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Overview of the lands of Dalaman agricultural enterprises using geographic information systems

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Abstract
Dalaman Agricultural Enterprise, located in the southeast of Muğla province, was established in 1935 as a subordinate of the State Agricultural Enterprises Institution. Field agriculture has an important place in the enterprise, which has an area of approximately 33630 decares. In addition, there are citrus plants in irrigated farming areas in the enterprise. The most important data source for the operating lands is the report "Study and Mapping of Dalaman State Production Farm Soils". Environmental data and soils of the study area are handled in the report. The maps of the enterprise lands were digitized in the GIS, the soil series and important phases were determined and various thematic maps were produced. Maps created and the soil properties are a summary of the Dalaman Plain soils. The results obtained will be a base map for the studies to be carried out in the region.

Keywords
Detailed soil survey, Geographic information system, Dalaman agricultural enterprises

Introduction
It is necessary to systematically examine the soils, which are specified as the most important source for agricultural production in nature. In this context, fieldworks, laboratory and office studies should be handled as whole. Soil survey and mapping studies which are explained as defining the characteristics of soils in an area, classifying soils according to a standard classification system, showing the boundaries of soil types and make a prediction about the behavior of soils, determination of important physical and chemical properties of soils are the whole of evaluation and mapping studies of lands (Dinç and Senol, 2009). The reports performed for the areas where detailed soil survey and mapping are carried out, are also consider as important materials for researchers working on different disciplines.

On the national scale, many countries that have completed detailed soil maps have been revising their soil maps. However, there is no attempt at the level of country for detailed soil survey and mapping studies. On the other hand, universities, public institutions and foundations performed detailed soil survey of some regions, especially their areas of responsibility. Among the universities, University of Çukurova has carried out and has been continue to do important studies on detailed soil surveys. In this context, the studies of the lands of the Çukurova Region, the Southeastern Anatolian Region Plains, the Turkish Republic of Northern Cyprus and the lands of the agricultural enterprises affiliated to the General Directorate of Agricultural Enterprises (TİGEM) have been completed. Some of these enterprise areas are also recently updated via GIS (Dingil et. al., 2013).

In this study, Dalaman Plain, which is one of 29 different TİGEM agricultural lands located in different locations of Anatolia in Turkey, is considered. However, maps created using the technological conditions of the relevant period were only hard print. Although there are studies on different subjects belonging to the enterprise, studies on its lands have been limited (Ata and Tekin, 2001; Kaya and Kaya, 2003; Koç et.al., 2004; Dedeoğlu et.al., 2019). In this study, it is among the objectives of this study to create the database of the enterprise lands, for which detailed soil surveys have been completed before (Anonymous, 1982), to produce various thematic maps and to present them to users in other disciplines.

Materials and Methods

Material

Dalaman Plain, which is located within the borders of Muğla province, is bordered by Fethiye in the east, Marmaris in the west, the Mediterranean in the south and Köyceğiz in the north. Dalaman Agricultural Enterprise is located in the south of this plain adjacent to the sea (Fig 1.). When detailed soil surveys were carried out, Dalaman TİGEM was surrounded by Tersakan and Taşlı streams in the east, Dalaman Stream in the west, the Mediterranean in the south and Dalaman County Prison in the north. It is reported that the Dalaman Plain belonging to TİGEM was 43050 decares (da) of land. However, current data report that the boundaries of the TİGEM land have changed over time and are currently 33630 decares (Anonymous, 2021a). Approximately 4800 acres of land is used as Dalaman Airport, which was opened to international air traffic in 1981.

