RESEARCH ARTICLE

International Journal of Agriculture, Environment and Food Sciences 2023; 7(1): 223-233
DOI: https://doi.org/10.31015/jaefs.2023.1.27

Evaluation of database and some soil characteristic of Kumkale Agricultural Enterprise soils in GIS

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Abstract

General Directorate of Agricultural Enterprises (GDAE), which has been operating since 1994, is a state institution whose aim is to protect the gene resources as well as the production of seeds, breeding and raw materials for agriculture and agriculture-based industry. There are more than 30 agricultural enterprises established for similar purposes in Türkiye. One of these enterprises is Kumkale Agricultural Enterprise (KAE) located within the borders of Çanakkale province. The aim of this study is to reveal the current potentials of KAE lands, for which detailed studies have been made before, to create a database in Geographic Information System (GIS) and to produce various thematic maps. In this study, important soil characteristics such as slope, soil depth, surface stones, drainage, as well as soil series and physiographic units included in the survey report were mapped and the areas covered were calculated in GIS. With the digitization has determined that the agricultural enterprises lands in question are spread over an area of 7309 decares in total. In terms of soil series, the highest distribution area belongs to Karabatak series (948.2 da), while Alluvial soils (3094.8 da) have the highest distribution area in terms of physiographic units. In addition, most of the lands consist of 0-2% slope (4478.9 da), deeper than 120 cm (5936.8 da), stone-free (5677.2 da) and without drainage problems. As a result, it will be useful to examine both the temporal and spatial changes of the lands of GDAE, which has a significant production capacity in Türkiye, to make new field studies and compare them with the old survey studies in terms of guiding future studies.

Keywords: Kumkale agricultural enterprise, GIS, Soil survey, Soil mapping, GDAE

Citation: Turgut, Y.S., Koca, Y.K. (2023). Evaluation of database and some soil characteristic of Kumkale Agricultural Enterprise soils in GIS. International Journal of Agriculture, Environment and Food Sciences, 7 (1), 223-233

Received: 24 November 2022
Revised: 01 January 2023
Accepted: 05 January 2023
Published Online: 27 March 2023

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INTRODUCTION

The General Directorate of Agricultural Enterprises (GDAE), whose purpose is to produce seeds, breeding stock and raw materials for agriculture and agriculture-based industry, and to protect gene resources, is an Economic State Entity. GDAE was established as a Public Economic Organization (PEO) with the merging of Stud Farms and State Farms under one roof in 1984, and was transformed into Economic State Enterprise (ESE) in 1994. The central organization of GDAE is the General Directorate, and the provincial organization is the business directorates. (Anonymous, 2019). GDAE had 37 business directorates spread over all geographical regions of Türkiye. Twenty of these enterprises have been rented for a long period of time with the decision taken. Seventeen of them continue to be operated within GDAE. One of GDAE's long-term rented enterprises is Kumkale Agricultural Enterprise (KAE). Detailed soil surveys of all GDAE enterprises in Türkiye, including the aforementioned enterprise soils, were

completed within the scope of a study conducted by Çukurova University Faculty of Agriculture, Department of Soil Science and Plant Nutrition (Anonymous, 1995). However, these study reports could not be transferred to the GIS environment due to the technological limitations of that period. Soil survey and mapping studies are the whole of evaluation and mapping studies of lands such as defining the characteristics of soils in an area, classifying soils according to a standard classification system, showing the boundaries of soil types on a map, making predictions about the behavior of soils (Dinç and Şenol, 2009) and determining the important physical and chemical properties of soils. Soil maps, including various office, field and laboratory studies, were produced in the traditional method, mostly in printed form. In the following years, the developments in computer technology and Geographic Information Systems (GIS) related to this technology have made it necessary to keep the printed maps in digital form. Recently, inferences regarding soil property information or land suitability made by transferring heritage soil data to digital environment (Tuğaç, 2021; Kılıç et al., 2021, Kaya et al., 2022, Koca and Turgut, 2022). The literature review showed that there were no studies conducted in previous years on the production potentials and soil properties of the lands in the study area. However, some researchers have conducted few studies that affect production preferences and economic profitability in Kumkale Plain (Alp, 2018; Uçan, 2018; Kocaköse and Aktürk, 2019; Demirel, 2020). Additionaly, in the study conducted by Özcan and Uygun (2004), salt and pH analyzes were made in soil samples taken from 13 points determined in the Kumkale Plain at 5 different depths and 7 different months, and distribution maps were created in GIS. Özcan and Akbulak (2006), hydraulic conductivity and texture data in the surface and subsurface layers of soils in the Kumkale plain were analyzed in GIS. Maps were created showing the spatial distribution of the texture and hydraulic conductivity of the surface and subsurface layers. In order to evaluate the suitability of Kumkale Plain for paddy cultivation, Everest and Özcan (2016) determined that 38.89% of the paddy lands are S1 (very suitable), 26.16% are S3 (marginally suitable) and 34.45% are N1 (temporarily unsuitable). Camoglu et al. (2018), 20 randomly selected businesses in the Kumkale Plain were handled and these businesses were evaluated in terms of design. In the study, it was concluded that in drip irrigation systems installed in the plain, uniform water distribution could not be achieved in general, that is, the systems were installed incorrectly. Everest and Everest (2020) analyzed the processes that decide the land use types of farmers in the Kumkale plain by paired comparison. In the study, a survey was conducted with 114 farmers who produce in the plain.

