Afyon Kocatepe Üniversitesi Fen ve Mühendislik Bilimleri Dergisi
Afyon Kocatepe University Journal of Science and Engineering

AKÜ FEMÜBİD **23** (2023) 045802 (1045-1055) AKU J. Sci. Eng. **23** (2023) 045802 (1045-1055)
DOI: 10.35414/ akufemubid.1229833

Araştırma Makalesi / Research Article

Determining the Suitability of Lands for Agricultural Use with the Best-Worst Method: Ankara Province Example

Gamze AKYUZ[1], Sukran YALPIR[1*], Ela ERTUNC[1]
[1]Konya Technical University, Faculty of Engineering and Natural Sciences, Department of Geomatics Engineering, Konya.

gamzeakyuz820@gmail.com ORCID ID: http://orcid.org/ 0000-0003-2739-4671
Sorumlu Yazar e-posta: syalpir@ktun.edu.tr ORCID ID: http://orcid.org/0000-0003-2998-3197*
eertunc@ktun.edu.tr ORCID ID: http://orcid.org/0000-0002-6982-0459

Geliş Tarihi: 05.01.2023 Kabul Tarihi: 01.08.2023

Abstract

The interaction of agricultural activities with the land starts with soil in the production part and continues until the consumption stage. Sustainable agricultural land for their use, a database regarding their current potential should be created and the land prepared based on this database should be evaluated by considering the use planning. The suitability of Ankara province lands for agricultural use by making use of the Geographical Information System analysis was carried out. To determine the suitability for agricultural use; Major Soil Groups, Land Use Capability Classes, soil depth, degree of erosion, elevation, slope, aspect, precipitation, and temperature criteria were used. This was done with the Best-Worst method, which is one of the multi-criteria decision-making approaches. It was ensured that the best and worst of the nine factors were determined by the decision makers. In the last layer, because of the analyzes made for the province of Ankara, the most appropriate land use map was created based on the natural abilities and capabilities of the lands. It has been determined that the most affecting criterion is Large Soil Groups, and Ankara's Kızılcahamam, Çankaya and Mamak districts are not very suitable for agricultural use, but other districts are generally suitable for use.

Keywords
Land quality; Best-Worst Method; Site selection; Geographic Information System

Best-Worst Yöntemi ile Arazilerin Tarımsal Kullanıma Uygunluklarının Belirlenmesi

Öz

Tarımsal faaliyetlerin arazi ile olan etkileşimi üretim kısmında toprak ile başlamakta ve tüketim aşamasına kadar devam etmektedir. Tarım topraklarının sürdürülebilir kullanımları için, mevcut potansiyellerine ilişkin veri tabanının oluşturulması ve bu veri tabanına göre hazırlanacak arazi kullanım planlaması dikkate alınarak değerlendirilmesi gerekmektedir. Bu çalışmada, Ankara ilindeki arazilerin Coğrafi Bilgi Sistemi'nden yararlanarak tarımsal kullanıma uygunluk analizi gerçekleştirilmiştir. Tarımsal kullanıma uygunlukların belirlenmesi için Büyük Toprak Grupları, Arazi Kullanım Kabiliyet Sınıfları, toprak derinliği, erozyon derecesi, yükseklik, eğim, bakı, yağış ve sıcaklık kriterleri kullanılmıştır. Bu kriterlerin etki dereceleri, çok kriterli karar verme yaklaşımlarından biri olan Best-Worst Yöntemi ile yapılmıştır. Etken olan 9 kriterden en iyilerinin ve en kötülerinin karar vericiler tarafından belirlenmesi sağlanmıştır. Son aşamada Ankara ili için yapılan analizler sonucunda arazilerin doğal yetenek ve kabiliyetleri baz alınarak en uygun arazi kullanım haritası oluşturulmuştur. En fazla etkileyen kriterin Büyük Toprak Grupları olduğu, Ankara'nın Kızılcahamam, Çankaya ve Mamak ilçelerinin tarımsal kullanıma çok uygun olmadığı ancak diğer ilçelerin genelinin kullanıma uygun olduğu tespit edilmiştir.

Anahtar kelimeler
Arazi kalitesi; Best-Worst Yöntemi; Yer seçimi; Coğrafi bilgi sistemi

1. Introduction

Agriculture which one of the most important economic activities on earth is closely related to the soil that one of the sources of life. The interaction of agricultural studies with the land is an ongoing process from production to consumption. Perform of agricultural works on the land is factors which affect the land cover. For instance, the production of an agricultural work in unsuitable land conditions causes a decrease in yield (Alevkayalı and Tağıl 2020).