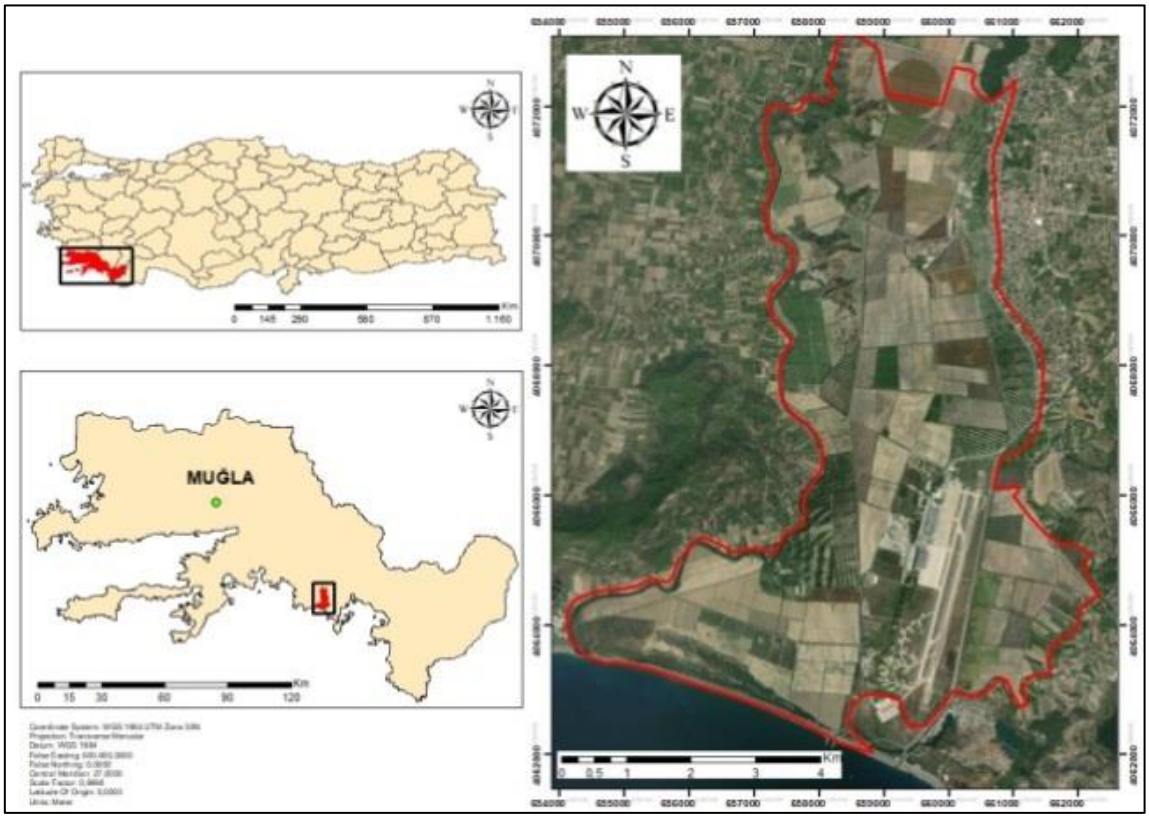

Figure 1. Geographic location of the study area

The meteorological climate of the study area is hot in summers; winters are considered mild (Anonymous, 2021b). Considering annual climatic data, the lowest precipitation is in July (11.7 mm); the highest precipitation is seen in December (265.5 mm). Average temperature values are the lowest in January (5.3ºC); shows that the highest temperature is in July (26.4ºC). Generally, a significant part of the plain has alluvial deposits (Keskin, 2012). The most important geomorphological formation is the alluvial fan formed as a result of the activity of the Dalaman Stream in Holocene and Pleistocene. In addition to, there are also elevations consisting of ophiolites that cover a very small area. Croplands have an important place in land use. For the purpose of certified seed production; for the production of wheat, maize and vetch, alternation crops; grain corn and oil sunflower and roughage production for livestock needs. In addition, there are citrus plants in irrigated farming areas in the enterprise. In addition, as mentioned before, Dalaman Airport also occupies an important area within the enterprise (Fig 2). There are 7 series in total in the enterprise. These series are Dalaman, Eskiköy, Adaköy, Havaalanı, Camikırı, Gökdağ and Söğüt series. All of these series are defined in Entisol order, and all series except Gökdağ series are classified in Fluvent order. Gökdağ series, on the other hand, is located in the Orthent sub-order. Some general characteristics of the series will be given together with the maps obtained in the research findings section of the study.