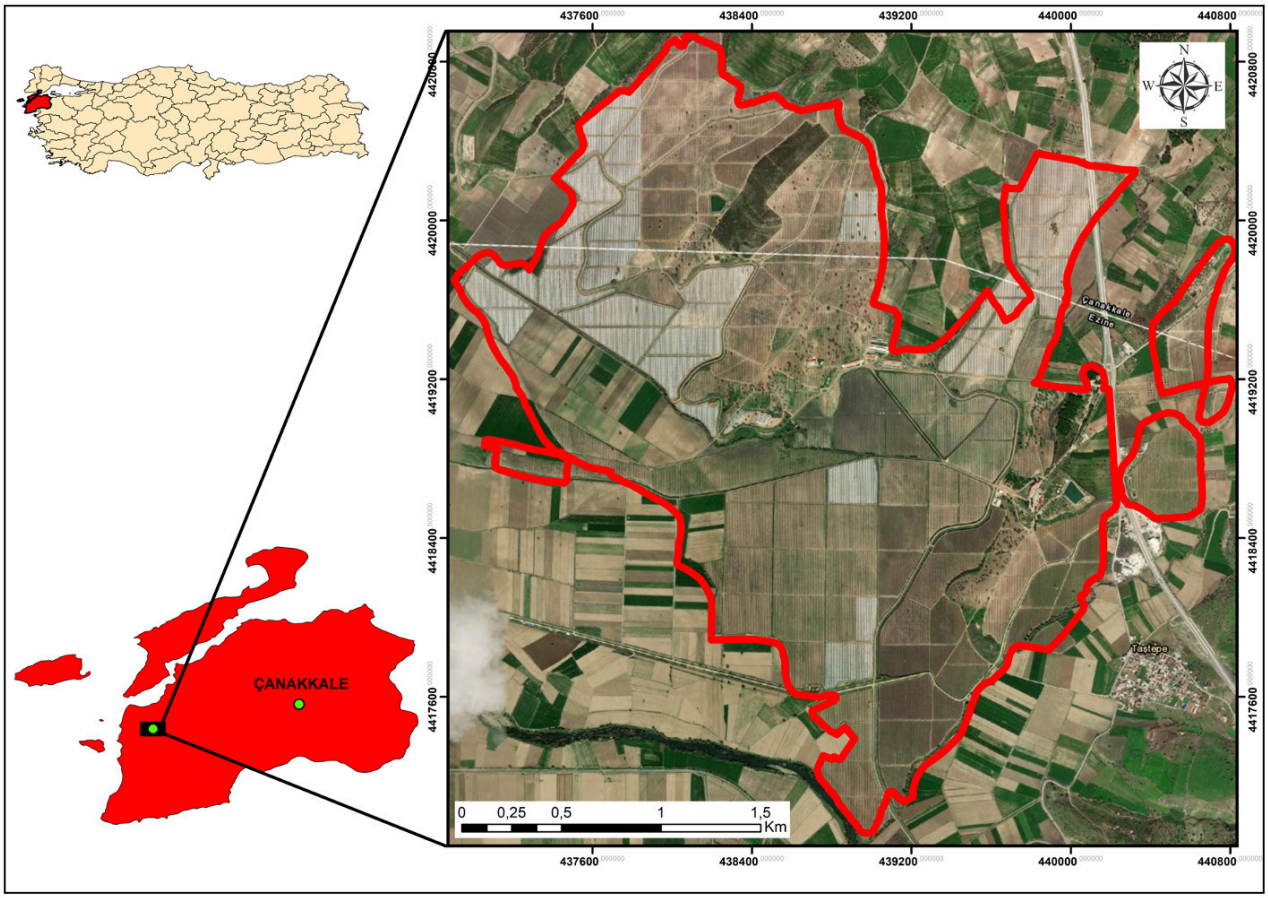

Figure 1. Location map of study area

It has been determined that the most effective factor in the farmers' decision on land use types is the cost of production. Considering the technological possibilities and conditions of the period in which this study was conducted, the lack of current coordinate information, scale shifts and deviations in the printed maps, and a number of numerical evaluation deficiencies for the area necessitated this study. Thus, the aim of this study is to create a database and produce various thematic maps of the soils of KAE (Anonymous, 1995), for which detailed soil surveys by means of the GIS.

MATERIALS AND METHODS

Material

KAE within the provincial borders of Çanakkale is located approximately 2 km west of Akçapınar town of Çanakkale central district (436886.00 E, 4419675.00 N; 440844.00 E, 4419110.00 N: WGS84 UTM Zone 35N). Çanakkale-Ezine highway in the east of the enterprise and the Ezine district border begins in the south of the enterprise and some of the lands in the south of the enterprise are located in the district of Ezine (Fig.1). Karamenderes Stream, located to the west of the enterprise, is located in the south of the enterprise and passes through it. In addition, Gökçalı village is located in the north of the enterprise. In a significant part of the lands, which cover an area of approximately 7.200 da, horticultural agriculture is carried out. Stone fruits such as peach, nectarine and apricot produces in almost all of the study area (6200 da).

According to the climate data of the study area, the annual average precipitation is 625.5 mm (between 1929 and 2021 years). Precipitation is generally in the form of rain and very little snow in December and January (Table 1). Although it is similar to the Mediterranean climate type, the winter months are colder and in summer, evaporation is less in summer. For many years, average temperature values rise above 25 °C in summer and fall below 10 °C in winter. The annual average temperature is 15.2 °C. The study area, which is semi-humid according to the Aydeniz and Erinç climate classification, has a C1: semi-arid-less humid structure according to the Thornthwaite climate classification (Anonymous, 2022). Soil moisture regime in the study area is xeric and temperature regime is mesic.

A large part of the lands consists of unconsolidated alluvial material stored in the Holocene. These deposits are usually calcareous and very calcareous materials, depending on the geological characteristics of the materials in the places where the rivers pass. Apart from the alluvial formations, in the area between the northwest and east of the enterprise, there are marine-derived marl, calcareous clay deposits and Paleocene aged caliches. In the study area, 14 different series were defined, spreading over 4 different physiographic units. Among these series, Menderes, Hanay, Fidanlık, Karabatak, Köprübaşı, Kumkale, Boğaz, Çıplaktepe, Kemerdere and Karabağlar series are included to Entisol. Gökçalı, Akçeşme, Maltepe and Akçapınar series are included to Inceptisol (Anonymous, 1995).

