Turkish Journal of Agriculture - Food Science and Technology, 11(12): 2394-2401, 2023
DOI: https://doi.org/10.24925/turjaf.v11i12.2394-2401.6466

Turkish Journal of Agriculture - Food Science and Technology

Available online, ISSN: 2148-127X | www.agrifoodscience.com | Turkish Science and Technology Publishing (TURSTEP)

Spatial Evaluation of Land and Soil Properties with Geography Information Systems (GIS): The Case Study from Meriç District of Thrace Region in Türkiye

Muhammed Cüneyt Bağdatlı[1,a,*]

[1]*Niğde Ömer Halisdemir Üniversitesi, Mimarlık Fakültesi, Şehir ve Bölge Planlama Bölümü, Niğde, Türkiye*
[*]*Corresponding author*

ARTICLE INFO

Research Article

Received : 11.10.2023
Accepted : 20.11.2023

Keywords:
Soil and Land Properties
GIS Mapping
Spatial Analysis
Meric District
Thrace Region

ABSTRACT

This research was carried out within the scope of spatial evaluation of the land and soil properties of Edirne-Meriç district, located in the Thrace region (Türkiye) by using GIS. Arc GIS 10.3.1 software was used in the classification of soil and land features. Digital soil maps (1/25.000 scale) were used to determine soil and land properties. Alos Palsar (12.5m) satellite images were used to determine land elevation and aspect distributions. As a result of the research, it was seen that the soil class with the largest area in terms of large soil groups in Meriç district is lime-free brown forest soils (261.2 km^2). III. It was determined that class lands (153.7 km^2) cover the largest area. In general, it was observed that the soil depth was greater than 150 cm (261.9 km^2). It was determined that 23.3 km^2 of the Meriç district lands were exposed to severe water erosion. It was determined that the study area consists of lands with a steep slope of 12-20% (126.7 km^2). It has been observed that the height distribution of Meriç district lands varies between 4.7-120.5 m. It was defined that the majority of the lands were in the southwestern direction group. It is thought that the soil and land information database created as a result of the research will make significant contributions to researchers and the public, institutions and organizations.

[a] *cuneytbagdatli@gmail.com* *https://orcid.org/0000-0003-0276-4437*

Introduction

The population in the world and in Türkiye is in an increasing trend. This has led to an increase in consumption and the development of the industrial sector. The increase in population has affected the unconscious and incorrect use of natural resources (Tekinel, 2004). Soil is a living thing that is affected by the environmental situation and can show structural changes depending on the environmental situation they are in. The methods used in agricultural production are extremely important in terms of preserving a sustainable soil resource (Tunçay and Bayramin, 2010; Koca et al., 2017).

For the sustainable use of production areas, it is necessary to determine all the characteristics of the existing soils and review the management techniques applied from the beginning to the end of production in order to identify and solve the problems at this stage (Tunçay et al., 2010; Dingil et al., 2014). It is extremely important to protect and sustain soil and water resources. Soil survey and mapping studies come to the fore in studies on soil and water resources. (Anderson et al., 1976; Başayiğit et al., 1998).

It is extremely important to present the data obtained in soil survey studies to users. Presenting soil data in a database makes significant contributions to environmental modeling studies, protection of natural resources and other engineering studies (Dengiz and Sarıoğlu, 2011). GIS has an important place in digitizing non-numeric data. GIS makes significant contributions to collecting different information in a database and presenting graphic and attribute data simultaneously (Başayiğit et al., 2008).

GIS technologies are a set of systems that perform the functions of storing, analyzing and presenting data obtained from different sources as a whole. In this environment, maps can be created by evaluating data spatially. These advantages provided by GIS make it easier for users to make quick and effective analyzes and make decisions (Kol and Küpçü; 2008).

GIS provides significant contributions to researchers in many subjects such as agricultural production planning, yield estimation, soil and water resources planning, plant monitoring, irrigation and drainage studies and rural settlement planning. (Delibaş et al., 2015; Öztekin et al., 2021; Öztekin and Dingil, 2022). It is necessary to evaluate the current situation in order to evaluate soil resources and make projects and investments for the future (Bağdatlı et al., 2014).

The rapid development of technology around the world has led to significant gains in engineering studies. The use of GIS technologies in planning studies and the ability to store and analyze the obtained data quickly and effectively have provided significant gains for decision makers. Effective evaluation of soil resources with the help of GIS technologies makes significant contributions to sustainable land management (Doğan and Aslan, 2013).

