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# Evaluating Election, Imperialist Competitive Algorithms and Artificial Neural Network Method in Investigating the Groundwater Level of Reshtkhar Plain

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**ABSTRACT:**Evaluating the groundwater level in arid and semi-arid regions of the country requires accurate prediction and efficiency of its fluctuations. The use of modern methods, including evolutionary algorithms, artificial neural networks, and fuzzy methods, is very useful for predicting the groundwater level and generating artificial water surface data due to its high efficiency. In this research, by using Election and Imperialist Competitive Algorithms, artificial neural network, monthly data for 9 years as well as groundwater level of 10 wells, predicted the 7-year the groundwater level of Reshtkhar plain in Khorasan-Razavi. To train the models, the statistic data was provided on 10 observation wells with a 9-year (2002-2014), which 70% of the data was introduced as training data to the model and 30% of the data was used as a test for calibration of the model. The results of the Election Algorithm predicted Reshtkhar groundwater level for the year 1400, between 14 to 16.5 meters in different areas of the plain. Based on the calculations and the results obtained from the statistical parameters, the Election algorithm was RMSE, R2 and NSE, 0.029, 0.90 and 0.73 respectively, compared with the two methods of artificial neural network and Imperialist Competitive Algorithm has a significant ability to predict the groundwater level.

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## 1. INTRODUCTION

Climate change, water scarcity, population growth, population displacement, and urbanization have already created a major challenge for water supply systems. Groundwater is the most important source of fresh water in the world. Two billion people drink water, especially in arid and semi-arid regions directly from groundwater, and are used to irrigate the world's largest food supply sector [1].

In recent decades due to the drought and water scarcity in a vast area of the country (Iran), groundwater management is of great importance and high sensitivity. The emergence of deep and semi-deep well technology, while providing better facilities for extracting water from underground aquifers, has brought about profound changes and many problems in the system of exploitation [2]. Many models been used to predict groundwater levels. These models include empirical time series models, physical models and modern methods (Meta-heuristic algorithms, fuzzy-neural methods, etc.).

Many studies have used modern methods to predict and investigate the groundwater level, such as Pahhei et al., Mohtasham et al., Rajaie and Pour Aslan, Habibi et al., Moosavi et al., Akbarzadeh et al., Mohammadi et al., Sahoo et al., and Wang et al. [3-11].

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## 2. MATERIAL AND METHODS

### 2.1. Case Study

Reshtkhar plain is located in Khorasan Razavi with a geographical location of 34 degrees 50 minutes to 37 degrees and 15 minutes north latitude and 45 degrees and 50 minutes to 46 degrees and 15 minutes east and has dry and desert climate. The height of the plain is 1140 from the sea. The plain has 2,172 hectares of forest land and 5 hectares of green space (Fig. 1).

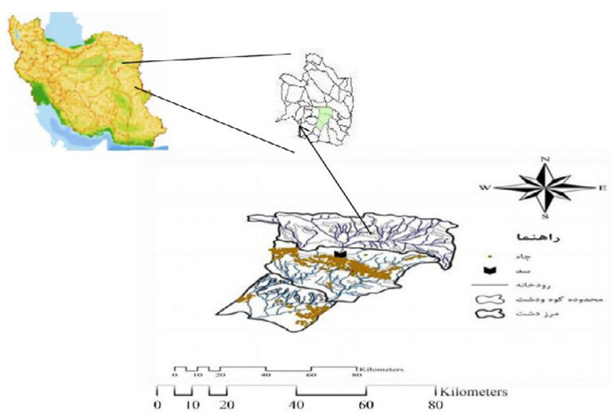


**Fig. 1. Location of the Reshtkhar plain**

### 2.2. Election Algorithm (EA)

EA begins its search and optimization process with a population of solutions. Each individual in the population is called a person and can be either a candidate or a voter. Forming several parties in the solution space, people can participate in their preferred party. Then these parties begin their advertising campaign. Advertising campaign forms the basis of this algorithm and causes the persons to converge to the global optimum of solution space. During advertisements, popular candidates attract more voters using various techniques. Therefore, the unpopular ones lose their supporters and might resign from the election arena. Advertisement causes the persons to converge to the global optimum of solution space. On election days, voters cast their votes and the candidate that attains the most votes would be announced as the winner [12].

### 2.3. Optimization using Artificial Neural Network (ANN)

All optimization problems consist of two stages of modeling and planning including, the formation of objective function, constraints and limitations (first stage, modeling), and the determination of the optimal conditions to achieve the ideal solution (second stage, planning). Artificial neural network consists of a set of neurons with internal links with one another, which can provide output responses based on the input data and information. Neural networks are usually created in a layered and regular manner. The first layer, which the input data are entered, is the input layer. The middle layers of the hidden layers and the last layer, which provides the output responses, are the model, is the output layer [13].

a) Tracking, chasing, and approaching the prey,

b) Pursuing, encircling, and harassing the prey until it stops moving,

c) Attack towards the prey.

