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Detailed soil mapping and classification in semi-humid regions: A focus on Kahramanmaraş-Çağlayancerit

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Abstract

Soil classification studies are an integral part of soil survey and mapping activities. This study examines into soil classification within the context of soil survey and mapping efforts, providing crucial insights into the physical and chemical characteristics of soils in the area of Boylu village of Çağlayancerit district in Kahramanmaraş. The research area covers approximately 761 ha. The research identified eleven distinct soil series in the region. Based on soil taxonomy, five series are classified as Entisols, three as Vertisols, two as Inceptisols, and one as Alfisols. In addition, according to the World Reference Base for Soil Resources (WRB) classification system, the series comprises three Vertisols, two Calcisols, two Regosols, and two Cambisols, along with one Luvisol and one Fluvisol. The most extensive soil series in the area was Çamlık, encompassing 14.37% of the total study area. Following this series were the Bölükkamalak (10.25%), Merkyazısı (10.22%), and Körkuyu (9.96%) series. The smallest represented series was also Boylu, accounting for 2.12% of the area.

Introduction

Soil is a precious natural resource that takes thousands of years to form. Its conservation is crucial for future generations because it serves as the foundation that provides essential sustenance and habitat for living organisms (Soil Survey Staff, 2022). Recent scientific research indicates that soil faces threats from pollution (Varol, 2020; Akbay et al., 2023; Yılmaz, 2023), erosion (Aytop and Pınar, 2024), and overuse (Bhattacharyya et al., 2023) particularly when land is exploited beyond its ecological capacity. For instance, transforming productive agricultural land into industrial or residential areas results in a significant loss of high-quality soil. To address these issues, it is important to understand land characteristics, by implementing classification systems based on detailed soil surveys and mapping studies, which are vital for sustainable land management (Dengiz, 2011; Şenol et al., 2015). Soil survey and mapping are the methods used to classify soils and determine their characteristics. As a result of these studies, detailed soil maps are produced (Soil Survey Staff, 2022).

Soil maps are generated through comprehensive soil survey and mapping research studies, forming an essential foundation for scientific analyses in soil science. Soil maps offer vital insights into land characteristics such as soil depth, stoniness, slope,

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salinity, and texture. With advancements in modern soil science, the data depicted in these maps has become increasingly detailed. Throughout history and today, soil maps have played a crucial role across various sectors, including agriculture (Aytop and Şenol, 2022; Saygın and Dengiz, 2023; Gozukara et al., 2024), industry (Chumaidiyah et al., 2023), environmental regulation (AbdelRahman et al., 2022), taxation (Weiers and Reid, 1974), and military planning (Rose and Clatworthy, 2024).

Soil maps serve as essential tools in agricultural sciences, offering crucial data that sustain land evaluation studies. The outcomes of such evaluations play a significant role in informing the development of agricultural land use planning, thereby mitigating the risk of overexploiting land resources and ensuring sustainable management (Aytop and Şenol, 2022).

The soil survey and mapping project encompasses various phases, including office works, field investigations, laboratory analyses, and soil classification processes (Şenol et al., 2015). Soil classification entails a comprehensive assessment of the physical, chemical, biological, and morphological properties of soils to systematically categorize them. These classification frameworks are instrumental in producing detailed soil maps (Soil Survey Staff, 2022). Numerous nations have developed their own soil classification systems; notably, the Soil Taxonomy developed by the United States Department of Agriculture (Soil Survey Staff, 2022) and the World Reference Base (WRB) established by the Food and Agriculture Organization of the United Nations (FAO) are among the most widely adopted systems.

During the soil survey and mapping process, the most useful tool is Geographic Information System (GIS). GIS are extensively utilized in soil survey and mapping endeavors within the academic sphere (Saleh et al., 2023). These systems markedly enhance the digitization of various cartographic elements, including slope, elevation, and topography, thereby supporting rigorous scientific analysis (Saygın and Dengiz, 2023). Furthermore, GIS technologies are instrumental in precisely delineating the boundaries of soil series and mapping units, contributing to the advancement of soil science research (Aytop and Şenol, 2022).

The current study aims to characterize the fundamental physical, chemical, and morphological properties of soils within an approximately 761-hectare agricultural area situated in Boylu village, Çağlayancerit district, Kahramanmaraş Province, located at semi-

