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Research Article

GIS-Based IDW Mapping of Soil Index Properties: A Case Study of Elazığ Center

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ABSTRACT

In this study, Geographic Information Systems (GIS)-based Inverse Distance Weighting (IDW) spatial mapping of soil index properties was conducted for a 133.65 km² study area using borehole data obtained from the city center of Elazığ. Data from between 33 and 210 selected boreholes were evaluated, and spatial prediction maps were generated based on the Unified Soil Classification System (USCS), Atterberg limits, water content, and groundwater distribution. The results indicate that ML, GM, and CL soil classes are dominant at shallow depths (1.5–4.5 m), while the GM soils coexist with MH soils at intermediate depths (7.5–9 m). At greater depths (15 m), ML, SM, and GM soil types become dominant again. Water content values predominantly range between 11% and 20% across the study area, whereas other ranges (0–10%, 21–30%, and 31–44%) exhibit depth-dependent variations. Overall, the distribution suggests that low to moderate water content predominates and that the groundwater potential of the study area is limited. Based on liquid limit, plastic limit, and plasticity index values, two distinct soil zones were identified using IDW-based spatial prediction maps.

Introduction

The accurate determination of soil properties at the locations where structures are planned to be constructed in different geographical regions is of great importance for foundation design, highway and railway infrastructures, urban planning, and disaster risk analyses, considering the sensitivities of geotechnical engineering. Parameters such as soil classification, plasticity characteristics, natural water content, and groundwater level directly affect soil behavior, including bearing capacity, settlement, swelling, and liquefaction [1],[2]. Although various studies [3],[4],[5] have been carried out in recent years to improve the engineering properties of soils, determining the spatial and depth-wise distribution of soil properties, especially in urban areas, is a fundamental requirement for safe, economical, and environmentally sustainable applications. In traditional geotechnical approaches, soil properties are generally evaluated based on point-scale borehole data. However, such studies often remain insufficient to represent soil behavior over large areas and introduce uncertainties [6]. In this respect, GIS which are widely used in many disciplines [6],[7],[8],[9],[10] have become prominent tools for storing, analyzing, and spatially interpreting geotechnical data. Through GIS-based analyses, the spatial distribution of soil parameters can be visualized, and meaningful engineering predictions for different depths can be generated. In GIS applications, spatial interpolation methods allow continuous surfaces to be derived from point data. Among these, IDW method is based on the assumption that nearby points have greater influence than distant ones, and it is widely used in geotechnical investigations due to its ease of application and ability to produce consistent results [11]. Numerous researchers have demonstrated that the IDW method yields effective results in predicting soil properties [12],[13],[14],[15],[16]. Evaluating soils according to the USCS enables comparison of the engineering behavior of fine- and coarse-grained soils [17]. Atterberg limits are accepted as fundamental parameters for determining the potential deformation and plasticity characteristics of especially fine-grained soils. In addition, natural water content and groundwater level are among the factors that directly influence the strength characteristics of soils and therefore have critical importance [18]. Moreover, the evaluation of soil properties through GIS-based approaches is considered to facilitate more reliable decision-making in the planning processes of urban development and civil engineering structures. Elazığ Province, located in the Eastern Anatolia Region, is thought to require detailed and comprehensive geotechnical assessments due to its rapid urbanization. In this context, the analysis of borehole data using GIS-based methods will contribute to a better understanding of the spatial variability of soil properties and to modeling soil behavior at the regional scale. For the safe design of engineering structures in Elazığ, it is essential to identify soil classification parameters, soil plasticity characteristics, natural water content, groundwater level, and physical soil properties. Although various geological and seismic studies related to Elazığ and its surroundings are available in the literature [19],[20],[21],[22] studies that integrate detailed and large-scale borehole data with GIS remain rather limited.

This study evaluates geotechnical parameters such as USCS soil classification, Atterberg limits, water content, and groundwater level, obtained from borehole data in the city center of Elazığ, Türkiye, using GIS-based maps generated according to the principles of the IDW method. Spatial data analysis was carried out for a study area of approximately 133.65 km², and the variation of soil parameters with depth and location was demonstrated through thematic maps. In addition, the results provide significant practical contributions by producing preliminary assessment and decision-support data that can be used in urban planning, foundation design, and infrastructure projects. The study conducted specifically for Elazığ may also serve as an example for GIS-based geotechnical analyses in other settlements with similar geological and urban characteristics. In this context, the study both establishes a regional-scale data infrastructure and demonstrates the effectiveness of GIS-supported approaches in geotechnical engineering, making it one of the relatively few studies to be included in the literature.

General Propertıes of the Study Area

Elazığ Province is located in the Upper Euphrates Section within the Eastern Anatolia Region in the southwestern part of the area. The province has a total surface area of 9,153 km² and an elevation of 1,067 m above sea level. Its main landforms consist of mountainous areas, plateaus, and plains. Covering approximately 0.12% of Türkiye's total surface area, the province lies between 40°21′–38°30′ E longitudes and 38°17′–39°11′ N latitudes. Within these coordinates, Elazığ, which is roughly rectangular in shape, extends about 150 km in the east–west direction and about 65 km in the north–south direction.

The province is bounded by Bingöl to the east; Tunceli to the north across the Keban Dam Lake; Malatya to the west and southwest through the Karakaya Dam Lake; and Diyarbakır to the south. The most important river within the province is the Euphrates and its tributaries. Lake Hazar, with a surface area of 86 km², is located approximately 30 km from the city center. In addition, Elazığ is surrounded by several major dam lakes such as Keban, Karakaya, Kralkızı, and Özlüce [23]. The location map of the study area is presented in Figure 1.