When examining the qualification of the land, it is an important element to predict the predisposition of the land in order to ensure a more sustainable and efficient use without damaging the land (Turan and Dengiz 2019). In order to sustainable agriculture, the use of agricultural technologies that do not cause damage to the region is as important as the protection of resources in the long-term use of natural resources. Synthetic production products are used uncontrolled in our country as well as in many developed countries of the world. Agricultural production is continued without taking into account the production techniques and the results caused by technology (Turhan 2005).

Natural resources are faced with an extraordinary use due to rapid population growth in all countries of the world, increasing regional consumption as a result, easy access to resources, industrialization and urbanization. While these situations expose the lands to misuse; it brings such as erosion, decrease in soil fertility and migration from rural areas to cities (Dağlı 2016). Unconscious use of resources is a risk to the agricultural sector which is the building block of sustainable rural development. In order to prevent risks in sectors such as agriculture, forestry, industry, transportation and settlement, it is necessary to *determine* the qualities and capacities of the lands and to make the most efficient use plan and map (Saykili *et al*. 2017). The well-maintained and controlled use of the lands within a plan will enable us to make optimum use of the existing potentials of the living spaces and natural environment (Demir *et al*. 2011).

The best use of soils according to their suitability greatly helps the farmer (Vasu *et al*. 2018). In our country, there are no legal studies for the selection of suitable sites in the agriculture and livestock sector, and there is no clear regulation regarding this. As a result of this deficiency, enterprises carry out location selection in accordance with their own decisions and face some problems as a result of this. Conditions that are not suitable for enterprise such as soil type, weather conditions, distance to natural resources are some of these problems (Mercan *et al*. 2017).

Geographic Information System (GIS) is one of the methods that facilitates conformity assessment in data collection. In order to obtain the data which transferred to the system quickly and reliably the Geographical Information System is used. The cultural and natural capacities of the lands are evaluated correctly and their correct use ensures sustainable rural development (Demir *et al*. 2011).

Topic of land suitability assessments which many applications in the literature GIS has been used (Albaji *et al*. 2017, Elbeih 2021, Ustaoglu *et al*. 2021). It is observed that different approaches are used in the studies that create of land suitability maps. Wang used the artificial neural networks method in his land suitability assessment study in 1994. In another study, fuzzy modelling was used and the land suitability was estimated with a weighted average (Kurtener *et al*. 2008).

Multi-Criteria Decision Analysis (MCDA) methods are widely used in spatial applied studies with GIS (Al-Ghobari and Dewidar 2021, Yegizaw and Ejegu 2021). The Best-Worst Method (BWM) which is one of the MCDA methods is a method used in applications such as rainwater, determination of agricultural plans, relocation of wheat storage facilities and risk determination in agricultural production (Aghaloo and Chiu 2020, Smith *et al*. 2021, Atta and Micheels 2020). In spatial applied studies result maps can be obtained with BWM and

GIS integration (Yousefi-Babadi *et al*. 2021, Minaei *et al*. 2021, Everest *et al*. 2022). There are not many studies on the spatial suitability of agricultural areas with the BWM method. For this reason, the BWM method was used in the study to determine the suitability of agricultural areas.

In this study, it is aimed to analyse the suitability of Ankara province lands for agricultural use by using GIS. For this reason, criteria that large soil groups, land use capability classes, soil depth, degree of erosion, elevation, slope, aspect, precipitation and temperature were determined. In the province of Ankara, suitable areas for agricultural use were determined by using the Best Worst Method (BWM) to determine the suitability of agricultural lands.

2. Material and Method

2.1 Study Area

The study area is Ankara province which is located in the middle of 39-57' north latitude and 32-53' east longitude and it has a total area of 25.632 km2 (Figure 1). Ankara which is the capital of Turkey is also the second most populous city. It is surrounded by Kırıkkale in the east, Eskişehir in the west, Konya in the south, Çankırı in the northeast, Bolu in the northwest, Kırşehir and Aksaray in the southeast.

It has a terrestrial climate. More than half of the lands of Ankara province are used as agricultural land. Barley, wheat, sugar beet are the most abundant field products. In addition, pears, apples, onions, melons, watermelons, carrots, tomatoes, cherries and grapes are also field products.

