect of continental changes on water resources in south of Taiwan. Results showed temperature rise in long periods of time and also extreme changes in daily rainfall occurrence transition probabilities in a way that affects rainfall. And it was determined that the produced runoff of future continental in south Taiwan foes up and down in wet and dry seasons respectively.

Rajou et.al.used the ANN nonlinear model to simulate the daily current in two basins with different geography. After comparing the results, they offered that large basins must split into some sub basins.

Kaisi (2004) usedfeedforwardneural network with feedback error training method to calculate monthly discharge of Goksdar 4 river in Turkey and compared the results withauto regressiontime-series method. She has designed the best network architecture for each input in order to have maximum correlation coefficient and minimum mean square error.

Huang and Chan Hilton (2004) predicted Apalachi Kola 6 River's discharge in the US using multilayer perceptron neural network with error feedback training and time series model. Statistics related to the years 1939-2000 was used in this research. At first, they divided data into two parts: train and test. After that they trained the network by the previous amount of discharge and rainfall. The results showed that correlation coefficient between the observed and simulated amounts of discharge in daily, monthly, seasonal and annual eras are 98%, 95%, 91% and 83% respectively. It is also shown in this research that correlation coefficient for ARMA models are 49% and 37% in annual and seasonal eras respectively which clearly proves that neural network has a better performance in forecasting the river's currents in comparison to ARMA models.

Tadson (2007) in a study about the effect of continental changes on Denmark river's current during the years 1961-1990 showed that the amount of river's discharge has come down from December to August and it's risen in September and October.

Aoideng et.al. (2008) studied the discharge changing process in Lahasa river's basin in China during the years 1956-2003 using Mann-Kendal test. The results showed that the average annual discharge in this period had a progressive trend.

Zou et.al. (2009) did study on Yellow river in China which proved that there is a significant growing trend in amount of minimum and maximum temperature. Moreover, a growing trend in rainfall can be seen.

Islam (2) and Sce (2010) studied the continental changes effect on water supplies in India. According to this study, the earth's continental is warming and this alteration influenced water supplies.

Sing 4 et.al. (2013) evaluated the performance of ANN in a small basin in India according to RMSE and R criteria. They observed in their results that the ANN model has had an acceptable performance based on one day and two days delays. It was also found that the model based on 5-5-1 network structure with a 2-day delay overlaps the 3-3-1 one with a 1-day delay.

Finally, minor and major human programs will not come to desire outcome without a good understanding of continental situations and its fluctuations. Due to extension of Iran capital cities and their industrial growth, the need of continental change detecting studies, has increased. Case studies in line with the

research showed that the researches constituted with continental changes' effect had a progressive trend in recent years.

MATERIALS AND METHODS

Region of study

The Gorganrood-Gharehsoo basin is located in south-east of Caspian Sea and it's counted as a part of Caspian sea basin in Iran's general hydrologic segmentation.This basin is located between eastern 54˚00' to 56˚29' longitude and northern 36˚36' to 37˚47' latitude. It is bounded to AtrakRiver from north and east, to salt desert basin from south and to NekaRiver from south-west. The area of this basin is 13061 km2 and it has two plains called Robat-Gharehbil which is in south-east of basin and Gorgan-Gonbad which contains the other parts except mountainous zones. The average annual rainfall fluctuates between 300 to 1000 mm from northern and eastern borders to central parts and annual rainfall changes is semi Mediterranean. The average annual temperature in this basin varies from 17˚C in low lands to 7.5˚C in southern heights. Gorganrood-Gharehsoo basin has lots of small and medium rivers which make the main two rivers in this basin after passing high lands and a distance in plains. These two go to the Caspian sea through an east to west path.
Daily data of maximum and minimum temperature and rainfall parameters and also daily data of 12 stations inSubscribe period of thirty yearswas used to do analyses. And in fact nonparametric tests Mann-Kendal, SenSlop and Kenall's are used to determine trend orientation, trend slop or magnitude and desired parameters' correlation.

After calibration and validation the continental data and current of discharge; discharge changes are studied as a function of continental changes in the period 2011-2030 (near future) to simulate rainfall-runoff using artificial neural network model. In order to forecasting the discharge, continental data which are predicted by GCM models, are used.