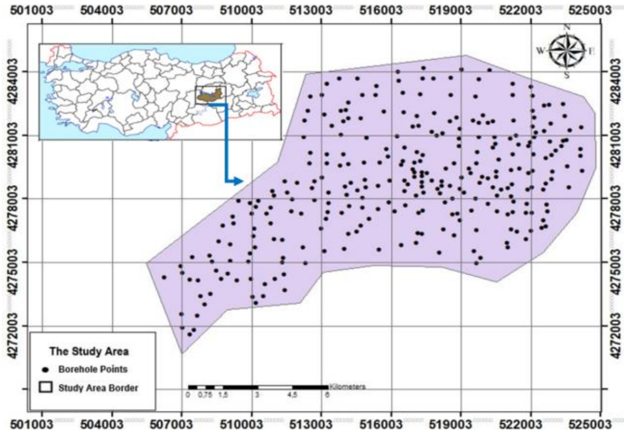

Figure 1. The map of the study area

General Geological Properties of the Area

The study area is located in the central part of the Eastern Taurus belt, and the geological evolution of the region has been shaped by the spreading of the Neotethys during the Late Paleocene–Early Eocene period. During this time, most of the area around Elazığ remained in a continental environment; however, with the transgression that occurred in the Middle Eocene, the region largely returned to marine conditions. It is frequently noted that there is a stratigraphic unconformity between the Seske and Kırkgeçit formations, which is attributed to local variations within the Eocene units and the absence of complete sections throughout the region. The oldest units in the study area are the Keban Metamorphics, which include recrystallized limestone, calc-schist, marble, and metaconglomerate levels. These are overlain by the Elazığ Magmatics, consisting of island-arc tholeiites, basaltic–andesitic volcanics, volcaniclastic rocks, and collision-related granodiorites. These magmatic units are interpreted as arc-related products that developed as a result of north-dipping subduction during the Late Cretaceous [24],[25]. The geological map of Elazığ Province is presented in Figure 2.

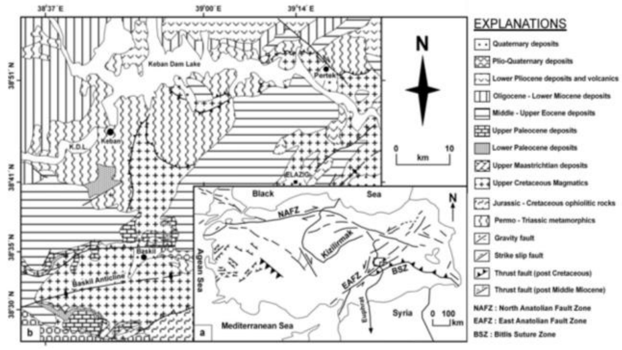

Figure 1. Geological map of Elazig [24]

Materials and Methods

Geographic Information Systems

GIS are high-capacity information technologies that enable the collection of data related to objects on the Earth, their storage in digital environments, retrieval when needed, mapping and visualization at different scales, and their subsequent analysis. This system, which can compile, update, process, and rapidly generate new outputs from all kinds of information associated with geographic locations, provides users with comprehensive data-management capabilities [26],[27],[28]. Using GIS techniques, data associated with each spatial element can be processed, queried in various ways, and transformed into multipurpose thematic maps. These features offer significant advantages for both researchers and practitioners and allow GIS to be used across a wide range of fields. GIS are widely applied across various Earth science disciplines, including urban information systems, natural hazard assessment, general geology, and geotechnical investigations. GIS provides an effective framework for managing, analyzing, and visualizing spatial data, thereby supporting the assessment of spatial variability in complex geological environments. While GIS does not replace field investigations or data acquisition, its capacity to process large datasets enables efficient analysis of spatial patterns. Furthermore, GIS facilitates the integration and evaluation of multiple environmental variables within decision-support processes [27],[29].

The IDW Interpolation Method

In GIS-based studies, various interpolation techniques are employed, with the IDW method being one of the most commonly used. The IDW method is an approach that generates an estimated value for each analysis cell by calculating the weighted average of the values of sample points surrounding that cell. It is a deterministic spatial analysis technique that enables the estimation of unknown values in unsampled areas using known point data. The fundamental assumption of this method is that points located close to each other exhibit similar characteristics, and that this similarity decreases as the distance increases. In the IDW method, data points closer to the location being estimated are assigned higher weights, while the influence of more distant points is reduced depending on their distance. Through this weighting process, the spatial surface can be represented with either smoother or sharper transitions. Particularly in geotechnical engineering studies where data are limited and irregularly distributed, such as borehole investigations, the IDW method is widely preferred due to its ease of application and its ability to produce interpretable results [12],[30]. It is considered that such spatial analyses and maps produced using GIS contribute to significant savings in both time and effort in the evaluation of soil properties within the study area.

Unified Soil Classification System

The classification of soils can be considered a common language used among engineers. A few letters or numbers assigned to a soil sample can quickly provide engineers or technicians with an idea about its probable physical characteristics and even its mechanical behavior. Thanks to soil classification systems developed since the 1910s, most countries today use similar criteria and systems for soil classification. The USCS is the most widely used system at present. In this system, soils are classified according to the following criteria: the percentage of material passing the No. 200 sieve, for coarse-grained soils the percentage retained on the No. 4 sieve, grain-size distribution characteristics (Cu and Cc values), Atterberg limits, the position of the fraction passing the No. 40 sieve on the plasticity chart, and the organic-matter content. Using these criteria, soils are divided into four main groups—coarse-grained soils, fine-grained soils, organic soils, and peat—and each sample is designated by a two- or four-letter symbol (e.g., GW, SM, GW–GM, etc.). In the unified system, soils are ordered according to particle size (D) as follows:Blocks > 300 mm; Cobbles 75 < D < 300 mm; Gravel 75 < D < 4.76 mm (No. 4); Sand 4.76 < D < 0.076 mm (No. 200); and Fines < 0.076 mm [31].

