Black Sea Journal of Engineering and Science
doi: 10.34248/bsengineering.1436087

Open Access Journal
e-ISSN: 2619 – 8991

Research Article
Volume 7 - Issue 4: 764-770 / July 2024

DETERMINATION OF SUITABLE BEEKEEPING PLACES IN SİNOP PROVINCE (TÜRKİYE) BY WEIGHTED OVERLAY ANALYSIS

Şule YAMAN[1]*, Mustafa YAMAN[2]

[1]*Karadeniz Technical University, Department of Geomatics Engineering, 61080, Trabzon, Türkiye*
[2]*Bolu Abant İzzet Baysal University, Department of Biology, 14030, Bolu, Türkiye*

Abstract: Bees and beekeeping activities are very important for the sustainability of natural life. Beekeeping has become one of the main sources of income of our country due to products such as pollen, royal jelly, honey and wax obtained from beekeeping activities. In addition, our country's rich geography, climate and topography are very suitable for beekeeping activities. Interest in beekeeping activities has increased because it does not require large areas and costs, requires less maintenance than other agricultural activities, and has high income. With the increasing interest, conscious beekeeping, increasing the efficiency obtained from beekeeping activities and therefore determining suitable beekeeping places have gained importance. For this purpose, a study was carried out to determine suitable places for beekeeping in Sinop province, which is suitable for beekeeping activities due to its flora, climate and location. ArcGIS 10.7.1 program was used to determine suitable areas and weighted overlay analysis was performed using criteria such as slope, aspect, elevation, precipitation, vegetation, and distance to roads, streams and settlements. As a result of the analysis, it was determined that 96.38% of Sinop province was suitable for beekeeping. Additionally, it was checked whether the existing beekeeping sites were in suitable locations, and as a result, it was observed that approximately half of the beekeepers were in the correct locations.

Keywords: Beekeeping, Weighted overlay analysis, GIS, Suitability analysis

***Corresponding author:** Karadeniz Technical University, Department of Geomatics Engineering, 61080, Trabzon, Türkiye
E mail: suleyaman98@hotmail.com (Ş. YAMAN)
Şule YAMAN https://orcid.org/0000-0002-7426-9358
Mustafa YAMAN https://orcid.org/0000-0001-5656-7266

Received: February 12, 2024
Accepted: July 10, 2024
Published: July 15, 2024

Cite as: Yaman Ş, Yaman M. 2024. Determination of suitable beekeeping places in Sinop province (Türkiye) by weighted overlay analysis. BSJ Eng Sci, 7(4): 764-770.

1. Introduction

Beekeeping, one of the most common agricultural activities in the world, starts from the nuclear family and dramatically contributes to the environment and economy with products for the agricultural sector, food, health, cosmetics, and paint. At the same time, they contribute to the economy and the natural environment with pollination, in which they play a role in the sustainability of the natural cycle. Although almost every part of our country is suitable for beekeeping activities with its topography, rich geography, and suitable climatic conditions, wax and honey production is decreasing despite the increasing number of hives, according to the General Directorate of Agriculture and Forestry data so the low efficiency obtained from beekeeping activities shows a deficiency in performing beekeeping activities (TOB, 2023).

Although Sinop province is a very suitable location for beekeeping (Alkan, 2020) since it receives much precipitation and has a diverse flora such as pine, fir, oak, hornbeam and beech, and the winters are cool, and the summers are warm (Ayan et al., 2014; Albayrak, 2019) it has been observed that the potential of the region has not been fully utilized so determining suitable locations and criteria for beekeeping activities will enable the correct use of the region's potential and increase yield and production.

Determining suitable beekeeping places to increase the efficiency obtained from beekeeping activities, continue beekeeping activities healthily and consciously, and contribute more to the environment and the country's economy will provide a solution to this problem to a large extent.

