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Mapping of Karacabey agricultural enterprise by GIS

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ABSTRACT

Karacabey Agricultural Enterprise is located in the west of Bursa province in the Marmara Region of Türkiye. Susurluk and Tohmalı rivers flow to the west and northwest of the study area of approximately 102 ha and Simav stream flows to the east. The Susurluk Basin, which is under the influence of the Marmara and Aegean Seas and where the study area is located, is very similar to the Mediterranean climate type. The mean annual precipitation is 710 mm and the mean annual temperature is 14.5°C. Enterprise lands are generally composed of high, low and colluvial lands. In addition to cereals such as wheat, barley and oats, crops such as sunflower and corn are grown. Vegetable cultivation and fruit production are also widespread. The aim of this study is to make various numerical inferences by digitizing the soil and land properties of Karacabey Agricultural Enterprise, where soil surveys were carried out and soils were classified in the past. Within the scope of the study, soil series, physiography, slope, topsoil texture, depth and drainage maps were produced by GIS. Results of this study are thought to be a guide for future studies in the related field and may help in the production of digital soil maps.

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1. Introduction

The world population as well as the country population is increasing day by day. According to current data, the population is known to be 85.279.553 [1]. In addition to population growth, plant cultivation gains importance in the increasing demand for food. In order to increase welfare in agricultural production, to ensure stable food supply by increasing yield and quality, necessary studies are carried out and different results are obtained. According to 2023 data, cereals and other vegetable products (excluding fodder crops) increased by 10.3%; vegetables by 0.6%; fruits, beverage and spice plants by 2.3% [1]. The demand for food should encourage us to make better use of agricultural land and prioritize the proper management of land.

According to TSI data for 2023 [1], the total agricultural area was reported to be 38.063.000 hectares (including meadow and pasture land). Of the total agricultural area, 52.2% is cultivated land, 9.4% is under perennial crops (perennial orchards), and 38.4% is permanent meadows and pastures. There have been changes in the amount of agricultural production and product exports have increased. According to current data, agricultural exports increased by 15.3% in 2022 compared to the previous year, reaching 34.246 billion dollars [2].

Utilizing modern technological developments in agriculture is of great importance in carrying the studies to a higher level. Determining the suitability of the land for use is a comparison between the current condition of the soil for cultivation and the possibility of growing the desired product. Consideration of the physical, chemical and social characteristics of the lands studied enables the land use to be done in the desired way [3]. Implementation of soil conservation measures, sustainable agriculture, mapping of lands and review of ready-made maps should be done with a proper planning to prepare. The field boundaries and geometric shapes of the parcels cannot complement each other with the soil series. Mapping is of great importance for determining the field boundaries of farm and village lands and for parceling. One of the most important problems is that the density of soil series makes mapping difficult. Such problems are more common in areas with alluvial deposits and as a solution; more detailed aerial photographs can be recommended [4].

There are farms engaged in agriculture and animal husbandry with different sized lands in different places under the General Directorates of Agricultural Enterprises (GDAE), which provide high income to agricultural production. Farms contribute to the economy of the country to a great extent and develop it [4]. Soil maps of all enterprises under GDAE in our country have been prepared and soil classification, land use status, water use status, suitability for plant cultivation have been determined and mapped [5]. All enterprises operating in the field of agriculture are based on seed, raw material production and protection of gene resources and there are 37 enterprises under GDAE and 17 of them are operated by GDAE, 20 of them are leased by private companies [6]. The activities of these enterprises have been the subject of various studies [7-12].

In this study, it is aimed to digitized the lands of Karacabey Agricultural Enterprise, one of the important agricultural enterprises of Turkey, to make various queries with the help of GIS and to produce thematic maps

2. Materials and methods

The 2.1. Geographical Location of Karacabey Agricultural Enterprise

Karacabey Agricultural Enterprise is located within the borders of Karesi District of South Marmara Zone in Marmara Region. A significant part of the enterprise land is located within the borders of Karacabey district and a small part is located within the borders of Mustafakemalpaşa district (Fig 1). The total area of their land is 89.2 km^2 [13].

