Black Sea Journal of Agriculture
doi: 10.47115/bsagriculture.1826314

Open Access Journal
e-ISSN: 2618 – 6578

Research Article
Volume 9 - Issue 2 : 161-171 / March 2026

THE SPATIAL ANALYSIS OF GROUNDWATER POTENTIAL IN THE ASI BASIN USING THE ANALYTIC HIERARCHY PROCESS METHOD IN GIS ENVIRONMENT

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Abstract: This study applied a multi-criteria evaluation method based on Geographic Information Systems (GIS) and the Analytic Hierarchy Process (AHP) to determine the groundwater potential of the Asi Basin. Eight key factors affecting groundwater formation were used as layers: geology, soil texture, land use, slope, elevation, drainage density, linearity and precipitation. The factors were weighted using the AHP, and the consistency ratio was checked. The weighted layers were combined in a GIS environment to produce a groundwater potential map. The results showed that the groundwater potential of the basin varied across different classes, ranging from very low to very high. It was determined that areas with high and very high potential are concentrated in the Amik Plain and Dörtyol-Erzin Plain, which feature low-slope alluvial soils with high infiltration capacity. In contrast, areas with high slopes and impermeable geological units such as the Amanos Mountains, have been identified as low-potential zones. The model results were validated by comparing them with the safe groundwater reserve values reported in Hatay 2023 Environmental Status Report, and the reliability of the findings was confirmed. The results showed that combination of GIS and AHP provides an effective and reliable method for determining groundwater potential in areas with complex hydrogeological conditions. Agriculture, being one of the main economic activities in the basin makes groundwater especially critical for irrigation. The map produced is expected to serve as an effective decision support tool for improving irrigation planning, organizing crop patterns in line with water potential, and managing groundwater use in a sustainably.

Keywords: Groundwater potential, Analytic hierarchy process, ArcGIS 10.8, Asi Basin

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Received: November 18, 2025
Accepted: January 21, 2026
Published: March 15, 2026

Cite as: Özbuldu, M. (2026). The spatial analysis of groundwater potential in the Asi Basin using the analytic hierarchy process method in GIS environment. *Black Sea Journal of Agriculture*, 9(2): 161-171.

1. Introduction

Groundwater accounts for approximately one-third of the total freshwater reserves worldwide. Water plays a fundamental role in every area of life, from agricultural production to industry and drinking water to the sustainability of ecosystems (Benjmel et al., 2020; Li et al., 2023). The increased demand for agricultural products and industrialization is steadily increasing the demand for water. This increases the need for groundwater, along with a decrease in surface water (Das, 2019). Consequently, groundwater levels are decreasing, and salinity levels are increasing significantly, especially in arid and semi-arid regions. Today, approximately 40% of the world's population lives under water stress, and this percentage is expected to increase significantly by 2030 (Kaya et al., 2023). The increasing scarcity of water has made groundwater the primary source of freshwater in many regions. However, excessive water extraction and precipitation variability caused by climate change also cause problems such as aquifer depletion and ecosystem degradation (Chakraborty et al., 2022). Therefore, the sustainable management of groundwater resources has become a global imperative for environmental and socioeconomic stability (Shelar et al., 2023).

Determining groundwater potential requires the assessment of numerous environmental, geological, and topographical factors owing to the complex nature of hydrogeological processes (Patle et al., 2022; Zewdie et al., 2024). Therefore, geographic information systems (GIS) and remote sensing techniques have been widely used in recent years to identify groundwater potential zones by integrating different data layers. GIS facilitates the spatial analysis of hydrogeological factors, such as geology, soil, slope, drainage density, precipitation, and land use, enabling a comprehensive assessment across large areas. The combined use of these techniques is considered a more economical and time-saving alternative to traditional drilling and geophysical methods (Khan et al. 2022). This approach enables the mapping of groundwater potential by weighting and overlaying layers. For the spatial analysis of groundwater potential in large areas, GIS applications based on Analytical Hierarchy Process (AHP) are widely preferred today as a reliable and effective decision support tool (Alrawi et al., 2022; Shelar et al., 2023; Baykal et al., 2024).

The AHP method enables the systematic evaluation of various environmental and hydrogeological factors through a multi-criteria decision-making approach to determine groundwater potential zones. AHP weighs the impact of various thematic layers on groundwater formation according to their relative importance (Alrawi et al., 2022; Zewdie et al., 2024). In a study conducted in the Shivan Sub-Basin of Iraq, reliable potential zones were obtained by evaluating lithology, drainage density, slope, soil structure, and precipitation factors (Al-Gburi et al., 2022). In a similar approach, studies conducted in Syria's Al-Qalamoun region found the AHP method to be effective in the comprehensive assessment of geological, hydrogeological, land use, and climatic factors (Alrawi et al., 2022). The accuracy of a groundwater potential map created using eight thematic layers in a study conducted in the Urmodi River Basin in India was found to be 84% (Shelar et al., 2023). In the Chemoga Basin of Ethiopia, studies have demonstrated that the AHP-based GIS approach provides accurate results even in complex geological environments (Zewdie et al., 2024). Similar studies conducted in Turkey have demonstrated that these analyses provide reliable results under different geological and hydrogeological conditions. In a study conducted in Antalya, different layers, such as lithology, slope, drainage intensity, soil, land use, and precipitation, were evaluated using the AHP and frequency ratio methods, the groundwater potential in the region was mapped with high accuracy. (Ahmadi et al., 2021). In another study conducted in the Konya Closed Basin, the accuracy of the model created using the AHP method with nine different layers was determined to be 0.87, demonstrating the reliability of the method (Baykal et al., 2024). These results show that the AHP-based GIS method is an effective tool for sustainable water management in Turkey's semi-arid regions.

