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Research Article

Modeling and Evaluation of Ömerli Basin (Mardin, Southeastern Türkiye) Groundwater Potential using the GIS-Based Analytical Hierarchy Process (AHP) approach

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ABSTRACT

Water, which is an indispensable element of human life, is also a basic need for living things and nature. Groundwater, which is the world's freshwater source, has low-cost usage opportunities because it is generally of high quality and does not need to be treated. For this reason, there has been an excessive increase in the use of groundwater in recent years due to the low rainfall and limited surface waters. Accordingly, in recent years, the lack of precipitation and the decrease in surface water potential have led to an excessive increase in groundwater use. Nowadays, technology, which is called the information age and finds its place in almost all professional applications, supports practitioners in terms of time, effort, and cost. Among these technological studies, Geographic Information System (GIS) applications are one of the most popular fields of study (detection and monitoring of groundwater resources and application of thematic maps with spatial analysis). The AHP technique, one of the GIS-supported MCDM methods, was used to reveal the groundwater potential of the Ömerli district basin of Mardin province. First of all, raster maps were created in the GIS program ArcGIS ArcMap environment, and then reclassified maps were produced. These data regarding the basin study were obtained from official institutions and private drilling companies that work on groundwater. In the first stage of the study, data related to groundwater potential such as precipitation, static water level, dynamic water level, well yield, depth, and aspect were modeled. In the second stage, these data were weighted in AHP and the resulting map was created and interpreted; It was created and interpreted with very bad, bad, moderate, good and very good values. In the third and last stage, the results and recommendations were discussed.

1. Introduction

Groundwater is the general name for water found in the layers below the earth's surface. This water is stored in underground aquifers and fed from various sources. In our country, the average total rainfall per square meter is measured as 574 mm. However, the amount of precipitation may vary depending on geographical regions. There fore, groundwater can be found at different levels and quantities depending on the region [1]. Depending on the changing precipitation amounts, the amount of water leaking and stored subsurface also changes. In some regions, water is constantly infiltrating into the ground, and groundwater is fed. However, in today's world, together with the effects of man on nature, water discharges directly into the streams and seas as surface flows, and groundwater level is drawn deeper. The decrease in groundwater in response

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to the rapidly increasing water demand in the world has led to the determination of existing resources primarily with a reliable and controllable database.

It is known that the vast majority of usable fresh water in the world and in our country is found in groundwater resources. The use of groundwater resources is usually made possible by drilling wells. Underground water is extracted from these deep water wells with the help of drilling, with deep water well pumps. The number of deep water well pumps, the use of which is increasing every year in our country, has reached 191173 as of 2019 [2].

It is known that well features are as important as the pump in transporting the water to the surface of the wells. Well Properties also lead to the use of the properties of the pump in the well. In this case, it causes the pumping system to be taken [3]. In deep water wells, the feed conditions affect the pumping operation that will be used, such as the water velocity, and the length and width of the well. In addition, it was emphasized that the water level in the deep water well depends on the aquifer type, aquifer depth, reserve and degree of saturation [4-5].

The water levels in the well differ depending on the characteristics of the aquifer and the well. The position of the pump in the well becomes important in response to the water levels formed in the well. In deep water wells, it shows certain heights according to the movement or condition of the water. It is known that water levels in pumping wells affect pump operating characteristics. The height of the pump, when it is not working, is defined as the static water level, and the decreasing water level after a while is defined as the dynamic water level, and the difference between these two heights is expressed as a decrease [6]. Immersion depth, on the other hand, refers to the water level up to the pump suction inlet when the well is at the dynamic water level. The vertical hydraulic head is the water level between the static water level and the pump inlet axis (Figure 1).

Schulz (2013) reported that the immersion depth of deep well pumps should be 5 m below the dynamic water level. In another study, it was emphasized that determining the dynamic submersion depth of the deep water well pump installation as 2-3 m and placing it according to this level depending on the fixed deep water well equipment and feeding would be more appropriate for the pump. Working conditions [7-8].

Detailed information about the hydraulics of the wells and their water-giving formations (aquifer) are obtained from the pumping tests carried out in the wells. This information, other geological, chemical, etc. Information about the groundwater basins and capacities of the plain is obtained. A good business project can be prepared in proportion to the accuracy of the experiments and values. In this direction, there are different package programs that have emerged with the developing technology in the field of surface and ground waters. Each surface and groundwater program has its own software features and advantages.

In this sense, program selection is a very important issue for such businesses and program selection requires multi-criteria decision making. In this study, the Analytical Hierarchy Process (AHP) technique, which is one of the GIS audio MCDM methods, is discussed by considering the criteria to be considered in choosing the most appropriate package program and finding the most appropriate solution.

2. Material And Method

The location map of the study area has been considered as a map showing both the topographic and geological structure of the Ömerli basin, which has an annual precipitation of approximately 460 mm/year, has a plateau appearance and attracts attention with its simplicity. Surface forms (Fig. 1). The land structure within the boundaries of the district is in the form of consecutive reverse layers with a total surface area of 409 km^2 [9].

Drilling data obtained from institutions and organizations related to water wells were extracted and those within the borders of the basin were discussed. These data were arranged in the Excel table by giving their coordinates. Subsequently, these data, which were called to the ArcMap 10.2 environment in the GIS program, were digitized and a thematic map was created. In the same way, a slope map was created with the help of a DEM map. A precipitation map was created with the data related to precipitation received from the meteorology institution. Then, Static Water Level, Dynamic Water Level, Well Yield, Depth, and Aspect thematic maps were created and reclassified maps of these maps were obtained.