Before determining suitable places, it is important to determine suitable conditions for bees, know the geography, and offer them appropriate opportunities. For bees to continue their activities, many criteria, such as natural water resources, habitat types, settlements, roads, precipitation, and temperature, must be suitable. According to experiments, bees cannot operate at temperatures below 10 °C and above 36 °C, but they operate very effectively at temperatures between 29-33 °C (Yalçın et al., 2019). Similarly, while determining the hive locations, it is important to choose the diversity and continuity of the flora, the locations that do not receive much wind and precipitation and are not exposed to direct sunlight, and away from the city and traffic (Yalçın et al., 2019). The Ministry of Food, Agriculture and Livestock published a regulation in the Official Gazette on 30 November 2011. In paragraph “k” of Article 5 of the regulation, “Apiculture is placed at least 200 meters from the road in areas with heavy traffic, and at least 30

meters away from stabilized side roads", in paragraph "l", "Fixed beekeepers place their colonies in villages and towns in a way that does not disturb the environment and at least 200 meters away from similar areas such as mosques, schools, health centers, police stations, where people receive services collectively. In areas where the settlement is scattered, this distance should be at least 50 meters to the nearest house" (Anonymous, 2023). Topographic criteria such as land surface, slope, aspect, and height, which are directly related to beekeeping activities, are important. Considering these terms and conditions, the right places should be determined at the beginning since changing the apiary places will be difficult and troublesome after the beekeeping activity has started.

Considering that the world we live in is a purely geographical space, it is seen that all events occurring on Earth are directly or indirectly related to geography (Kapluhan, 2014), so using Geographic Information Systems (GIS), which is a decision-making mechanism that provides the storage, analysis, and presentation of data by associating all kinds of verbal/textual data with each other and their geographical locations, appropriate location analysis is a correct decision and is a tool.

Beekeeping activities are closely related to the agriculture and land resources and modern beekeeping uses various information technology solutions that support beekeepers in their activities (Kotovs and Zacepins, 2023). The geographical information system (GIS) has been used in apiculture (Rogers and Staub, 2013; Kotovs and Zacepins, 2023). for many purpose such as classifying regions according to their suitability honey bees, impacts of climate change and land cover on apiculture (Abou-Shaara et al., 2013; Abou-Shaara, 2013; Abou-Shaara, 2016), mapping floral resources for honey bees (Adgaba et al., 2017; Ausseil et al., 2018) and regional recognition of multifloral honey (Radovic et al., 2014).

In the present study, we determined suitable beekeeping places of Sinop province by using weighted overlay analysis in terms of flora, climate and hive location. With this context, Weighted Overlay Analysis was carried out for Sinop province by using ArcGIS 10.7.1 program with the criteria of precipitation, flora, water resources, road, settlement, slope, aspect, and elevation.

2. Materials and Methods

2.1. Study Area

Sinop province, which is located between 41° 12' and 42° 06' north latitudes and 34º 14' and 36º 26' east longitudes, was determined as the study area. It is a suitable location for beekeeping because of the low-temperature difference between the seasons, cool winters, warm summers, rich vegetation, and year-round rainfall. The map of the study area is given in Figure 1.

2.2. Data Collection

The study created a suitability map by weighted overlay analysis with ArcGIS 10.7.1 desktop software. Flora, distance to water sources, road and settlement, slope, aspect, elevation and precipitation data are required for analysis, so data collection was carried out in the first stage of the study. The sources from which the data were obtained are shown in Table 1.

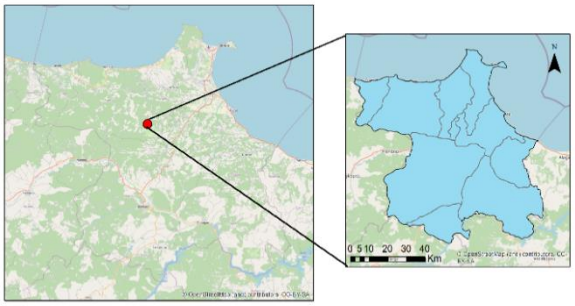

Figure 1. Study area Sinop province and its borders.

Table 1. Data and data sources used in the study

Data Name	Data Source
Provincial and District Boundary	General Directorate of Maps
The settlement, Road, and Water Resources	Open Street Map
Flora	CORINE 2018
Digital Elevation Model	USGS Earth Explorer

Criteria have been determined by considering suitable conditions for beekeeping activities. Details of the selected criteria are given below.

Flora: Flora affects honey yield and quality, so flora selection should be made sensitively by paying attention to the plant species in the environment where the beehives are located and the product diversity in agricultural areas for beekeeping activities (Kouchner, 2019).