Method

In this study, which was carried out in an office environment, the maps of the enterprise land, for which detailed soil surveys were made, were transferred to the GIS, and various thematic maps were produced. Therefore, the basic soil map, which is in the form of a printed map, was scanned with a scanner and then geographically corrected with the help of Google Earth in the GIS. Soil boundaries and other mapping units were digitized manually, database (attribute) was created and maps were produced. ArcGIS 10 software was used throughout this phase.

Table 1. Climate Data of the Study Area (1929-2021)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
AT	6.3	6.7	8.4	12.6	17.6	22.2	25.1	25.1	21.1	16.3	12.1	8.4	15.2
AHT	9.6	10.2	12.5	17.2	22.7	27.7	30.7	30.7	26.4	20.8	16.0	11.7	19.7
ALT	3.2	3.4	4.7	8.3	12.7	16.6	19.3	19.6	16.1	12.2	8.6	5.4	10.8
ANRD	12.8	11.3	10.7	7.5	6.2	5.6	1.8	1.0	4.2	7.3	7.7	11.5	87.6
MTP	92.4	72.3	66.0	45.0	30.1	25.7	14.3	9.2	25.0	55.6	84.3	105.6	625.5

AT: Average temperature (°C); AHT: Average highest temperature (°C); ALT: Average lowest temperature (°C); ANRD: Average number of rainy days; MTP: Monthly total precipitation (mm)

RESULTS AND DISCUSSION

Soil Series

Soil series (n:14) were defined in the agricultural enterprise. These series are named as Akçapınar, Akçeşme, Boğaz, Çıplaktepe, Fidanlık, Gökçalı, Hanay, Karabağlar, Karabatak, Kemerdere, Köprübaşı, Kumkale, Maltepe and Menderes. Among these series, the series with the highest distribution area is Karabatak series with 948.2 da. This is followed by the Karabağlar series

with 796.4 da. Series with the least distribution area is Fidanlık series with 54 da (Table 2). Series map prepared in GIS is given in the Fig.2.

Karabatak series soils, which are most widespread in the study area, are soils formed on alluvial terraces. $CaCO_3$ content is moderate and generally dominant cations are Ca^{+2} and Mg^{+2}. Increasing ESP and salt amounts towards the lower parts of the profile may cause serious salinity and alkalinity problems in the future if precautions are not taken. In these soils, where the texture is mostly clay, horizons below the Ap horizon are completely massive. Their color is mostly pale yellowish brown. Intense

Table 2. Soil Series in the study area

Series (n:14)	Area (da)	Percentage (%)
Akçapınar	788.4	11
Akçeşme	291.8	4
Boğaz	227.5	3
Çıplaktepe	774.6	11
Fidanlık	54.0	1
Gökçalı	566.3	7
Hanay	769.6	11
Karabağlar	796.4	11
Karabatak	948.2	13
Kemerdere	268.8	4
Köprübaşı	346.3	5
Kumkale	313.5	4
Maltepe	592.8	8
Menderes	394.2	5
Others	176.5	2
Total Area	7309.0	100