The Asi Basin, located in southern Türkiye, has significant groundwater potential owing to its geological diversity, complex topography, intensive agricultural activities, and influence of the Mediterranean climate. Population growth and increasing water demand in agriculture threaten the sustainability of groundwater resources, particularly during dry periods. Therefore, determining the groundwater potential in the Asi Basin is of great importance for regional water management. In this study, factors such as geology, soil properties, land use, elevation, lineament density, drainage density, slope, and precipitation were weighted using the AHP method and analyzed in a GIS environment. As a result of the analysis, a groundwater potential map of the Asi Basin was created and classified.

2. Materials and Methods

2.1. Study Area

This study was conducted in the Asi Basin which is located in southern Türkiye and has a precipitation area of approximately 7800 km² (Dikici, 2019). The basin is located between the coordinates 36° 21′ N – 35° 48′ E and 36° 41′ S – 35° 53′ W (Figure 1). Approximately 70% of the area within Türkiye's borders is covered by the Hatay Province (Anonymous, 2022).

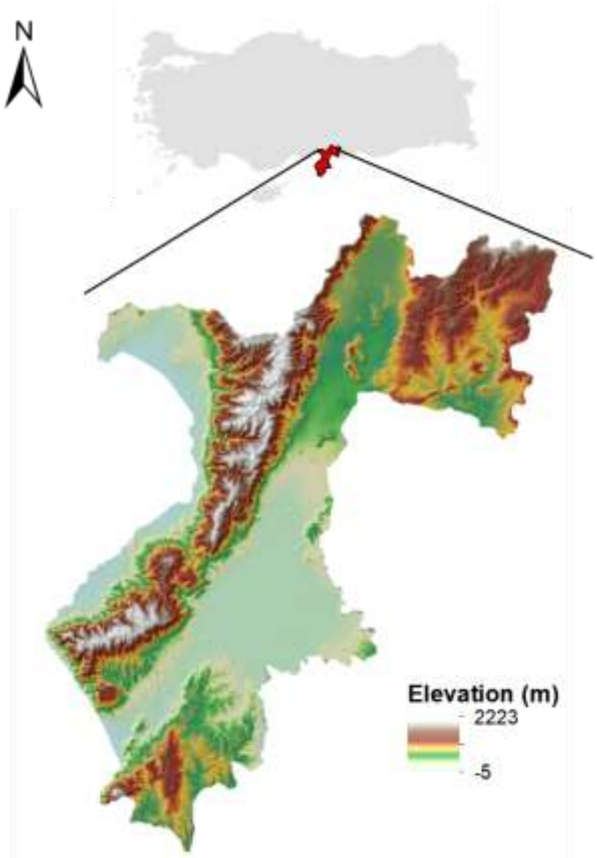

Figure 1. Location of the study area.

The Asi Basin contains flat plains and mountainous regions. The elevation starts at sea level and rises to over 2000 m in the Amanos Mountains. The region has a Mediterranean climate; winters are warm and rainy, summer periods are hot and dry. The average annual rainfall in the basin is 788.5 mm, and the average temperature is 18.3 °C (Anonymous, 2022). Owing to these climatic and topographical conditions, the management of surface and groundwater resources and agricultural water supply in the basin plays a critical role. Agriculture is especially concentrated in the plains, and groundwater is of great importance for irrigation and as drinking water.

The Asi Basin was chosen as the study area because it represents one of the most critical regions in southern Türkiye in terms of groundwater use. Agriculture is widespread in the basin, and groundwater is a primary water source, especially during dry periods. At the same time, the basin has a complex structure, including flat alluvial plains as well as steep mountainous areas, which directly affect groundwater recharge. This diversity makes the Asi Basin a suitable area for evaluating groundwater potential using a GIS-based AHP approach.

2.2. Data Sets

Land use/land cover (LULC), elevation, slope, lineament density, precipitation, drainage density, geology, and soil property data were used to determine the groundwater potential zones of the Asi Basin using the AHP method (Table 1). All maps of the data were created using ArcGIS software.

2.3. GIS based AHP analysis

AHP, which is a multi-criteria decision-making approach, has been widely used to solve complex decision-making problems in different fields. This method enables the systematic evaluation of different thematic layers and makes complex problems more comprehensible. The AHP-based approach is recognized as a robust method accepted globally because of its success in handling complex decision-making processes (Agarwal and Garg, 2016). In this study, the AHP multi-criteria modeling approach was applied to determine the groundwater potential zones in the Asi Basin. First, the fundamental thematic layers affecting groundwater recharge were defined and structured based on studies in the literature. Numerical values were assigned to each thematic layer for these hierarchically organized parameters, and the relative importance of each factor was calculated using the pairwise comparison matrix method (Table 2). As a result of weight normalization, eigenvectors, maximum eigenvalues, consistency index (CI), and consistency ratio (CR) were obtained (Zewdie et al., 2024). After checking the consistency of each thematic layer, the relative importance weights were overlaid in the CBS environment, and a general groundwater potential zone map was produced using ArcGIS software. The general methodological flow of this study is shown in Figure 2.

The values of each column in the pairwise comparison matrix were summed to obtain the layers and sublayers of the main factors affecting groundwater formation and distribution (equation 1).

$$L_{ij} = \sum_{j=1}^{n} a_{ij} \quad (1)$$

In this equation, a_{ij} represents the factor layer. To create the normalized pairwise comparison matrix, the elements in each row of the matrix are divided by the sum of the values in the column in which that element is located (equation 2).

$$X_{ij} = \frac{a_{ij}}{\sum_{j=1}^{n} a_{ij}} \quad (2)$$

The average final weights of the factor layers are determined by dividing the sum of the values in each row of the normalized matrix by the number of factor layers (N) (equation 3).

$$W_{ij} = \frac{\sum_{i=1}^{n} X_{ij}}{N} \quad (3)$$

CI was calculated using equation 4.