Slope: Flat or low-slope lands are more suitable environments for beekeeping activities. It is a critical criterion because it depends on topography and height.

Aspect: Priority should be given to the hive entrances facing south while determining the hive locations. It is known that the morning sun hitting the hive entrances forces the bees to fly (Yalçın et al., 2019).

Altitude: The altitude of the study area is related to meteorological events and flora. The decrease in air temperature as you go higher is not suitable for beekeeping activities. It is important to determine the appropriate height.

Precipitation: The precipitation criterion, which directly affects flora diversity and vegetation density, is one of the criteria for beekeeping activities.

Distance to Roads and Settlement: To get the highest efficiency from the work area and the products, the hives should be away from the roads and settlements.

Distance to Water Sources: The proximity of the hives to clean water sources is another critical criterion to

increase the efficiency obtained from beekeeping activities.

2.3. Determination of Class Ranges and Criterion Weights

After obtaining the data of the determined criteria, ArcGIS 10.7.1 software was used to create the analysis and result in visual maps. First, since the provincial and district borders obtained from the General Directorate of Maps are in line format, the study area was selected by converting it to polygon format. Then, the data needed to analyze the distance criteria to water sources, roads, and settlements were obtained from the Open Street Map platform, and these data were cropped to suit the study area. Taking into consideration the "k" and "l" paragraphs of the 5th article of the Beekeeping Regulation published in the Official Gazette No. 28128 on 30 November 2011, buffer zones of 1000 meters each for the distance to water sources, roads, and settlements were created with the "multiple buffer" process. Digital Elevation Model (DEM) data were downloaded from the USGS Earth Explorer page, and slope, aspect, and elevation data suitable for the study area were produced. Flora base was created from the data of CORINE 2018 by the study area. The areal precipitation data were obtained by processing the annual precipitation amount received from the General Directorate of Meteorology on a provincial basis in the region. After creating the map bases for each criterion, the class ranges of the data were determined to carry out weighted overlay analysis, which includes weighting and overlapping concerning each other and creating the resulting map. The studies in the literature were taken as references in determining the class intervals (Ceylan and Sarı, 2017; Yılmaz et al., 2021).

The criteria were given a value from 1 to 9, considering their contribution to beekeeping activities and their importance. Table 2 shows the class ranges and importance levels of the criteria.

According to these values, 9 class values were given to the most suitable class range, and 1 class value was given to the unsuitable class range. A weighted overlay analysis model was established with "Model Builder", and the analysis was performed by entering the weight value of the criteria. Table 2 also includes the weight values of the criteria. In the resulting layer map, 9 indicates the most suitable areas for beekeeping activities, while 1 indicates areas not suitable for beekeeping activities.

As a result of the study, suitable places for beekeeping were determined by weighted overlay analysis. At the same time, it was evaluated whether the existing beekeeping places were in suitable locations. Weighted overlay analysis is a multi-factor analysis used in Geographic Information Systems (GIS). It is the process of obtaining the resulting map by evaluating, weighting, and combining more than one thematic map concerning each other. Each criterion is represented by its thematic map, and these maps are combined by multiplying the weights. The mathematical representation of this process is given in the formula below.

Table 2. Assignment of criteria class ranges and severity levels

Criteria	1	2	3	4	5	6	7	8	9
Altitude	1845>	1435-1845	1230-1435	1025-1230	820-1025	615-820	410-625	205-410	205<
Slope	50-80	40-50	30-40	25-30	20-25	15-20	10-15	5-10	0-5
Aspect	North	NE, NW	-	-	West-East	-	-	SE, SW	South
Precipitation	680	780	880	980	1080	1180	1280	1380	1540>
Flora	City Areas	Rocky Field	-	Farming Areas	Sparse Plant Areas	-	Meadows	Natural Plant Areas	Forests
Distance to Water Resources	8000>	8000	7000	6000	5000	4000	3000	2000	1000
Distance to settlement	1000	2000	3000	4000	5000	6000	7000	8000	8000>
Distance to Roads	1000	2000	3000	4000	5000	6000	7000	8000	8000>

3. Results and Discussion

It is important to choose a suitable place and get high performance of bee colonies in order to continue beekeeping activities and increase the yield of these activities. Beekeeping and bee performance are affected by several factors, such as the distance of the beehives to clean water sources, settlements and highways, the altitude of the location where the hives are located, precipitation and flora. Each of these factors can have different effects on beekeeping activities. Weighted overlay analysis helps us to determine the land selection and management strategy (Yılmaz et al., 2021). In the

present study, we determined suitable beekeeping places of Sinop province by using weighted overlay analysis in terms of flora, climate and hive location.