This study was carried out to determine some soil and land properties of Meriç district of Edirne province, located in the Thrace Region of Turkey. Digital soil maps prepared by the repealed Ministry of Agriculture and Rural Affairs were used in the research (Anonymous, 2000). In addition, for the numerical evaluation of some land features, land elevation and aspect features were revealed by using Alos Palsar (12.5 m) satellite images. GIS (Arc GIS) software was used to evaluate the data in the study. The distributions of major soil groups, land use capability classes, erosion degrees, soil depth classes, land elevation and aspect characteristics of the study area are revealed spatially (Anonymous, 2010). In this way, it is aimed to make significant contributions to investor organizations that will contribute to the development of the region and support agricultural production by sharing the research results.

Material and Method

This study was carried out to determine the soil and land properties in Edirne-Meriç district in the Thrace region of Türkiye. The location and location of Meriç district, which is the subject of the research, is shown in Figure 1.

The Thrace region is located in the northwest of Türkiye. There are 3 provinces, 26 districts and 678 villages in the Thrace region. Its surface area (excluding lakes) is 18,665 km^2. Edirne, the subject of the research, is one of the three provinces of the Thrace region. Edrine province has 9 districts in total, including the central district. One of these districts is Meriç district. Meril district is 89 km away from Edirne. The natural borders of the district are the Ergene River in the southeast and south, and the Meriç River in the west and north. The district lands consist of wavy plains and plains between these rivers. The people of the district make their living from agriculture. The main agricultural products grown in the research area are rice, wheat, sunflower, sugar beet and legumes. Animal husbandry is also practiced in the district, where small amounts of apples, grape apples, grapes, pears, sesame and barley are grown.

In the study, GIS software (Arc GS 10.3.1) was used in the analysis and classification of land and soil properties. (Anonymous, 2010). In the study, digital soil maps (1/25.000 scale) were used to determine soil and land properties. Digital elevation models with 12.5 m resolution provided from the Alos Palsar Satellite image were used to determine the aspect and elevation distribution from land features. The classification of soil and land properties was carried out by taking into account the values specified in the Ministry of Agriculture and Forestry in Türkiye, Soil and Land Classification Standards Technical Instruction and given in Tables 1-6 (Anonymous, 2005).

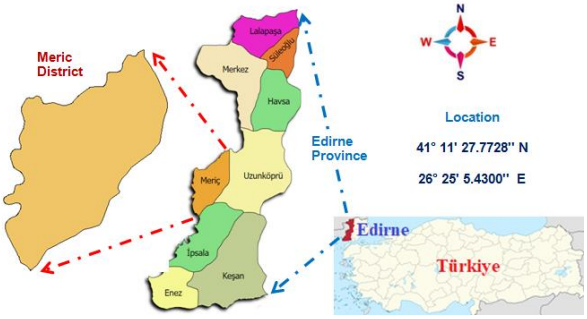

Figure 1. Location of Research Area

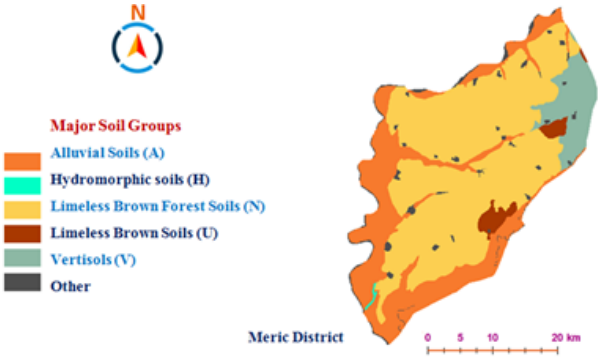

Figure 2. Spatial distributions of major soil groups

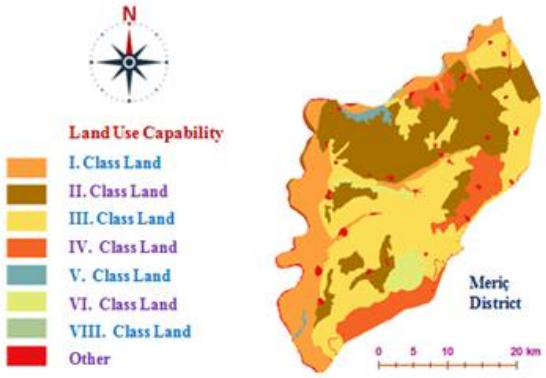

Figure 3. Spatial distributions of land use capability classes

Result and Discussion

In the research, some soil and land characteristics of Meriç district were examined spatially. In the study, the spatial distributions of the large soil groups of Meriç district are presented in Figure 2, and their areal amounts are calculated and presented in Table 6.

When we look at the distribution of large soil groups in Meriç district, it is seen that non-limestone brown forest soils are mostly distributed in the area. Alluvial soils are especially prevalent in areas close to the borders of Meriç district. Vertisol soil group is partially seen in the northeastern part of the district. Alluvial soils cover an area of 116.7 km^2 and their ratio in the total area is 26.78%. Limeless brown forest soils are most distributed in the study area and cover an area of 261.2 km^2 and their ratio in the total area is 59.95%. The spatial distributions of land use capability classes of Meriç district are gived in Figure 3 and the accordingly calculated areal distributions and ratios are summarized in Table 7.