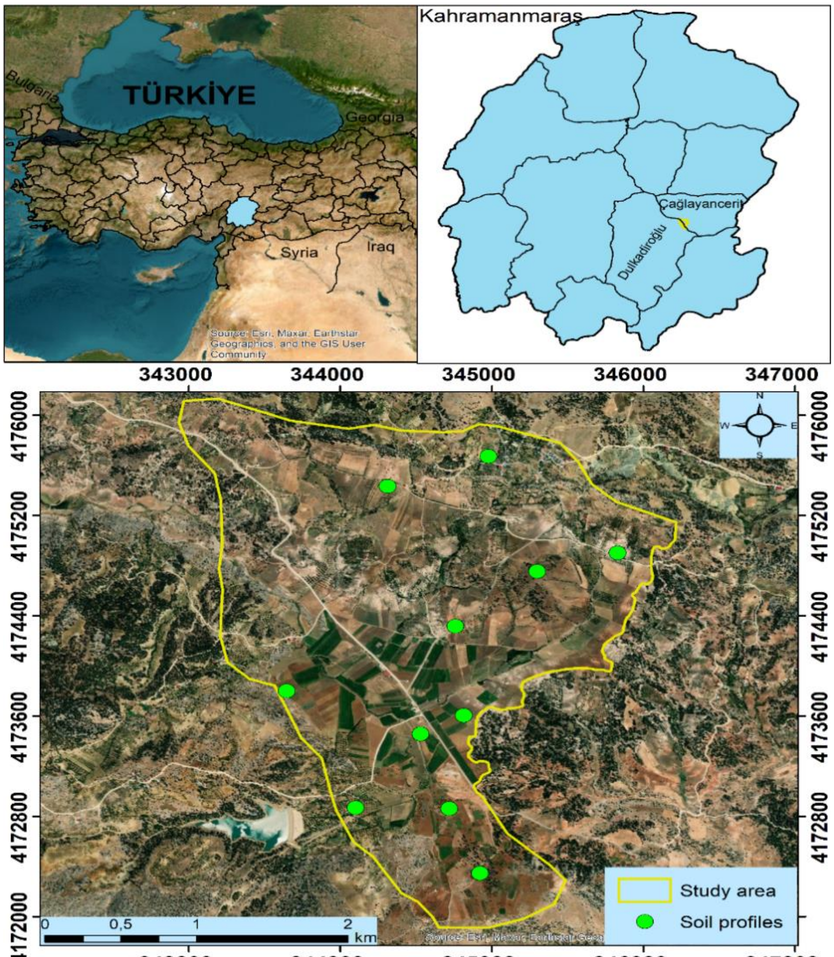

Figure 1. Spatial distribution map of the study area showing its geographic location and the defined soil profile sites

humid environmental region, and to classify these soils utilizing GIS.

Materials and Methods

Materials

The study area is situated between 37°41′ and 37°43′ North latitudes and 37°12′ and 37°16′ East longitudes, within the district of Çağlayancerit in Kahramanmaraş Province. The southwestern part of the study area is bordered by Dulkadiroğlu District. The area of the study area is 760.57 ha.

The Çağlayancerit district exhibits a climate characterized by high temperatures and aridity during the summer months, accompanied by severe cold and substantial rainfall in winter. The region's mean annual rainfall is recorded at 744.1 mm, with an average annual temperature of 13.6 °C. In the summer, temperatures can surpass 40°C (Anonymous, 2019). the soil temperature and moisture regimes were classified as mesic and xeric. The research site's elevation varies from 1393 to 1652 metres above sea level (Figure 2). The Boylu neighborhood, located in the northern part of the region, is situated at a higher elevation. Conversely, the southern areas have an average elevation of approximately 1400 m. Consistent with the elevation data, the slope map indicates that northern areas are characterized by steeper slopes, with a gradual decrease in slope steepness toward the south (Figure 2). Annual crops are cultivated in the central zones where the terrain is flat, whereas walnut trees are grown on steeper slopes at higher elevations. Additionally, there are forested areas in the southern part of the study area (Figure 1).

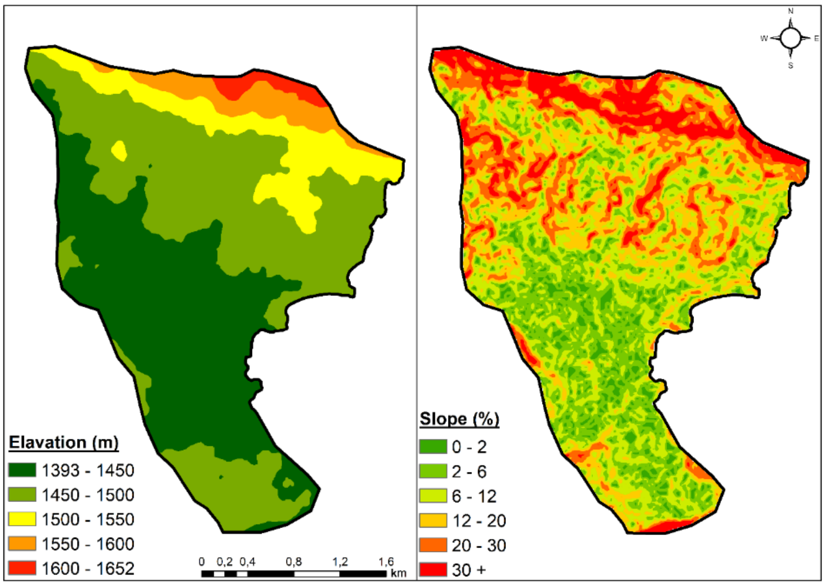

Figure 2. Slope and elevation map of the study area

Methods

First, preliminary information about the study area was collected, including the acquisition of a DEM map (Anonymous, 2025), a geological map, Google Earth imagery, and topographic maps. Temporary soil boundaries within the study area were delineated using Google Earth imagery from various years and supplementary sources. Subsequently, location points for profile pits were identified and examined in the field, with soil samples collected from the profiles based on horizon principles. The profile pits were excavated using an excavator. The morphological properties of soils were identified based on Soil Survey Staff (2022). A 10% HCl solution, a tape measure, and the Munsell colour chart were employed to assess the morphological characteristics of the soils (Dinç and Şenol, 2001). Following laboratory analyses, the second field survey was conducted, and the soil boundaries were finalized. While establishing soil boundaries, terrain features—including stoniness, color, texture, lime content, and slope—were carefully considered.