2.1. Study area and geographical structure

The Assyrian State was established in the geography called Upper Mesopotamia and including the Ömerli basin. When the Yaylatepe (Hıbatok), Göllü, İkipınar, Beşikkaya (Fafit), and Maserati ruins in the district are examined, the region where this settlement is quite old has remained under the rule of Assyrians, Persians, Romans, Byzantines and Turkish-Islamic States 28 km from Mardin. It is in the east of the city center.
Ömerli is adjacent to Midyat in the east, Yesilli in the west, Nusaybin in the south and Savur in the north. The total area of the district is 409 km^2 [10].

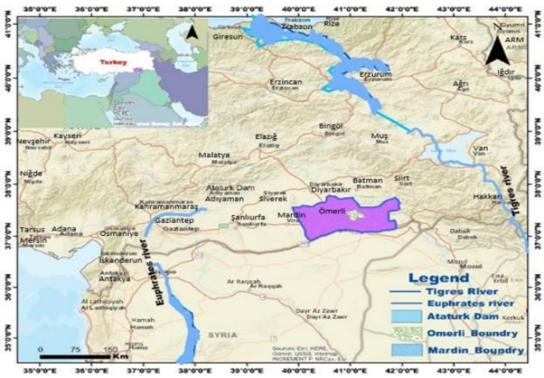

Figure 1. Ömerli Basin Location Map

The south and east of the basin consist of slightly rugged and limestone hills extending in the east-west direction. The Mardin Mountains, sandwiched between the Syrian platform in the south and the Diyarbakır-Siirt pliocene depression in the north; mostly composed of southward inverted anticlines, and their peaks are the southern slopes. The base of the Cretaceous lime stones is seen only on the Sadan-Derik line. The thickness here is close to 400 meters; It continues as an alternation of various hard massive lime stones, brecciated lime stones and marly lime stones, forming large cliffs on the Derik-Sadan line. It starts with the Cretaceous pedestal conglomerates, and these conglomerates, ranging in size from 10-30 meters, have large elements and include all Paleozoic series stones. The elements include old effusive and intrusive pebbles and all Paleozoic series elements. Conglomerates gradually pass upwards into marls and limestone's [11].

The land structure within the boundaries of the district is in the form of successive reverse layers and consists of hills at an altitude of 800 to 1100 meters around the streams that usually separate in the north-south direction. The land structure is closed and covered with oak vegetation varying between 0.50 meters and 3.5 meters in length. Plant density decreases towards the north. Partially flat lands in the valleys can be irrigated with the help of springs within the boundaries of the district. The district has a continental climate with low temperature and precipitation in summers, and severe cold and snowfall in winter. There are seasons when heavy snow or heavy rain is recorded from time to time [10].

2.2. Method

The Ömerli basin groundwater potential study was determined by GIS. For this, the data obtained from approximately 320 boreholes drilled for irrigation and drinking purposes by drilling companies, as well as relevant institutions and organizations, were used. 130 of them were evaluated in the study area (Figure 2).

2.2.1. Outline of the study

GIS is a system that creates situations such as collecting, storing, querying, controlling, processing, analyzing and displaying the data of the earth for a purpose. With its additional extensions such as Spatial Analyze and Geostatistical Analyze, it has a wide range of uses such as interpolation, modeling, and production of state and forecast maps while performing statistical analyses. Applications such as ARC INFO, TNTmips, Map Info, and Net cad are the most common. In this study, the ArcMap 10.5 program was used. Within the scope of this information, the following explanations were obtained;

➢ Along with the arrangement and digitization of the well data, these data were classified and results such as well depth, static water level, dynamic water level, well pump efficiency and opening time were obtained in 1/1,000.000 and 1/500.000 scales.

➢ Through the digitization of maps, shape (.shp) files have been created for contour lines, settlements, rivers, and streams. Using digital 1:100.000 and 1:50.000 map data, a Digital Elevation Model (DEM) map has been generated.

➢ In the Net cad program, Ömerli Basin (.ncz) files were first converted to (.shp) format with the ArcGIS Data Interoperability program and then opened in the ArcMap program.

➢ Ömerli basin groundwater data were collected and corrected in the Microsoft Excel program and converted to digital map with a GIS program.

➢ Spatial Analysis → Interpolation → IDW method was used in the ArcMap environment. Thanks to this technique, data belonging to unknown regions were obtained by using the data values in the known region and interpolating the weighted average method.

➢ Annual well data was organized, and separate thematic maps were created for each period. These maps include the Static Water Level map (Figure 3-III), Dynamic Water Level map (Figure 3-IV), Pump Efficiency map (Figure 3-V), and Well Depth map (Figure 3-IV).

➢ Spatial Analysis-evaluation, as seen in Table 1, estimated on pump efficiency; Achieved with 30% impact, 25% impact at low dynamic water level, 20% impact at near-surface static water levels, and 10% impact at depth [11].

➢ These thematic maps were reclassified and converted into raster maps. While preparing data for Optimum Groundwater Potential as shown in Table 1, a Spatial Analysis-assessment was performed with the following effects: 30% for pump efficiency, 25% for low dynamic water levels, 20% for static water levels, 10% for surface and depth [11].

➢ Geographic Coordinate System GCS_WGS_1984 is used as a projection on the map.

2.2.2. AHP technique approach for determining groundwater potential of ömerli basin

In the study, the AHP method was used to maintain the groundwater processes. Fuzzy AHP is used to determine the preference weights of the evaluation [12].

In order to better express the verbal uncertainty to be encountered in determining the target market, Chang's [4] Order Analysis Technique, which is widely used in fuzzy AHP applications, was used as a solution technique [4].

The AHP method was developed in 1970 by Thomas L. Saaty at the Wharton School of Business to think for the solution of complex multi-criteria decision-making problems. This method is a technique that decision-makers (experts) need to have in determining the degree of importance by considering all criteria. Decision-makers, criteria, and sub-criteria make comparisons with Saaty's criteria 1-9 by filling out the criteria questionnaires. Ranks of alternatives to consider all criteria are found [13-23].