Method

In this study, which was carried out in the office, the maps of the TİGEM land, for which detailed soil surveys were carried out before, were transferred to the Geographic Information Systems (GIS) and various thematic maps were produced. For this purpose, the

basic soil map, which is in the form of a printed map, was scanned on the scanner and then geographically corrected with the help of Google Earth in the GIS. Land boundaries and other mapping units were manually digitized, a database (attribute) was created and maps were produced. At this stage, ArcGIS 10.4 software was used.

Results and Discussion

Soil Series

7 soil series, namely Dalaman, Eskiköy, Adaköy, Havaalanı, Camikırı, Gökdağ and Söğüt series, have been defined in the TİGEM field. The distribution map of these series within the TİGEM lands is given in Figure 2. According to the inquiries made under GIS, the most widespread series soils in the study area are Dalaman and Havaalanı series. The least widespread series is the Camikırı series. The area covered by the series defined in the enterprise is given in Table 1. The Dalaman series consists of materials brought and deposited in the alluvial terraces of the old Dalaman Stream with subsequent floods. For this reason, the texture, which is partially light in the upper horizons, becomes heavier towards the depths and because they are terrace soils, there are sand and gravel deposits after 150 cm. Color is brown in the whole profile and free $CaCO_3$ is dispersed in the whole profile. Eskiköy series, which is the second series showing the most area, was formed on the alluvial terraces of Dalaman Stream, just like Dalaman series. $CaCO_3$ is high in the profile. The soils of this series also have a clayey loam texture on the surface, but have a coarser sandy clay loam texture in the lower horizons. Havalaanı series, which has the highest spread, is also among the lands affected by Dalaman Stream. The soils of the series located on the terraces of Dalaman Stream are similar to the Dalaman series, but are distinguished from the soils of this series by the presence of silty clay loam bands exceeding 30cm in thickness under the surface.

