Research Paper

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Spatial Modeling of Groundwater Capacity Using A Combination of Maximum Entropy Method and Random Forest Method in GIS Environment Case Study: Ardabil Ghorichay Catchment

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1-Introduction

Population growth is increasing the need for food and water, and as a result, the water demand is increasing worldwide. In arid and semi-arid regions where surface water resources are limited due to climatic conditions, water needs are met through groundwater. Groundwater is one of the main sources of consumption in various aspects of human needs, especially in arid and semi-arid regions. Limited access to surface water resources in these areas leads to greater utilization of nutrition, which increases the level of stress in aquifers. Therefore, it is important to study the relationship between groundwater resources, freshwater, and regenerated water to meet water supply and demand needs. The purpose of this study is to measure the groundwater potential of the Ghorichay watershed located in Ardabil province. The final map of groundwater capacity in this area was prepared using the method of random forest algorithm, R programming language, and specialized software of GIS such as ArcGIS and SAGA. The final accuracy of the model used in this research based on validation indicators was about 87%, which can be almost a very good accuracy in this type of research. This research can pave the way for managers and planners of various organizations such as the Regional Water Organization, the Agricultural Jihad Organization and other related organizations.

2-Methodology

Ghorichay watershed is a part of the Qarasu sub-basin of the Aras main basin, which is located 5 km away from Ardabil city. Ghorichay watershed is located in the south of Nir city, Ardabil province, in the geographical area with the UTM coordinate system from 4185513 to 4225134 meters. The total area of the basin is 79842 hectares, and its average height is 1752 meters above sea level according to the digital model map. This basin is connected to Nayr city from the north, Ardabil from the east, Kowsar city from the south,

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and Miyaneh city of East Azerbaijan province from the west. This basin has two asphalt communication routes to Ardabil and Nir cities. The Ghorichay basin has two main branches, Geruchai and Koraim Chay. These rivers eventually form the main river of Ghorichay. Figure 1 shows a map of the location of the study area in Ardabil province.

Factors were used in identifying areas with groundwater capacity to identify areas with groundwater capacity based on some sources in this field. Eleven indices, including Slope, Elevation, Aspect, Distance from River, Drainage Density, Distance from Fault, Topographic Wetness Index (TWI) Lithology, Land Use, Relative Slope Position (RSP), and Topographic Position Index (TPI), were used that affected groundwater. In this study, the information of 230 semi-deep wells inside the watershed was obtained from the Regional Water Organization of Ardabil province and used as a dependent factor. Out of 230 available wells, 69 wells (30%) were randomly classified for test data and 161 (70%) for training data. The SRTM radar image was used to produce the digital elevation layer.

3- Results and Discussion

In this study, the R species distribution modeling package was used to spatially predict groundwater potential. The Random Forest (RF) algorithm from the RF library was considered to prepare the groundwater potential map in the study area. RF is a forecasting method that uses historical data to predict values using independent and dependent variables. This algorithm can be constructed based on the available data set. RF, on the other hand, predicts the value of a dependent variable based on several independent variables. The relative operating characteristic curve (ROC) analysis, which is commonly used for the accuracy of a diagnostic test, was used in this study. The area under the curve (AUC) of the ROC was calculated to evaluate the performance of the forecast. AUC is a qualitative indicator for predicting forecast performance that has been widely used in several recent studies. The AUC value varies from 0.5 to 1 and a value close to 1 indicates better forecasting performance. In the present study, a sensitivity analysis was used to provide a robust estimate of the uncertainties associated with the model input layers and to investigate the effects of removing each of the conditioning factors on the groundwater potential map. Table 3 shows the effect of each of the indicators on the groundwater capacity of the Ghorichay watershed, which are obtained by applying an RF model using the effective indicators.

According to Table 3 and Figures 4 and 5, the impact of each of the indicators on the groundwater capacity of the Ghorichay watershed is as follows:

The highest impact is related to the TWI index with a rate of 0.329. The lowest impact is related to the distance from the river index and the aspect index with a value of 0.175. Elevation indices (0.289), lithology (0.277), the slope index (0.258), distance from fault

(0.242), the RSP index (0.237), the drainage density index (0.188), the land use index (0.186), and the TPI index (0.178) are the values affecting the groundwater capacity of the Ghorichay watershed, respectively. Figure 6 shows the result of the evaluation and performance of the model based on the AUC obtained from the ROC diagram, which had an almost reasonable accuracy (0.773) in the model execution and prediction of values.

4-Conclusions

Since groundwater exploration with traditional methods has always been costly and time-consuming with very low accuracy, it is necessary to prepare a groundwater power map with new methods such as the RF algorithm and GIS. In this research, the groundwater potential map of the Ghorichay watershed located in Ardabil city was prepared by considering effective environmental variables and using the RF algorithm method, GIS, and R programming language.The results of this study and previous studies show that the TWI index or the same low and high humidity with an impact of 0.329 has the greatest impact on the groundwater potential of this watershed. Moreover, the height index with a rate of 0.289 has a great effect after TWI. Regarding the effect of the slope index, the outlet area of the watershed has the highest groundwater potential due to its lower slope. In the lithology section, areas with low-size deposits (Qt2) are located in high-potential areas due to their water storage properties.

The ROC curve shows that the accuracy of the model is very well in estimating the level of groundwater potential in the training stage and has achieved a relatively high accuracy (0.87). This shows the relatively good accuracy of the RF algorithm in predicting the effects of factors and indicators. It has different groundwater potential estimates that can be relied on for future and similar research.

Recent research can pave the way for future planning of managers at various organizations in the management of water resources of the studied watershed to achieve various agricultural, industrial, and domestic goals due to over-harvesting of springs and semi-deep wells and possibly in the future deep wells. Applying the results of this research to the management of groundwater resources in the Ghorichay watershed can make planning easier and more accurate for managers.

Keywords: Groundwater, Random Forest, Zoning, Spatial Modeling, GIS, Maximum Entropy, Ghorichay catchment, North Western Iran.

5-References

Arab Ameri, A., Rezaei, Kh., Yamani, M., Shirani, K., (2018). Modeling and preparation of groundwater potential map using a data-driven combined method of definitive evidence function-entropy index (Case study: Basin Najafabad.) *Journal of Water and Soil Conservation Research*, 25 (2), 25-48. doi: 10.22069 / jwsc.2018.14021.2879.