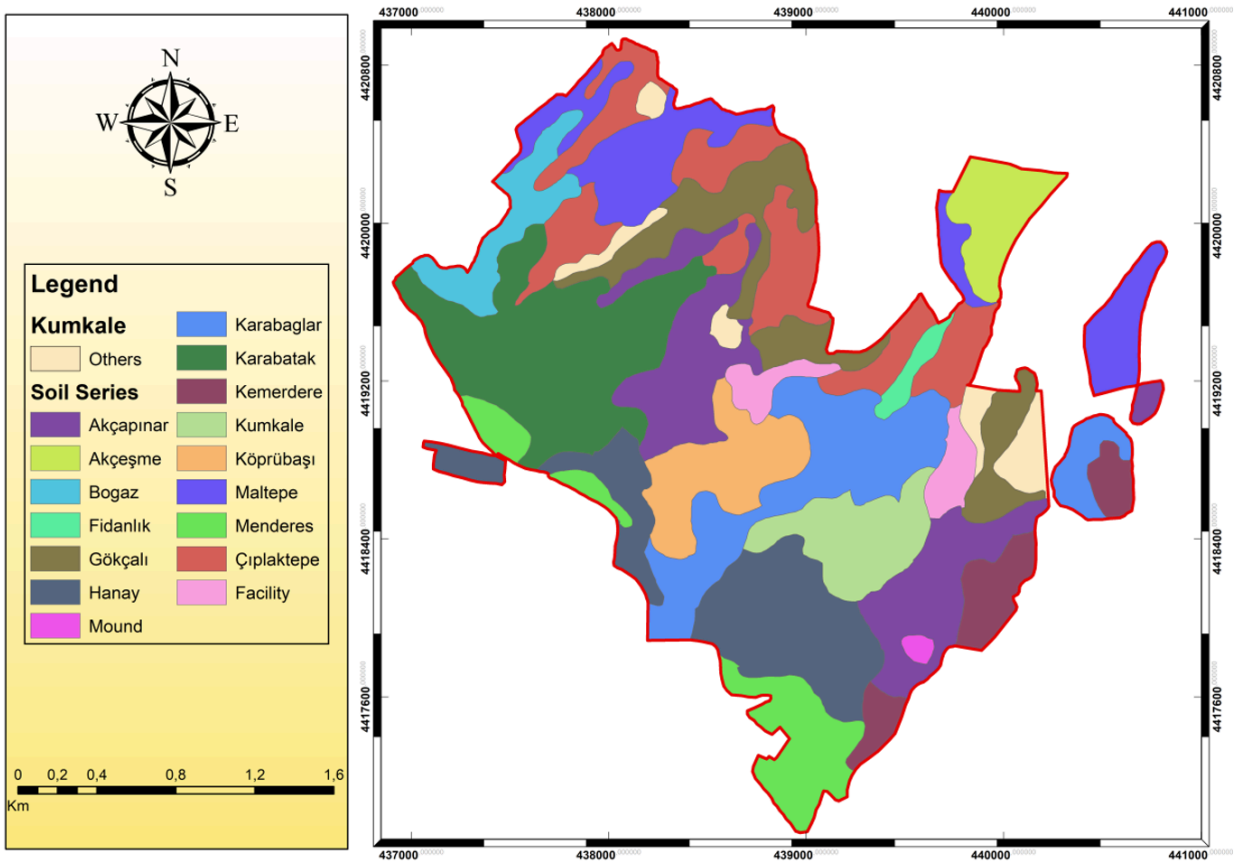

Figure 2. Distribution map of the soil series

yellowish red rust spots are seen in all profiles below the Ap horizon and intense black colored Mn concretions in addition to rust spots in lower layers. The Karabağlar series, which has the highest distribution area after Karabatak series, are deep soils with AC horizons, formed on the Alluvial parent material, in the base land formed at the intersection of Alluvial-Coluvial lands, and located in slightly wavy topographies. As in the Karabatak series, yellowish-reddish rust spots and rare Mn concretions are observed in the soils of this series as a result of the seasonal rise and fall of the ground-water.

Physiographic Units

Within the boundaries of the enterprise, 4 different physiographic units were defined. These are Alluvials, Lowlands, Highlands (Colluvial) and Bajadas. Alluvials occupy the most space among these units. This physiography, which spreads in 42% of the agriculture enterprise, is defined in the field of 3094.8 da. Lands that covered the least area are the Bajadas. This physiographic unit, which spreads over 227.5 da of land, constitutes only 3% of the enterprise (Table 3). Physiographic units map prepared in GIS environment is shown in the Fig.3.

Most of the series defined in the enterprise were developed on the Alluvial parent material. The high lands between the northeast, north and west of the enterprises center are generally Mesozoic and Paleozoic in age. Maltepe, Gökçalı, Akçapınar, Akçeşme and Çıplaktepe series were defined on these lands. Kumkale, Köprübaşı, Hanay and Karabatak series were defined on the river terraces that occupy the most space in the enterprise. Among these four series, apart from the Hanay series, the soils belonging to the other three series were covered horizons, which are indicative of the important periodic floods of the Kemer and Karamenderes streams, which are especially effective in the southern part of the enterprise.

Table 3. Physiographic Units in the study area

Physiographic Units	Area (da)	Percentage (%)
Alluvials	3094.8	42
Lowlands	796.4	12
Bajadas	227.5	3
Highlands(Colluvial)	3013.9	41
Others	176.5	2
Total Area	7309.0	100

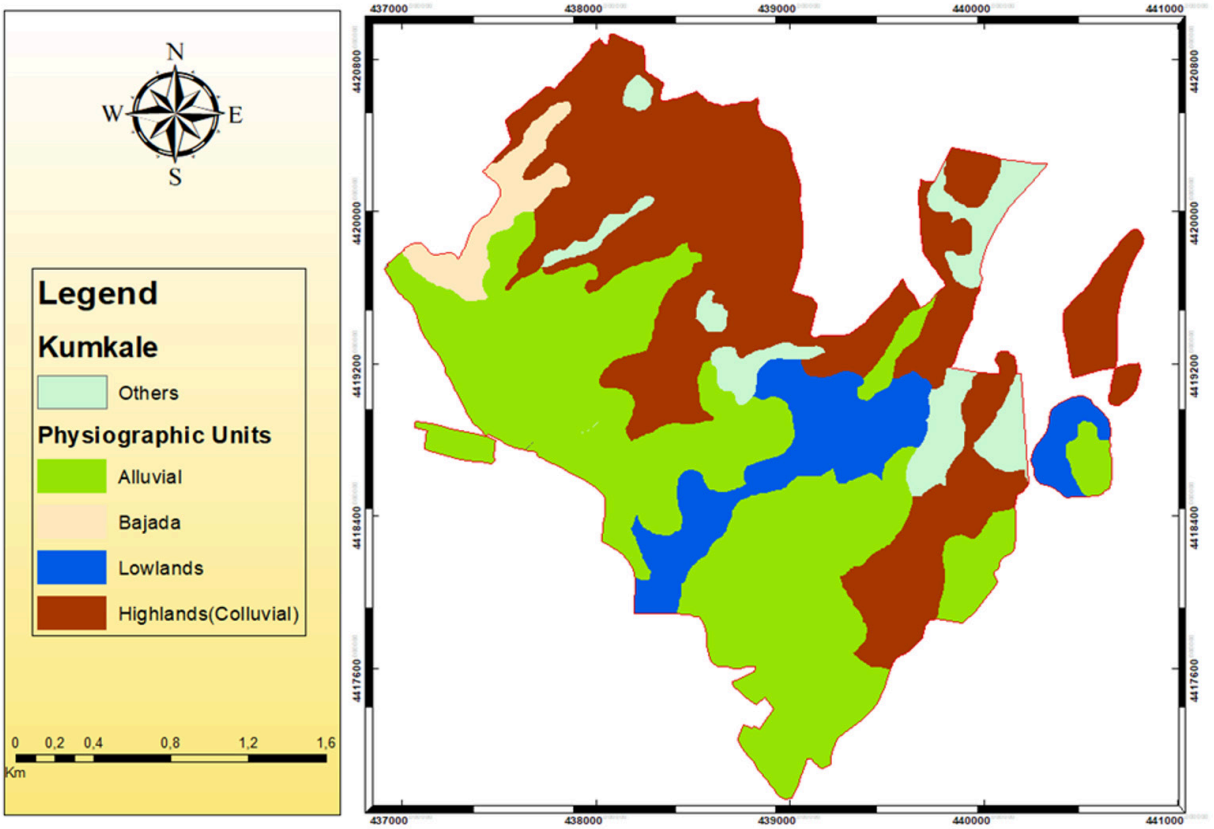

Figure 3. Map of the physiographic units created in GIS

Slope

Significant part of the enterprise consists of flat or almost flat alluvial lands. Therefore, a significant part of the enterprise lands consists of lands with 0-2% slope, which is almost flat (Table 4). According to the maps produced in the GIS environment (Fig. 4) and the database inquiries, 61% of the enterprise area (4478.9 da) consists of nearly flat lands with 0-2% slope class. Lands with a slope of 2-6% within the boundaries of the enterprise were determined as 32% (2292 da), while the lands with a slope of 6-12% were determined as 4% (289.60 da). Also, the proportion of areas with a slope of more than 12% is 1% (72 da). The sloping lands are located in the northeast of the enterprise and are generally defined as colluvials.