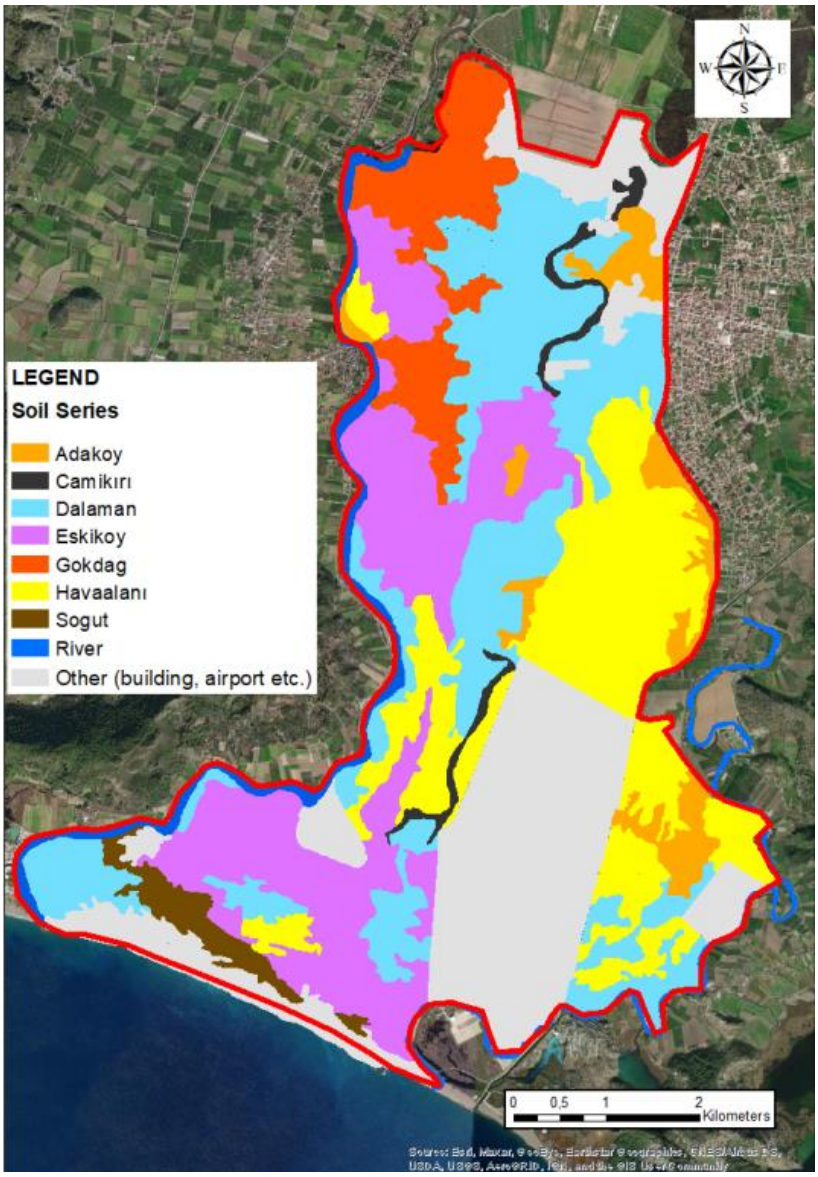

Figure 2. Distribution map of the soil series

Table 1. Defined series and total areas of the study area

Series Name	Series Area (da)	Series Area (%)
Adaköy	1826	4
Camikırı	629	1
Dalaman	9174	21
Eskiköy	8118	19
Gökdağ	2973	7
Havaalanı	8950	21
Söğüt	792	2
Others	10627	25
Total Area	43088	100

Physiographic Units

The defined 7 soil series are located in different physiographic units. These units are the old coastal dunes, the old riverbed, the ridge, the river terrace and the uplands. Dalaman and Eskiköy series are located in the most widespread river ridge physiographic unit. Adaköy and Havaalanı series, which are among the river terrace physiographic units, are distributed in 25% of the study area. Gökdağ series high lands, Camikırı series old riverbed and Söğüt series old coastal dunes are included in physiographic units (Table 2). Physiographic unit map created in GIS is given in Figure 3.