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

Table 1. Data sets used in the study

Data Type	Source	Purpose
SRTM DEM	http://earthexplorer.usgs.gov	Elevation Map Slope Map Drainage Density Map
MTA Fault data	https://yerbilimleri.mta.gov.tr	Lineament Density Map
GLiM Geological data	https://www.geo.uni-hamburg.de	Geology Map
FAO Soil Data	https://www.fao.org	Soil Map
ESRI Land Cover	https://www.arcgis.com	Land Use Land Cover Map
MGM Meteorological Stations Data	https://mgm.gov.tr	Precipitation Map

Table 2. The pairwise comparison matrix between all factors for the AHP model

Factors	Factors							
	Geology	Lineament Density	Precipitation	Slope	Soil Texture	Drainage Density	LULC	Elevation
Geology	1	2	3	4	5	6	7	8
Lineament Density	1/2	1	2	3	4	5	6	7
Precipitation	1/3	1/2	1	2	3	4	5	6
Slope	1/4	1/3	1/2	1	2	3	4	5
Soil Texture	1/5	1/4	1/3	1/2	1	2	3	4
Drainage Density	1/6	1/5	1/4	1/3	1/2	1	2	3
LULC	1/7	1/6	1/5	1/4	1/3	1/2	1	2
Elevation	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1

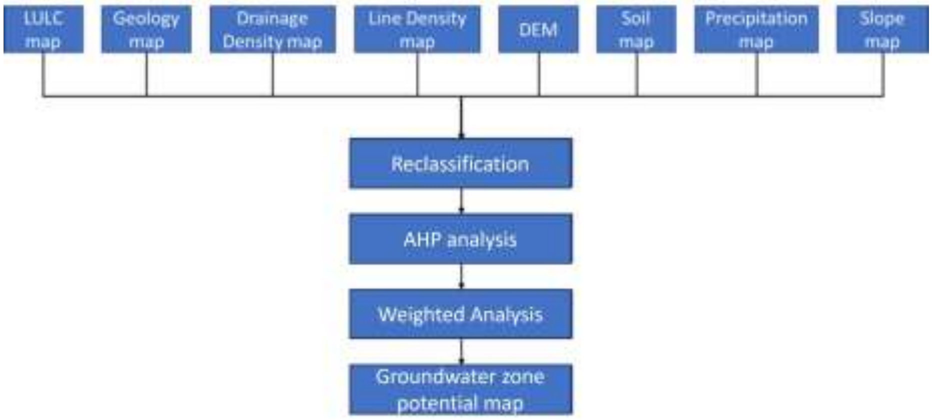

Figure 2. Flow chart of the study.

In this equation, λmax represents the largest eigenvalue obtained from the matrix, and n represents the total number of thematic layers (El Jazouli et al., 2019). The consistency level of the method verified for each parameter. This process ensured that the results remained within an acceptable consistency ratio (CR≤10%). If the CR value is greater than 10%, the model is considered inconsistent, and the weightings must be reviewed to ensure consistency (Equation 5).

$$CR = \frac{CI}{RI} \tag{5}$$

Where CI and RI denote the consistency and random consistency indices, respectively. These values depend on the size of the pairwise comparison matrix and are determined according to the standard table created by Saaty (1977) (Table 3). In this study, a total of eight main factors were used in the AHP analysis. Therefore, the random consistency index (RI=1.41) value proposed by Saaty (1977) for n = 8 was used in the consistency ratio calculations. All factors affecting groundwater formation and distribution were compared based on their relative importance to each other to determine the most suitable model. These comparisons were made using a standard scale based on a nine-step importance rating scale developed by Saaty (1980) (Table 4). The relative weight of each criterion has been calculated as shown in Table 5. To prepare the groundwater potential (GWP) map, the calculated weights of each thematic layer were multiplied by their class values. The influencing factors (thematic layers) were overlaid and combined using the weighted linear combination (WLC) technique. Equation 6 was used to calculate groundwater potential (Zewdie et al., 2024).

$$GWP = \sum_{i=1}^{n} W_i R_i \tag{6}$$

Where GWP represents the groundwater potential, W_i represents the weight of each thematic layer, and R_i represents the scores of the classes in each thematic layer obtained using the AHP method.

Table 3. Random consistency index values (Saaty, 1977)

Matrix Size (n)	RI
1	0.00
2	0.00
3	0.58
4	0.90
5	1.12
6	1.24
7	1.32
8	1.41
9	1.45

Table 4. The basic scales of AHP (Saaty, 1980)

Importance Level	Definition
1	Equally importance
3	Moderate importance of one over another
5	Strong importance
7	Very strong importance
9	Extreme importance
2,4,6,8	Intermediate values between the two adjacent judgment

3. Results

3.1. Geology

Geology is a fundamental factor that determines groundwater formation and storage capacity. In the Asi Basin, units of different ages and lithological characteristics coexist, and the Quaternary-Miocene and Neogene-Quaternary sediments, composed of sand, gravel, and loose alluvium, provide high porosity and good permeability (Figure 3). Therefore, these units constitute the lithologies with the highest groundwater potential in the basin (Bhattacharya et al., 2021). Volcanic rocks and Paleogene units offer moderate permeability owing to their fractured structures, whereas Paleozoic, Jurassic, and Cretaceous dense and massive rocks have low potential owing to their low porosity (Arulbalaji et al., 2019; Al-Gburi et al., 2022). In general, loose sediments create a high groundwater potential, whereas compact rocks create a low groundwater potential.