There are several multi-criteria decision-making (MCDM) methods available, among which the Analytic Hierarchy Process (AHP) offers significant advantages. One of its key benefits is its widespread use, which enables it to provide good results for complex decision problems involving both objective and subjective judgments [14].

AHP is a method that collects more than one statement under one heading and includes it. The hierarchical structure of complex numbers consists of binary comparisons, multiple factors and eigenvectors obtained by calculating their weights. Saaty gathered everything together, connected them and found a powerful method, AHP. With this method, the analysis became easier and improved, and the number of applications using the AHP method increased by introducing the Expert Choice program. The first academic interviews by the International AHP Association were held in Tianjin, China [15].

AHP method is often used to evaluate decision options and solve problems. AHP is used in many studies such as making predictions, comparing, and ranking the factors that differ according to their importance. It is a multi-criteria decision-making formulation that shows the result of comparisons between factors using the eigenvalue method and reveals the importance of numerical scales. In the AHP method, factors and options are compared in pairs by experts in this method. These comparisons generally use a scale of 1-9 developed by Saaty and given in Table 1 below [16].

The weights to be given to the criteria for groundwater performance in the AHP method by Vaidya and Kumar (2006) are given in Table 1 below.

Table 1. Importance ratings used in comparisons [17-18].

Importance level	Definition	Explanation
1	Equally Important	Both factors are equally important.
3	Moderately Important	According to experience and judgment, one factor is slightly more important than the other.
5	Strongly Important	One factor is strongly more important than the other.
7	Very Strongly Important	One factor is strongly more important than the other.
9	Absolutely Important	One of the factors is much more important than the other.
2, 4, 6, 8	Represents Intermediate Values	They are the intermediate values of the degrees found in the explanations above in the preference between the two factors.
Mutual Values	If a value (x) is assigned when comparing i with j; The value to assign when comparing j with i will be (1/x).	

In order to create a hierarchical structure in decision problems, the values of the criteria are found at each stage and pairwise comparisons are made. In the solution of the AHP method, the following process is followed;

1) Defining the decision problem and revealing the purpose,

2) Determining the criteria to reveal the purpose,

3) Creation of decision options,

4) Creation of hierarchical structure,

5) Making binary comparisons for each step, creating importance levels by using eigenvalues and eigenvector values,

6) Pairwise comparisons of options and priorities based on criteria,

7) Finding the compliance ratio,

8) Sorting the options and putting the option with the strongest priority first,

9) Calculation by sensitivity analysis

While finding W (weight matrix), the result is reached by using pairwise comparison. It is used relatively, that is, in verbal comparisons, as well as in comparisons with numerical data at the decision stage. Comparisons are usually made using Saaty's 1-9 weight scale. All comparison results will be positive. The diagonal values of the comparison matrix are 1. This is because the criterion is compared with itself [14].

If n relative importance weights with criteria a_1, $a_2,\ldots, a_n$ and weights $w_1, w_2,\ldots, w_n$ are taken into account, the general expression of the pairwise comparison matrix is as in Equation 1;

$$\begin{bmatrix} a_{11} & \cdots & a_{1j} & \cdots & a_{1n} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ a_{i1} & \cdots & a_{ij} & \cdots & a_{in} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ a_{n1} & \cdots & a_{nj} & \cdots & a_{nn} \end{bmatrix} \quad (1)$$

It exists as $a_{ij}= 1/a_{ji}$ and $a_{ij}= a_{ik}/a_{jk}$. In the real expression of the problem, W_i/W_j is unknown, therefore, the predicted $a_{ij}≅W_i/W_j$ in AHP is to determine the result of a_{ij}.

The general expression of the weight matrix is Equation 2;

$$\begin{bmatrix} W_1/W_2 & \cdots & W_1/W_j & \cdots & W_1/W_n \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ W_i/W_1 & \cdots & W_i/W_j & \cdots & W_i/W_n \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ W_n/W_1 & \cdots & W_n/W_j & \cdots & W_n/W_n \end{bmatrix} \quad (2)$$

W (weight matrix) and w (weight values) values are multiplied and the result is;

$$W.w= \begin{bmatrix} W_1/W_2 & \cdots & W_1/W_j & \cdots & W_1/W_n \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ W_i/W_1 & \cdots & W_i/W_j & \cdots & W_i/W_n \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ W_n/W_1 & \cdots & W_n/W_j & \cdots & W_n/W_n \end{bmatrix} . \begin{bmatrix} W_1 \\ \vdots \\ W_i \\ \vdots \\ W_n \end{bmatrix} = n. \begin{bmatrix} W_1 \\ \vdots \\ W_i \\ \vdots \\ W_n \end{bmatrix} \quad (3)$$

The equation takes the form of 2.

There is a base value for each evaluation factor. When we take the arithmetic average of these values, λmax (eigenvalue) is obtained for comparison [20]. $A.w = \lambda max.w$ and λmax are found together with the eigenvector w considering the relative weight values. λmax is the eigenvalue of the matrix A and the eigenvector w and is calculated with $(A - \lambda max I).w=0$. Consistency Index (CI) and Consistency Ratio (CR) are included to find consistency of subjective results and correct relative weights. The Consistency Index (CI) is calculated as follows;

$$CI = \frac{\lambda max - n}{n-1} \quad (4)$$

Here n represents the total number of features, that is, the number of criteria. For a reliable result, the CI (Consistency Index) value should not exceed 0.1. Otherwise, the study must be repeated until this value (<0.1) is achieved. Consistency Rate (CR) is calculated as follows;

$$CR = CI/RI \quad (5)$$

RI stands for random value index. The RI values that different element values (n) can take are shown in Table 2 below [17].