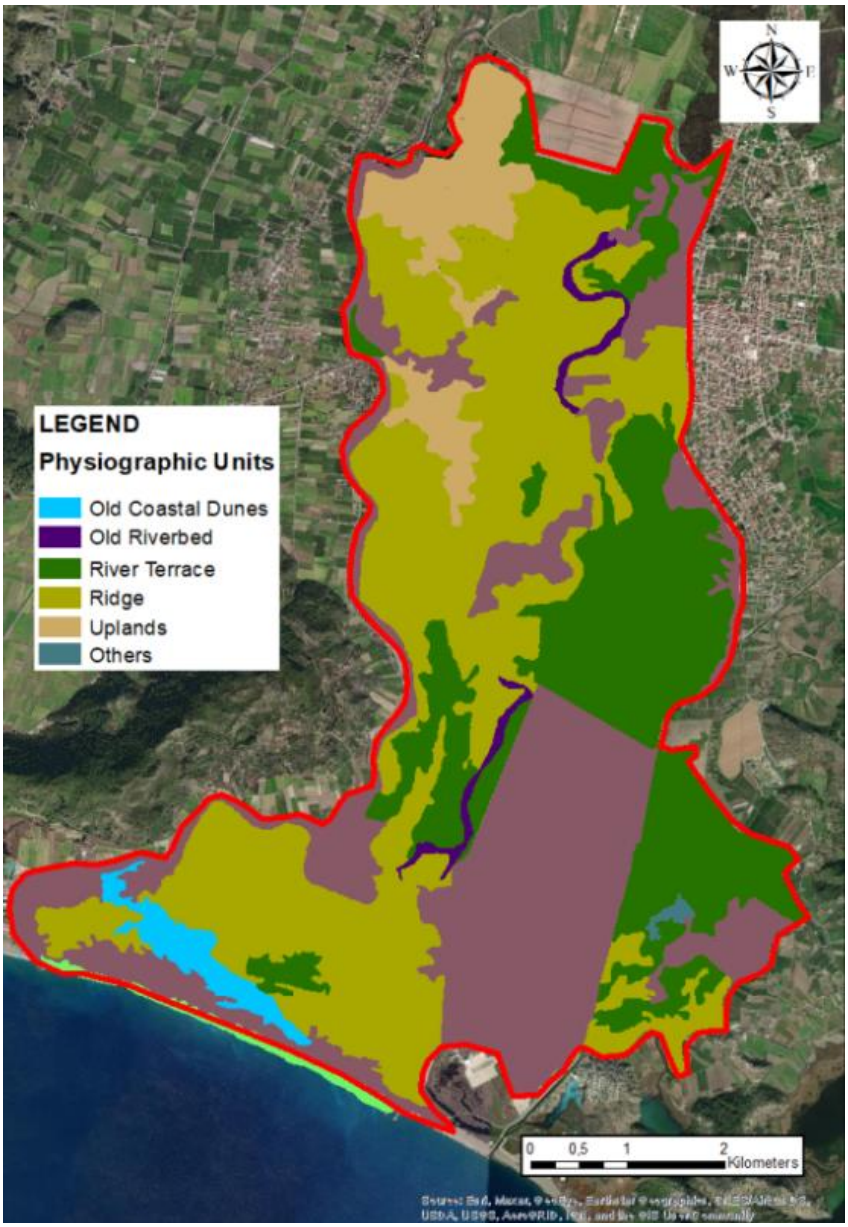

Figure 3. Physiographic units of the study area

Table 2. Physiographic units in the study area

Physiographic Units	Area (da)	Area (%)
Old Coastal Dunes	792	2
Old Riverbed	629	1
Ridge	17291	40
River Terrace	10776	25
Uplands	2973	7
Others	10627	25
Total Area	43088	100

Top Soil Texture

When the textures of the surface horizons of the soils are examined, it is seen that there are medium and fine textured soils. Top soil textures are clay, silty clay ones are heavy; Loam, clay loam, silty clay loam and sandy loam are evaluated as medium textured. With this approach, the top textures of Dalaman TİGEM soils generally have a medium texture. While 47% of the study area has a medium texture, 28% has a heavy texture. Since 25% of the study area is used for various purposes such as cattle breeding facility, airport, farm building, there is no information about the soil structure. Surface soil texture classes and distributions obtained by database inquiries are given in Table 3; The distribution map of this data is given in Figure 4.