Table 1. Results of morphological, physical analyses and chemical of the soil series

Horizon	Depth (cm)	Soil Colour (Dry-moist)	$CaCO_3$ (%)	Texture			
				Clay (%)	Silt (%)	Sand (%)	Class
			Beşenli				
Ap	0-19	5YR 6/6 5YR 4/6	28.33	23.38	52.75	23.87	SiL
A2	19-50	5YR 5/6 5YR 4/6	27.74	29.71	37.98	32.31	CL
Ck1	50-71	5YR 6/4 5YR 4/4	32.51	20.09	51.99	27.92	SiL
Ck2	71-100	5YR 7/4 5YR 4/4	36.76	19.16	54.86	25.98	SiL
			Boylu				
Ap	0-30	10YR 5/4 10YR 4/4	0.82	46.59	27.43	25.98	C
ACss	30-60	10YR 5/6 10YR 4/6	0.86	55.03	23.21	21.76	C
C1ss	60-80	10YR 6/6 10YR 4/6	0.15	50.81	23.21	25.98	C
C2	80-102	7.5 YR 7/4 7.5YR 6/4	1.28	40.30	10.93	48.77	SC
2C	102-112	7.5YR 6/4 7.5YR 5/6	3.50	23.38	32.71	43.91	L
			Bölükkamalak				
Ap	0-19	10YR 7/2 10YR 5/3	24.24	23.38	37.98	38.64	L
A2	19-32	10YR 7/2 10YR 4/3	31.26	25.49	43.26	31.25	L
C	32-74	10YR 7/1 10YR 7/2	36.34	19.16	44.31	36.53	L
Crk	74-150	10YR 7/1 10YR 7/2	38.73	14.94	37.98	47.08	L
			Elmacıkderesi				
Ap	0-30	10YR 5/4 10YR 3/4	7.46	27.60	37.98	34.42	CL
A2	30-50	10YR 5/4 10YR 4/4	10.27	30.64	35.11	34.25	CL
2A	50-90	10YR 5/3 10YR 3/2	7.70	36.97	33.00	30.03	CL
2C	90-135	10YR 5/4 10YR 4/4	19.73	33.93	39.04	27.03	CL
			Epcingüney				
Ap	0-34	2.5Y 6/3 2.5Y 5/6	33.85	44.48	31.65	23.87	C
A2	34-54	2.5Y 6/2 2.5Y 3/2	31.71	49.46	27.73	22.81	C
C	54-100	2.5Y 7/3 2.5Y 6/6	37.20	47.35	30.89	21.76	C
			Hacıağalar				
Ap	0-30	7.5YR 4/4 7.5YR 3/4	0.75	51.57	26.67	21.76	C
A2ss	30-67	7.5YR 5/6 7.5YR 4/6	0.97	68.45	18.23	13.32	C
A3ss	67-93	7.5YR 6/4 7.5YR 5/6	0.97	68.45	16.12	15.43	C
C1	93-114	7.5YR 6/5 7.5YR 6/8	0.82	51.57	18.23	30.20	C
C2	114-169	7.5YR 6/4 7.5YR 6/8	0.86	55.79	16.12	28.09	C

			İnala				
A	0-19	7.5YR 4/4 7.5YR 3/4	0.89	32,58	33,00	34,42	CL
Bt1	19-45	5YR 4/6 2.5YR 3/6	0.89	68,45	18,23	13,32	C
Bt2	45-78	5YR 4/6 2.5YR 3/6	1.04	70,56	18,23	11,20	C
BC	78-103	5YR 4/6 2.5YR 4/6	0.98	68,45	16,12	15,43	C
C	103-135	7.5 YR 5/6 (moist)	1.34	72,67	7,68	19,65	C
			Körkuyu				
Ap	0-25	10YR 4/6 10YR 3/6	2.74	36.80	26.67	36.53	CL
BA	25-42	10YR 5/4 10YR 3/3	1.78	47.52	26.67	25.81	C
Bw	42-70/85	10YR 3/4 (moist)	2.23	50.69	25.62	23.70	C
			Küllucular				
Ap	0-32	7.5YR 6/6 7.5YR 4/4	17.66	26.42	26.67	46.91	SCL
Bw	32-67	7.5 YR 6/4 7.5YR 3/4	4.29	47.52	20.34	32.14	C
BC	67-90	7.5 YR 6/3 7.5YR 4/4	20.82	49.63	22.45	27.92	C
Ck	90-125	7.5YR 7/3 7.5YR 6/6	36.66	39.08	29.84	31.08	CL
			Merkyazısı				
Ap	0-22	10YR 4/4 10YR 3/4	0.89	43.30	24.56	32.14	C
Ad	22-45	10YR 5/3 10YR 3/4	0.74	45.41	21.40	33.19	C
Bss1	45-75	10YR 5/3 10YR 3/4	0.82	47.52	22.45	30.03	C
Bss2	75-117	10YR 5/3 10YR 3/4	0.74	49.63	23.51	26.86	C
BC	117-137	10 YR 7/4 10YR 5/4	18.22	32.75	29.84	37.41	CL
Ck	137-170	7.5YR 7/3 7.5YR 6/6	36.58	39.08	21.40	39.52	CL
			Çamlık				
A	0-22	10YR 4/2 10YR 2/2	1.81	20.93	38.74	40.32	SCL
AC	22-49	10YR 5/4 10YR 4/3	1.98	18.82	45.07	36.10	SCL
C1	49-90	10YR 6/4 10YR 5/4	1.82	25.53	29.92	44.55	SL
C2	90-116	5YR 5/6 (moist)	1.20	8.65	21.48	69.87	SL
2C1	116-141	5YR 5/4 (moist)	1.82	10.38	17.64	71.98	L
2C2	141-166	5YR 5/4 (moist)	1.51	27.26	19.75	52.99	L
2C3	166-189	5YR 5/8 (moist)	2.61	21.31	25.70	52.99	L

Additionally, horizon sequences were examined with a soil auger to verify soil layers, and the precise locations of soil boundaries were delineated. Additionally, the soils were classified according to both Soil Taxonomy and World Reference Base (WRB). The ArcGIS 10.7.1 (GIS) software was employed in the creation and digitization of the maps.