The thematic map for each criterion, used in the weighted overlay analysis was created to determine suitable beekeeping places in Sinop province (Figure 2). The green areas on the maps show suitable beekeeping areas, and the red areas show unsuitable areas.

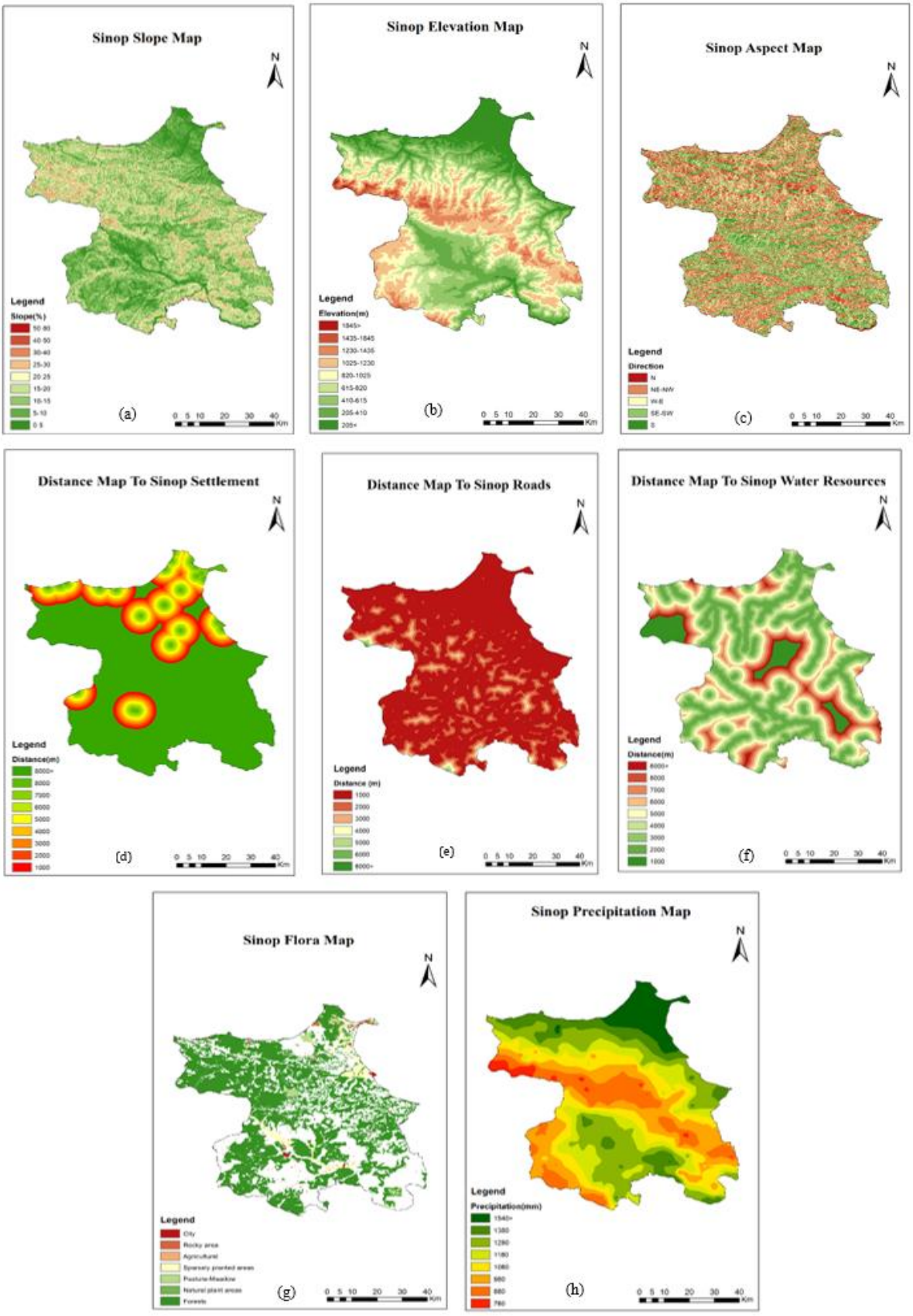

Figure 2. The class ranges and suitability map of the criteria (a: slope map, b: elevation map, c: aspect map, d: distance to settlements map, e: distance to roads map, f: distance to water resources map, g: flora map, h: precipitation map).