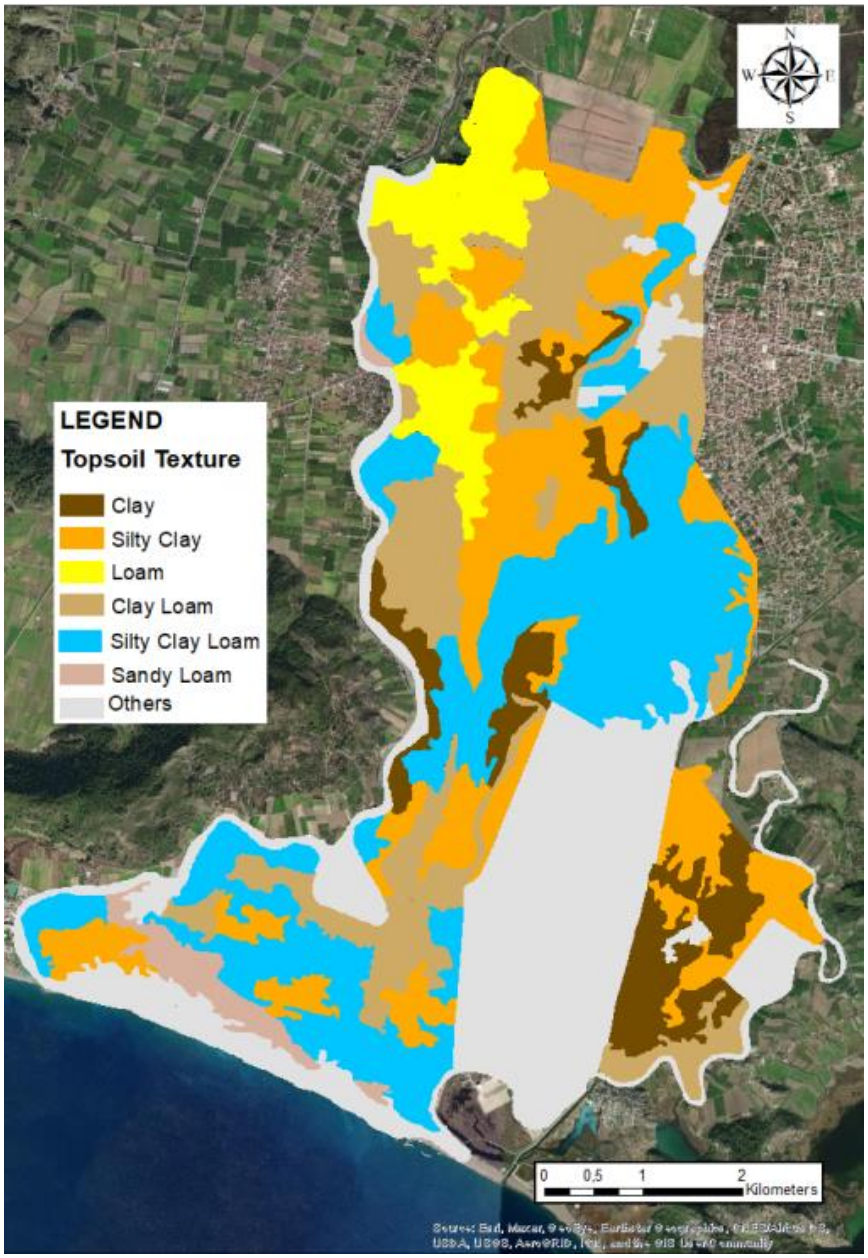

Figure 4. Top soil texture map of the study area

Table 3. Top soil texture of the study area

Top soil texture	Area (da)	Area (%)
Clay, Silty Clay	12072	28
Loam, Clay Loam, Silty Clay Loam, Sandy Loam	20389	47
Others	10627	25
Total Area	43088	100

Erosion

Soil erosion is one of the important problems in the study area. There are severe erosion effects in some lands spreading in the higher parts of Gökdağ and Aladağ series in the northwest. These lands have both steep and shallow. However, these lands constitute only %4 of the study area. There is no erosion problem in a significant part of it. Information on the erosion distribution obtained in the GIS is given in Table 4.

Table 4. Erosion levels of the study area

Erosion	Area (da)	Area (%)
Severe	1865	4
No erosion problem	30596	71
Others	10627	25
Total Areas	43088	100

Drainage

According to the detailed soil survey report; there are good, poor, bad, very bad and excessive drainage classes in the study area. While most of the lands have good drainage, an area of 6304 da (15%) has poor, very bad and excessive drainage conditions (Table 5). Excessive drainage conditions, which are define as one of the worst drainage classes are especially observed in Söğüt series soils. The soils of series extend in a narrow strip on the coast. There is not enough soil formation for agriculture on these lands, which have sparse scrub as natural vegetation. The drainage map of the enterprise land created in the GIS is given in Figure 5.