Atterberg Limits Analysis

The consistency of soils is a fundamental property that defines their stiffness depending on the bonding forces between particles, shear strength, and water content. As the water content increases, the soil exhibits different consistencies ranging from solid to liquid, and different soils may display different consistencies at the same water content. The liquid limit is the water content at which the soil changes from a plastic state to a viscous liquid state, representing the condition where its bearing capacity is at its lowest. The plastic limit is the water content at which the soil changes from a semi-solid to a plastic state and indicates the onset of permanent deformation risk. The shrinkage limit defines the point at which volume change ceases with changes in water content. The plasticity index expresses the range within which the soil remains in a plastic state and its sensitivity to water; as water content increases, cohesion decreases and deformation increases. In short, consistency and plasticity are critical properties that control the volume change, cohesion, and load-carrying behavior of soils [32].

Soil Water Content and Groundwater

Earthquakes create sudden movements in the ground, and when the groundwater level is close to the surface, they eliminate the contact forces between soil particles, causing the soil to lose its strength; in such cases, the soil behaves like a liquid. The groundwater level is determined by monitoring the static water level in boreholes equipped with sufficiently rigid perforated pipes. If groundwater is present near the foundation level, laboratory tests are conducted to investigate its effects on structural elements. Water content plays a critical role in soil behavior and mechanical modeling. Soil water content is defined as the ratio of the amount of water in a soil to either the dry weight or the volume of the same soil. In other words, it indicates the amount of water present between soil particles and is a parameter that directly affects soil density, bearing capacity, and overall behavior. Soil water content represents the measure of water within the soil and determines its mechanical properties [13].

Findings

In this study, GIS-based spatial prediction maps were generated for USCS-based soil classifications, Atterberg limits, water content, and groundwater level parameters using borehole data. The IDW interpolation method was employed in the ArcGIS environment, and all prediction maps were produced with a grid resolution of 10 m. Figure 3 illustrates the simplified workflow of the GIS-based IDW spatial mapping procedure applied in this study. Borehole data obtained from the Elazığ city center were first collected and organized according to soil index properties. Data quality control and soil classification were then performed in accordance with the USCS, and the processed data were integrated into a GIS-based spatial database. Subsequently, spatial interpolation analyses were conducted using the IDW method, and the resulting prediction maps were interpreted to evaluate depth-dependent soil distribution and to identify distinct soil zones within the study area.

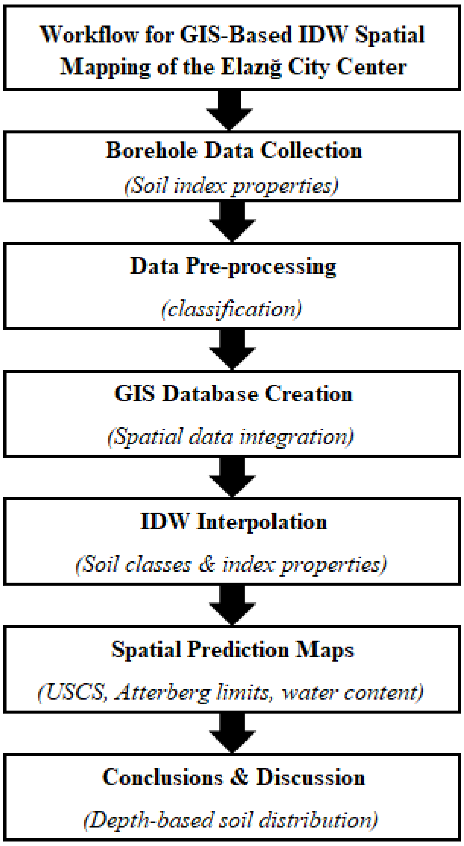

Figure 3. Flowchart of the study

Soil Analysis Maps According to the USCS

USCS prediction maps were generated using data obtained from 21 locations at a depth of 1.5 m, 82 locations at 3 m, 82 locations at 4.5 m, 48 locations at 7.5 m, 33 locations at 9 m, and 34 locations at 15 m within the study area. The prepared maps are presented in Figures 4–9.