In addition, there is an area with a very steep (+12%) slope at the intersection of Alluvial lands and Highlands (shown in red on the slope map) in the northwest part of the enterprises center. It is necessary to keep under control the surface flow in such lands where slope is high and soil depth is shallow. Therefore, these areas should be constantly kept covered with vegetation. In this way, surface runoff can be prevented as well as the preservation of soil held by plant roots without soil erosion.

Soil Depths

Soil water-storage capacity and effective rooting depth are mainly related to the soil depth. Soil degradation due to soil erosion is a serious threat to the soil quality and productivity in hilly areas. The effects of soil erosion on productivity depend largely on the thickness and quality of the topsoil and on the nature of the subsoil. Productivity of deep soils with thick topsoil and excellent subsoil properties may be virtually unaffected by erosion.

Table 4. Slope Levels in the study area

Slope (%)	Area (da)	Percentage (%)
0-2	4478.9	61
2-6	2292.0	32
6-12	289.6	4
12+	72.0	1
Others	176.5	2
Total Area	7309.0	100

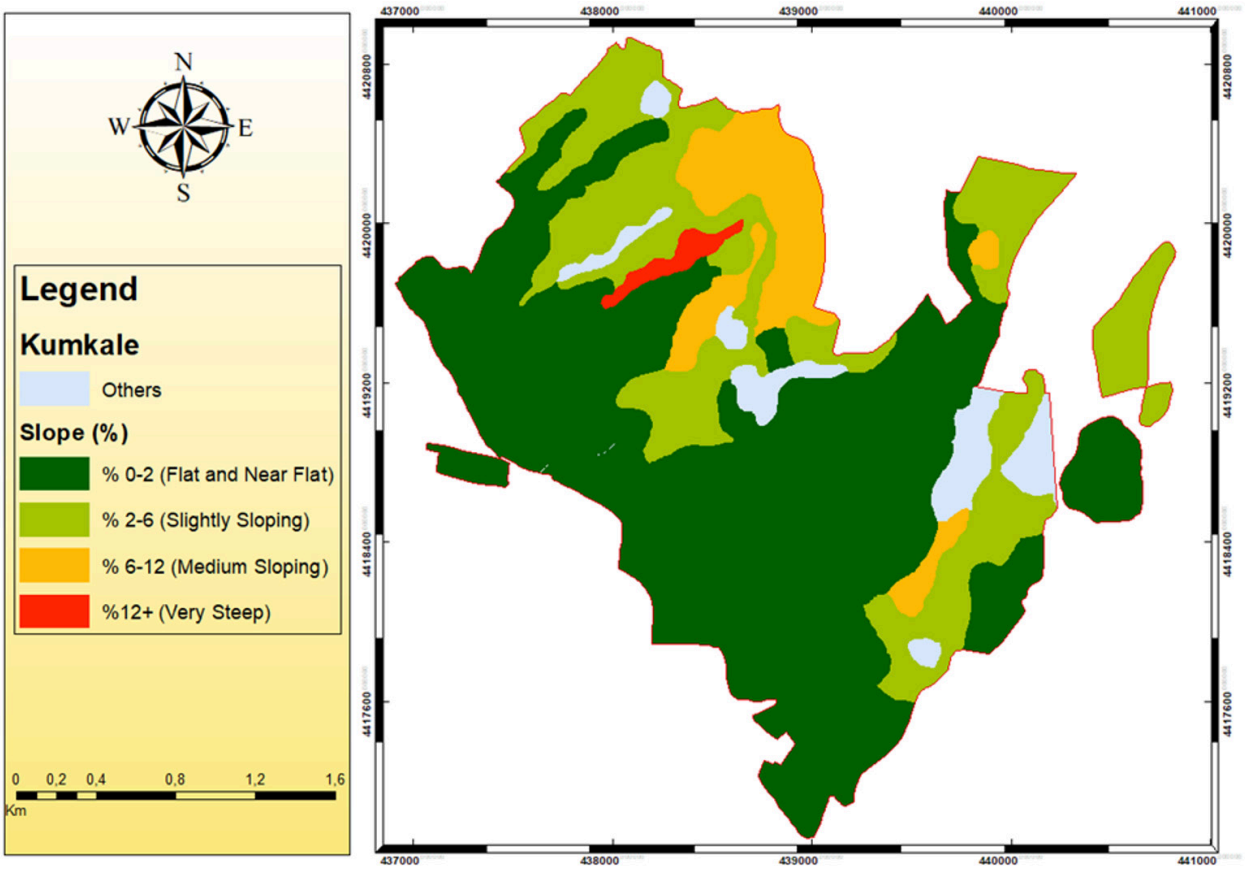

Figure 4. Map of the slope classes created in GIS

However, most hilly soils are shallow or have some undesirable properties in the subsoil such as petrocalcic horizon, or bedrock that adversely affects yields. In either cases, productivity will decrease as the topsoil gets thinner and undesirable subsoil is mixed into the topsoil by tillage. Soil depth largely affects plant productivity and therefore farm income. Soil depth defines the root space and the volume of soil from where the plants fulfil their water and nutrient demands (Kosmas et al., 1999). As a result of the inquiries made in the map and GIS of the enterprise, it was determined that soils consisted of very shallow (30-60 cm), shallow (60-90 cm), deep (90-120 cm) and very deep (120 cm+) soils (Table 5). The depth map produced as a result of digitization is shown in Fig 5.