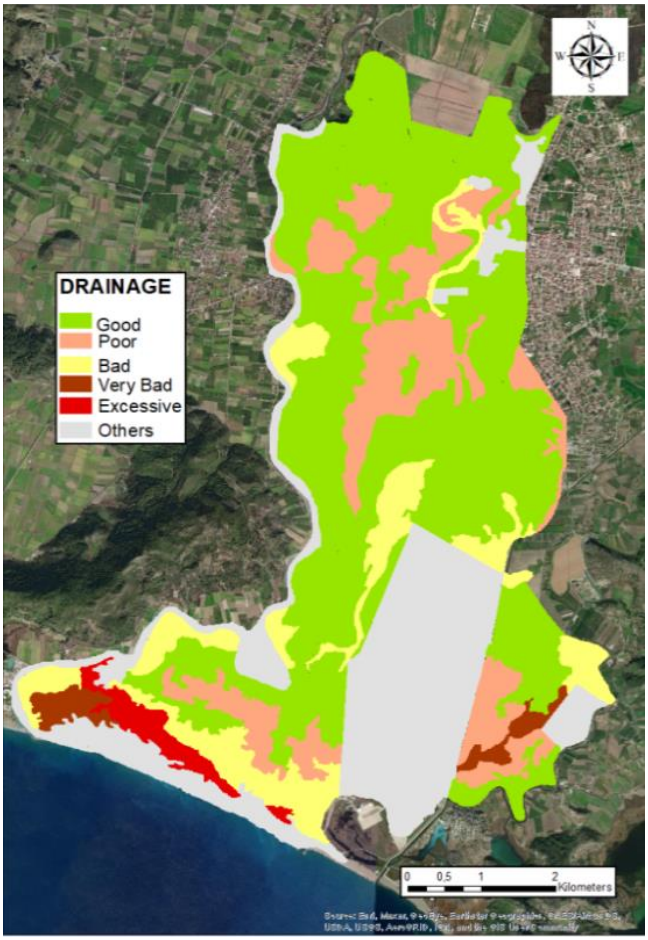

Figure 5. Drainage map of the study area

Table 5. Drainage class of the study area

Drainage Classes	Area (da)	Area (%)
Good	19685	46
Poor	6472	15
Bad	4730	11
Very Bad	782	2
Excessive	792	2
Others	10627	25
Total Areas	43088	100

General Properties of Surface Horizons

Except for Gökdağ series, the general features of the 6 series are given together. When the report of the study area was examined, it was seen that soil sampling was not made for identification purposes from Gökdağ series, and therefore its physical and chemical properties were not determined. For this reason, the data were evaluated over 6 series in the study area. The classifications of the properties of the soils have been evaluated within the framework of the Soil and Land Classification Standards Technical Instruction and Relevant Legislation" (Anonymous, 2008).

pH

The pH of the surface horizons of the soils varies between 7.65 and 8.75. While the lowest pH belongs to Adaköy series soils, the highest pH belongs to Dalaman and Camikırı series. While the Adaköy, Söğüt, Eskiköy and Havaalanı series soils, which are in the light alkali class, are distributed in a total of 19384 decares, the Dalaman and Camikırı series, which have a strongly alkaline surface horizon, are located in the land at 9803 decares (Table 6).

Table 6. pH of surface soils of study area

Surface Soil pH	Series	Area (da)	Class
7.65	Adaköy	1826	Slightly Alkaline
7.80	Söğüt	492	Slightly Alkaline
7.85	Eskiköy	8118	Slightly Alkaline
7.90	Havaalanı	8950	Slightly Alkaline
8.75	Dalaman-Camikırı	9803	Strong Alkaline

Salinity

Salinity levels of the study area vary between 0.05% and 0.18%. Lowest salinity is in Eskiköy, Dalaman and Adaköy series whereas, the highest salinity is observed in Söğüt series soils. There are salty plants in some of the lands located in the south and southeast parts of the study area. There are also areas where there are salt deposits in places. While the soils defined in the salt-free class are 28697 decares, the lightly salted lands are 492 decares (Table 7).

Table 7. Salinity clases of the study area

Salinity Level (%)	Series	Area (da)	Class
0.05	Eskiköy, Dalaman, Adaköy	19118	Saltless
0.07	Havaalanı	8950	Saltless
0.10	Camikırı	629	Saltless
0.18	Söğüt	492	Lightly Salted

Cation Exchange Capacity (CEC)

Cation Exchange Capacity (CEC), one of the most important chemical indicators of soils, is also considered as one of the fertility indicators of the soil. In the study area, it can be seen that the CEC ranges between 7.60 and 28.20 me/100gr (Table 8). It belongs to the lowest CEC Söğüt series in the study area. The coarse texture of these soils is a factor in the low CEC level. On the other hand, Eskiköy series are the soils with the highest CEC level in the study area.