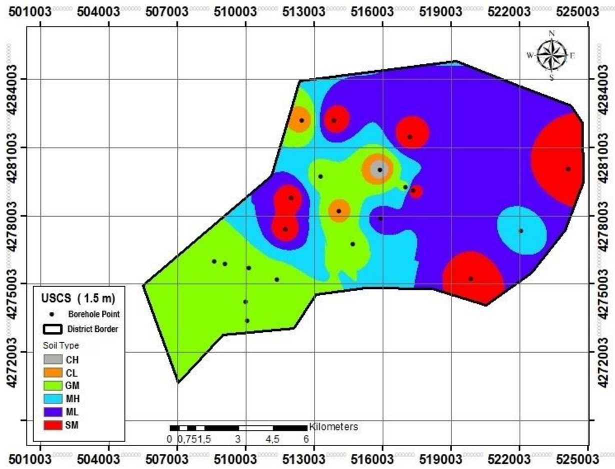

Figure 4. Soil classification map according to USCS for a depth of 1.5 m

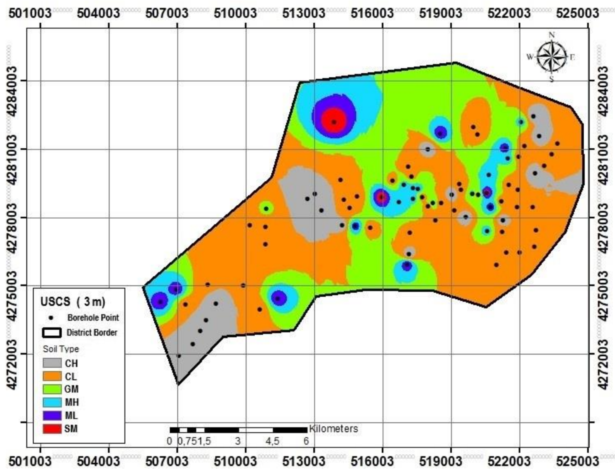

Figure 5. Soil classification map according to USCS for a depth of 3 m

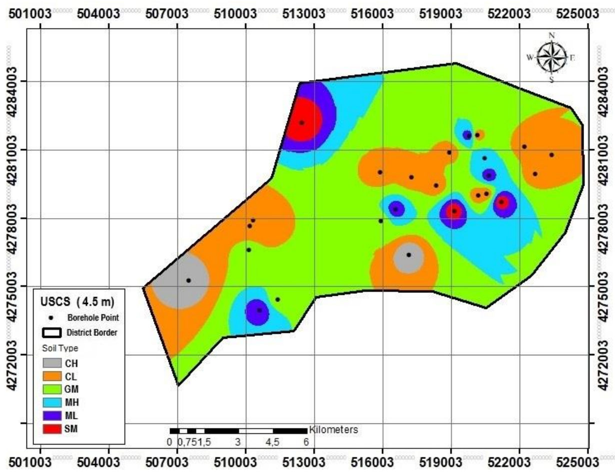

Figure 6. Soil classification map according to USCS for a depth of 4.5 m

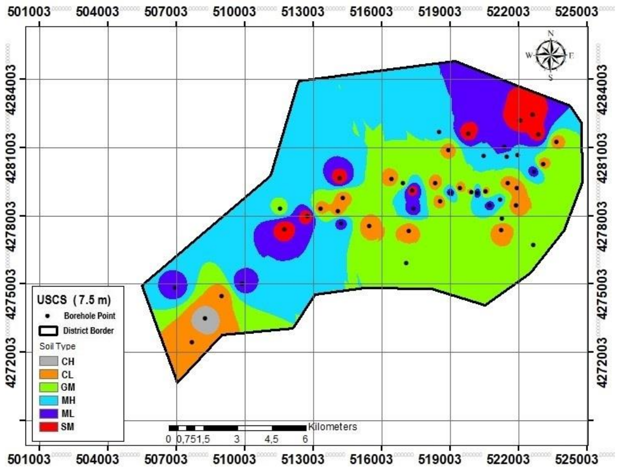

Figure 7. Soil classification map according to USCS for a depth of 7.5 m

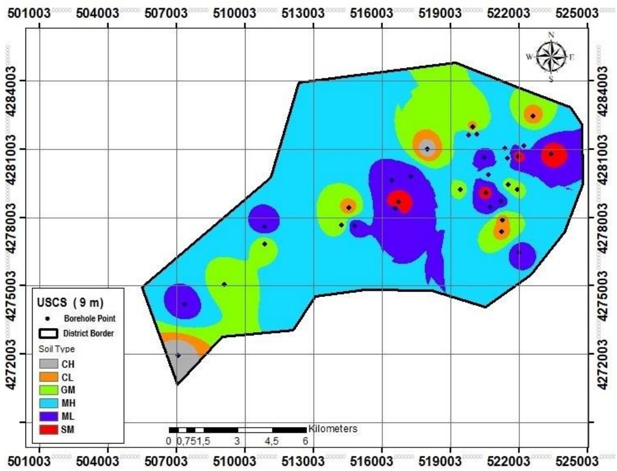

Figure 8. Soil classification map according to USCS for a depth of 9 m

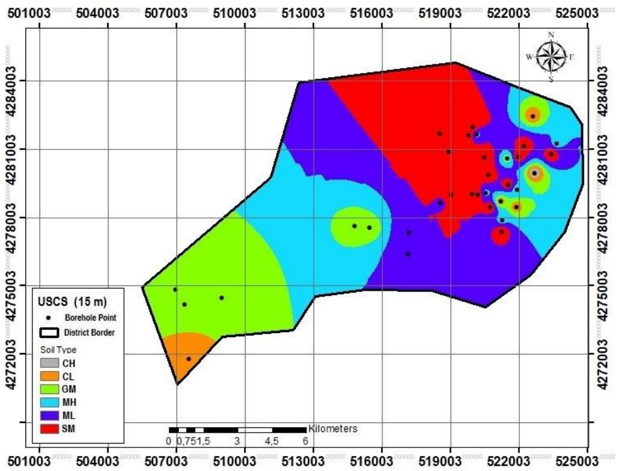

Figure 9. Soil classification map according to USCS for a depth of 15 m

Evaluations conducted at different depths within the study area indicate that soil types exhibit significant variability both laterally and with depth. At a depth of 1.5 m, the ML (low-plasticity silt) soil class predominates along the northwest–southeast axis, whereas GM (silty gravelly sand or gravelly sand) soils are dominant in the southwestern and central parts of the area. At depths of 3 m and 4.5 m, the CL (low-plasticity clay) class becomes prevalent in the southwestern and central zones, while GM soils are observed around the Nuralı–Gümüşbağlar area in the south and near Yemişlik in the north. At a depth of 7.5 m, GM soils predominate in the southeastern and central parts, with localized zones characterized by the MH (high-plasticity silt) class. At 9 m depth, the MH soil class is dominant across most of the study area. At 15 m depth, ML soils occur in the southeastern and northeastern sections, SM (silty sand) soils are widespread in the northern and northeastern parts, and GM soils are common in the southwestern portion and some localized areas. These results reveal that the region possesses a geotechnically heterogeneous structure and that soil properties vary considerably with depth. The observed lateral and vertical variations in soil classes can be attributed to the heterogeneous depositional environment of the study area. The dominance of ML and GM soil types at shallow depths indicates the presence of fine-grained alluvial materials interlayered with granular soils, suggesting variable sedimentation conditions. The increase in CL and MH soil classes at intermediate depths reflects a higher clay and silt content, which may be associated with lower-energy depositional phases and reduced drainage conditions. At greater depths, the reappearance of ML, SM, and GM soil types implies stratified soil layering and changing sediment sources over time. From a geotechnical perspective, this pronounced spatial and depth-dependent variability highlights the heterogeneous nature of the subsurface conditions, which should be carefully considered in foundation design and ground improvement applications within the study area. This heterogeneity is consistent with the geological evolution of the region and supports the findings of previous studies [24],[25].