In KAE, the areas that have problems in terms of soil protection and need to be taken precautions are generally located in the north, northwest and northeast of the enterprises center. In these regions, the slope is "medium (6-12%)" (Fig 4.) and the soil depth varies between "very shallow (30-60 cm) and shallow (60-90 cm)". Apart from these areas, most of the study area consists of deep soils. Generally, relevant lands where slope and soil depth limit agricultural productivity are class IV lands. Crop selection and soil tillage methods to be grown on the lands included in this class are important. In addition, the low water holding capacity of the soils in the aforementioned lands and the continuous flooding that may damage plant cultivation, surface stones, water-wind erosion and shallow soil depth are other important issues that may affect agricultural production. The lands opened to cultivated agriculture without the necessary precautions will result in the loss of existing lands.

Table 5. Soil Depths in the study area

Depths (cm)	Area (da)	Percentage (%)
30-60	174.7	2
60-90	338.0	5
90-120	683.0	9
120+	5936.8	82
Others	176.5	2
Total Area	7309.0	100

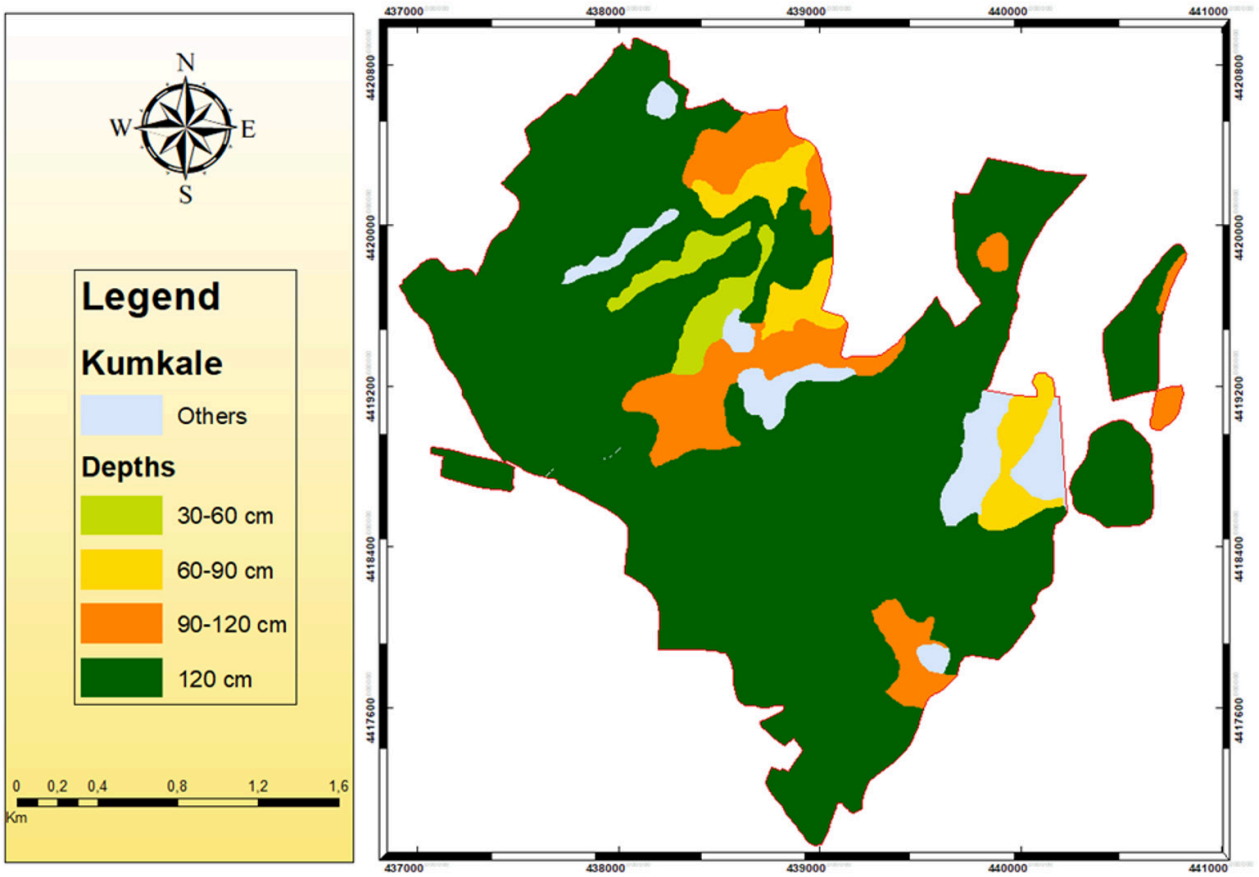

Figure 5. Map of soil depth classes created in GIS

Surface Stones

Stone content is particularly important when planning the agricultural productivity of an area, as high stone content can cause difficulties for both soil preparation and planting (Saksa et al. 2018). Knowledge of soil stones can also be helpful when developing tree growth, weathering, and hydrological models (Panagos et al. 2014, Melander,2019). Almost all of the enterprise lands consist of Alluvial and Colluvial lands with flat or almost flat slopes, without or with less stones. Accordingly, only 5% of the lands (stony or very stony) have stony problems. 78% (5677.2 da) of the study area consists of stone-free and 15% (1058.6 da) less stony soils (Table 6). The surface stones map obtained in GIS is given in Fig 6.

As the surface stones map is carefully examined, it is resulted that there is no stoniness problem in the alluvial and lowlands shown on the physiographic map (Fig.3). On the other hand, especially in the slope (Fig.4) and depth maps (Fig.5), it is seen that the stones problem is high in lands where slope is high and soil depth is weak.