Table 1. Layers of major soil groups (Anonymous, 2005)

Major Soil Groups	
Alluvial soils	Hydromorphic soils
Brown Soils	Colluvial soils
Limeless Brown Soils	Regosols
Chestnut Color Soils	Brown forest land
Reddish Chestnut Color Soils	Nursery Brown Forest Soils
Reddish Brown Mediterranean Lands	Red Yellow Podzolic Soils
Reddish Brown Soils	Rendzinal Soils

Table 2. Land use capability classes (Anonymous, 2005).

Land use Capability Classes	Explanations
Class I Land	These lands have deep soil structure. They are flat and nearly flat. It has fertile and easily cultivated soil.
Class II Land	In this type of land, the soil can be easily cultivated by taking some precautions. These lands may be slightly sloping and subject to moderate floods and erosion.
Class III Land	Agricultural activities can be carried out on these lands using appropriate agricultural methods.
Class IV Land	This type of land can be used as meadow land. There is poor soil character and exposure to erosion. They have poor drainage.
Class V Land	It is not suitable to grow cultural plants on these lands. This type of land can be used as meadow and forest area. These lands are stony and wet areas and agricultural production cannot be done..
Class VI Land	This type of land is very sloping. They are subject to severe erosion. They are not suitable for soil cultivation.
Class VII Land	These lands include sloping lands. It has been exposed to a lot of erosion. These are stony and swampy areas.
Class VIII Land	Agricultural production is not possible on this type of land. These lands should be left more naturally. These lands are extremely stony, mountainous and swampy areas.

Table 3. Erosion degree (Anonymous, 2005).

Erosion Degree	
1	Light (less than 25% of top soil eroded)
2	Hydrangea (25-75% of topsoil eroded)
3	Severe (more than 75% of topsoil and less than 25% of subsoil eroded)
4	Very Severe topsoil and 35-75% of subsoil eroded)

Table 4. Soil depth layers (Anonymous, 2005).

Soil Depths (cm)		
A	>150	Deep
B	90 - 150	Medium Deep
C	50 - 90	Shallow
D	20 - 50	Too Shallow
E	0 - 20	lithosolic

Table 5. Land slope groups (Anonymous, 2005).

Land Slope	
0 - 2 %, Straight	20 - 30, Very Steep Slope
3 - 6 %, Slight Slope	30 - 45, Steep Slope
7 - 12 %, Medium Slope	45 + Cliff
13 - 20 %, Steep Slope	

Table 6. Area distributions of major soil groups

Major Soil Groups	Area (km^2)	Ratio to Total Area (%)
Alluvial Soils (A)	116.7	26.78
Hydromorphic Soils (H)	0.60	0.14
Limeless Brown Forest Soils (N)	261.2	59.95
Limeless Brown Soils (U)	10.8	2.48
Vertisols (V)	34.4	7.90
Other	12	2.75