Table 2 Random value index [17]

n	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.54	1.56	1.57	1.59

3. Results

The planned management of groundwater resources plays a very important role for the sustainability of life in arid and semi-arid regions at every stage. The southern part of the study basin shows semi-arid climate characteristics. In the study area, the highest precipitation falls in the winter season, and the lowest precipitation falls in the summer season. The annual average temperature of Ömerli District is 19.7°C. The annual average rainfall is 425 mm.

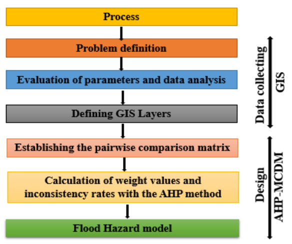

Figure 2. AHP method implementation template with GIS support [19].

First of all, raster thematic maps of the 6 parameters were produced in ArcMap (Figure 3) [3].

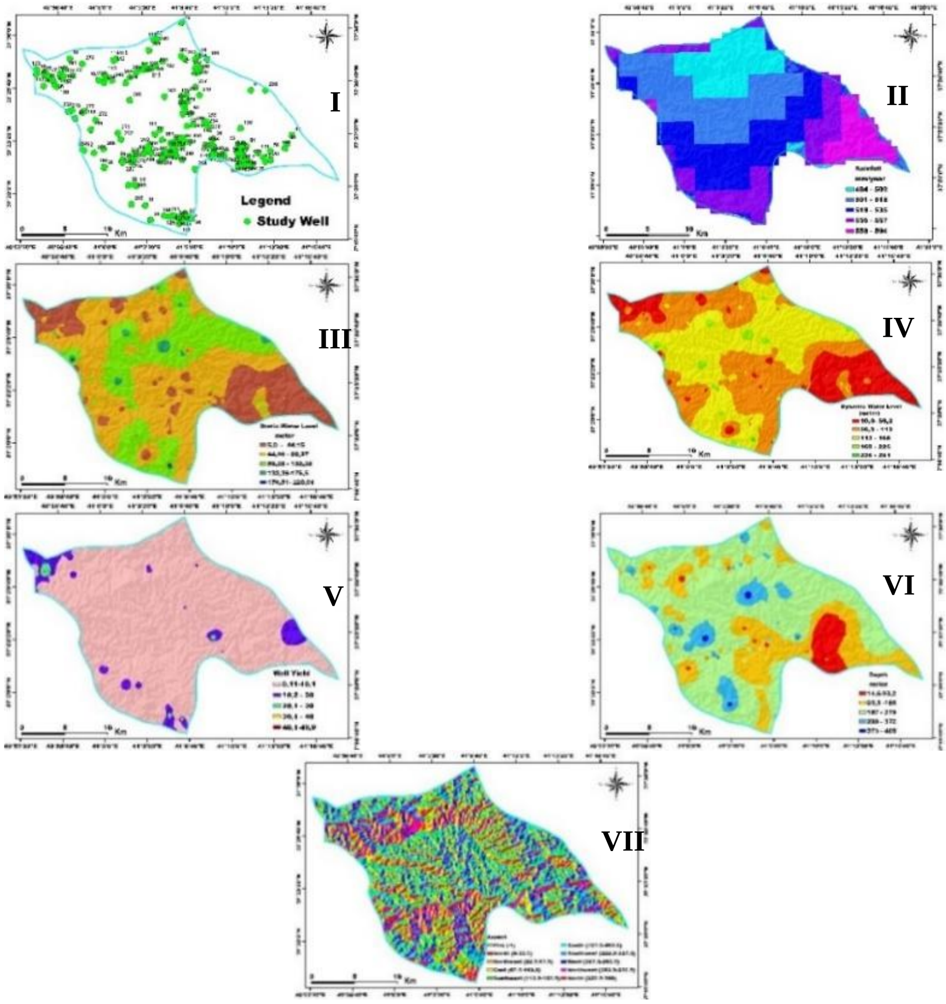

Figure 3. Thematic maps created according to the outline of the study **(**I. Study well**,** II. Rainfall, III. Static water level, IV. Dynamic water level**,** V. Well yield, VI. Depth, VII**.** Aspect map**)**

After the creation of raster thematic maps, these maps were reclassified (Figure 4) [21-27].