Table 5. The relative weight of each criterion

	Geology	Lineament Density	Precipitation	Slope	Soil Texture	Drainage Density	LULC	Elevation	Weight
Geology	0.37	0.44	0.40	0.35	0.31	0.27	0.25	0.22	0.33
Lineament Density	0.18	0.22	0.27	0.27	0.25	0.23	0.21	0.19	0.23
Precipitation	0.12	0.11	0.13	0.18	0.19	0.18	0.18	0.17	0.16
Slope	0.09	0.07	0.07	0.09	0.12	0.14	0.14	0.14	0.11
Soil Texture	0.07	0.05	0.04	0.04	0.06	0.09	0.11	0.11	0.07
Drainage Density	0.06	0.04	0.03	0.03	0.03	0.05	0.07	0.08	0.05
LULC	0.05	0.04	0.03	0.02	0.02	0.02	0.04	0.06	0.03
Elevation	0.05	0.03	0.02	0.02	0.02	0.02	0.02	0.03	0.02

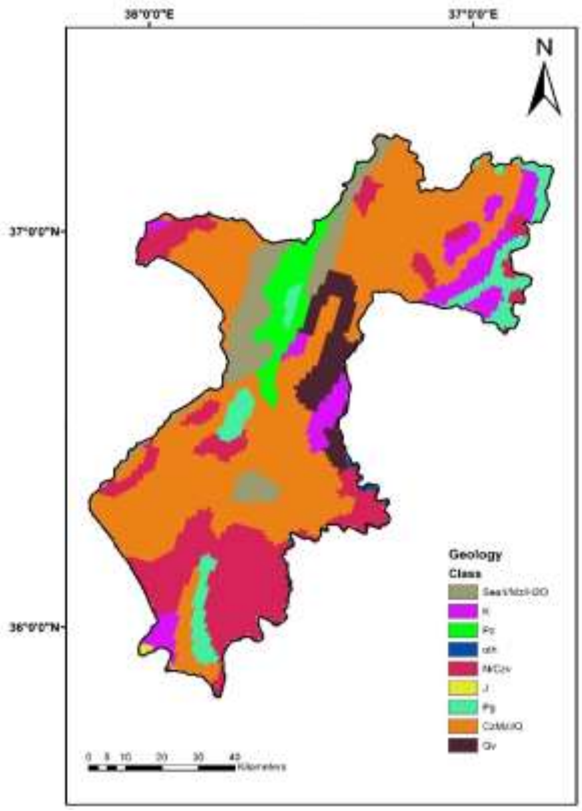

Figure 3. Geology map of the study area.

3.2. Lineament Density

Linear features are important structural elements that create secondary porosity and permeability in rocks by representing linear traces of fault and fracture systems on the surface. Therefore, lineament density is a fundamental indicator that directly affects groundwater recharge and flow (Choudhary et al., 2022). A lineament density map of the Asi Basin was created using a GIS-based line density method, and it was observed that densities were concentrated along specific directions (Figure 4). These areas form advantageous zones in terms of groundwater potential owing to their fractured and more permeable structures (Ahmed and Sajjad, 2018). The literature also indicates that groundwater potential increases with increasing lineament density, and in the classification performed, high-density areas were assigned higher weights (Hammouri et al., 2012; Arulbalaji et al., 2019; Shelar et al., 2023).

3.3. Precipitation

Precipitation is the fundamental hydrological factor that directly determines groundwater recharging. Changes in precipitation amount and intensity control groundwater formation by affecting the surface runoff-infiltration balance (Biswas et al., 2020). Annual precipitation in the Asi Basin has been determined to be higher in the western and southwestern parts and lower in the eastern and southeastern parts. This spatial pattern is thought to be due to topography, elevation, and orographic effects (Figure 5). This spatial variation also significantly affects the infiltration potential. The literature clearly states that increased precipitation strengthens groundwater recharge (Arulbalaji et al., 2019; Murmu et al., 2019; Kaur et al., 2020). Therefore, areas with high precipitation were considered suitable supply zones, whereas areas with low precipitation were considered regions with limited potential.

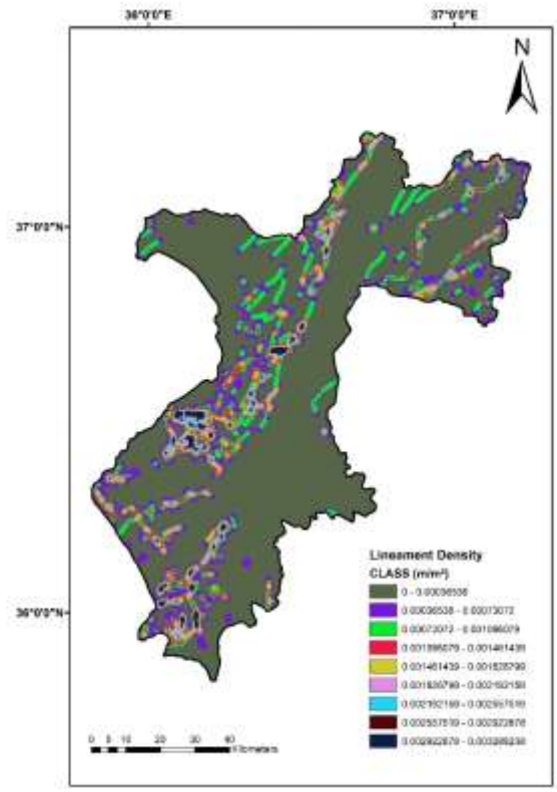

Figure 4. Lineament density map of the study area.