In disturbed soil samples, various analyses were conducted to determine key soil properties. These included texture assessment following Bouyoucos (1951), organic matter content as per Jackson (1979), $CaCO_3$ content measured with the Scheibler calcimeter according to Soil Survey Laboratory Staff (1992), exchangeable cations and cation exchange capacity (CEC) following Rhoades (1982), as well as soil pH and electrical conductivity (EC) measurements performed on saturation extracts.

Results and Discussion

Eleven soil series have been identified in the study area. These include two marine, four alluvial, two colluvial, one Palaeozoic sediment, one formed on crystalline limestone, and one resulting from mudflow. The Beşenli and Bölükkamalak series are formed on marine parent material. Marine fossils have been found in patches within these soils, suggesting that these areas may have once been shallow sea beds. These soils contain diagnostic horizons with high $CaCO_3$ content (Ck), as shown in Table 1. In two profiles, the soils are deep, non-saline, and exhibit pH levels exceeding 7.50. The Ap, Ck1, and Ck2 horizon order of the Beşenli series are classified within the silty loam (SiL) texture class, whereas the A2 horizon belongs to the clay loam (CL) class. All horizons of the Bölükkamalak series are categorized under the loamy (L) texture class. The soils of the Beşenli series display a 5YR colour according to the Munsell colour scale, while the horizons of the Bölükkamalak series exhibit a 10YR spectral color (Hue). The base saturation levels of both series exceed 80%. The amount of organic matter in all horizons of these two series is less than 2% and contains low organic matter (Table 2).

The Boylu, Elmacıkderesi, Çamlık and Hacıağalar series were developed on alluvial parent material. The slopes of areas formed on alluvial parent material are flat or nearly flat. The Boylu series includes low calcium carbonate content, with the exception of the 2C horizon, which exceeds 2%. In contrast, the Hacıağalar series is entirely free of $CaCO_3$ throughout its profile (less than 1%). The Elmacıkderesi series exhibits moderately calcareous horizons with calcium carbonate content below 11%, except for the 2C horizon. Texture analysis indicates that all horizons of the Hacıağalar series are clayey, while those of the Elmacıkderesi series are clay loam. In the Boylu series, textures vary: Ap, ACss, and C1ss horizons are clayey; C2 is sandy clayey; and the 2C horizon is loamy. Soil colour readings show a consistent 10YR for the Boylu and Elmacıkderesi series, whereas the Hacıağalar series horizons are uniformly 7.5YR (refer to Table 1). The pH levels range from 5.05 to 6.65 in the Hacıağalar series, 6.32 to 7.42 in the Boylu series, and 7.64 to 7.76 in the Elmacıkderesi series, with higher $CaCO_3$ content likely contributing to the slightly alkaline pH of the latter due to calcium's role in increasing soil pH. Notably, the organic matter in the Ap horizons exceeds two across all series, whereas it is lower in other horizons. Base saturation values are 78-83% for Boylu, 90-95% for Elmacıkderesi, and 58-90% for Hacıağalar. The Hacıağalar series, characterized by consistently clay-textured horizons, exhibits higher CEC values than the other two series. All three soil series are non-saline (see Table 2). The Çamlık series features various textured horizons: the A and AC horizons are sandy clay loam, the C1 and C2 horizons are sandy loam, and the 2C1, 2C2, and 2C3 horizons are loam. Notably, the CaCO3 content is generally below 2%, except for the 2C3 horizon, which contains 2.61% CaCO3. The A horizon of the Çamlık series, located in a forested area, exhibited a notably higher organic matter content at 13.30%, with its sub-horizon, AC, containing 5.11%. Organic matter content tends to decline in sub-horizons. The Çamlık series has demonstrated neutral to slightly acidic pH levels and is non-saline. The base saturation values for horizons within the Çamlık series ranged from 79% to 91% (refer to Table 1;2).

In this research, the parent material of two soil series was classified as colluvial. Colluvial parent material refers to material that has been transported downslope from sloping terrain predominantly through the action of water or wind (Leopold and Völkel 2007; Kühn, 2025). Epcingüney and Küllucular are soil series formed on colluvial parent material. The Epcingüney series is characterized by uniformly clayey horizons throughout, with a high $CaCO_3$ content ranging from 31.71% to 37.20%. In contrast, the Küllucular series exhibits variable $CaCO_3$ content between 4.29% and 36.66% and includes a Ck horizon. The organic matter content in the Küllucular series exceeded 1% in the upper two horizons but fell below 1% in the BC and Ck horizons. In the Epcingüney series, the Ap and A2 horizons contained 2.70% and 2.18% organic matter, respectively, while the C horizon had 0.78%.

The pH levels across all horizons in the Küllucular and Epcingüney series were slightly alkaline. Both series are characterized by non-saline soils. In the Epcingüney series, the Ap, A2, and C horizons had base saturations of 95%, 94%, and 96%, respectively. For the Küllucular series, the Ap horizon's base saturation was 92%, with the Bw at 88%, BC at 90%, and Ck at 97% (Table 2).

The parent material of the Merkyazısı series is mudflow. It has the Ap, Ad, Bss_1, Bss_2, AC, and Ck horizons. The lower two horizons have a silty loam texture, whereas the other horizons are clay-textured.