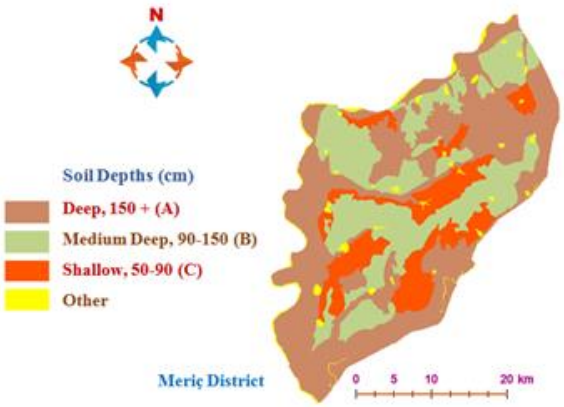

Figure 4. Spatial distributions of soil depth classes

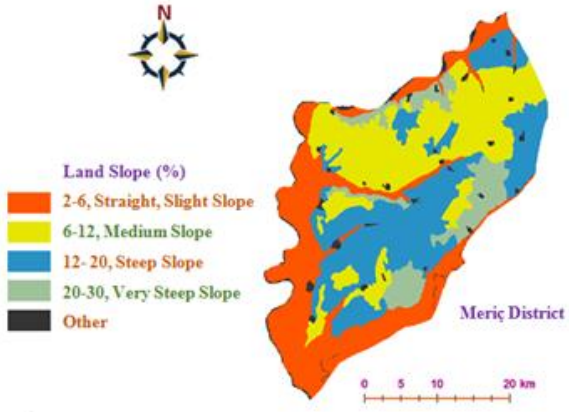

Figure 5. Spatial distributions of land slope classes

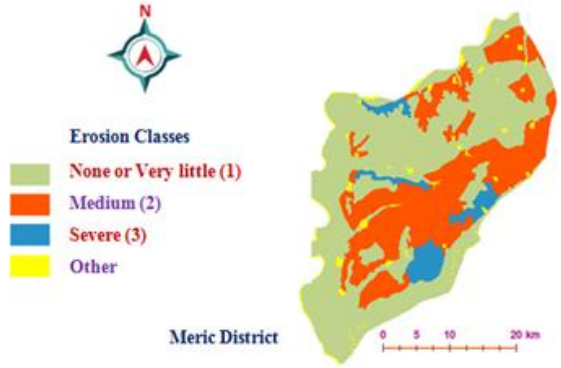

Figure 6. Spatial distributions of erosion classes

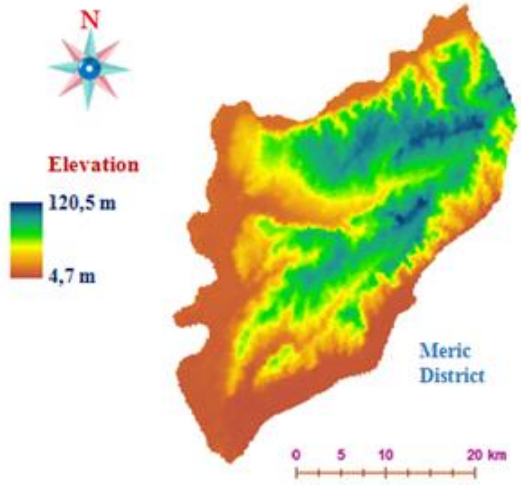

Figure 7. Spatial distribution of land elevations

In the study, land use capabilities of Meriç district were classified. In this context, the lands throughout the district are in III and VI. It is seen that it consists of lands that fall into this category. III. class lands correspond to 35.28% of the total area of the district. VI. class lands constitute 30.53% of the total area. In the research area, class I lands cover an area of 77.7 km^2 and cover 17.83% of the total area. Class I lands are distributed especially in the western and northern parts of Meriç district. Especially in the western part of the district, the Meri River, the 10th largest river of our country, passes. In this context, this region is a rich and favorable region in terms of both efficiency and agricultural production. In this respect, the lands in this section are areas where agricultural production is carried out effectively. II and III. Class lands are distributed in the slightly more central parts of Meriç district.

These lands are also suitable for agricultural production and agricultural production activities are carried out. The soil depth classes of Meriç district was analyzed as spatially and the results obtained are presented in Figure 4 and Table 8.

It is inevitable to have sufficient soil depth to carry out agricultural production effectively. Having different soil depths depending on the type and type of plant to be grown is extremely important in terms of plant root development and ensuring optimum productivity. An appropriate and sufficient soil depth provides a suitable development environment for seeds, seedlings and saplings. In this context, knowing the appropriate soil depth, which is extremely important for agricultural production, will make significant contributions to production.

In the examined area, it is seen that the soil depths are predominantly 90-150 cm and there are areas larger than 150 cm. Areas with soil depth greater than 150 cm correspond to 49,8% of the total area. Lands with a soil depth of 90-150 cm cover an area of 138.7 km^2 and constitute 31.8% of the surface area of Meriç district. In the research area, it was observed that the ratio of areas varying between 50-90 cm and described as shallow soil class in the total area was around 15.6%. It has been observed that the fields falling into the shallow soil class are distributed especially in the central parts of Meriç district. The land surface slopes of Meriç district, which is the subject of the research, were also evaluated spatially and the findings are given in Figure 5 and Table 9.

The land slope of Meriç district varies between 2-30%. Lands with a slope between 2-6% constitute 28% of the total area. These lands are mostly distributed on the western, northern and southern borders of Meriç district. Lands in the medium slope class are mostly spread in the northern regions and constitute 7.28% of the total area. Lands with very steep slopes (20-30%) constitute 21.18% of the total area. Areas with very steep slopes are partially distributed in the central part of Meriç district. The distribution map showing the erosion exposure of Meriç district is given in Figure 6 and the areal amounts are given in Table 10.

Water erosion is mainly observed in Meriç district. It is given that there are areas exposed to moderate erosion in the overall research area, which is 33.42% of the total area. Areas exposed to severe erosion correspond to 5.35% of the total area.