Drainage

The drainage problem seen in the flat and nearly flat, young and alluvial lands of the enterprise and the bottom lands in the middle of the coluvial and alluvial lands, limiting factor that reduces productivity of agricultural areas and even causes bigger problems such as salinity and alkalinity, if timely measures are not taken. Especially the most serious problem limiting the agricultural production of Kumkale agricultural enterprise is the drainage problem, which exists in 28%

Table 6. Surface Stones in the study area

Surface Stones	Area (da)	Percentage (%)
Stone-free	5677.2	78
Less Stony	1058.6	15
Medium Stony	174.7	2
Very Stony	222.1	3
Others	176.5	2
Total Area	7309.0	100

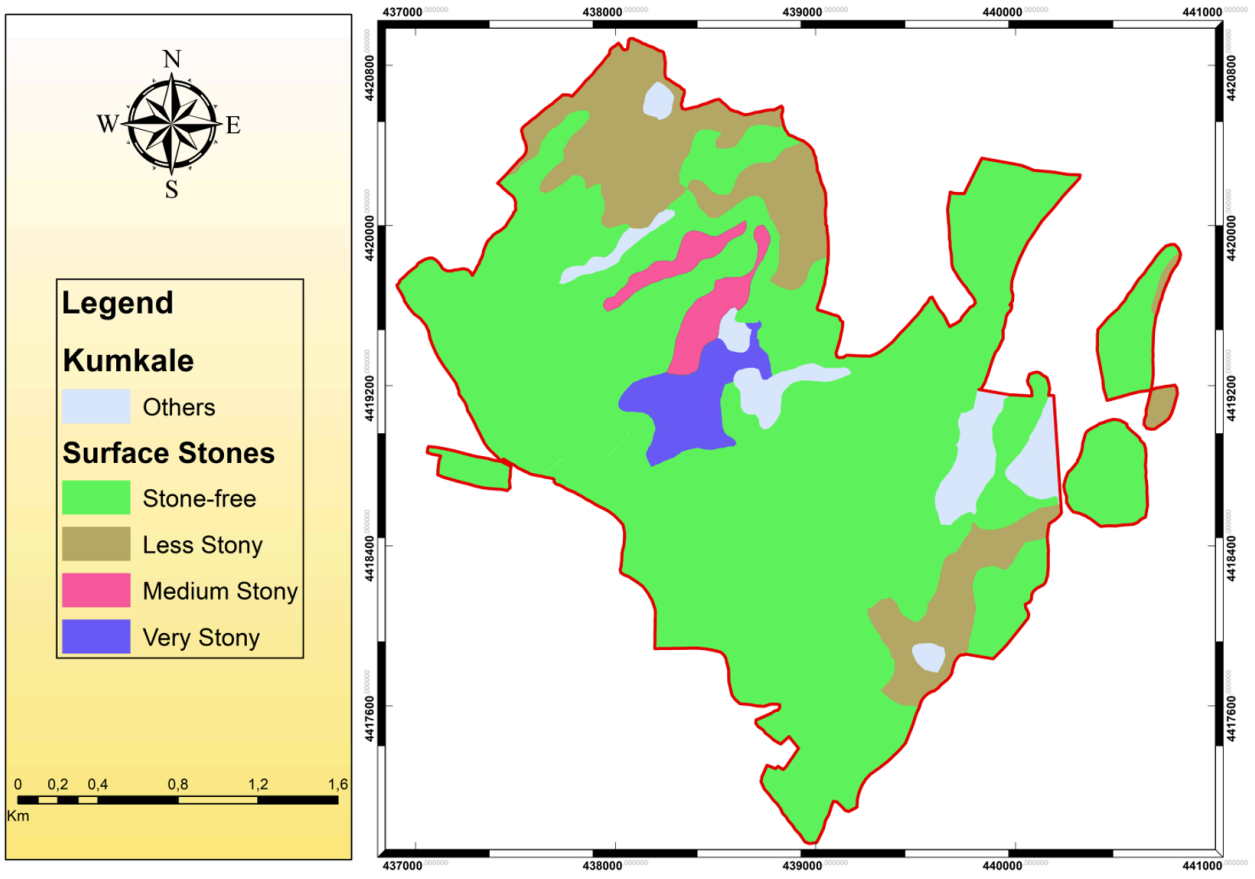

Figure 6. Map of surface stoniness classes created in GIS

of the total area (Table 7). According to this, drainage is well drained in 69% (5052.1 da) of the area, moderately drained in 16% (1132.5 da), somewhat poorly drained in 6% (406.4 da), 6% (465.4 da) poorly drained and 1% (76.2 da) very poorly drained. Fig. 7 shows drainage map of the enterprise lands.

In the drainage map prepared in the GIS, it is seen that there is a significant drainage problem in the center of the enterprise lands and especially in the regions where the base lands are common. There are drainage problems ranging from insufficient to bad in the soils of the Boğaz, Karabağlar, Menderes, Kemerdere, Kumkale, Hanay, Köprübaşı and Karabatak series. Especially the insufficiency of unleveling and surface drainage systems of a significant part of the soils belonging to some series (Boğaz, Köprübaşı, Karabatak and Fidanlık) cause drainage problems and surface ponding. In the northwest of the enterprise lands at the intersection of high lands and alluvial lands are in a more pitted position compared to their surroundings, so rain water and irrigation waters and waters coming from the environment cause the ground water to rise. Open surface drainage channels should be opened and proper soil leveling should be done in order to prevent water accumulation on the surface and to ensure a healthy drainage of water.