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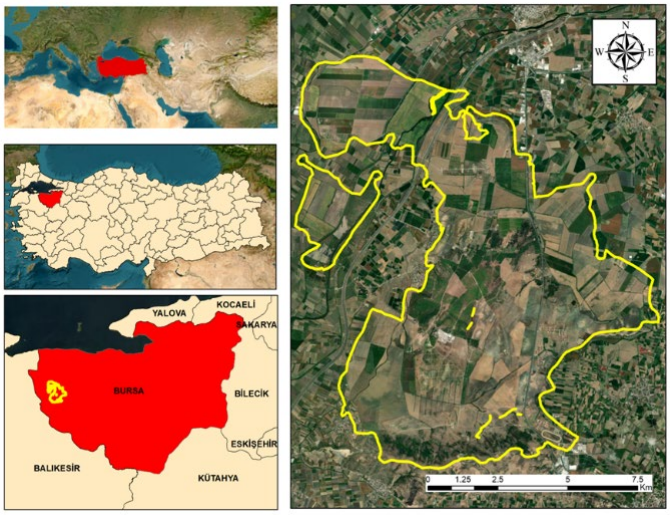

Fig. 1. Bursa province map and Karacabey Agricultural Enterprise satellite image

2.2. Climate

Precipitation, temperature, wind and humidity are parameters that greatly affect agricultural activities. Planting, fertilization programs, irrigation, spraying, and harvest timing are carried out taking into account the climate. It negatively affects not only crop production but also livestock activities, causing an increase in animal diseases [13, 14]. Karacabey Agricultural Enterprise is surrounded by the Marmara climate, which is characterized by a transition between the Mediterranean and Black Sea climates [13]. Compared to the Mediterranean climate, the research area has a lower temperature in winter months and summers are not as dry and hot as the Mediterranean climate. Karacabey plain receives less precipitation compared to other plains. Frontal precipitation is encountered in this area and rain is generally observed. The 20-year average rainfall is 428.5 mm [15]. The temperature measured in 2004-2020 is 15.4°C. The average monthly temperature is 25.2°C in August, 25°C in July, 25°C in July and 22.9°C in June. In September the average is 21.4°C, in October 16.3°C, in November 11.5°C [16]. Relative humidity in Karacabey enterprises is highest in December and lowest in July. Annual rainfall is highest in January with 106.4 mm/day. The number of days with the highest rainfall is 13.5. The months with the least precipitation are August and July with 1.6 and 2.4 precipitations (Fig 2.).

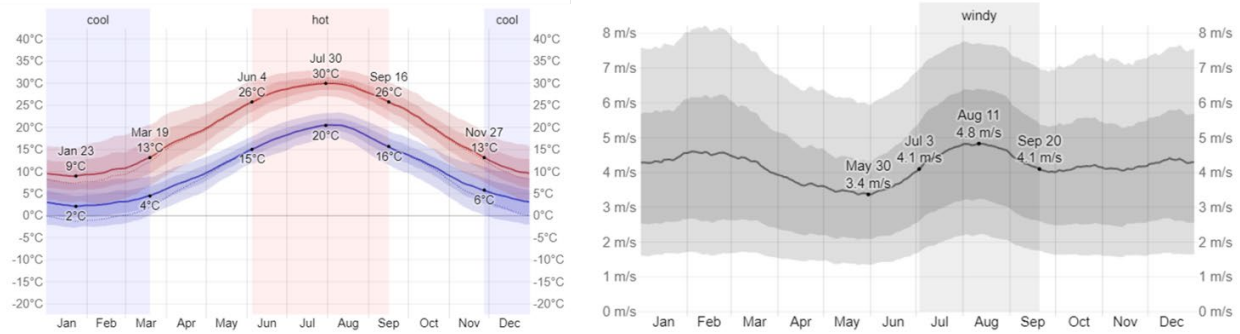

Fig. 2. Annual temperature and precipitation values of Karacabey Agricultural Enterprise and its surroundings