Table 7. Areal distributions of land use capability classes

Land Use Capability	Area (km^2)	Ratio to Total Area (%)
I. Class Land	77.7	17.83
II. Class Land	1.3	0.30
III. Class Land	153.7	35.28
IV. Class Land	45.2	10.37
V. Class Land	4.2	0.96
VI. Class Land	133	30.53
VIII. Class Land	1.7	0.39
Other	18.9	4.34

Table 8. Areal distributions of soil depth classes

Soil Depth Classes	Area (km^2)	Ratio to Total Area (%)
Deep (A), +150 cm	216.9	49.8
Medium Deep (B), 90-150 cm	138.7	31.8
Shallow (C), 50-90 cm	68.1	15.6
Other	12.0	2.8

Table 9. Areal distributions of land slope classes

Land Slope	Area (km^2)	Ratio to Total Area (%)
2-6 % Slight Slope	122	28.0
6-12 % Medium Slope	31.7	7.28
12-20 % Steep Slope	126.7	29.08
20-30 % Very Steep Slope	63	14.46
Other	92.3	21.18

Table 10. Areal distributions of erosion classes

Erosion Classes	Area (km^2)	Ratio to Total Area (%)
None or very little (1)	254.9	58.50
Medium (2)	145.6	33.42
Severe (3)	23.3	5.35
Other	11.9	2.73

Table 11. Areal distribution of land elevations

Elevation (m)	Area (km^2)	Ratio to Total Area (%)
4,7 – 27,9	155.3	35.64
27,9 – 51,1	81.7	18.75
51,1 – 74,2	83.5	19.16
74,2 – 97,4	86.6	19.88
97,4 – 120,5	28.6	6.56

Table 12. Areal distribution of land aspect (direction) groups

Aspect (direction)	Area (km^2)	Ratio to Total Area (%)
Straight	0.01	0.001
North	20.17	4.63
Northeast	34.07	7.82
East	40.06	9.19
Southeast	72.1	16.55
South	80.24	18.42
Southwest	53.18	12.21
West	53.28	12.23
Northwest	57.37	13.17
North	25.24	5.79

Areas exposed to no or very little erosion constitute 58.50% of the total area. The spatial distributions of land elevations in Meriç district are given in Figure 7 and the calculated areal amounts are given in Table 11.

Lands with an elevation range of 4.7-27.9 m correspond to 35.64% of the total area. Lands with land elevations ranging between 27.9-51.1 m cover 18.75% of the total area. Areas with land elevation between 97.4-120.5 m constitute 6.56% of the total area. Generally, the land elevations of Meriç district vary between 4.7-120.5 m. Especially in places where the district border is located, the land elevation is seen as the lowest compared to other areas. In the western part, where the land elevation is lowest and where the district borders pass, the Meriç River folowes from north to south. In the eastern part of the district, the Ergene River flowes from north to south. Therefore, these areas are seen as the areas with the lowest elevation of the land. The spatial distributions of the aspect

status of Meriç district lands are given in Figure 8, and the areal amounts of the aspect classes are calculated and presented in Table 12.

When we look at the land direction distribution, it is seen that there are no flat areas. Eastern oriented lands constitute 9.19% of the total area. Western oriented areas cover 12.23%. Generally speaking, it constitutes 4.63% of the total area.

It is possible to come across many researches in the literature on the evaluation of soil and land resources with GIS. A study was carried out within the scope of Mapping Some Soil Properties of the Lower Kelkit Basin with GIS and Remote Sensing. Within the scope of the research, soil samples were taken from the field to determine the physical and chemical properties of the soil. The data obtained as a result of the analysis were transferred to GIS software and spatial distribution maps of soil properties were produced (Doğan and Aslan, 2013).

In another research, it was determined some land and soil properties in Siirt province with GIS and to create a database of the results obtained. Digital soil maps were used in the study. Within the scope of the research, distribution maps of Siirt province's land slope and aspect distributions, erosion classes, distributions of large soil groups and current land use situations were produced (Özyazıcı et al., 2014).

Another research was carried out within the scope of determining and mapping the local changes in soil properties of the Dicle basin with geostatistical and geography information systems. In this context, soil samples were taken from the study area. Some physical and chemical analyzes were performed on the soil samples taken. The obtained analysis results were evaluated spatially in the GIS environment and distribution maps for the examined parameters were produced (Budak et al., 2018).

Many studies similar to this study have been carried out in Niğde, Nevşehir, Kırşehir, Kayseri, Malatya, Thrace Region and Kızılırmak Basin to evaluate soil and land properties. In these studies, some soil and land properties were evaluated in the GIS environment and distribution maps for the examined features were produced (Oztekin and Kosar, 2021; Bağdatlı and Can 2021b; Bağdatlı and Can, 2021a; Bağdatlı and Oztekin 2021; Bağdatlı and Arslan 2021; Bağdatlı and Ballı 2021; Bağdatlı and Arıkan 2021; Bağdatlı and Arslan, 2020; Bagdatlı and Nazari 2022a; Bağdatlı et al., 2022; Bağdatlı and Ballı 2022; Bağdatlı and Arıkan 2022; Bağdatlı and Nazari 2022b; Bağdatlı and Can 2023; Bağdatlı and Nazari 2023).