Table 2. Results of some chemical analyses of the series

Horizon	Organic Matter (%)	pH	EC (dS/m)	Base Saturation (%)	CEC (me/100g)	Exchangeable cations (me/100g)			
						Ca^{++}	Mg^{++}	K^{+}	Na^{+}
Beşenli									
Ap	1.18	7.50	0.68	94	31.18	17.05	7.47	4.01	0.92
A2	1.01	7.66	0.69	99	31.24	19.60	6.06	4.64	0.79
Ck1	0.29	7.69	0.62	96	29.10	17.85	5.30	3.91	0.92
Ck2	0.45	7.83	0.46	99	26.79	15.91	5.13	4.40	1.20
Boylu									
Ap	2.49	6.93	0.75	81	29.67	13.61	4.42	4.47	1.52
ACss	1.03	6.56	0.68	78	33.85	14.32	5.66	4.74	1.70
C1ss	0.85	6.32	0.70	78	34.07	15.30	6.97	3.34	1.13
C2	0.54	6.92	0.73	82	32.17	13.79	6.06	4.79	1.72
2C	0.51	7.42	1.00	83	39.09	19.19	5.76	6.15	1.46
Bölükkamalak									
Ap	1.82	7.53	0.45	93	30.30	15.73	6.01	5.42	1.13
A2	1.79	7.65	0.52	88	32.66	16.77	6.46	4.65	0.87
C	1.06	7.90	0.47	83	29.33	15.96	4.44	2.89	0.93
Crk	0.39	8.01	0.44	98	26.93	17.05	5.66	3.00	0.80
Elmacıkderesi									
Ap	2.32	7.70	0.72	90	22.95	11.06	5.15	3.94	0.56
A2	1.26	7.72	0.67	91	33.56	14.84	8.66	6.22	0.98
2A	1.99	7.64	0.60	93	30.74	14.93	6.85	5.62	1.22
2C	1.15	7.76	0.58	95	38.10	17.41	9.84	7.67	1.13
Epcingüney									
Ap	2.70	7.59	0.71	95	34.02	16.92	8.59	5.49	1.26
A2	2.18	7.63	0.85	94	33.00	17.58	7.47	4.65	1.32
C	0.78	7.86	0.46	96	46.44	27.39	10.64	4.89	1.51
Hacıağalar									
Ap	2.46	6.65	0.60	60	43.48	14.55	5.05	5.39	1.00
A2ss	0.79	5.70	0.41	58	58.74	19.60	7.27	5.74	1.41
A3ss	0.66	5.14	0.59	77	49.07	18.59	9.49	7.52	2.05
C1	0.32	5.05	0.47	90	38.67	17.58	7.27	7.67	2.18
C2	0.75	5.69	0.40	83	33.75	12.73	7.27	5.98	1.97
İnala									
A	2.56	6.56	0.41	74	32.06	12.32	6.06	4.52	0.84
Bt1	1.57	6.35	0.30	46	46.68	8.89	6.26	5.48	0.87
Bt2	1.33	5.81	0.21	42	43.55	8.89	4.24	4.13	0.83
BC	1.19	5.57	0.17	58	38.43	8.48	7.27	5.37	1.01
C	0.42	5.20	0.19	84	28.17	10.71	7.07	4.86	1.09
Körkuyu									
Ap	1.36	7.70	0.78	90	37.77	18.99	8.48	5.30	1.07
BA	1.15	7.61	0.76	85	37.33	16.26	8.48	5.88	1.23
Bw	0.98	7.58	0.84	98	36.04	16.57	13.54	4.17	1.07
Küllucular									
Ap	1.50	7.67	0.74	92	43.02	20.70	10.32	7.23	1.14
Bw	1.40	7.55	0.85	88	45.00	20.18	11.10	7.44	0.96
BC	0.52	7.60	0.82	90	38.94	19.09	9.55	5.30	0.93
Ck	0.42	7.73	0.48	97	39.31	20.45	10.45	6.67	0.71
Merkyazısı									
Ap	1.53	6.73	1.31	66	33.92	11.11	5.86	4.18	1.28
Ad	1.61	6.67	0.72	71	33.16	12.32	6.87	3.43	1.05
Bss1	1.03	6.77	0.73	64	40.18	12.73	8.28	3.24	1.32
Bss2	0.96	7.54	0.81	82	41.58	14.89	11.10	5.84	2.23
BC	0.18	7.52	0.73	94	32.50	14.39	8.84	5.07	2.19
Ck	0.21	7.75	0.61	99	33.38	13.64	10.61	6.29	2.67

				Çamlık					
A	13.30	6.60	0.75	91	34.29	13.26	10.61	6.45	0.96
AC	5.11	6.56	0.76	83	29.75	9.85	8.79	5.29	0.82
C1	2.60	6.18	0.47	79	38.36	17.55	7.68	2.90	2.19
C2	0.48	6.42	0.63	85	23.12	8.08	6.06	4.16	1.38
2C1	0.35	6.27	0.72	89	27.43	12.37	6.94	3.48	1.50
2C2	0.09	6.28	0.70	87	24.79	11.74	6.57	1.75	1.43
2C3	0.24	7.23	1.00	84	26.35	10.98	6.57	3.18	1.29

The bottom horizon displays a 7.5YR hue, while the others show 10YR. The $CaCO_3$ content of the upper four horizons is below 1%, with the AC horizon containing 18.22% and the Ck horizon 36.58%. The pH values of the Ap, Ad, and A3ss horizons are 6.73, 6.67, and 6.77, respectively. The pH values of the remaining horizons range from 7.52 to 7.75. Base saturation varies between 64% and 99%.