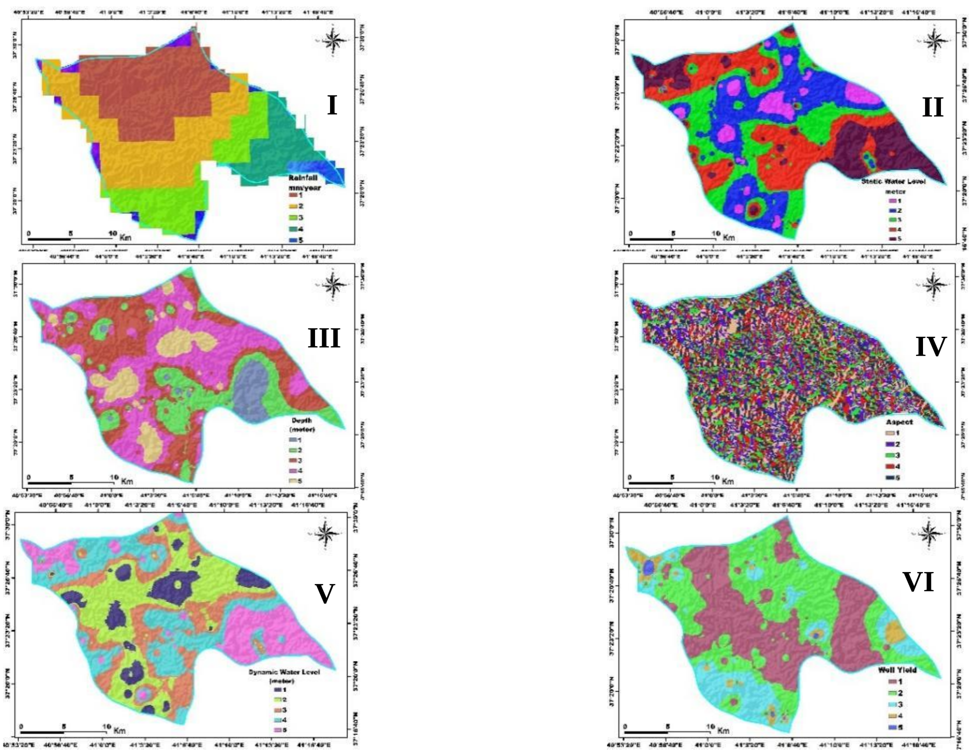

Figure 4. Classified maps created according to the outline of the study (I. Precipitation, II. Static water level, III. Dynamic water level, IV. Well yield, V. Depth map, VI. Aspect map)

Raster thematic maps were produced to create the infrastructure of the AHP method (Figure 2). These 6 parameters were then reclassified in the ArcMap environment (Figure 3).
After raster thematic maps are produced, Water wells are established for various purposes such as water supply, environmental monitoring, and Groundwater treatment. Technical parts related to well hydraulics;

Well Location Map: 220 of the 320 drilling data to be used in the well location map given in Figure 3-I were evaluated. Then, 15 of these data were taken into account as observation wells to be evaluated in the groundwater potential map.

Rainfall: The groundwater Potential Index distribution map is created to analyze the yearly 460-600 mm/year average rainfall, which is one of the crucial parameters. This thematic raster map is divided into five distinct classes during its creation within the ArcMap environment.

As seen in the map (Figure 3-II), the northern parts of the watershed have higher average annual rainfall, while the eastern regions experience lower average annual rainfall. Generally, the region exhibits similar precipitation patterns. It can be noted that not only the quantity of rainfall but also its duration and intensity play a significant role in nourishing the groundwater, in addition to the basin's groundwater potential. Extended periods of low-intensity rainfall will have a positive impact on the groundwater aquifer [6].

Static Water Level (SWL): The height at which the water level remains constant (the height between the surface level and the water level) when water is not drawn from a well. A static water level of 5 m in a well indicates that the water level is stable at 5 m below when pumping is not done. The static water level expressed for the basin is the general static level, not the specific static level in the plain where the well is drilled. If continuous observation is made within the basin boundaries, the average of the daily or monthly lowest levels of the surrounding wells is accepted as the general static level. The second point to be considered about the static level is that if more than one well is to be drilled in the field, the wells should be wetted outside of each other's area of influence; If there is a necessity in this, static levels should be calculated by taking this effect into account [11]. Spatial Analyst tools/Multiple Value Determination method. The altitude values are recorded in the Excel table and the level of the aquifer is found by subtracting the Static Water Level from the altitude value. The aquifer map was created using Spatial Analyst Tools/Interpolation/IDW methods (Figure 3-III).

Dynamic Water Level (DWL): It is the height at which the water remains constant while the water drawn from a well continues with a certain flow rate. It is the height of the water gushing from the well in an artesian well.
Figure 5 was created inspired by the information of Vaidya and Kumar (2006). In the light of this information, criteria such as static water level, dynamic water level, and well efficiency are explained.

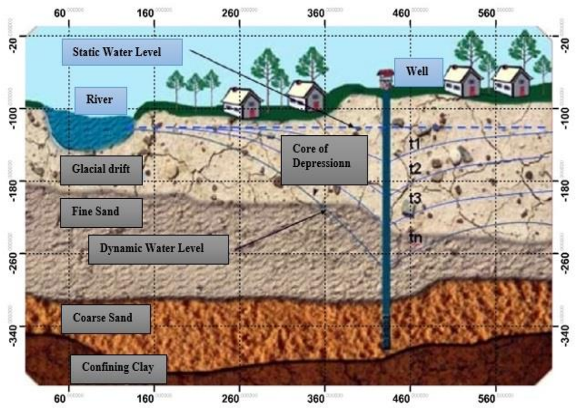

Figure 5. Groundwater and wells [20]

When the dynamic water level map of the groundwater of the basin is examined, it is seen that the groundwater flow is directed from the upper parts to the lower parts. As a natural consequence of this process, groundwater in the upper parts was carried to the lower parts, causing the water level to drop in the upper wells (Figure3-IV).

Well Yield: It is the volume of water drawn from a well per unit time. It is usually calculated in units of m^3/day, liters/hour. It is usually expressed as m^3/day or lt/s (Figure 3-V). The purpose of water yield tests in wells is to obtain information about the hydraulics of the wells and the formations that give water (aquifers). When this information is combined with geological information, the groundwater situation of the aquifers and the plain can be understood. Obtaining and analyzing this information completely and accurately is especially important for the error-free preparation of business projects and the selection of the appropriate pump. The main purpose of groundwater survey is;

• Determination of aquifer properties

• Revealing well characteristics

• Pump selection suitable for wells

Well productivity for Ömerli plain almost varies between 0.11-11 l/s in most of the basin, while productivity can be between 20-30 l/s in the northwestern parts. It varies between 10-20 lt/s in different parts of the region.

As a result, it is understood that the middle parts of the Ömerli basin are higher in terms of both groundwater potential and productivity. When the maps obtained in the Ömerli basin study were compared with the groundwater maps of the Harran plain made by Aslan, Sepetcioğlu in 2022; It is seen that both basins have an average groundwater potential.