2.3. Geological and Geomorphologic Features

Bedrock with different properties has an important role in the formation and classification of soil. The stratigraphic stacking around Karacabey Agricultural Enterprise consists of Paleozoic, Mesozoic and Cenozoic units. Paleozoic aged lands, which form the basis of Karacabey Agricultural Enterprise lands, consist of phyllate, shale, quartz, mica and marble (Fig. 3) [17]. Both sides of the Karacabey Strait consist of metamorphic lands. In the southeast and northeast of the study area, there are Mesozoic aged crumbs and carbonates. The limestones in this area are mostly clay, shallow and medium depth, permeable soils with stone

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content [18]. Andesite, basalt, tuff and agglomerate are scattered around Yenikarağaç, Taşpınar village in the east of Karacabey Agricultural Enterprise and in the west of Karacabey plain in the south [17, 19]. The slope and elevation increase in the northwest and southeast of Karacabey Agricultural Enterprise areas and the remaining areas are observed to be slightly sloping, flat and nearly flat lands. The elevation values of Karacabey Agricultural Enterprise lands vary between 9-214 m [13].

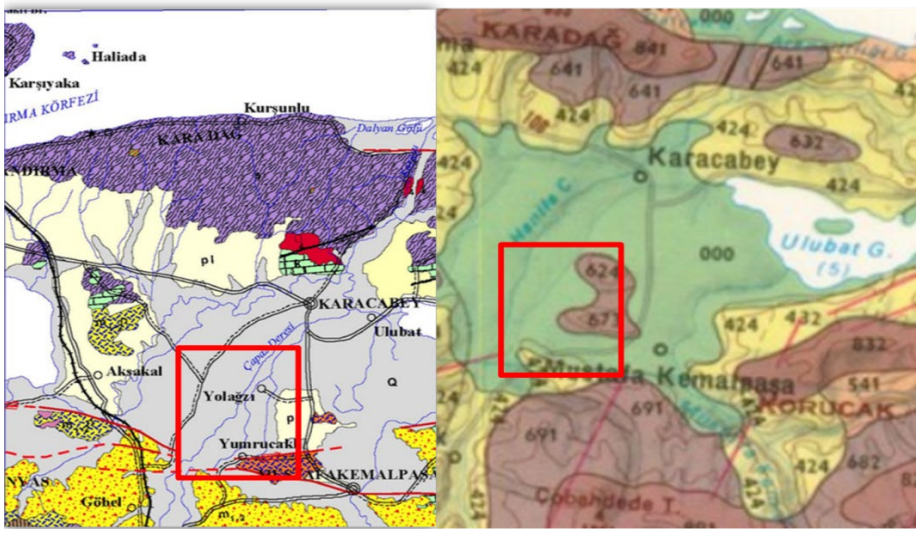

Fig. 3. Geological and geomorphological characteristics of Karacabey and it surroundings

2.4. Vegetation

The diversity of the climate in which Karacabey Agricultural Enterprise is located has an effect on the diversification of vegetation. When the vegetation in the area is examined, it is known that it consists of three groups with the presence of moist and dry forests, maquis and pseudomaki and grass formation. The vegetation forms the presence of dry forests on the southern slopes. Compared to the moist forests, the vegetation is sparse and the trees and shrubs have arid characteristics. There are oak trees around the lands of the Directorate of Agricultural Enterprise. As in a significant portion of the farms that have livestock activities, agricultural production is also carried out for feed purposes in the farm. However, the animals raised also need feed from outside periodically [20]. When we look at the grass distribution, legumes and meadow communities are encountered. Examples of these are barley grass, pasture grass, wild oats, tuberous barley, kanyash, clover and vetch.

Livestock activities also have an important place in the enterprise. The Karacabey Merino, obtained as a result of the crossbreeding of two different sheep raised in the Karacabey agricultural enterprise, is an important study on this subject [21].