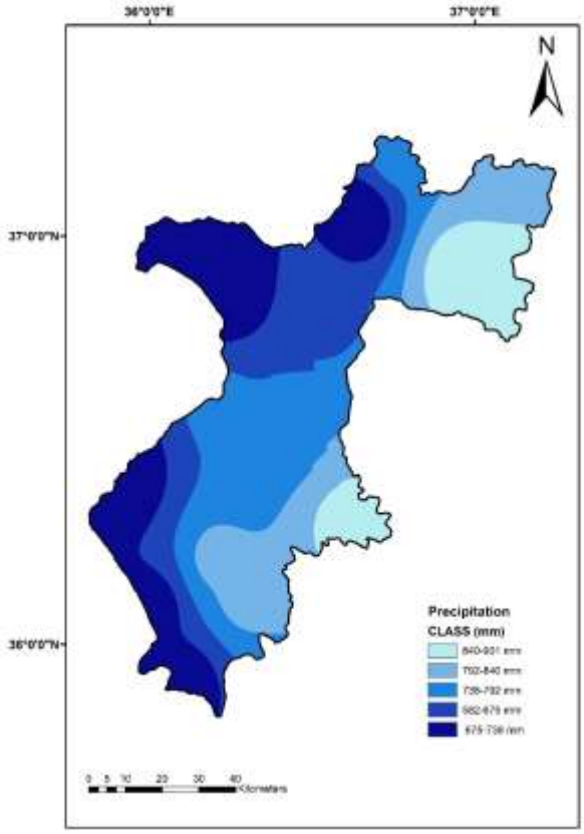

Figure 5. Precipitation map of the study area.

3.4. Slope

Slope is a fundamental topographic factor affecting groundwater potential, as it determines the flow velocity of surface water and the amount of infiltration into the soil. Water moves more slowly in low-slope areas and remains on the surface for a longer time, increasing infiltration. This supports the groundwater recharge. Conversely, surface runoff accelerates in areas with increased slopes, and water infiltration into the soil is limited. Consequently, the groundwater potential decreases (Ibrahim-Bathis and Ahmed, 2016; Rajaveni et al., 2017). The slope map produced for the Asi Basin shows that flat and slightly sloping areas are mostly located in the central and plain sections of the Basin. High slope areas were concentrated mainly in the northern and southern areas (Figure 6). In line with the literature, low-slope areas were assessed as zones with high groundwater potential, whereas high-slope areas were assessed as zones with lower potential due to rapid surface runoff (Oikonomidis et al., 2015; Patra et al., 2018; Kaur et al., 2020).

3.5. Soil Texture

Soil texture is a fundamental hydrogeological factor that determines the infiltration rate and water storage capacity. Sandy and loamy soils increase groundwater recharge by providing high permeability, whereas soils with a high clay content limit potential due to low infiltration (Kumar and Krishna, 2018; Al-Gburi et al., 2022; Pillai et al., 2023). Loam and clay loam soils are widespread in the Asi Basin, while clay-rich soils are concentrated mainly in the central and southern parts (Figure 7). In this study, areas with loamy and medium-textured soils were considered more advantageous in terms of groundwater potential, whereas areas with high clay content were classified as regions with weaker potential due to low infiltration.

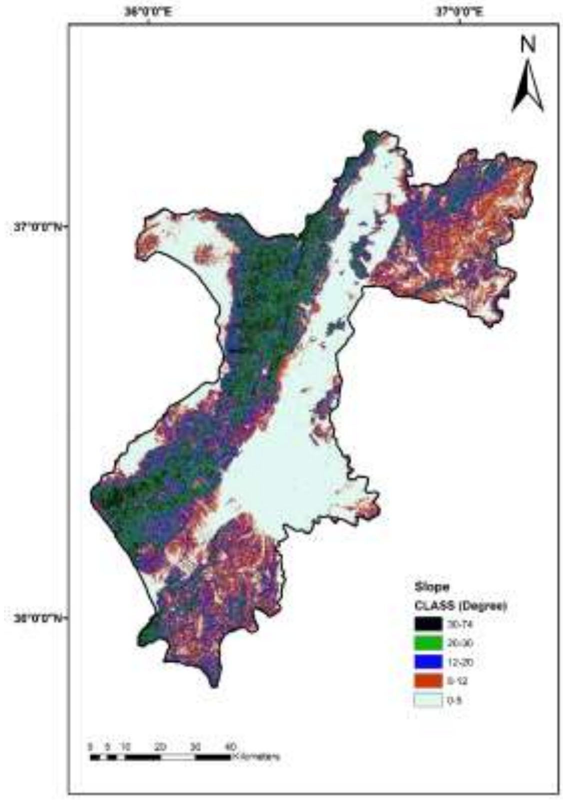

Figure 6. Slope map of the study area.