Since, because of continental changes, it isn't possible to predict the future of continental situation conclusively, the alternative solution is continental scenario. Today, the most authentic tool to produce these scenarios are GCM models. These models are based on physics rules which are solved in a 3D network on earth's surface by mathematical equations. In all these models, eight continental surface variants including rainfall level, average pressure of sea level, solar radiation, average temperature, dew point temperature, minimum temperatures, maximum temperatures and wind velocity at the height of 10 meters are simulated up to the year 2100 under different scenarios. In this research the GCM models used are MPEH5 and HadCM3 models.

Artificial neural network model

Generally, neural networks' structure contains some relevant elements called neurons that each of them has inputs and outputs and do a simple and local operation. The functions of neural networks are generally trained by a training process. ANN has a lot of applications in pattern determination, clustering (گروه بندی)and predicting or extrapolation.

In network structure design, the given input data are continental ingredients including maximum temperature, minimum temperature and rainfall. The amounts of river's discharge are determined as purpose data. (Figure 1)

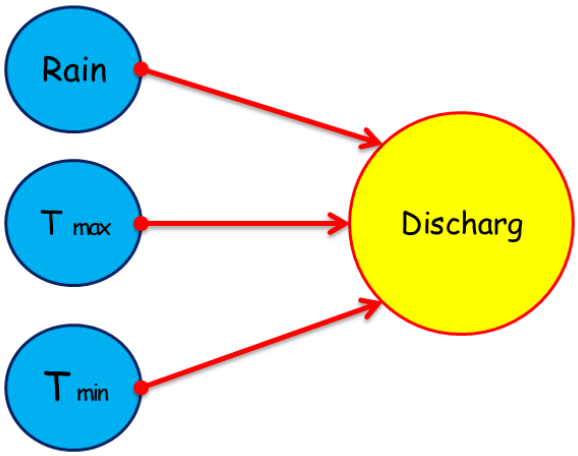

Figure 1 . inputs and outputs of ANN structure

In order to assess the performance of neural network in determining the relation between continental ingredients and river's discharge simulation, the statistics characteristics "determination coefficient" (R2) and "mean square error" (MSE) are used.
The transition function used to train the neural network is Sigmoid function with the domain of real numbers and the range of [0, 1]. (Figure 2)

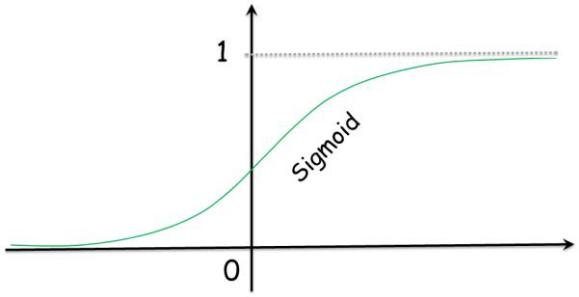

Figure 2 . Sigmoid transition function

ANN's mode of performance (Moasheri 2012)
1. Adjusting the weights according to input-output pair
2. Start weighting with random amounts.
3. Typical learnt input loading
4. Observing the output of calculations at the inputs
5. Weight correction to reduce the difference with the aimed amount
6. Repetition for all samples of test
7. Termination to stability of weight changes with error minimization

DISCUSSION AND RESULTS

After designing the network structure the results of its assessment with statistics characteristics "determination coefficient" and "mean square error"obtained. (Table 1)

Table 1. the results of the best neural network in discharge forecasting with continental data assessment

Max Abs Error	Min Abs Error	MSE	R^2
0.52042	0.000177	0.01143	0.9479

In table 1, the results of the best network structure with Sigmoid transition function and a hidden layer and an MLP type network and Levenberg-Marquaadt training algorithm, determines the network ability to link inputs to corresponding outputs which are presented to the network.
In order to study the effect of each continental parameter presented to the network, on discharge forecasting, sensitivity coefficient test was used. (Figure 3)