Atterberg Consistency Limits Maps

In determining the consistency limits, prediction maps were generated using the Liquid Limit (LL), Plastic Limit (PL), and Plasticity Index (PI) data obtained from a depth of 3 m at 84 borehole locations within the study area. The LL maps are presented in Figures 10 and 11, the PL maps in Figures 12 and 13, and the PI maps in Figures 14 and 15.

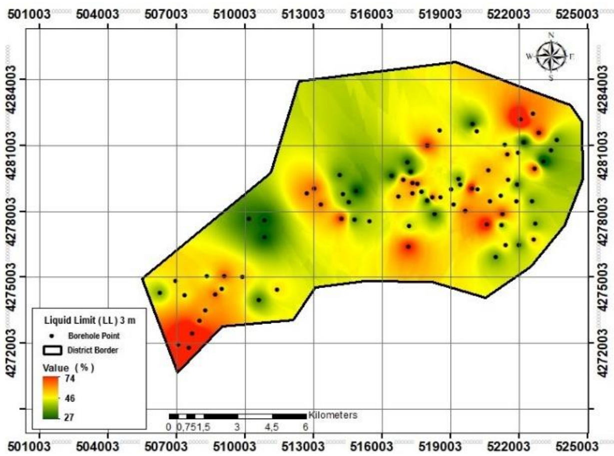

Figure 10.Liquid Limit (%) map for a depth of 3m

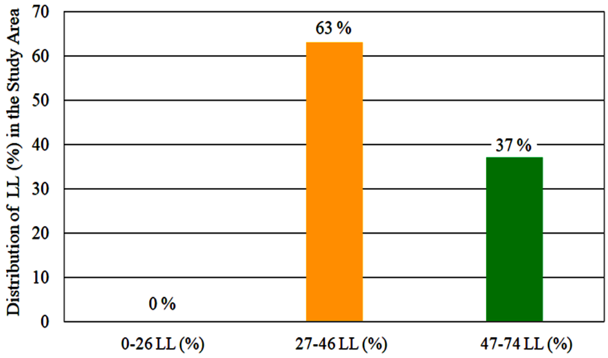

Figure 11. Comparison graph of Liquid Limit (%) at a depth of 3 m

The Liquid Limit (LL) distribution maps presented in Figures 10 and 11 indicate that LL values predominantly range between 26–46% in the Çatalçeşme District, around the vicinity of TED College, and to the north of the Fırat University Faculty of Communication. In contrast, LL values between 47–74% are dominant around Aşağıdemirtaş Village. No LL values within the 0–26% range were detected across the study area. With increasing depth, particularly in the Aşağıdemirtaş region, high LL values exhibit continuity, suggesting the presence of clay-rich and water-sensitive soils. Such soils are expected to display problematic engineering behavior due to their high swelling–shrinkage potential.

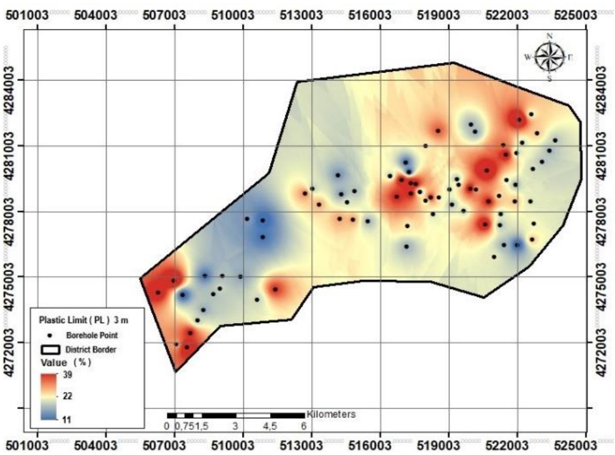

Figure 12. Plastic Limit (%) map for a depth of 3 m

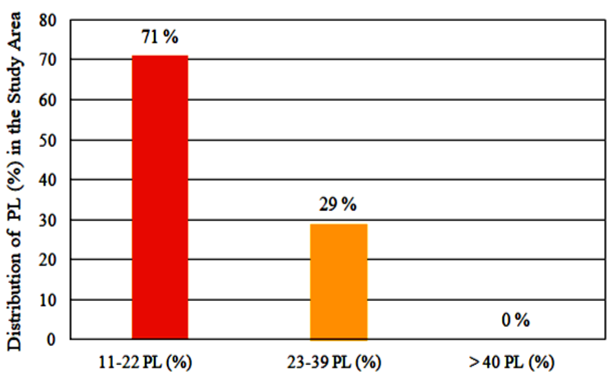

Figure 13. Comparison graph of Plastic Limit (%) for a depth of 3 m

The Plastic Limit (PL) maps shown in Figures 12 and 13 reveal that PL values are mainly concentrated within the 11–22% range in the Çatalçeşme District, the vicinity of TED College, and the northern part of the Faculty of Communication. Conversely, PL values increase to the 23–39% range around Aşağıdemirtaş Village and in certain local zones. The observed increase in PL values with depth indicates that the soils become more plastic and exhibit greater sensitivity to changes in water content.