Table 1. Distribution of soil series in the study area

Series	Area (ha)	(%)
Bağaltı	105,4	11
Çamlık	40,5	4
Çiftperde	46,1	5
Gerdene	161,2	16
Kabaağaç	29,7	3
Karacabey	86,8	9
Kızlan	44,9	5
Ortaçiftlik	53,1	5
Poyrazbahçe	30,0	3

Susurluk	172,8	17
Tepecik	33,9	3
Tohmalı	55,0	6
Yumurcaklı	127,5	13
Others	0,4	0
Total	**987,3**	**100**

3. Results and discussion

3.1. Soil Series

There are different soils in the enterprise in terms of various properties. There are 13 soil series identified enterprise lands (Table 1). The soils belong to the Susurluk series, which has an area of 172,8 ha, covering 17% of the enterprise. Susurluk series are generally clay loam, silty clay loam and sandy clay loam textured soils.

Gerdene, Yumurcaklı, Bağaltı series are the other most widespread soil series. Gerdene series is spread in 16% (161,2 ha) of the farm. It has mostly clay loam, silty clay loam, sandy clay loam texture. Yumurcaklı series is present in 13% (127,5 ha) of the enterprise and these soils have sandy clay and silty clay loam textures. 11% (105,4 ha) is Bağaltı series with sandy loam and sandy clay loam textures. The distribution map of Karacabey Agricultural Enterprise soil series is given in Figure.

Table 2. Distribution of soil series in the study area

Series	Area(ha)	(%)
Bağaltı	105,4	11
Çamlık	40,5	4
Çiftperde	46,1	5
Gerdene	161,2	16
Kabaağaç	29,7	3
Karacabey	86,8	9
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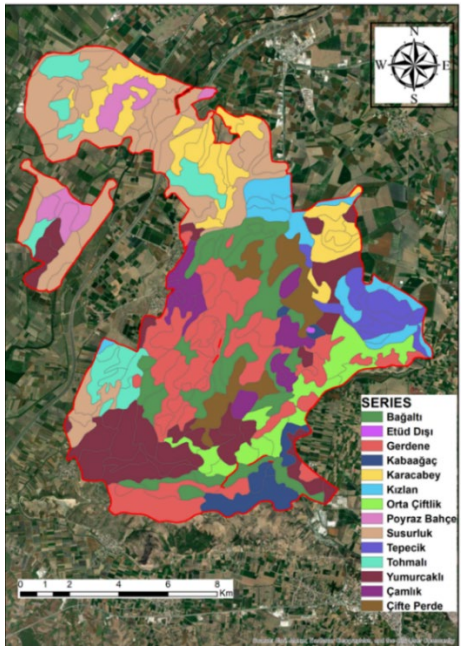

Figure 4. Soil series map of the study area

3.2. Physiographic Units

The study area consists of various physiographic units. River terrace soils are distributed in 28% (278,2 ha) of the enterprise lands (Table 2). Tepecik, Karacabey, Yumurcaklı, Poyrazbahçe series are located in these soils. The second largest area is the highlands soils, which are spread in 28% (277,5 ha). Gerdene, Çamlık, Kabaağaç, Çifteperde series are highland soils. Alluvial soils are distributed in 28% (272,7 ha) of the enterprise land. Susurluk, Tohmalı, Kızlan series are alluvial soils. Colluvial soils are distributed in 11% (105,4 ha) of the enterprise land. Bağaltı series are included in these soils. High clay soils are widespread in 5% (53,1 ha) of the farmland; Ortaçiftlik series is observed in these soils (Fig 5).