As can be seen from the literature, it is possible to come across many researches in the literature on the determination of soil and land resources by using GIS based mapping. The main feature of all these studies is that soil and land resources in the examined areas are analyzed digitally and distribution maps of the examined features are produced. It is thought that the results will make database to agricultural practices in the study areas.

In this study conducted in Meriç district, land and soil properties were evaluated numerically in the GIS environment and it was aimed that the results obtained would make significant contributions to investor organizations operating in the region.

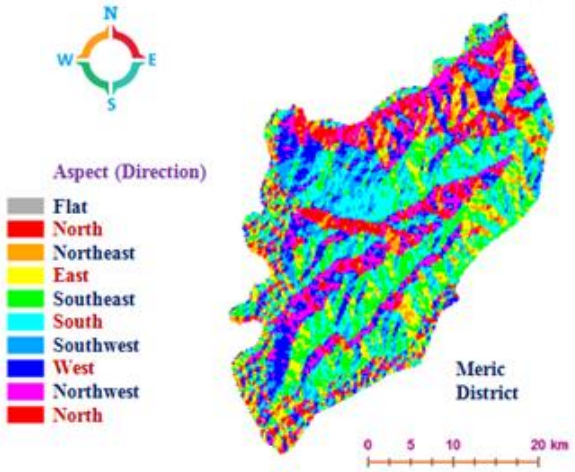

Figure 8. Spatial distribution of land aspect (direction) groups

Conclusion

GIS and Remote Sensing technologies are of vital importance in understanding and solving today's growing problems (Burrough, 1986; DeMers, 1997; Koçak, 1991). The main purpose of these systems is to manage data sets related to the environment or social structure with computer-aided studies and produce various information from these data for the benefit of society (Koçak, 1991).

GIS and its associated remote sensing are widely used in soil inventories, erosion control and pasture vegetation studies, as well as in many areas (Field, 1989).

These techniques, which are quite fast and sensitive compared to traditional methods, provide the opportunity to work in large areas and give very realistic results when combined with field studies (Chang et al., 1989, Mon Zan, 1989; Dogan and Dogan, 2006; Dogan, 2008). The main areas where GIS and Remote sensing are used in the world are issues related to soil structure, production systems and erosion (Hall-Bayer and Gwyn, 1997).

In this study, Meriç district of Edirne province, located in the Thrace region, was determined as the research area. In the study, some soil and land features of Meriç district were evaluated spatially with the help of GIS. In this context, distribution maps were created by classifying major soil groups, erosion degrees, land use capabilities, soil depths, land slope, elevation and aspect features.

The research area is a region where agricultural production is intense. Presenting the spatial distribution of data on some soil and land characteristics will provide significant contributions to investor organizations. The data obtained as a result of this study will provide infrastructure support, especially in the activation of areas that will be opened for agricultural production.

References

Anonymous 2000. Sayısal Toprak Haritaları, Mülga Köy Hizmetleri Genel Müdürlüğü, Ankara (in Turkish)

Anonymous 2010. Arc GIS 10.3.1 software, ESRI Environmental System Research Institute, Redland, CA, USA

Anonymous 2005. Toprak ve Arazi Sınıflaması Standartları Teknik Talimatı, Tarım ve Orman Bakanlığı, Ankara (in Turkish)

Anderson J R E E, Hardy J T, Roach and Witmer R.E. 1976. A Land Use and Land Cover Classification System for Use with Remote Sensor Data. U.S. Geological Survey, Professional, Paper 964, pp 28, Reston, VA

Bağdatlı MC, İstanbulluoğlu A, Bayar NA. 2014. Toprak ve su Kaynakları Potansiyelinin Coğrafi Bilgi Sistemleri (CBS) Yardımıyla Belirlenmesi: Tekirdağ-Çerkezköy İlçesi Uygulaması, Afyon Kocatepe Üniversitesi, Fen ve Mühendislik Dergisi, 14:17-25, Afyon. (in Turkish)

Bağdatlı MC, Arslan O. 2020. GIS Mapping of Large Soil Groups, Current Land Use, Soil Depths and Slopes, Soil Erosian in Kırsehir Province of Turkey, World Research Journal of Agricultural Science (WRJAS), 8(1):265-277. https://doi.org/10.5281/zenodo.4334128

Bağdatlı MC, Can E. 2021a. Spatial Evaluation of Land and Soil Properties in the Example of Nevşehir Province, Turkey, International Journal of Engineering Technologies and Management Research (IJETMR), 8(7):90-103. https://doi.org/10.29121/ijetmr.v8.i7.2021.1007

Bağdatlı MC, Arslan O. 2021. Classification and Mapping of Land Use and Some Soil Properties in Kırşehir Province, Turkey International Journal of Engineering Technologies and Management Research (IJETMR), 8(8):81-93, https://doi.org/10.29121/ijetmr.v8.i8.2021.1022