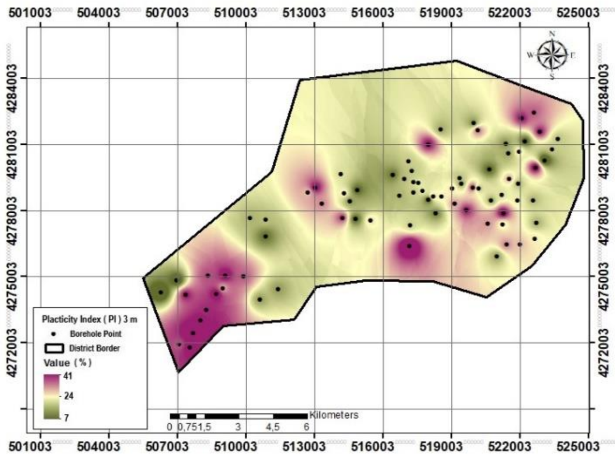

Figure 14. Plasticity Index (%) map for a depth of 3 m

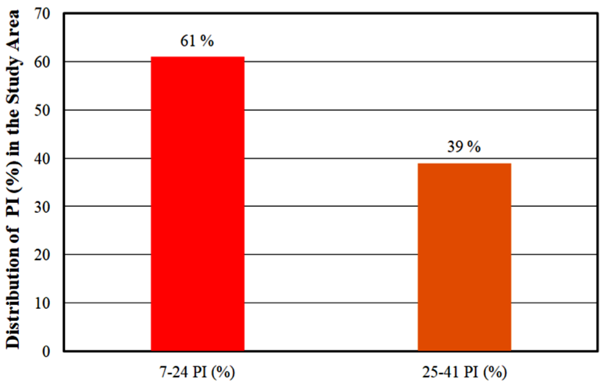

Figure 15. Comparison graph of PI values with respect to depth at 3 m

An examination of the Plasticity Index (PI) maps presented in Figures 14 and 15 shows that PI values mostly fall within the 7–24% range across a large portion of the study area, where low- to medium-plasticity clays are dominant. However, in the vicinity of Aşağıdemirtaş Village, PI values increase to the 25–41% range. Particularly at a depth of 3 m, these high PI values correspond to low bearing capacity, indicating that high-plasticity clays exhibit unfavorable engineering behavior.

When the spatial distributions of LL, PL, and PI are evaluated together, two distinct soil zones can be identified within the study area. The first zone consists mainly of low- to medium-plasticity clays and demonstrates relatively stable engineering behavior against variations in water content. The second zone is dominated by high-plasticity clays, characterized by high water sensitivity, significant swelling–shrinkage potential, and low bearing capacity. This finding indicates that soils with markedly different engineering properties coexist within the same study area, highlighting the necessity of soil zonation in geotechnical design.

Water Content and Groundwater Level Maps

In order to determine the variation of groundwater level with depth, the distribution of water content down to 20 m from the ground surface was examined, and a groundwater map was produced using these data. The evaluation revealed that groundwater is encountered from a depth of approximately 10 m, particularly in local areas between Gümüşkavak and Çatalçeşme neighborhoods and the vicinity between these neighborhoods and Fırat University. Overall, it was concluded that the study area does not have a rich groundwater potential.

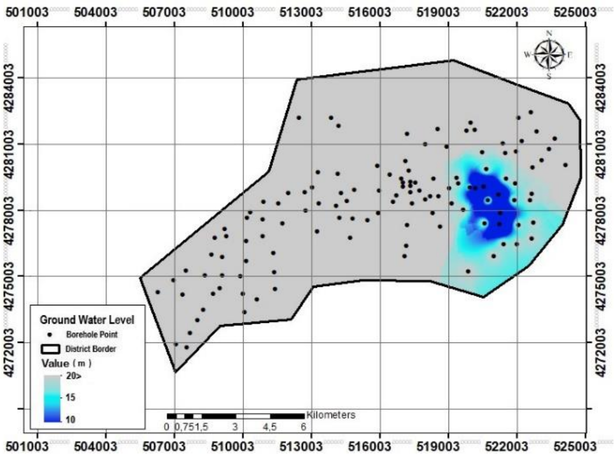

Figure 16. Groundwater level map of the study area

Water content distributions at different depths within the study area were evaluated, and the related maps are presented in Figures 17–22. At a depth of 1.5 m, water content is mostly in the range of 11–20% (52% of the total). Low values (0–10%) occur in the northeast and southwest, while higher values (21–44%) are observed around Sarıçubuk, Yemişlik, Gümüşkavak, and the prison area. At a depth of 3 m, water content exhibits a wider distribution, with the 11–20% range being dominant (33%). Low values are observed along the Sugözü–Çatalçeşme axis, whereas higher values are mainly concentrated around Örençay. At depths of 4.5 m and 7.5 m, water content is again predominantly within the 11–20% range. In general, water content is concentrated between 0–20%, while values of 21–44% occur in some parts of Sugözü, Yemişlik, and Örençay. At a depth of 9 m, water content is still mostly within the 11–20% interval (46%), with high values locally identified around Örençay and its surroundings. At a depth of 15 m, water content is predominantly concentrated within the 11–20% range (64%), while higher values are limited to small, localized zones around Çatalçeşme, Sugözü, and Yemişlik.