Table 3. Areas and percentage distributions of physiographic units of the study area

Physiographic Units	Area(ha)	(%)
River Terrace	278,2	28
Highlands	277,5	28
Alluvials	272,7	28
Colluvials	105,4	11
High Clayey Lands	53,1	5
Others	0,4	0
Total	**987,3**	**100**

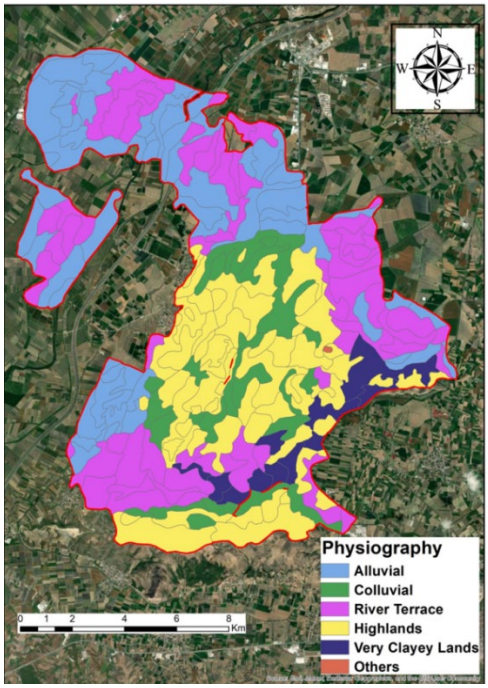

Figure 5. Physiographical units map of the study area

3.2. Soil Surface Texture

When the proportional amounts of sand, clay and silt in the unit mass of the enterprise soils are examined, it is determined that a significant part of the soil surface texture is clay loam, silty clay loam and sandy clay loam (Table 3). Especially Gerdene, Susurluk, Bağaltı, Tepecik series have these textures. Sandy clay and silty clay soils were observed in 22% (222,2 ha) of the area. 19% (182,8 ha) of the study area is sandy loam, 16% (156,7 ha) is clay textured, 6% (63,8 ha) is loamy, 4% (35,3 ha) is sand and loamy sand textured (Fig 6). In contrast to the topsoil texture, in the study conducted by Everest et al. [22], on soil texture, it was stated that SiC and C textures were more common.

Table 4. Areas and percentage distributions of soil surface texture classes in the study area

Surface Texture	Area(ha)	(%)
CL, SiCL, SCL	326,1	33
SC, SiC	222,2	22
SL	182,8	19
C	156,7	16
L	63,8	6
LS, S	35,3	4
Others	0,4	0
Total	**987,3**	**100**

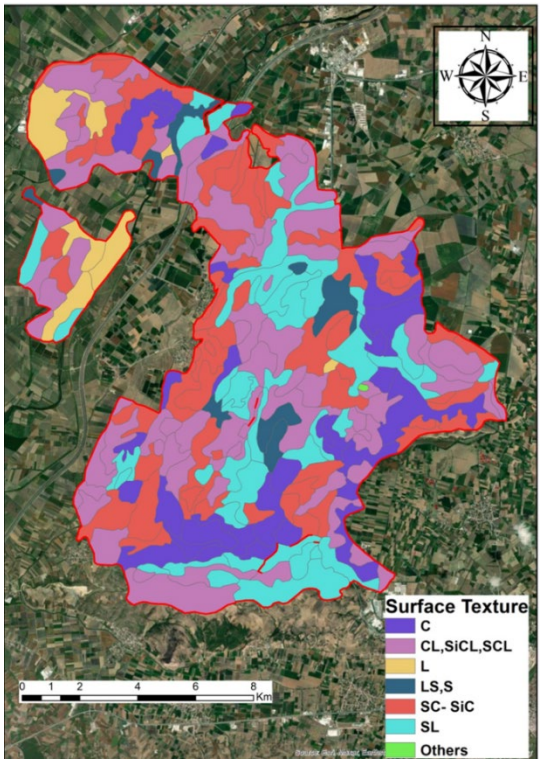

Figure 6. Topsoil texture map of the study area

3.3. Soil Depth

In terms of depth, it was determined that the majority of the enterprise lands were in deep soil class with 73% (721,0 ha) (Table 4). Susurluk series is present in a significant part of the deep soils. There are shallow soils covering 13% (127,9 ha) of the enterprise lands and these soils are mostly Gerdene series. 10% (95,1 ha) has very shallow soils and these soils are mostly Gerdene series. Very shallow areas are located in 4% (38,2 ha) and these soils are mostly Gerdene and Bağaltı series. There are medium deep areas in 0% of the lands (4,7 ha) and they include Yumurcaklı series (Fig 7). Everest et al. [22] also stated that soil depth in the enterprise land is an important problem in some regions.