Table 8. CEC levels of the study area

CEC (cmolc/kg)	Series	Area (da)
7.60	Söğüt	492
18.40	Havaalanı	8950
21.72	Dalaman	9174
22.20	Camikırı, Adaköy	2456
28.20	Eskiköy	8118

Soil Organic Matter (SOM)

Generally, low-medium organic matter levels are observed in continuously cultivated lands. This also applies to the farm land. The organic level in the study area is between 1.24% and 3.20%. Table 9 gives the organic matter level of the series. Accordingly, only Dalaman and Camikırı series contain rich organic matter. In terms of organic matter, poor areas are 8950 da, middle areas are 10436 da and rich areas are 9803 da.

Table 9. Soil organic matter classes of the study area

SOM (%)	Series	Area (da)	Class
1.24	Havaalanı	8950	Low
1.89	Adaköy	1826	Medium
2.09	Söğüt	492	Medium
2.16	Eskiköy	8118	Medium
2.61	Dalaman	9174	High
3.20	Camikırı	629	High

Calcium Carbonate ($CaCO_3^-$)

$CaCO_3^-$ level is high in all soil series of the soils except Gökdağ series. The high level of lime in the whole profile sometimes reflects negatively on plant production. High lime level negatively affects the intake of plant nutrients, especially useful phosphorus. When analyzed on the basis of series, Dalaman and Eskiköy series are classified as calcareous, while Camikırı, Adaköy, Söğüt and Havaalanı series are classified as very calcareous. 17291 da of the enterprise lands are calcareous; 11897 da is very calcareous (Table 10).

Table 10. Calcium carbonate classes of the study area

$CaCO_3^-$(%)	Series	Area (da)	Class
10.66	Dalaman	9174	High
12.74	Eskiköy	8118	High
16.23	Camikırı	629	Very High
17.39	Adaköy	1826	Very High
20.11	Söğüt	492	Very High
21.10	Havaalanı	8950	Very High

Conclusion

In this study, it is aimed to evaluate the Dalaman Agricultural Enterprise Lands in GIS and to create maps for general soil properties. There are 7 series in the enterprise. However, since no soil could be taken from Gökdağ series for sampling, evaluations were made about the characteristics of the 6 series soil and their maps were produced. Dalaman and Havaalanı series are the most widespread in the study area. Although the soils of both series have similar characteristics, they are distinguished from other series by the presence of silty clay loam bands under the surface in Havaalanı series. Dalaman Stream had a significant impact on the formation of soils. Dalaman Stream has an effect on the formation of the most widespread river ridge and river terrace physiographic units. In the inquiries made in the GIS, it was determined that these two physiographic units spread over 65% of the total area. In terms of soil texture, 47% of the soils have medium texture, while 28% have fine texture. There is no significant erosion problem in the study area. However, it should be taken into account that 4% of the study area has severe erosion. Lands generally have good drainage. However, it was determined that there was a drainage problem in the land in 6304. The study area generally consists of flat or near-flat lands. The general characteristics of the land were digitized and various inquiries were made with the detailed soil map of the enterprise land, which was transferred to the computer and digitized with ArcGIS software. In addition to this, various thematic maps were created, allowing users to interpret soil characteristics in an easier and more understandable way. This is the most important feature of GIS software. Soil maps in print are difficult to understand and interpreters by other researchers than soil experts. However, with the production and visualization of digitized and various thematic maps, the intelligibility of these maps is increased. A lot of information about agricultural production can be obtained by interpreting soil properties. In addition to determining the

appropriate product variety, management such as tillage, fertilization and irrigation, as well as the suitability of soils for various uses are also important for sustainable agriculture. It is stated that some soil properties are invariant. However, some dynamic properties of soils such as salinity, lime, surface pH, drainage may also change depending on usage conditions. For this reason, it is important to transfer the obtained maps to digital media and to update the changes in the soil and land periodically in the database. It is recommended to update the maps obtained with this study with revision soil surveys, and to make inquiries by processing the changes in the enterprise land into the database.

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

Not applicable.

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Data availability

Not applicable.

Consent for publication

Not applicable

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