The Körkuyu series is developed on a parent material of hard crystalline limestone. Although the Ap and Bw horizons exhibit slight calcareous properties, the BA horizon lacks calcium carbonate entirely, suggesting leaching of calcium carbonate in these soils. The upper horizon possesses a clay loam texture, whereas the underlying horizons are characterized by a clay texture. Soil color is classified as 10YR according to Table 1. Organic matter content across the series is low to very low. The pH levels are slightly alkaline in all horizons, and the soils are non-saline. Base saturation ranges from 85% to 98%. The CEC values for the series range between 36.04 and 37.77 me/100g, as detailed in Table 2.

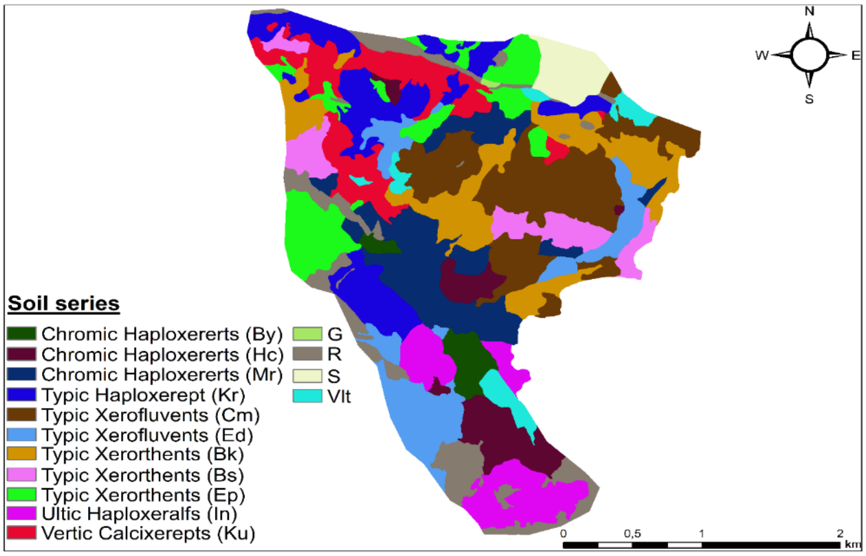

Figure 3. Spatial distribution map of soil series and other land use types

Table 3. Spatial distribution ratios of soil series and other land use types

Soil series and other land use types	Area (ha)	Ratio (%)
Bölükkamalak (Bk)	77.93	10.25
Beşenli (Bs)	36.51	4.80
Boylu (By)	16.13	2.12
Çamlık (Cm)	10.32	14.37
Elmacıkderesi (Ed)	60.68	7.98
Epcingüney (Ep)	58.62	7.71
Hacıağalar (Hc)	40.17	5.28
İnala (In)	50.54	6.64
Körkuyu (Kr)	75.73	9.96
Küllucular (Ku)	61.54	8.09
Merkyazısı (Mr)	77.70	10.22
Rocky (R)	56.68	7.45
Various land types (Vlt)	17.81	2.34
Settlement (S)	20.62	2.71
Graveyard (G)	0.60	0.08
Total	760.57	100.00

The Inala series comprises deep soils developed on Paleozoic sedimentary parent material. These soils possess Bt horizons with clay illuviation. While the Ap horizon has a CL texture, the other horizons have a clay texture. The profile is predominantly characterized by a red hue, and the soils are non-calcareous (see Table 1). The organic matter content is 2.56% in the surface horizon, decreasing progressively toward the lower horizons. The soil series displays a pH range from neutral to strongly acidic, with no evidence of salinity. Base saturation varies between 42% and 84% throughout the soil profile. Notably, the highest cation exchange capacity (CEC) is found in the Bt1 and Bt2 horizons, where clay illuviation is present (refer to Table 2).

Spatial distribution of soil series in the study area

The distribution of the soil series within the study area is shown in Figure 3, and their coverage within the total area is presented in Table 3. The predominant soil series within the study area is Çamlık, encompassing 109.32 hectares. Following in order of area coverage are Bölükkamalak (77.93 ha), Merkyazısı (77.70 ha), Körkuyu (9.96 ha), Küllucular (8.09 ha), Elmacıkderesi (7.98 ha), Epcingüney (7.71 ha), İnala (6.64 ha), Hacıağalar (5.28 ha), Beşenli (4.80 ha), and Boylu (2.12 ha). Additionally, rocky terrains constitute 7.45% of the total landscape. Land types such as built-up areas, settlements, and cemeteries account for 2.34%, 2.71%, and 0.08% of the total area, respectively (Table 3).

Classification of the study area soils

The soils within the study area have been classified following the standards of Soil Taxonomy and the World Reference Base for Soil Resources (WRB, 2015). Specifically, the Beşenli, Bölükkamalak, Elmacıkderesi, Epcingüney, and Çamlık soil series are categorized under the Entisols in Soil Taxonomy, reflecting their young geological age and absence of B horizons. As a suborder, the Elmacıkderesi and Çamlık series have been classified as Fluvent due to their alluvial parent material, while the other series have been classified as Orthents. The classification is further refined based on soil moisture regime: given the xeric conditions of the study area, the Elmacıkderesi and Çamlık series are classified as Xerofluvents within the great group, while the other series are designated as Xerorthents. The sub-groups of these series were determined as Typic Xerorthents and Typic Xerorthents (Table 4). According to WRB standards, the Beşenli and Bölükkamalak series are classified as Haplic Calcisol, the Elmacıkderesi and Çamlık series as Eutric Fluvisol, and the Epcingüney series as Eutric Regosol (Table 4).