It was determined that a large part of Sinop province, where is the study area, is covered with mountains and that it has altitudes between 205 m and 1845 m and contains large plains between the mountains and the coast. In addition, when the slope and settlement maps are examined, it was determined that the land has a high slope and the scattered settlement type is seen in the coastal areas. When the aspect map is examined, it was determined that the aspect direction of the region is often northwest, south and southeast. There are many large and small valleys in the region and the mountains generally extend in the east-west direction. When the precipitation map is examined, it is seen that the amount of precipitation increases from south to north direction and the annual average precipitation varies from 680 mm to 1540 mm. When looking at the flora map, it has been determined that the presence of forests, natural plant areas and meadows is high due to rainfall and the distance to the stream.

After the thematic map of each criterion classified according to their importance was created, their weights were entered into the established weighted overlay model. As a result of this process, the suitability map for determining the suitable beekeeping places for Sinop province is given in Figure 3.

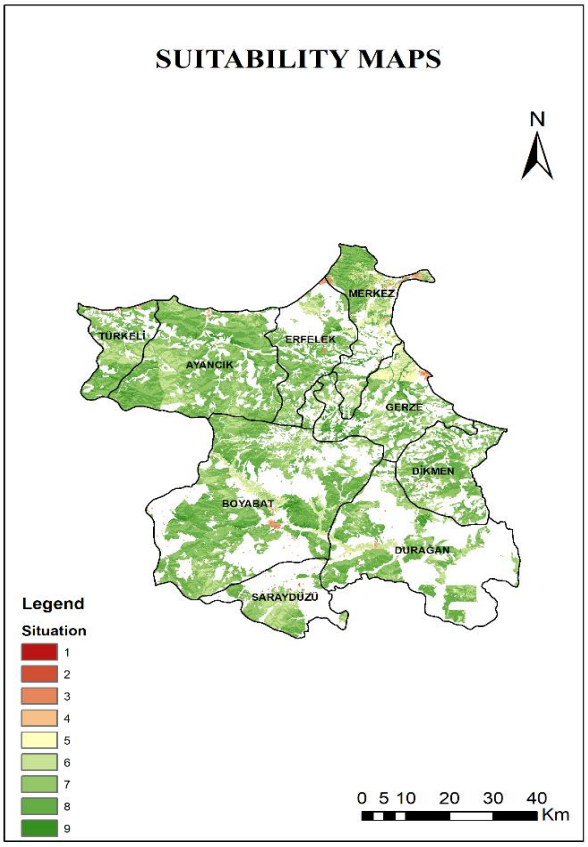

Figure 3. Map of suitable beekeeping places in Sinop province.

After the weighted overlay analysis, the appropriate places in the resulting map were classified to be evaluated from 1 to 9. Based on the 6, 7, 8, and 9 classes of values suitable for beekeeping, it was determined that 96.38% of the region is suitable for beekeeping activities. On the map, the red color corresponding to the value 1 represents the places unsuitable for beekeeping activities, the cream color corresponding to the 5 value represents the medium suitable places, and the green color corresponding to the 9 value represents the suitable places. Considering the weight values of the criteria, the fact that the most significant contribution is in the flora criterion, with a weight value of 44%, shows that it plays a significant role in determining suitable places, so when looking at the flora of suitable and unsuitable places, it is seen that suitable places are forest and meadow areas, and unsuitable places are areas such as cemeteries and bushes.

After the suitable places were determined, it was a matter of curiosity whether the 12 beekeepers reached were in the suitable places, and the current positions of the beekeepers were matched with the suitability map. The location is shown in Figure 4.