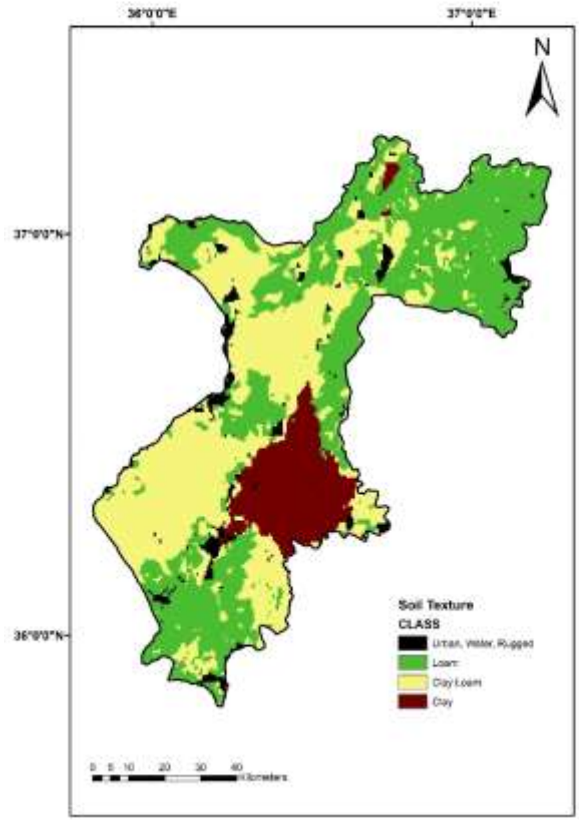

Figure 7. Soil texture map of the study area.

3.6. Drainage Density

Drainage intensity is an important hydrogeological indicator that determines the relationship between surface runoff and infiltration. In areas with dense stream networks, infiltration and groundwater potentials decrease. In areas with low drainage intensity, groundwater recharge increases because water remains in the system for a longer period (Chenini and Ben Mammou, 2010; Kumar et al., 2022). The drainage density map produced for the Asi Basin shows that high drainage density exists, particularly in the central and southern areas where rivers and tributaries converge, while lower drainage density prevails in the north, northwest, and some plain areas (Figure 8). In this study, the drainage density was classified, with a high weight assigned to low-density areas and a low weight assigned to high-density areas. Thus, the inverse effect of drainage density on groundwater potential was included in the assessment (Rizeei et al., 2019; Baykal et al., 2024).

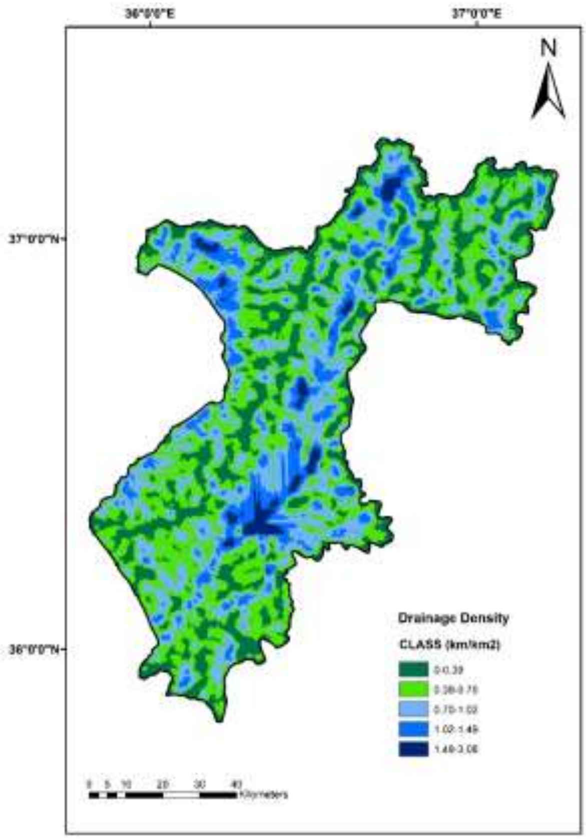

Figure 8. Drainage Density map of the study area.

3.7. Land Use Land Cover (LULC)

Land use and land cover are important parameters for determining groundwater potential because they directly affect hydrological processes such as surface runoff, evaporation, soil moisture, and infiltration. Agricultural areas and forest cover occupy a large area in the Asi Basin, and the vegetation in these areas supports infiltration by increasing the water-storage capacity of the soil. In contrast, settlement areas, bare soils, and heavily used surfaces limit groundwater recharge by increasing surface runoff (Figure 9) (Kaur et al., 2020; Zewdie et al., 2023). Water surfaces within LULC classes are areas where surface-groundwater interaction is most intense, and they have high infiltration potential owing to the long duration of water contact with the soil (Mohamed and Worku, 2020; Kumar et al., 2022). Therefore, forests, agricultural areas, and water surfaces in the Asi Basin are considered to have high groundwater potential, whereas settlements, bare areas, and compacted surfaces are classified as having low potential.

3.8. Elevation

Elevation is a fundamental topographic factor that determines the roughness of the terrain surface and the movement of water. Low-elevation areas are places where water can stay for longer periods of time, which makes infiltration easier and groundwater recharge more effective. In contrast, high elevation areas decrease the time water remains in the soil due to increased slope and surface runoff. This limits infiltration and reduces groundwater potential (El Jazouli et al., 2019; Ghosh et al., 2023). The elevation map of the Asi Basin shows that a large part of the basin consists of low and medium elevations, while high elevations are prominent in the mountainous areas to the north, east, and west (Figure 10).

This distribution has led to low elevation plains being considered more favorable in terms of groundwater potential, while high elevation and mountainous areas are considered to have lower potential due to rapid surface runoff. In the elevation classification, lower elevation areas have been assigned higher weights, while higher elevation areas have been assigned lower weights.