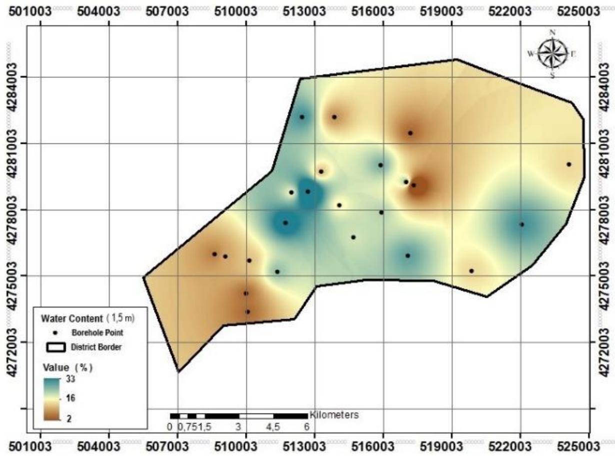

Figure 17. Water content (%) map for 1.5 m depth

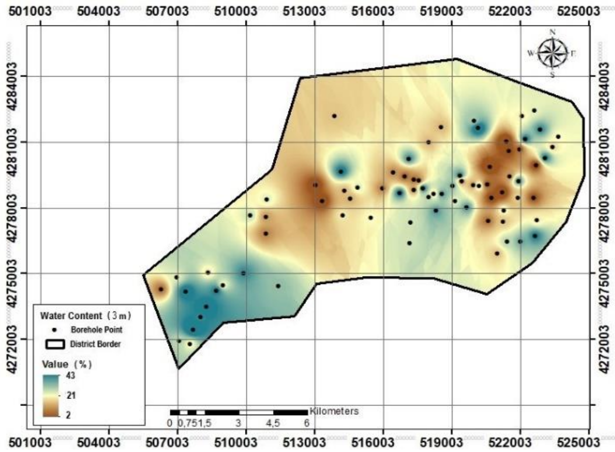

Figure 18. Water content (%)map for 3 m depth

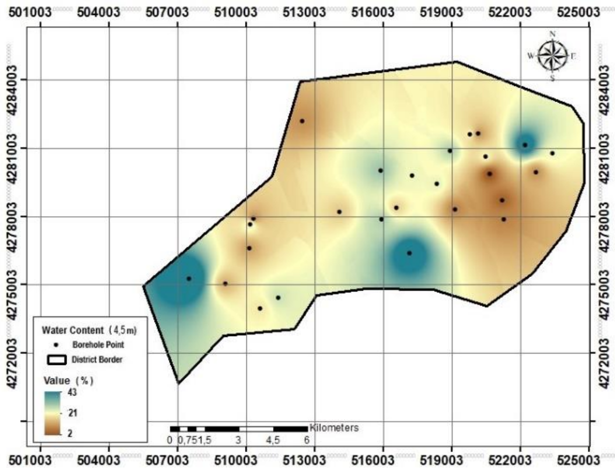

Figure 19. Water content (%) map for 4.5 m depth

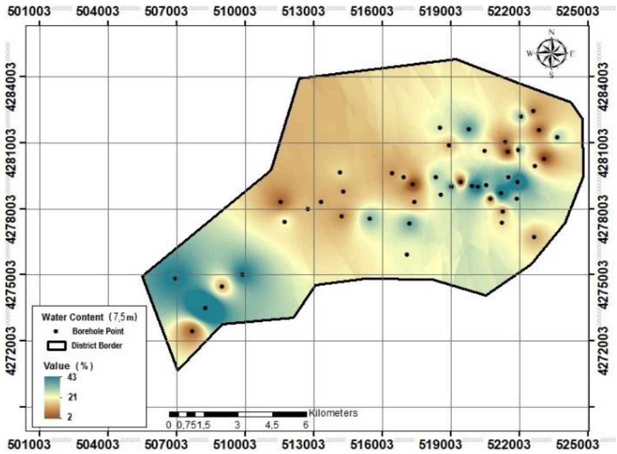

Figure 20. Water content (%) map for 7.5 m depth

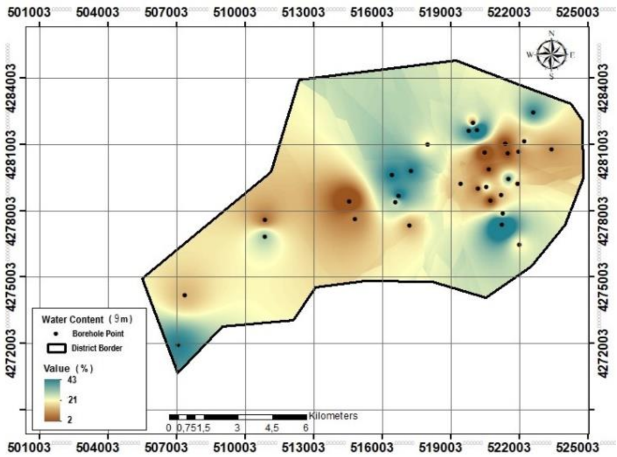

Figure 21. Water content (%) map for 9 m depth

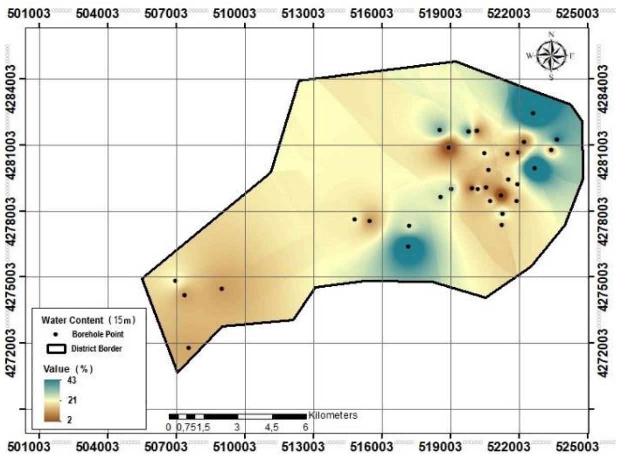

Figure 22. Water content (%) map for 15 m depth

A comparison of all depths, as shown in Figure 23, indicates that water content across the study area predominantly clusters within the 11–20% range. The maximum water content determined for all depths is 43%. This dominant 11–20% range may be associated with the presence of ML and SM soils, indicating relatively low degrees of saturation and partially drained soil conditions. These findings are also consistent with the groundwater level not being close to the surface and are in agreement with both the groundwater and USCS-based soil prediction maps.