### 2.4. ICA Algorithm

Pseudo code for the proposed algorithm as follows [14]:

1) Select some random points on the function and initialize the empires.

2) Move the colonies toward their relevant imperialist (Assimilating).

3) If there is a colony in an empire which has lower cost than that of imperialist, exchange the positions of that colony and the imperialist.

4) Compute the total cost of all empires (Related to the power of both imperialist and its colonies).

5) Pick the weakest colony (colonies) from the weakest empire and give it (them) to the empire that has the most likelihood to possess it (Imperialistic competition).

6) Eliminate the powerless empires.

7) If there is just one empire, stop, if not, go to 2.

The input of data in raw form reduces the speed and accuracy of the model, so the inputs and outputs must be standardized between 0 and 1. Hence the data are normalized as Equation 1:

$$Z_n = \frac{Z - Z_{min}}{Z_{max} - Z_{min}} \quad (1)$$

In which, $Z_n$, $Z$, $Z_{min}$ and $Z_{max}$, are standardized, observation values, minimum observational and the maximum observational values, respectively.

To predict the groundwater level, the numerical code was used in the MATLAB software in the form as relation 2:

$$min\, f = C_1 Gl_{act}^{\ C_2} + C_3 WT_{act}^{\ C_4} + C_5 Q_r^{\ C_6} + C_7 P^{C_8} + C_8 ET^{C_9} + C_{10} \quad (2)$$

## 3. RESULTS AND DISCUSSION

After normalizing the data, the training and verification steps for each of the wells were implemented. In order to compare the results of the EA and ICA algorithms and ANN method with observation values with each other, their evaluation of the correlation coefficient ($R^2$), NSE and RMSE were used.

The comparison of modeling results is presented in Fig. 2. As it is seen, the results obtained from the EA algorithm is highly optimal compared to the ICA algorithm and ANN and there is a very small difference with observational values, which indicates the high efficiency of the election algorithm.

The results also show that the EA algorithm has been able to simulate the process of Reshtkhar groundwater level changes, as compared to ANN and ICA algorithm, and thus able to change the water balance in different months with attention to calculate the change in the amount of feed and discharge from the aquifer during this period correctly.

According to Fig. 2 and the results of predicting the groundwater level by the three models used, the level fluctuations during the statistical period of 2010-2012 are facing a severe decline, due to the successive droughts in the region, as well as the excessive perception of deep and semi-deep wells in the plain.

Based on the results, the average of the parameters of the evaluation algorithm, $R^2$, RMSE, and NSE were 90.9, 0.029, and 0.73 respectively, which are in the ideal range.

After confirming the efficiency and accuracy of the EA algorithm in predicting the groundwater level of Reshtkhar plain compared to ANN and ICA algorithm, the groundwater level for the years 2015-2020 is predicted by the EA algorithm and concluded that if the current harvest of deep and

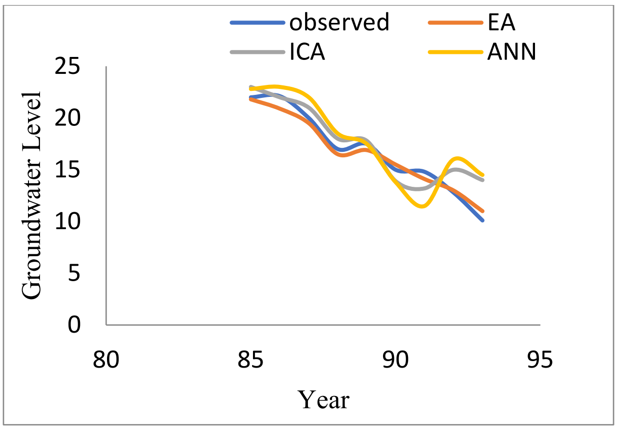


**Fig. 2. Predicted levels by models and values of observation wells**

semi-deep wells in the Reshtkhar plain is continued, the groundwater level changes in this plain will be reduced by a decreasing trend, which during these 7 years will be about 14-10 M) (two meters per year), indicating an unfavorable balance of aquifers in the current situation.

## 4. CONCLUSIONS

In the present condition, taking into account the consumption of more than 80% of water resources in the agricultural sector, as well as decreasing the availability of available water resources, as well as the prohibition of exploitation of groundwater resources in the Rastkhahr plain, requires a better attitude towards water consumption. Therefore, it is necessary to examine the factors and factors affecting the level changes of the groundwater level in this area. The water level data in previous months as inputs of models and groundwater level at time t were selected as output models. The most significant results of this study are the better correlation and the lower error of the electoral algorithm (with RMSE error equal to 0.029 and NS equal 0.73) in predicting the groundwater level, and it can be stated that the use of such an algorithm in predicting water table changes, it can improve the accuracy of management decisions to a high degree. Also, the results of the predictions indicate that with the unplanned harvesting of wells in the plain, during the next 5 to 7 years, we will see a decrease of about 14 meters of the level of the counter.

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