Table 7. Drainage Classes in the study area

Drainage	Area (da)	Percentage (%)
Well Drained	5052.1	69
Moderately Drained	1132.5	16
Somewhat Moderately Drained	406.4	6
Poorly Drained	465.4	6
Very Poorly Drained	76.2	1
Others	176.5	2
Total Area	7309.0	100

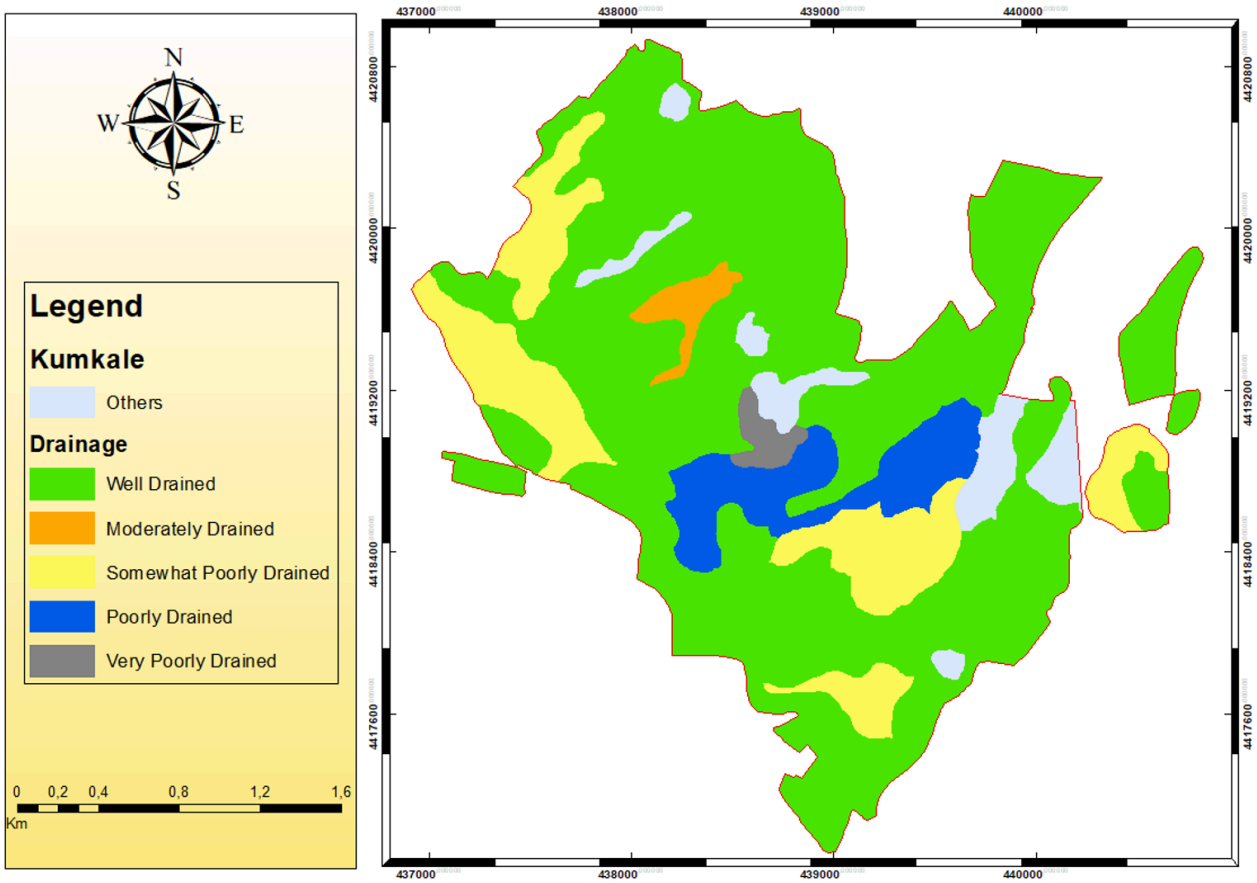

Figure 7. Map of drainage classes created in GIS

CONCLUSION

In this study, which deals with the important soil/land characteristics of KAE, the agricultural potential of the enterprise has been tried to be revealed. 14 soil series were defined in the agricultural enterprise. These series are named as Akçapınar, Akçeşme, Boğaz, Çıplaktepe, Fidanlık, Gökçalı, Hanay, Karabağlar, Karabatak, Kemerdere, Köprübaşı, Kumkale, Maltepe and Menderes. Among these series, the series with the highest distribution area is Karabatak series with 948.2 da. This is followed by the Karabağlar series with 796.4 da. Series with the least distribution area is Fidanlık series with 54 da. Most of the series defined in the enterprise were developed on the Alluvial parent material. The high lands between the northeast, north and west of the enterprises center are generally Mesozoic and Paleozoic in age. Kumkale, Köprübaşı, Hanay and Karabatak series were defined on the river terraces that occupy the most space in the enterprise.

In KAE, the areas that are problematic in terms of soil protection and need to be taken precautions are generally located in the north, northwest and northeast of the enterprises center. In these regions, the slope is "medium (6-12%)" and the soil depth varies between "very shallow (30-60 cm) and shallow (60-90 cm)". It is necessary to keep under control the surface flow in such lands where slope is high and soil depth is shallow. In this way, surface runoff can be prevented as well as the preservation of soil held by plant roots without soil erosion.

Another important trouble encountered in the enterprise is the drainage problem of the soils. The drainage problem seen in the flat and nearly flat, young and alluvial lands of the enterprise and the bottom lands in the middle of the colluvial and alluvial lands, limiting factor that reduces productivity of agricultural areas and even causes bigger problems such as salinity and alkalinity. In particular, the most serious problem limiting the agricultural production of KAE is the drainage problem, which exists in 28% of the total area. As a result, some soil characteristics and areal distributions were obtained by detailed soil surveys of KAE lands and digitizing the maps obtained in GIS. The survey report and detailed soil map of study area, which was carried out in the past, were digitized with this study. All relevant soil properties and classes are given in detail in the findings section of this study. With this and similar studies, it will be useful to examine both the temporal and spatial changes of the lands connected to GDAE, which has a significant production capacity in Türkiye, and to compare them with the old survey studies by making new field studies. In addition, the creation of a new database to be digitized in the GIS and the application of precision agriculture techniques can help the evaluation of the enterprise soils according to their suitable agricultural potentials.

COMPLIANCE WITH ETHICAL STANDARDS

Conflict of interest

The authors declared that for this research article, they have no actual, potential or perceived conflict of interest.

Author contribution

The contribution of the authors to the present study is equal. All the authors read and approved the final manuscript. All the authors verify that the Text, Figures, and Tables are original and that they have not been published before.

Ethical approval

Ethics committee approval is not required.

Funding

No financial support was received for this study.

Data availability

Not applicable.

Consent for publication

Not applicable.

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