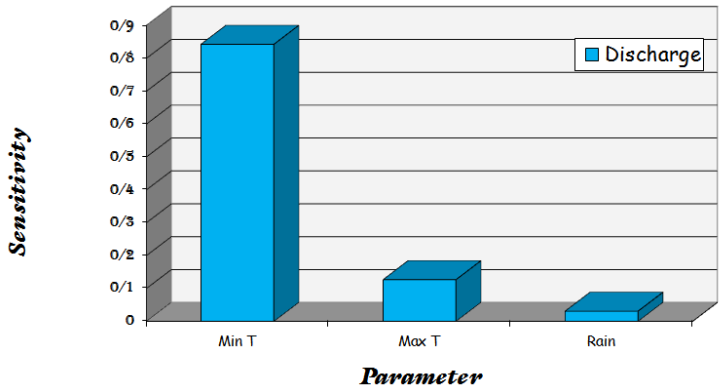

Figure 3 . the influence of each presented continental parameter on discharge forecasting.

The effect of minimum temperature changes on discharge amounts forecasting was also determined.

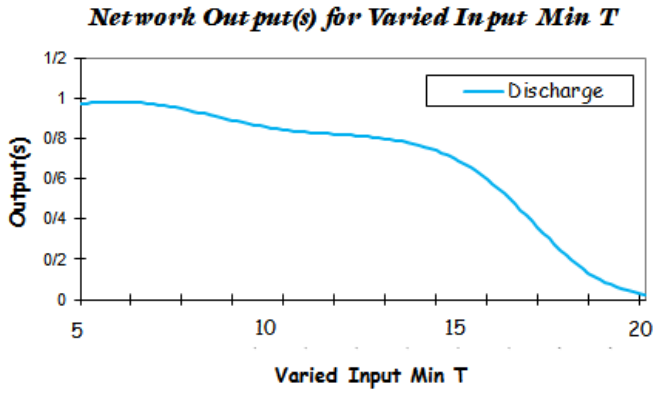

Figure 4. the trend of minimum temperature changes' influence on discharge forecasting.

Comparing the results of neural network method in discharge estimation and observed amounts (figure 5) proves that the ANN with the expressed structure has a better ability to predict.

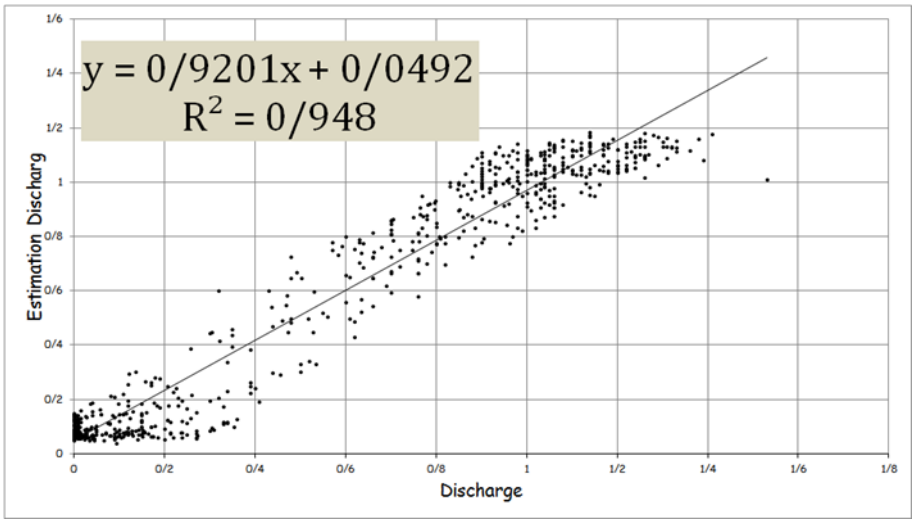

Figure 5 .m comparison between forecasted amounts of discharge and observed amounts.

As it is obvious in the diagram of figure 5, daily discharge of Gharehsoo-Gorganrood basin's river is predictable by the equation Y=0.9201X+0.0492 with the probability of 0.95 in the years 2011-2030 where X determines the forecasted amounts of discharge by neural network and Y determines the real amounts of discharge.

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