Bağdatlı MC, Ballı Y. 2021. GIS Mapping of Land Slopes, Soil Depths, Erosian Classes, Large Soil Groups and Some Soil Properties: A Case Study of Kayseri Province in Turkey, Universal Journal of Agricultural Research, 9(5):166-175. https://doi.org/10.13189/ujar.2021.090503

Bağdatlı MC, Can E. 2021b. Spatial Analysis of Soil Resources Potential by Using Geography Information Systems (GIS): A Case Study from Thrace Region, Turkey, International Journal of Innovative Research and Reviews (INJIRR), 5(2): 45-50

Bağdatlı MC, Arıkan E.N. 2021. Assessment of Some Land Properties by Using GIS in Niğde Province of Turkey International Journal of Recent Development in Engineering and Technology (IJRDET), 10(11):1-9

Bağdatlı MC, Öztekin ME. 2021. Determination of Land Use Capabilities by GIS Analysis in Nigde Province, Turkey, Eurasian Journal of Agricultural Research (EJAR), 5(2):121-129.

Bağdatlı MC, Nazari MA. 2022a. GIS Based Mapping and Assessment of Major Soil Groups and Land Capabilities in Nevsehir Province of Turkey, International Journal of Research in Advent Technology (IJRAT), 10(1):1-6.

Bağdatlı MC, Arslan O, Ballı Y, Uğuz AN. 2022. GIS Modelling and Evaluation of Climate Variability in Kızılırmak Watershed of Turkey, International Journal of Engineering Technologies and Management Research (IJETMR), 9(5):48-54. https://doi.org/10.29121/ijetmr.v9.i5.2022.1153

Bağdatlı MC, Ballı Y. 2022. Assessment and Classification with GIS of Land Use, Capability Classes and Land Types in Kayseri Province of Turkey, Eurasian Journal of Agricultural Research (EJAR), 6(1):43-5.

Bağdatlı MC, Arıkan EN. 2022. Determining and GIS Mapping Some Soil and Land Properties in Niğde Province of Turkey, International Journal of Research in Advent Technology (IJRAT), 10(2):7-12.

Bağdatlı MC, Nazari MA. 2022b. Evaluation and Spatial Analysis of Agricultural Soils by GIS based Mapping in Nevsehir Province (Türkiye), Eurasian Journal of Agricultural Research (EJAR), 6(2):133-142.

Bağdatlı MC, Can E. 2023. Spatial Analysis of Soil Resources Potential with GIS Mapping in Thrace Region of Türkiye, International Journal of Engineering Technologies and Management Research (IJETMR), 10(2): 85-95. https://doi.org/10.29121/ijetmr.v10.i2.2023.1296

Bağdatlı MC, Nazari MA. 2023. Spatial Evaluation of Current Landuse, Elevation and Aspect Features of Nevsehir Province Lands (Türkiye) by GIS Mapping, International Journal of Research in Advent Technology (IJRAT), 11(2):1-5.

Başayiğit L, Şenol H, Müjdeci M. 2008. Isparta İli Meyve Yetiştirme Potansiyeli Yüksek Alanların Bazı Toprak Özelliklerinin Coğrafi Bilgi Sistemleri ile Haritalanması. Süleyman Demirel Üniversitesi Ziraat Fakültesi Dergisi, 3(2):1-10. (in Turkish)

Başayigit L, Öztekin ME, Dingil M, Şenol S, Dinç U. 1998. Detailed soil mapping of the Adıyaman-Kahta irrigation Project area using digital satellite data" M.Şefik Yeşilsoy International Symposium on arid Region Soil., 21-24 September, İzmir/Turkey, pp: 529-532

Burrough PA, 1986. Principles of Geographical Information Systems for Land Resources Assessment, Monographs on Soil and Resources Survey (No:12). London: Oxford Science Publications

Budak M, Günal H, Çelik İ, Acir N, Sırrı M. 2018. Dicle Havzası Toprak Özelliklerinin Yersel Değişimlerinin Jeoistatistik ve Coğrafi Bilgi Sistemleri ile Belirlenmesi ve Haritalanması, Türkiye Tarımsal Araştırmalar Dergisi, 5(2): 103-115 (in Turkish)

Chang XG, Jing X, Shen-Siu C. 1989. The Application of Remote Sensing to Grassland Resource Survey of the Counties in China. Nice, France: Proceedings of XVI International Grassland Congress, p.1383-1384.