The Körkuyu and Küllucular soil series are categorized as Inceptisols due to the presence of a Bw horizon and observable profile development, distinguishing them from series classified within the Entisols. Additionally, these series are designated as Xerepts as a suborder, reflecting their soil moisture regime. The Küllücüler series has been classified as Calcixerepts because of the presence of the Ck horizon, while the Körkuyu series is classified as Typical Haploxerepts. The appearance of weak, shiny slip surfaces in the subhorizons of the Küllucular series leads to its classification as Vertic Calcixerepts within this subgroup. Conversely, the Körkuyu series remains classified as Typic Haploxerepts. According to WRB, the Körkuyu and Küllucular series were classified as Eutric Cambisol due to the presence of a Cambic horizon (Table 4).

Table 4. Classification of soils in the study area

Soil Series	Soil Taxonomy (2022)				WRB (2015)
	Orders	Suborders	Great Group	Subgroups	
Beşenli	Entisol	Orthent	Xerorthents	Typic Xerorthents	Haplic Calcisol
Bölükkamalak					Haplic Calcisol
Epcingüney					Eutric Regosol
Elmacıkderesi	Entisol	Fluvents	Xerofluvents	Typic Xerofluvents	Eutric Fluvisol
Çamlık					
Körkuyu	Inceptisol	Xerepts	Haploxerepts	Typic Haploxerepts	Eutric Cambisol
Küllucular			Calcixerepts	Vertic Calcixerepts	
Boylu	Vertisol	Xererts	Haploxererts	Chromic Haploxererts	Chromic Vertisol
Hacıağalar					Chromic Vertisol
Merkyazısı					Calcic Vertisol
İnala	Alfisol	Xeralfs	Haploxeralfs	Ultic Haploxeralfs	Chromic Luvisols

The Boylu, Hacıağalar, and Merkyazısı series are classified within the Vertisols in the taxonomy owing to their high clay content and prominent slickensides. According to the classification system, these series belong to the same class, suborder (Xererts), great group (Haploxererts), and subgroup (Chromic Haploxererts). Under the WRB system, they are classified as Chromic Vertisols, characterized by their vertical structure and reddish colouration (Table 4).

The Inala series is classified within the Alfisols, characterized by the presence of an argillic horizon and a base saturation exceeding 35%. As a suborder, it is designated as Xeralfs, reflecting its xeric soil regime. At the great group level, it classified Haploxeralfs. Specifically, the Inala series is further classified as Ultic Haploxeralfs, a subgroup distinguished by a base saturation of less than 75% within the upper 75 cm of the soil profile. This series was classified as Chromic Luvisols according to the WRB (2015) (Table 4).

Conclusions

This study provides an in-depth assessment and classification of soils within the 761-hectare research region, identifying eleven distinct soil series developed on various parent materials, including marine, alluvial, colluvial, limestone, Paleozoic sediments, and mudflow deposits. The findings clearly indicate that parent material and landscape position significantly influence soil morphology, texture, carbonate accumulation, organic matter content, and pH levels. Marine-derived soils exhibit high $CaCO_3$ contents and low organic matter, whereas alluvial soils display a wide range of textures and higher organic matter concentrations in surface horizons. Colluvial soils are characterized by elevated clay content and increased carbonate levels, with processes of carbonate accumulation and leaching affecting soil fertility and stability. Soils originating from Paleozoic and limestone parent materials show more advanced profile development, including clay illuviation and evidence of carbonate leaching, which are essential for understanding soil resilience and land use suitability. Spatial analysis indicates that the Çamlık series is the most prevalent in the area, while the Boylu series is the least extensive, highlighting the heterogeneous distribution of soil-forming environments. Based on classification, five soil series are categorized as Entisols, three as Vertisols, two as Inceptisols, and one as Alfisols under Soil Taxonomy. Additionally, the World Reference Base (WRB) identifies Calcisols, Regosols, Cambisols, Fluvisols, Vertisols, and a Chromic Luvisol. These results underscore the complexity of pedogenic processes operating under the region's xeric moisture regime, emphasizing the coexistence of both weakly and strongly developed soils within a relatively small spatial extent.

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Author Contributions

H.A.: Soil survey studies, soil sampling, data analysis, interpretation, conceptualisation, investigation, writing, reviewing and editing. **C.H.Y.:** Soil survey studies, soil sampling and writing. **Y.K.K.:** Soil survey studies, soil sampling, writing, reviewing and editing. **R.S.:** Soil survey studies, soil sampling and writing. **S.Ş.:** Soil survey studies, soil sampling, writing, reviewing and editing. **O.D.:** Writing, reviewing and editing.

Conflict of Interest

The authors declare that they have no known conflicts of interest, whether financial, non-financial, professional, or personal, that could influence the work reported in this article.