Table 5. Areas and percentage distributions of depth classes in the study area

Soil Depth	Area(ha)	(%)
Very Deep	721,0	73
Deep	127,9	13
Shallow	95,1	10
Surface	38,2	4
Medium	4,7	0
Others	0,4	0
Total	**987,3**	**100**

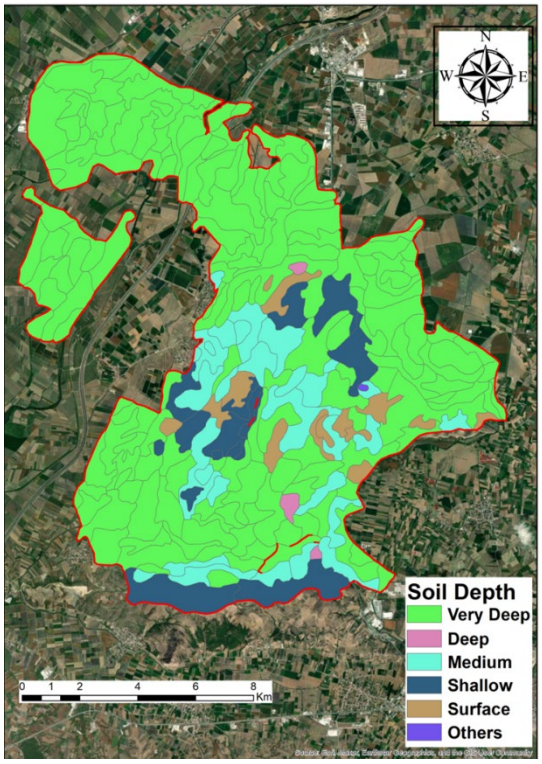

Figure 7. Soil depth map of the study area

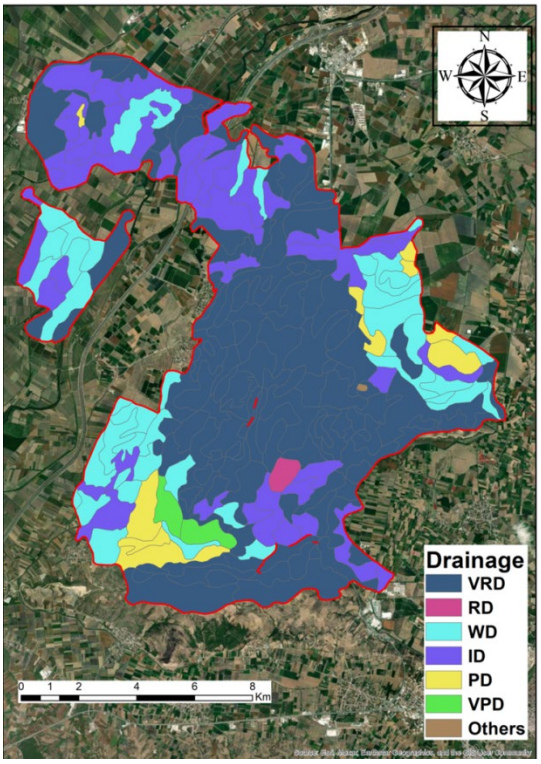

Figure 8. Drainage map of the study area

3.4. Soil Drainage

A total of the farmland has good drainage and the land is mostly (54%; 537,2 ha) in the Gerdene and Bağaltı series (Table 5). Inadequate drainage is present in 22% of the land (217,3 ha) and in these areas Yumurcaklı, Karacabey. Tohmalı series are present. 18% (173,1 ha) of the land has moderate drainage and Susurluk, Tohmalı, Yumurcaklı series are found in these areas. 5% of the land (45,0 ha) has poor drainage and these areas have Yumurcaklı series. Very bad drainage is found in 1% of the land (14,3 ha) and Yumurcaklı series is also found in this area. There are non-study areas in the enterprise lands (Fig 8).