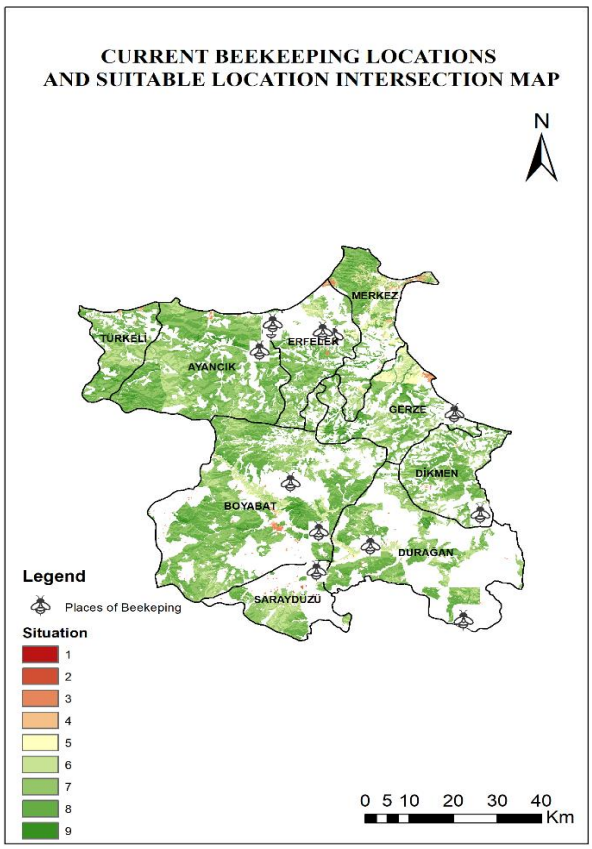

Figure 4. Existing beekeeping locations and intersection map of available locations.

In a recent study carried out by Yılmaz et al. (2021), the most suitable places for beekeeping in Şavşat district of Artvin province was determined by using weighted overlay analysis. The analysis in that study was carried out according to 8 criteria, and as a result of the study, suitable places for beekeeping were determined by dividing the study area into 5 classes such as very low, low, medium, high and very high suitability. Similarly,

suitable places for beekeeping in the Karaburun, Çeşme and Urla districts of İzmir were determined by using multi-criteria decision analysis and weighted overlay analysis (Yalçın et al., 2019). The applications of Geographic Information System (GIS) and Multi-Criteria Decision

Analysis to determine beekeeping locations were discussed in detail in Selangor (Maris, 2008). In the most recent study, suitable beekeeping locations for

Bolu province were determined by using weighted overlay analysis. As a result of the study, it was determined that 90.95% of Bolu province was suitable for beekeeping (Yaman and Yaman, 2023).

Our results show similarities with the literatures mentioned above. However, appropriate beekeeping locations determined by weighted overlay analysis were verified with actual data from existing beehives. A reasonable consistency was determined as a result of the study.

4. Conclusion

In this study, suitable beekeeping sites for Sinop province were determined by weighted overlay analysis for the first time. The results in this study will contribute to beekeepers finding suitable places. Furthermore, our study will lead to other studies in this field. On the other hand, the resulting map in this study is only in the context of Sinop province. Increasing the number of criteria used in the study, keeping more detailed records, and opening source data will increase the efficiency of the study.

Author Contributions

The percentage of the author(s) contributions is presented below. All authors reviewed and approved the final version of the manuscript.

	Ş.Y.	M.Y.
C	50	50
D	50	50
S	50	50
DCP	50	50
DAI	50	50
L	50	50
W	50	50
CR	50	50
SR	50	50
PM	50	50
FA	50	50

C=Concept, D= design, S= supervision, DCP= data collection and/or processing, DAI= data analysis and/or interpretation, L= literature search, W= writing, CR= critical review, SR= submission and revision, PM= project management, FA= funding acquisition.

Conflict of Interest

The authors declared that there is no conflict of interest.

Ethical Consideration

Ethics committee approval was not required for this study because of there was no study on animals or humans.

References

Abou-Shaara HF, Al-Ghamdi AA, Mohamed AA. 2013. Identifying possible regions for using modified beehives in Saudi Arabia using a geographical information system (GIS). Int J Agri Technol, 9: 1937-1945.

Abou-Shaara HF. 2013. Using geographical information system (GIS) and satellite remote sensing for understanding the impacts of land cover on apiculture over time. Int J Remote Sens Appl, 3: 171.