However, in the Ömerli basin, groundwater has been used as alternative drinking and utility water in other water sources as well as irrigation. The upstream part of these sources is Karacadağ. It reaches the historical Sur region with basalt cracks. However, considering the entire basin, these available resources alone are not sufficient to meet the water needs. When there is no mains water, the existing groundwater potential is at a level to meet the drinking water of the region [2].

The water levels in the well differ depending on the characteristics of the aquifer and the well. The position of the pump in the well becomes important in response to the water wells levels formed in the well. In deep water wells, it shows certain heights according to the movement or condition of the water. It is known that water levels in pumping wells affect pump operating characteristics.

The height of the pump, when it is not working, is defined as the static water level, and the decreasing water level after a while is defined as the dynamic water level, and the difference between these two heights is expressed as a decrease [6]. Immersion depth, on the other hand, refers to the water level up to the pump suction inlet when the well is at the dynamic water level. The vertical hydraulic head is the water level between the static water level and the pump inlet axis (Figure 1).

Schulz (2013) reported that the immersion depth of deep well pumps should be 5 m below the dynamic water level. In another study, it was emphasized that determining the dynamic submersion depth of the deep water well pump installation as 2-3 m and placing it according to this level depending on the fixed deep water well equipment and feeding would be more appropriate for the pump. working conditions [7].

Well Depth: The efficiency of a well depends on the specific flow and the reduction achieved.

Since the fall also depends on the thickness of the aquifer, in principle it is most convenient to drill a well at the bottom of the aquifer. If there is wells throughout the aquifer. The depth of the wells varies between 15 meters and 400 meters Since the fall also depends on the thickness of the aquifer, in principle it is most convenient to drill a well at the bottom of the aquifer. If there is no known poor quality or inefficiency in the aquifer layers, each well should be drilled to the (Figure 3-VI).

An inspection of the water surveillance in boreholes and observation wells is required from time to time before and during the pumping test or in various polluting water investigations. Accurate measurements are very important. Water levels in free and country aquifers can be measured by various methods. Measurement in free aquifer with advanced measuring instruments such as steel meter, electric meter, pressure gauge, air pipe. In the pressurized aquifer, the measurement is made with a plastic pipe and a manometer.

Aspect: Aspect refers to the direction of slope or the orientation of the hillside surface with respect to magnetic north, represented by values ranging

from 0 to 360 degrees in a clockwise direction. Additionally, the value for each cell in the dataset encompasses the direction of the cell's sloping surfaces.
Aspect determination possibilities, which have an important place in field analysis, without the direction of flat surfaces defined by the value of -1;

- To calculate the solar illumination of each location and to determine the biodiversity living in the area.

- After determining all the southern slopes of the mountains, finding where the snow will melt first and revealing the settlement areas that will be affected by snow waters,

- Besides recognizing flat areas, it can be used to identify many places of need and to see a kind of compass work.

Parameters are measured at different scales and thus standardized using the GIS reclassification tool. Each parameter is weighted according to its significance level (W_i) and applied as in Equation 5. The GIS technique is not capable of finding these weights (W_i);

For this reason, Analytical Hierarchy Process (AHP), one of the Multi-Criteria Decision Making methods, is used (Saaty, 2008). Each criterion is evaluated using a matrix of pairwise comparisons with the scales shown in Table 1 Table 3).

Table 3. Parameter values according to groundwater potential

Parameters	Values of Parameters for Groundwater (%)	Weighting of Parameters
Static Water Level	20	3
Dynamic Water Level	30	4
Well Yield	40	5
Groundwater Depth	10	2

3.1. AHP Approach for determination of ömerli basin groundwater potential

In the study, the Analytic Hierarchy Process (AHP) analysis method was employed to determine preference weights for the continuation and assessment of groundwater processes. This method is widely used as a solution technique for better expressing the verbal uncertainty encountered in target market identification. Additionally, it is a technique that requires the opinions of decision-makers to determine the relative importance levels concerning all criteria. Below is the AHP Method Sequential Application Working Template (Figure 6). In this study, decision-makers compared the criteria and sub-criteria using Saaty's 1-9 scale. Subsequently, all parameters were taken intoconsideration, and the priority sequence of alternatives was determined (Figure 4-5-6).

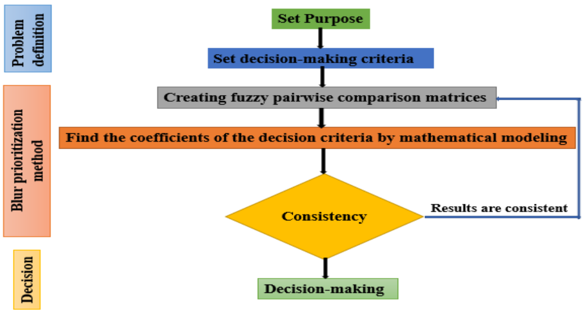

Figure 6. AHP method sequential application working template [12].

In establishing criteria for parameters, comparisons are needed to determine the importance of one criterion relative to another. The importance comparisons of the criteria were made within the framework of the experience gained so far and according to Table 1, which is the criterion comparison scale suggested by Saaty (2008) (Table 4).

Table 4. Used parameters and their weights

	Parameters	Grade	Explanation
R	Rainfall	25	Very Strong
SWL	Static Water Level	10	Strong Plus
DWL	Dynamic Water Level	20	Very Strong
WY	Well Yield	30	Very Important
D	Groundwater Depth	9	Extra Important
A	Aspect	6	Important

Thus, a comparison matrix was created by comparing the importance of each criterion with each of the other criteria. In order to create the vector that will indicate the priorities of the criteria, the column total values of the comparison matrix were first calculated (Table 5).