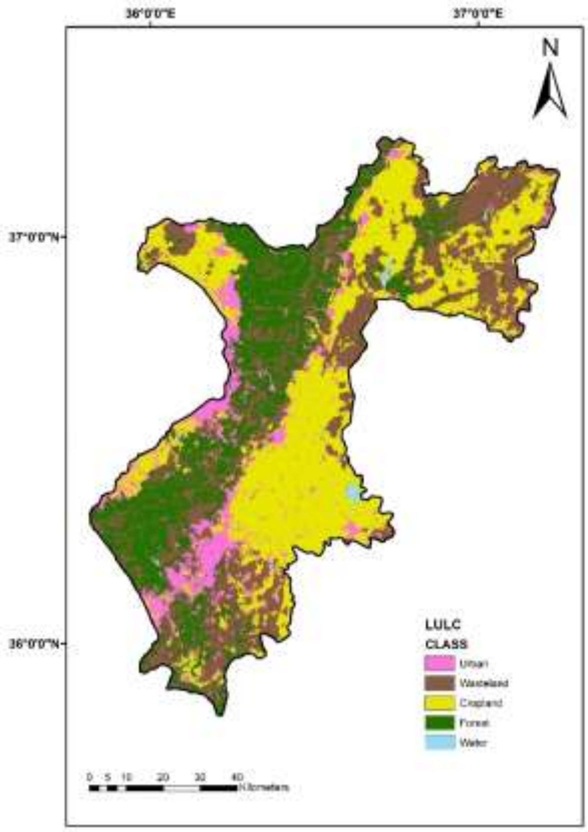

Figure 9. LULC map of the study area.

3.9. Groundwater Potential Map

The groundwater potential (GWP) map obtained as a result of the AHP-based weighted overlay analysis reveals that the Asi Basin exhibits a distinct spatial differentiation from a hydrogeological perspective (Figure 11). High and very high GWP values in the Asi Basin are particularly prominent in areas with low slopes, low elevations, widespread permeable alluvial soils, and concentrated agricultural/forest areas. These areas enhance groundwater recharge by allowing water to be stored in the soil for longer periods due to their high infiltration capacity and limited surface runoff. In contrast, areas such as the Amanos Mountains, which are dominated by high slopes, high drainage intensity, and impermeable geological units, have been determined as low-potential zones.

The areal distribution of groundwater potential classes indicates that the moderate groundwater potential zone dominates the basin, covering 46.0% (3589.52 km^2) of the total area (Table 6). This is followed by high (19.6%, 1527.03 km^2) and very low (17.9%, 1396.92 km^2) potential classes. The very high groundwater potential zones occupy 8.7% (677.47 km^2) of the basin, while low potential areas account for 7.8% (607.04 km^2). These results demonstrate that more than half of the basin is characterized by moderate to high groundwater potential, highlighting the significant groundwater prospect of the Asi Basin.

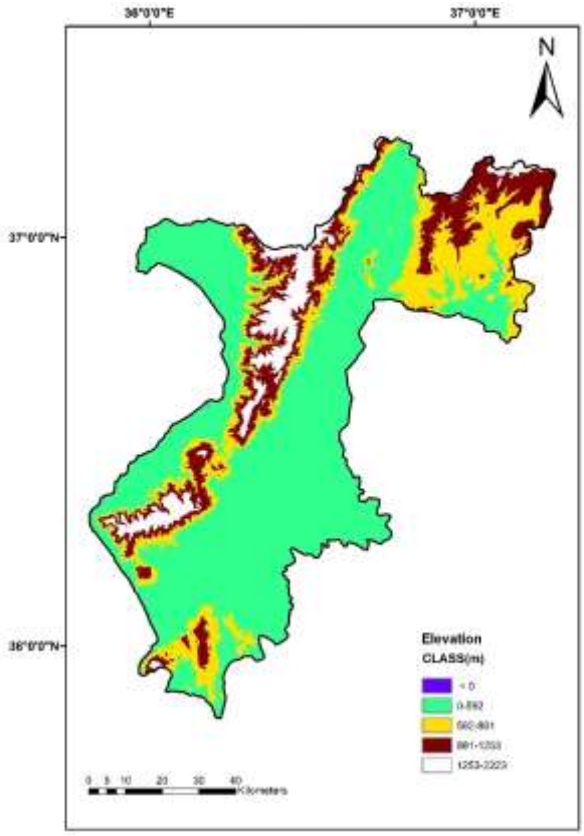

Figure 10. Elevation map of the study area.

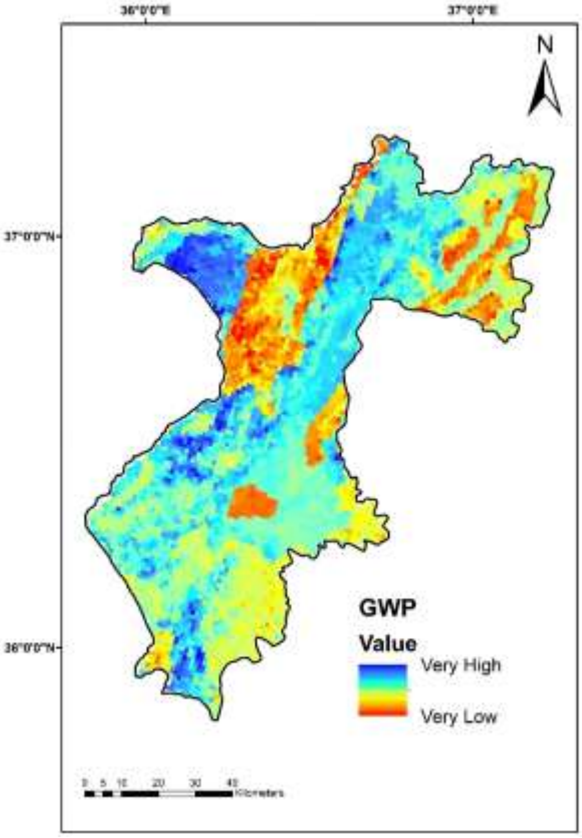

Figure 11. GWP map of the study area.