Table 6. Areas and percentage distributions of drainage classes in the study area

Soil Drainage	**Area(ha)**	**(%)**
Very Rapidly	537,2	54
Rapidly	173,1	18
Well	217,3	22
Imperfectly	45,0	5
Poor/Very Poor	14,3	1
Others	0,4	0
Total	**987,3**	**100**

3.5. Slope

The areas with slope 0-2% mostly belong to Susurluk, Tohmalı, Karacabey and Yumurcaklı series. Flat to nearly flat sloped lands are located in 61% of the study area (Table 6). 23% (232,7 ha) of the areas with slope 2-4% belong to Bağaltı and Çifteperde series. Poyrazbahçe, Gerdene, Kabaağaç and Ortaçiftlik series are found in areas with slope 4-6%. Kabaağaç is the series in areas corresponding to 12-25%. Gerdene is the series in 2% areas with slope 6-12% (Fig 9). Similar results were also reported by [22].

Table 7. Slope of area

Slope (%)	**Area (ha)**	**(%)**
0-2	603,8	61
2-4	232,7	23
4-6	115,8	12
6-12	16,8	2
12-25	17,8	2
Others	0,4	0
Total	**9873**	**100**

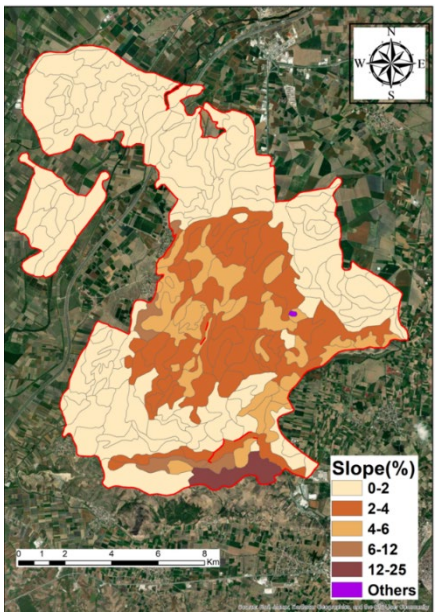

Fig. 9. Slope map of the study area

4. Conclusion

Karacabey Agricultural Enterprise is managed under state supervision and detailed soil surveys were carried out about 40 years ago. With the data obtained from the general characteristics and mapping of the enterprise lands, soil use and production pattern are revealed. The revision emphasizes production according to the characteristics of all series in soils, when the various series are evaluated on an area and percentage basis. The texture of the enterprise is generally sandy clay, silty clay loam and sandy clay loam. Silty clay loam soils are generally preferred for vegetable cultivation. Since clay soils are rich in nutrients, they allow various plants and some vegetables to grow.

Especially root vegetables and many vegetables and fruits can be grown on sandy soils. Most of the areas on the land are salt-free soils and are suitable for plant cultivation. The depth requirements of the plants are different from each other and the deeper the depth, the easier it is to grow plants. Deep soils have high water retention and water uptake is possible even at high temperatures. Areas with deep soils are suitable for oak and linden plants. In areas with shallow soils, cultivation is possible with the establishment of appropriate irrigation systems. Trees such as acacia and poplar are suitable for planting in shallow soils. Beech, alder require medium depth and production in line with these characteristics is suitable. Most of the areas in the land are good in terms of drainage, but various problems arise in areas where drainage is insufficient. In order to increase the expected benefit from irrigation, leveling and proper drainage systems should be established. Since these data contain quantitative observations from many years ago, they should be revised by resampling with current sampling methods and should produce digital prediction maps.

In past decades, land situations and total land assets should be determined by removing the areas, lost by misuse, if they exist. Not just the physical or chemical attributes of soil but also analysis for elements of the plant nutrients should be performed in the fields undergoing intensive crop production to ensure the success of fertilization and cultivation in those areas.

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