Dengiz O, Sarıoğlu F.E. 2011. Samsun İlinin Potansiyel Tarım alanlarının Genel Dağılımları ve Toprak Etüd ve Haritalandırma Çalışmalarının Önemi. Anadolu Tarım Bilim. Dergisi, 26(3): 241-250. (in Turkish)

Delibaş L, Bağdatlı MC, Danışman A. 2015. Topoğrafya ve Bazı Toprak Özelliklerinin Coğrafi Bilgi Sistemleri (CBS) Ortamında Analiz Edilerek Ceviz Yetiştiriciliğine Uygun Alanların Belirlenmesi: Tekirdağ İli Merkez Köyleri Örneği. GÜFBED/GUSTIJ, 5 (1): 50-59.(in Turkish)

DeMers MN. 1997. Fundamentals of Geographic Information Systems. New York: John Wiley Sons, Inc.

Dingil M, Oztekin ME, Senol S. 2014. Definition of the physiographic units and Land use capability classes of soils in mountainous areas via satellite imaging., Fresenius Environmental Bulletin, 23(3A): 952-955.

Doğan HM, Dogan M. 2006. A new approach to diversity indices-modeling and mapping plant biodiversity of Nallihan (A3-Ankara) forest ecosystem in frame of geographic information systems. Biodiversity and Conservation 15: 855-878

Doğan HM. 2008. Applications of remote sensing and geographic information systems to assess ferrous minerals and iron oxide of Tokat province in Turkey. International Journal of Remote Sensing, 29(1): 221-233.

Doğan HM, Aslan S. 2013. Aşağı Kelkit Havzası`nın Bazı Toprak Özelliklerinin Coğrafi Bilgi Sistemleri ve Uzaktan Algılama ile Haritalanması. Gaziosmanpaşa Bilimsel Araştırma Dergisi, 3:25-33.

Field TRO 1989. Vegetational Survey of Management Pastures in New Zealand. Nice, France: Proceedings of XVI International Grassland Congress (pp. 1407-1408).

Hall-Bayer M, Gwyn QHJ 1997. Integrating Satellite Images and Species-Based Vegetation Maps to Manage Native Grasslands. Winnipeg-Manitoba, Canada: Proceedings of XVI International Grassland Congress, pp: 123-124

Koca YK, Senol S, Dingil M, Oztekin ME. 2017. Effect of topographic map scale on quality of soil maps in detailed soil surveys of undulated lands, Fresenius Environmental Bulletin , Vol:26, Issue:10, Pages:6266-6271.

Kol Ç, Küpçü S. 2008. Esri Arc GIS Spatial Analiz, İşlem Şirketler Grubu Eğitim Dokümanları.

Koçak E. 1991. Arazi Bilgi Sistemi, Genel Yapısı ve Özellikleri. Ankara: III. Harita Kurultayı (pp: 99-110).

Mon Zan Y. 1989. Using LANDSAT Images for Grassland Mapping in the Inner Mongolia of China. Nice, France: Proceedings of XVI International Grassland Congress (pp. 1387- 1389).

Öztekin ME, Antmen ZF, Onat B. 2021.,Monitoring and Yield estimation of Soybean using satellite data in North yüreğir region, Adana Turkey, Fresenius Environmental Bulletin Volume 30(06A) :6602-6608.

Öztekin ME, Dingil M. 2022. Determination of Corn Planting Areas and Yield Forecasting Using Landsat Images, Fresenius Environmental Bulletin, 31(04): 4420-4426 .

Öztekin ME, Kosar M. 2021. Gis and remote sensing are used by multi criteria decision analysis method to determine the landside sensitive areas of Malatya province, Fresenius Environmental Bulletin, 30(04): 3524-3536.

Özyazıcı A, Dengiz O, İmamoğlu A. 2014. Siirt İli Bazı Arazi ve Toprak Özelliklerinin Coğrafi Bilgi Sistem Analizleriyle Değerlendirilmesi, Türkiye Tarımsal Araştırmalar Dergisi, (1): 128-137

Tunçay T, Bayramin İ. 2010. Çiçekdağı-Kırşehir Tarım İşletmesi Topraklarının Detaylı Toprak Etüt ve Haritalanması. Anadolu Tarım Bilim Dergisi, 25(1):53-60 (in Turkish)

Tunçay T, Bayramin İ, Erpul G, Kibar M. 2010. Kırşehir Çiçekdağı Tarım İşletmesi Topraklarının Kalite Durumlarının Belirlenmesi. Anadolu Tarım Bilim. Dergisi, 25(3):185-19 (in Turkish)

Tekinel O. 2004. Sulu Tarımında Problemler ve Çözüm Yolları. 21. Yüzyılda Su Sorunu ve Türkiye (Fırsatlar- Zorluklar, Güçlü ve Zayıf Yanlarımız) Konulu Toplantı Kitabı, VAKIF 2000. 2000'li Yıllarda Türkiye Stratejik, Sosyal ve Ekonomik Araştırmalar Vakfı, Ankara