Table 6. Areal distribution of groundwater potential classes

Groundwater potential class	Area (km^2)	Area (%)
Very Low	1396.92	17.9
Low	607.04	7.8
Moderate	3589.52	46.0
High	1527.03	19.6
Very High	677.47	8.7

4. Discussion

This study demonstrates that the groundwater potential in the Asi Basin has been successfully identified using the GIS-based AHP method. The results reveal that hydrogeological conditions in the basin vary spatially and that the potential is shaped by the combined effect of multiple environmental factors such as geology, lineament density, slope, and drainage density. In particular, it was determined that permeable alluvial soils in areas with low slope and low drainage density offer high groundwater potential, whereas high slope and impermeable lithologies have low potential. These findings are consistent with the literature emphasizing that the interaction between topography, geology, and drainage is decisive in groundwater formation (Arulbalaji et al., 2019; Kaur et al., 2020; Biswas et al., 2020).

In geological terms, it is observed that alluvial and loose sedimentary units in the Asi Basin offer high groundwater potential, while massive and low-porosity rocks have low potential. This is consistent with the literature indicating that dense rocks have low storage capacity due to their limited permeability (Ahmed and Sajjad, 2018; Bhattacharya et al., 2021). The increase in potential in areas with high fault and lineament density is related to the strengthening of secondary porosity in fractured zones (Hammouri et al., 2012; Shelar et al., 2023). Furthermore, the increase in potential in areas with high precipitation in the west and southwest is consistent with studies showing that infiltration is directly linked to precipitation (Murmu et al., 2019; Kaur et al., 2020).

In terms of topographic parameters, an inverse relationship was found between slope and elevation and groundwater potential; low-slope and low-elevation areas were found to offer high potential. These findings support the hydrological mechanism whereby low slope increases infiltration and reduces surface runoff (Oikonomidis et al., 2015; Ibrahim-Bathis and Ahmed, 2016). In soil texture analyses, sandy and loamy soils having high potential is related to the permeable structure of these textures, which facilitates infiltration (Kumar and Krishna, 2018). The high potential of agricultural and forest areas in land use classes supports the surface runoff–infiltration relationship highlighted in the literature (Mohamed and Worku, 2020; Kumar et al., 2022).

The accuracy of the study has also been supported by a comparative assessment with the safe groundwater reserve values published in Hatay Province 2023 Environmental Status Report. According to official data, the Dörtyol–Erzin (100 hm^3/year) area has the highest groundwater reserves, and Reyhanlı (29 hm^3/year), and Kırıkhan (22 hm^3/year) areas coincide with high and very high potential zones on the GWP map, indicating that the model accurately reflects the hydrogeological reality in the field (Anonymous, 2024). This consistency supports literature studies showing that the AHP-based CBS method can provide reliable groundwater potential assessments at regional and local scales (Baykal et al., 2024; Zewdie et al., 2024).

The results obtained are considered to be an important guide for regional water management, given the climatic and topographic diversity of the Asi Basin. The high-potential areas around Dörtyol, Amik Plain, and the Asi River are critical for sustainable agricultural production. However, precipitation reduction and regime changes associated with climate change may negatively affect groundwater recharge in the future. The comparison with official reports indicates a general spatial agreement between the high and very high groundwater potential zones and the regions reported to have high groundwater reserves. This qualitative consistency suggests that the AHP-based GWP map reasonably represents the overall groundwater potential distribution in the basin and can be used as a supportive decision-making tool for sustainable water management.

5. Conclusion

This study evaluated the groundwater potential of the Asi Basin using a multi-criteria analysis based on AHP and GIS. The results revealed that hydrogeological conditions in the basin exhibit significant spatial variability. Dörtyol, Amik Plain, and their surroundings, characterized by low-gradient, permeable sediments, offer high groundwater potential, while the Amanos Mountains, dominated by steep-gradient and impermeable lithologies, have been identified as low-potential areas. The consistency between the GWP map and the safe groundwater reserves provided in the Hatay 2023 Environmental Status Report demonstrates that the model accurately reflects the hydrogeological conditions in the field. These results show that the study provides a reliable decision support tool that can be used in regional water management.

Certain measures are crucial for sustainable groundwater management in the Asi Basin. Controlled water extraction should be implemented in high-potential areas to prevent excessive uses. Regular monitoring of groundwater levels will enable the early detection of potential declines. Protecting areas with high recharge potential will contribute to balancing the water budget, particularly in regions with intensive agricultural activities. Furthermore, the impact of changing precipitation regimes due to climate change on the basin's water resources should be considered, and future scenarios should be integrated into the model. The use of well data, geophysical measurements, and time series analysis in future studies will further improve the accuracy of the GWP map. In future studies, the integration of long-term precipitation trends and modeling analyses will contribute to a more detailed assessment of groundwater recharge processes in the temporal perspective.

Author Contributions

The percentages of the author' contributions are presented below. The author reviewed and approved the final version of the manuscript.

	M.Ö.
C	100
D	100
S	100
DCP	100
DAI	100
L	100
W	100
CR	100
SR	100
PM	100
FA	100

C= concept, D= design, S= supervision, DCP= data collection and/or processing, DAI= data analysis and/or interpretation, L= literature search, W= writing, CR= critical review, SR= submission and revision, PM= project management, FA= funding acquisition.

Conflict of Interest

The author declared that there is no conflict of interest.

Ethical Consideration

Ethics committee approval was not required for this study because of there was no study on animals or humans.

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