Looking at the results in Table 6, the best the alternative parameters with the best performance are precipitation (22%), static water level (13.3%) and finally aspect sub-criteria (10%).

Table 5. Pairwise comparison matrix

Layers	Assigned Weights	R	SWL	DWL	WY	D	A
R	**7**	**1.000**	1.167	0.875	0.778	1.400	1.750
SWL	**6**	0.857	**1.000**	0.750	0.667	1.200	1.500
DWL	**8**	1.143	1.333	**1.000**	0.889	1.600	2.000
WY	**9**	1.286	1.500	1.125	**1.000**	1.800	2.250
D	**5**	0.714	0.833	0.625	0.556	**1.000**	1.250
A	**4**	0.571	0.667	0.500	0.444	0.800	**1.000**
Total		**5.571**	**6.500**	**4.875**	**4,434**	**7.800**	**9.750**

Table 6. Pairwise comparison matrix (Standardized matrix)

Layers	R	SWL	DWL	WY	D	A	Geometric mean	Normalized weight
R	0.63650	0.17954	0.17949	0,17546	0.17949	0.17949	1.47821	0.22575
SWL	0.15383	0.15385	0.15385	0.15043	0.15385	0.15385	0.93983	0.15328
DWL	0.20517	0.20508	0.20513	0,20049	0.20513	0.20513	1.03875	0.17094
WY	0.23084	0.23077	0.23077	0.22553	0.23077	0.23077	1.38976	0.22991
D	0.12816	0.12815	0.12821	0,12539	0.12821	0.12821	0.65298	0.10682
A	0.10250	0.10262	0.10256	0.10014	0.10256	0.10256	0.62414	0.10216

In establishing criteria regarding parameters, comparisons are needed to determine the degree of importance of one criterion relative to another.

$\lambda_{max} = 6.12367$

Consistency Index: CI=(6.12367-6)/5=0.024734

CI/RI = 0.057743/1.24 = 0.019947

If the consistency ratio is less than 0.10, the matrix is considered consistent, implying that the judgments of the decision-makers are consistent [22]. Therefore, the applied AHP technique for the Ömerli Basin is suitable for the research article (0.1 > (CI/RI = 0.019947).

The values obtained as a result of the applied AHP Method are in ArcMap environment of ArcGIS; The GWPI region map was obtained by applying ArcToolbox → Spatial Analyst Tools → Overlay → Weighted Overlay.

3.2. Production of groundwater potential ındex distribution map

Six parameters, namely Rainfall (mm/year), Static Water Level (m), Dynamic Water Level (m), Well Pump Efficiency, Well Depth (m), and Aspect, have been classified and used to create the Groundwater Potential Index Distribution map. The calculation for the parameter "P" is defined as P = (QH)/200, where Q represents the discharge of extracted water (m^3/hour), and H represents the manometric height (m) (Figure 7).

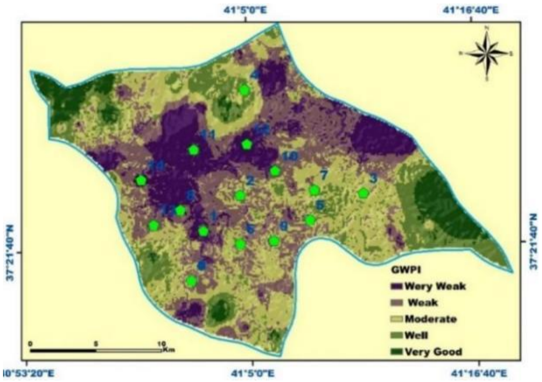

Figure 7. Ömerli basin optimum ground water enterprise map

The values in the GWPI area map of the Ömerli basin range between 454 and 594 and the corresponding percentage area calculations are shown in Table 7. Groundwater is potentially good or even very good, especially at the extreme points of the basin.

It can be said that the groundwater potential is weak or very weak, especially in the middle parts of the basin. It is a normal level in the southeast and northwest regions (Figure 7). Additionally, the green dots shown in Figure 7 represent observation wells [23].

Table 7. Classification according to Ömerli district boundary GWPI distribution values

GWPI Value	Description	Percentage (%)	Total area (409 km^2)
454-500	No bad	12.32	50,59
501-518	Not bad at all	14,27	58,36
519-535	Moderate level	25,35	103,68
536-557	Enough for the area	28,62	117.06
558-594	Pretty good for the county.	19,44	79,51

3.2.1. Validity (Verification)

Data obtained from 15 observation wells within the basin boundaries were utilized to validate the groundwater index area map of the basin. The groundwater study area map, indicating the locations of observation wells, is illustrated in Figure 4 within the GWPZ map. Nearly all the irrigation pumping wells currently in use are assessed as having very good, poor, (weak), or very weak groundwater potential for the region. Based on this classification, only 1 out of the 15 reference well data showed partial compatibility. Perfect compatibility was achieved for 14 of these wells [24-26] (Table 8).