Abou-Shaara HF. 2016. Expectations about the potential impacts of climate change on honey bee colonies in Egypt. J Apicult, 31: 157-164.

Adgaba N, Alghamdi AA, Sammoud R, Shenkute AG, Tadesse Y, Ansari MJ, Sharma D, Hepburn C. 2017. Determining spatio-temporal distribution of bee forage species of Al-Baha region based on ground inventorying supported with GIS applications and Remote Sensed Satellite Image analysis. Saudi J Biol Sci, 24: 1038-1044.

Albayrak T. 2019. Research on the economic structure of the building sector in Sinop. MSc Thesis, Maltepe University. Institute of Social Sciences, İstanbul, Türkiye, pp: 104.

Anonymous. 2023. Arıcılık yönetmeliği. Resmî Gazete Tarihi: 30.11.2011, Resmî Gazete Sayısı: 28128. URL: https://www.mevzuat.gov.tr/mevzuat?MevzuatNo=15529&MevzuatTur=7&MevzuatTertip=5 (accessed date: May 19, 2023).

Ausseil AG, Dymond JR, Newstrom L. 2018. Mapping floral resources for honey bees in New Zealand at the catchment scale. Ecol Appl, 28(5): 1182-1196. https://doi.org/10.1002/eap.1717

Ayan S, Ayan Ö, Altunel T, Yer EN. 2014. Honey forests as an example of agroforestry practices in Türkiye. Forestry Ideas, 48: 141-150.

Ceylan DA, Sarı F. 2017. Konya ili için çok ölçütlü karar analizleri ile en uygun arıcılık yerlerinin belirlenmesi. Uludağ Arıcılık Derg, 17(2): 59-71. https://doi.org/10.31467/uluaricilik.373637

Erkan Alkan P. 2020. Pollen analysis of chestnut honey in some provinces of the Black Sea Region, Türkiye. Mellifera, 20(2): 18-31.

Kapluhan E. 2014. Coğrafi bilgi sistemleri'nin (CBS) coğrafya öğretiminde kullanımının önemi ve gerekliliği. Marmara Coğrafya Derg, 29: 34-59. https://doi.org/10.14781/mcd.85148

Kotovs D, Zacepins A. 2023. Importance of GIS solutions for beekeepers: a review. Agron Res 21(2): 799-813. https://doi.org/10.15159/ar.23.049

Kouchner C. 2019. Bee farming system sustainability: An assessment framework in metropolitan France. Agri Syst, 176: 1-8. https://doi.org/10.1016/j.agsy.2019.02.006

Maris N, Mansor S, Shafri H. 2008. Apicultural site zonation using GIS and multi-criteria decision anaylsis. Pertanika J Trop Agri Sci, 31(2): 147-162.

Radovic DI, Lazarević KB, Trifković J, Andrić F, Tešić ŽL, Anđelković I, Nedic NM, Stanimirovic Z, Stevanovic J, Curcic BPM. 2014. GIS techology in regional recognition of the distribution pattern of multifloral honey: The chemical traits in Serbia. Arch Biol Sci, 66: 935-946.

Rogers SR, Staub B. 2013. Standard use of geographic

information system (GIS) techniques in honey bee research. J Apicult Res, 52(4): http://dx.doi.org/10.3896/IBRA.1.52.4.08

TOB. 2023. Tarım ve Orman Bakanlığı Türkiye arıcılık İstatistikleri (1991-2023). URL: https://arastirma.tarimorman.gov.tr/aricilik/Link/2/Aricilik-Istatistikleri (accessed date: July 01, 2024).

Yalçın H, Ağaçsapan B, Çabuk A. 2019. Coğrafi bilgi sistemleri ile uygun arıcılık yerlerinin belirlenmesi. GSI J Series C: Adv Info Sci Technol, 1(2): 1-15.

Yaman Ş, Yaman M. 2023. Determination of suitable beekeeping places by weighted overlay analysis: A case study of Bolu, Türkiye. U Bee J, 23(2): 239-251.

Yılmaz E, Sesli FA, Uzun ÖF. 2021. Arıcılık faaliyetleri için uygun yerlerin coğrafi bilgi sistemleri ile belirlenmesi: Şavşat ilçesi örneği. BSJ Eng Sci, 4(3): 111-116. https://doi.org/10.34248/bsengineering.948181.