References

AbdelRahman, M. A., Farg, E., Saleh, A. M., Sayed, M., Abutaleb, K., Arafat, S. M., & Elsharkawy, M. M. (2022). Mapping of soils and land-related environmental attributes in modern agriculture systems using geomatics. *Sustainable Water Resources Management,* 8(4), 116. https://doi.org/10.1007/s40899-022-00704-2

Akbay, C., Aytop, H., & Dikici, H. (2023). Evaluation of radioactive and heavy metal pollution in agricultural soil surrounding the lignite-fired thermal power plant using pollution indices. *International Journal of Environmental Health Research*, 33(12), 1490-1501. https://doi.org/10.1080/09603123.2022.2102157

Anonymous, (2025). DEM data for the study area. Retrieved August 14, 2025, from https://search.asf.alaska.edu

Anonymous, (2019). Seasonal normals for the provinces. Retrieved April 15, 2019, from https://www.mgm.gov.tr

Aytop, H., & Pınar, M. Ö. (2024). Evaluation of agricultural productivity loss of vineyards through water erosion in Türkiye. *Applied Fruit Science*, 66(2), 667-676. https://doi.org/10.1007/s10341-024-01035-6

Aytop, H., & Şenol, S. (2022). Farklı Ana Materyaller Üzerinde Oluşmuş Mikail Çayı Mikro Havzası Toprakları. *Turkish Journal of Agricultural and Natural Sciences*, 9(1), 85-96. https://doi.org/10.30910/turkjans.1014874

Bhattacharyya, R., Bhatia, A., Ghosh, B. N., Santra, P., Mandal, D., Kumar, G., ... & Chaudhari, S. K. (2023). Soil degradation and mitigation in agricultural lands in the Indian Anthropocene. *European Journal of Soil Science*, 74(4), e13388. https://doi.org/10.1111/ejss.13388

Bouyoucos, G.J. (1951). A Recalibration of the hydrometer method for making mechanical analysis of soils. *Agronomy Journal*, 43(9), 434-438.

Chumaidiyah, E., Dewantoro, M. D. R., Fauzi, P. M., & Kamil, A. A. (2023). Selection of industrial sites using a WEB-based geographical information system to minimize risks: A case study in West Java, Indonesia. *Sustainability*, 15(22), 16034. https://doi.org/10.3390/su152216034

Dengiz, O. (2011). Samsun ilinin potansiyel tarım alanlarının genel dağılımları ve toprak etüd ve haritalama çalışmalarının önemi. *Anadolu Tarım Bilimleri Dergisi*, 26(3), 241-250.

Dinç, U., Şenol, S. (2001). Toprak Etüd ve Haritalama, Ç.Ü. Ziraat Fakültesi Genel Yay, 161.

Gozukara, G., Hartemink, A. E., Zhang, Y., Huang, J., & Dengiz, O. (2024). Soil evolution following the shrinking of Burdur Lake in Türkiye. *Catena*, 237, 107824. https://doi.org/10.1016/j.catena.2024.107824

Jackson, M.L. (1979). Soil Chemical AnalysisAdvanced Course. 2nd Ed, 11th Printing. Published by The Author, Madison.

Kühn, P. (2025). "Understanding Colluvial Deposits." *Catena* 254: 108963. https://doi.org/10.1016/j.catena.2025.

Leopold, M., & Völkel, J. (2007). Colluvium: Definition, differentiation, and possible suitability for reconstructing Holocene climate data. *Quaternary International*, 162, 133-140.

Rhoades, J. (1982). Cation Exchange Capacity, Methods of Soil Analysis. Part 2. Chemical and Microbiological Properties (Methodsofsoilan2), 149-157.

Rose, E. P., & Clatworthy, J. C. (2024). Mud and blood in the final months of World War II:soil maps of north-west Germany that helped to guide British and Canadian Military Operations in Early 1945. *The Cartographic Journal*, 61(1), 27-48. https://doi.org/10.1080/00087041.2024.2376375

Saleh, T. M., Jubeir, A. R., & Al-Tememe, M. S. O. (2023). The Role of Geographic Information Systems (GIS) in Soil Surveying and Classification. In IOP Conference Series: Earth and Environmental Science 1158(2), 022028. IOP Publishing. https://doi.org/10.1088/1755-1315/1158/2/022028

Saygın, F., & Dengiz, O. (2023). Detailed soil mapping and classification study for sustainable agricultural land management; Samsun-Vezirköprü example. *Soil Studies*, 12(1), 40-53. https://doi.org/10.21657/soilst.1328981

Soil Survey Lab. Staff. (1992). Soil Survey Laboratory Methods Manual, USDA- SCS- NSSC, 42.

Soil Survey Staff, (2022). Keys to Soil Taxonomy. 13th Edition, USDA-Natural Resources Conservation Service, Washington D.C.

Şenol, S., Küsek, G., Sarı, M., & Kurucu, Y. (Eds.). (2015). Toprak etüt haritalama el kitabı. Tarım Reformu Genel Müdürlüğü, Tarım Arazileri Değerlendirme Dairesi Başkanlığı. Ankara.

Weiers, C. J., & Reid, I. G. (1974). Soil Classification, Land Valuation and Taxation: The German Experience. Centre for European Agricultural Studies, Wye College (University of London).

WRB, (2015). World reference Base for Soil Resources 2014, update 2015. International Soil Classification System for Naming Soils and Creating Legends for Soil Maps. Worls Soil Resources Reports No. 106. FAO, Rome.

Varol, M., Sünbül, M. R., Aytop, H., & Yılmaz, C. H. (2020). Environmental, ecological and health risks of trace elements, and their sources in soils of Harran Plain, Turkey. *Chemosphere*, 245, 125592. https://doi.org/10.1016/j.chemosphere.2019.125592

Yılmaz, C. H. (2023). Heavy metals and their sources, potential pollution situations and health risks for residents in Adıyaman province agricultural lands, Türkiye. *Environmental geochemistry and health*, 45(6), 3521-3539. https://doi.org/10.1007/s10653-022-01423-5