The depth-dependent variation of water content reveals a relatively consistent hydrogeological behavior across the study area. The dominance of the 11–20% water content range at all investigated depths indicates generally low to moderate moisture conditions, suggesting partially drained soils and the absence of a shallow groundwater table. The limited occurrence of higher water content values (21–44%) in localized zones, particularly around Örençay, Sugözü, and Yemişlik, may be attributed to local lithological differences, finer-grained soil units, or reduced permeability conditions.

The increase in the proportion of the 11–20% range with depth, especially at 15 m, implies more uniform subsurface conditions and reduced influence of surface-related hydrological effects. From a geotechnical perspective, the predominance of this water content range is consistent with the widespread presence of ML and SM soil classes, which are characterized by moderate plasticity and relatively favorable drainage properties. This condition suggests generally acceptable bearing behavior; however, localized zones with higher water content may exhibit reduced shear strength and increased compressibility, which should be carefully considered in foundation design and ground improvement applications.

Overall, the water content distributions support the interpretation that the study area does not possess a rich groundwater potential, which is also compatible with the groundwater level and USCS-based soil prediction maps.

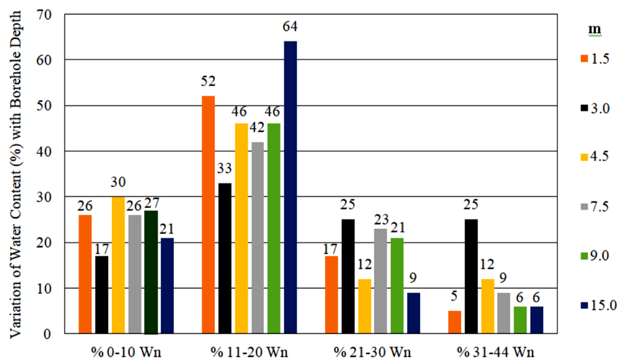

Figure 23. Comparison graph of water content (%) with respect to borehole depth

Discussion

The GIS-based analyses conducted using borehole data from the central district of Elazığ reveal pronounced lateral and vertical variability in soil properties. The USCS-based classification maps demonstrate that the subsurface structure does not follow a regular or systematic stratigraphic sequence with depth. Instead, the alternation of ML, GM, CL, MH, and SM soil classes indicates a heterogeneous depositional environment. Such heterogeneity is typical of tectonically active regions and has been widely reported in previous geotechnical and geological studies conducted in similar settings [24],[25].

At shallow depths (1.5–4.5 m), the dominance of ML, GM, and CL soil classes suggests the presence of fine-grained alluvial materials interlayered with granular soils, reflecting variable sedimentation conditions. At intermediate depths (7.5–9 m), the increased occurrence of GM together with MH indicates a higher proportion of silty and plastic fine-grained soils, which may be associated with lower-energy depositional phases and reduced drainage conditions. Similar depth-dependent variations in soil plasticity have been reported in GIS-based geotechnical studies of urban areas [33].

The Atterberg limit analyses provide important insight into the engineering behavior of the soils. The notably higher plasticity values observed at a depth of 3 m indicate the dominance of fine-grained soils with medium plasticity. The spatial coincidence of high plasticity indices with zones exhibiting reduced bearing capacity highlights the strong influence of plasticity on soil mechanical behavior. This relationship between plasticity characteristics and bearing performance is well documented in the literature and is particularly critical for shallow foundation design [33].

The evaluation of water content distributions shows that low to moderate moisture conditions (11–20%) dominate across all investigated depths. The limited detection of groundwater, generally below 10 m and only in a small number of boreholes, indicates that the study area does not possess a shallow or extensive groundwater system. This hydrogeological behavior is consistent with the observed soil classifications and supports the interpretation of partially drained subsurface conditions. Similar findings have been reported in regional-scale groundwater assessments based on borehole-derived GIS analyses [26].

Overall, the combined interpretation of USCS classification, Atterberg limits, water content, and groundwater conditions through GIS-based spatial mapping provides a comprehensive understanding of subsurface behavior. The pronounced spatial and depth-dependent variability emphasizes the necessity of site-specific geotechnical investigations, particularly in regions affected by active fault systems such as the East Anatolian Fault Zone.

5. Conclusions

- GIS-based spatial analyses were successfully performed using borehole data to evaluate USCS soil classification, Atterberg limits, water content, and groundwater level parameters for the central district of Elazığ.
- The results indicate pronounced lateral and depth-dependent variability in soil properties, confirming that the subsurface does not exhibit a regular stratigraphic transition with depth.
- ML, GM, and CL soil classes dominate at shallow depths (1.5–4.5 m), while GM and MH soils become prevalent at intermediate depths (7.5–9 m). At greater depths (15 m), ML, SM, and GM soils reappear as dominant units.
- Atterberg limit analyses reveal elevated plasticity values particularly at a depth of 3 m, which spatially coincide with zones of reduced bearing capacity, highlighting the strong influence of plasticity on soil mechanical behavior.
- Water content analyses show that the 11–20% interval is dominant across all investigated depths, while groundwater was detected only below approximately 10 m in a limited number of boreholes, indicating a generally low groundwater potential.
- The produced GIS-based maps provide a valuable decision-support tool for regional-scale urban planning, disaster risk reduction, and preliminary geotechnical assessment in an area affected by the East Anatolian Fault Zone.
- Nevertheless, it is emphasized that regional GIS-based evaluations cannot replace detailed site-specific in-situ and laboratory investigations required for safe and reliable geotechnical design.

Ethics committee approval and conflict of interest statement

There is no need to obtain permission from the ethics committee for the article prepared.

There is no conflict of interest with any person / institution in the article prepared.

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