Table 8. Data from GWPI and wells are compared

RN	Town	X	Y	Z	Depth	SWL	DWL	Yield	GWPI	Evaluation	Rapport
1	Alicli	680992	4134521	250	250	103	112	11	**254**	Poor	Compatible
2	Gollu	681904	4148060	250	325	123	129	10	**239**	Good	Compatible
3	Alicli	680926	4138342	225	311	113	129	4	**224**	Poor	Compatible
4	Salih	677324	4146986	250	271	53	77	3	**245**	Good	Compatible
5	Kocakuyu	674886	674886	110	197	80	90	2	**233**	Poor	Compatible
6	Catalyurt	680926	4138342	86	174	45	54	3	**227**	Poor	Compatible
7	Yesilli	686277	4139659	65	159	43	51	8	**212**	Good	Compatible
8	Salih	676559	4146844	79	183	60	85	2	**203**	Good	Compatible
9	Yeni Mahalle	671691	4146078	160	85	22	59	2	**208**	Good	Compatible
10	Besikkaya	683729	4141036	80	92	43	57	4.9	**201**	Poor	Compatible
11	Kayaüstü	670137	4146177	200	270	60	85	3	**273**	Good	Compatible
12	Salih	678596	4149312	160	221	53	71	2	**231**	Poor	P Compatible
13	Kayadere	669266	4148076	180	200	19	44	2	**204**	Moderate	Compatible

Partially Compatible: P. Compatible

3.3. Analysis of the study

In the Ömerli basin, annual rainfall generally ranges between 480 mm/year and occasionally reaches 590 mm/year. The majority of this precipitation occurs in the southeastern part of the area, which is the mountainous region. The city center, being a plain area, receives relatively low amounts of rainfall. Instead of relying on surface runoff, groundwater is predominantly used, particularly for irrigation purposes. Static Water Level (SWL) values vary between 5 m and, to a lesser extent, 220 m. The Dynamic Water Level (DWL) within the basin ranges from around 10 m depth to partially 280 m. Well yield varies between 0.11 and 12 l/s, while well depths range from 22 m up to around 400 meters in certain areas. The Baki map highlights the significance of terrain orientation and groundwater flow directions.

From an operational perspective in the study, pump efficiency was considered significant, and thus assigned a weight of 30%. Subsequently, the importance of rainfall was evaluated at 25%. The assessment for Dynamic Water Level (DWL) was set at 20%, followed by 12% for Static Water Level, 7% for groundwater depth, and 6% for the Aspect parameter. The groundwater potential within the basin is at a good level. This signifies the region's economic capacity to extract groundwater and its possession of a substantial groundwater potential. While the groundwater potential is lower at the basin's center, it tends to be generally moderate in the eastern and western parts, as well as the northwest region. However, in the northwest and western areas, namely Kocakuyu, Koçak, Çatalyurt, and Kayadere, groundwater management seems to be weaker.

4. Conclusion and Recommendations

Within the scope of this study, a water potential evaluation index was developed by using the GIS-supported AHP method in order to evaluate the groundwater potential within the boundaries of the Ömerli basin in terms of drinking and utility water. In the creation of the water potential index, the results of the analysis of the data obtained from the water wells drilled by the relevant institutions and organizations, and the private sector were used.

The criteria constituting the water potential evaluation index were selected by taking into account the expert opinions and water potential standards, and a weight indicating the water potential status was obtained for each criterion. In this way, an index showing the total water potential suitability ratio was developed. The water potential index for the study area is very good (19.44%), high quality (28.62 %), medium quality (25.35%), low quality (14.27%) and very poor (12.32%) defined in five categories.

A geostatistical method known as the groundwater potential index and the Inverse Distance Weighting (IDW) method was used to generate distribution maps of the water potential of the study area. According to these maps, in the southeast and northwest parts of the study area, which covers an area of approximately 200 km², water quality is seen as very high and high areas.

As a result of this study, the proposed method can be reliably and successfully used for identifying areas with high water potential and in water potential assessment studies. The utilization of groundwater potential maps indicating areas with high water potential can enhance the productivity of drinking water, irrigation, and agricultural activities. Simultaneously, it can also help mitigate potential economic losses arising from wells in regions with low water potential.

Groundwater potential maps created for the study area can be used by local authorities, engineers, urban and regional planners, further enhancing their decision-making processes. Also, as a recommendation;

Moreover, the findings of this research suggest that the developed groundwater potential assessment method could provide reliable results for identifying areas suitable for water supply and sustainable agricultural practices. The integration of these maps into water resource management and land-use planning strategies could lead to more informed and efficient decision-making processes, benefiting both local communities and regional development efforts [25].

- Penal sanctions should be applied to machines that drill wells without permission.
- In order to make irrigation system transformations on time, regularly and at the desired speed, and to apply drip irrigation systems in pressurized systems instead of flood irrigation, joint funds should be created and resources should be transferred to institutions and organizations.
- Considering that groundwaters are public property, it should be taken into account that the waters in the region are the most important strategic national resource for our country, and ways of transferring the heritage to the future by protecting it in a cleaner and usable way should be sought.
- The equipment and insulation of the wells to be drilled for irrigation, utility, and drinking water should be done in accordance with the standards.
- When the data of the last 10 years are evaluated, it is seen in the graphs that the YES level in the Basin has decreased by

approximately 20-25 m. For this reason, regardless of the number of reservoirs and wells, after deciding at which meter to keep the targeted groundwater level, excess water withdrawal should be prevented.

- First of all, the water drawn from the wells should be taken under control. If gravity is controlled it can be controlled and the management of groundwater will be more effective, easier, and sustainable.

- Considering the certified, undocumented and additional wells, projects at the planning stage, and cooperative irrigation areas in surface irrigation in the enterprise, is it primarily surface water or groundwater? choice must be made [26-27].

- All undocumented wells should be taken under control. It should be ensured that the wells are used in the project by looking at the inventory of the mourning wells opened by the citizens for the groundwater projected in the region.

- The electrification networks of these wells should be projected and transferred to units to be established by the State.

- Underground water wells will be controlled and illegal electricity usage will be prevented.

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This study does not require ethics committee permission or any special permission.

The Declaration of Research and Publication Ethics
The author of the article declares that they complied with the scientific, ethical and citation rules of SAUJS in all processes of the article and did not falsify the collected data. He also declares that Sakarya University Science Journal and its editorial board have no responsibility for ethical violations that may be encountered, and that this study has not been evaluated in any academic publication environment other than Sakarya University Science Journal.

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