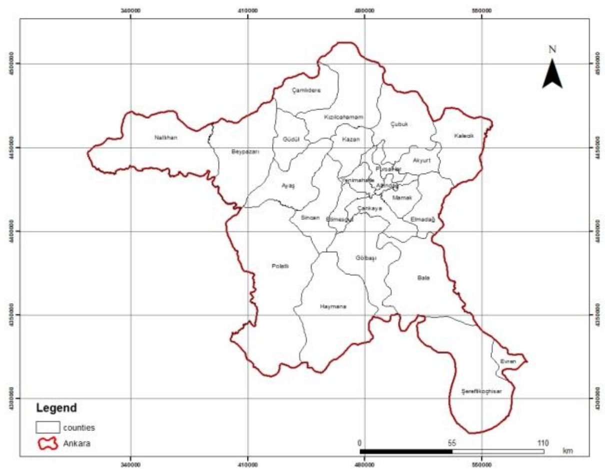


Figure 1. Study area

2.2 The criteria for the suitability of lands for agricultural use

GIS are defined as whole systems involving the combined use of computer hardware and software, personnel, and geographical data for the purposes of gathering positional data from various sources and storing, processing, updating, analysing, managing, and presenting them in a computer environment.

The study is to determine the suitability of Ankara province lands for agricultural use. The criteria in Table 1 were used to determine their suitability for agricultural use.

Table 1. Agricultural suitability criteria that used in the study

Criteria	Criteria no
Large Soil Groups	T1
Land Use Capability Classes	T2
Soil Depth	T3
Erosion Degree	T4
Elevation	T5
Slope	T6
Aspect	T7
Precipitation	T8
Temperature	T9

Agricultural Land Evaluation and Information System (TAD Portal) is the management automation of non-agricultural demands and Turkey's soil database that performs non-agricultural field controls of the large plains to be protected. It contains all the detailed data catalogs related to the soil texture. Large Soil Groups (LSG), Land Use Capability Classes (LUCC), Soil Depth, Erosion Degree data used in the study were obtained from TAD Portal (Tarım ve Orman Bakanlıgı, 2020).

The United States Geological Survey USGS is an information gathering and research organization that studies natural resources. Elevation, slope, aspect data were obtained from the USGS site (USGS, 2022).

Climate Data is a site where data from thousands of weather stations around the world are analyzed, and information and statistics are updated from time to time. Precipitation and temperature data were obtained from Climate Data 'Climate Data for Cities Worldwide' (WorldClim, 2021).

2.2.1 Large Soil Groups (LSG)

Different soil classifications that differ according to the region you are in helps to use the areas more efficiently, the compatibility of the soil and the environment with each other and to keep the criteria up to date (Anonymous 2005). Knowing which major soil group the soil has makes it easy to predict the performance of the soil. Large Soil Groups (LSG) should be determined in determining the suitability of land for agricultural use. Soil groups that are alluvial soils, chestnut soils, brown soils, brown forest soils, non-calcareous brown forest soils, non-calcareous brown soils, reddish brown soils, coluvial soils in Ankara province.

2.2.2 Land Use Capability Classes (LUCC)

According to their land use capabilities, soils are examined in eight classes. While the first class lands are the most economical and highest quality lands, the areas that are not suitable for agricultural use and are not used even as pasture and forest areas constitute the eighth class (Anonymous 2005). For the suitability of the production of products, it is necessary to look at the land use capability classes. Study area has from I. class to VIII of the land.

2.2.3 Soil Depth

Soil depth is the distance from the bottom of the roots that meet the water and nutrient needs of the plants. In order to get the maximum yield from plants, soil depth which ensures good root development is required (Anonymous 2005). Soil depth is of great importance in agricultural production. The increase in depth indicates that the land is suitable for agriculture.

2.2.4 Degree of erosion

Lands which has a sloping surface and poor vegetation wear relatively more. Uncontrolled grazing of animals, increase in precipitation per m^2 and unconscious land use increase erosion. In addition, eroding lands are exposed to mineral loss. (Anonymous 2005). Erosion causes degradation of fertile soils. Therefore, lands with low erosion are preferred for the suitability of agriculture.

2.2.5 Elevation

Temperature changes due to altitude cause differences in vegetation in the regions (Akıncı *et al*. 2015). Increase in altitude causes decrease in relative humidity and temperature. This means that the lands with low altitude are suitable for agricultural use.

2.2.6 Slope

One of the most important factors affecting wear is the slope. Increasing the slope rises erosion. On the other hand, if the slope is low or the land has no slope, it may have a negative effect on the drainage. Reasons such as the adaptation of plants and the protection of the land are among the factors affecting the slope. Damaged areas where the elevation is too high increase the wear. At the same time, there is difficulty in form, which reduces the quality of the land (Anonymous 2005).

2.2.7 Aspect

It can be said that aspect causes differences in agricultural production due to reasons such as sunbathing and exposure to wind between the north and south-facing slopes of an area. Plants need the sun for agricultural production. In this case, it requires the use of aspect as a criterion.

2.2.8 Precipitation

The amount of precipitation, the time of precipitation and the form of precipitation are of great importance in growing plants. During the development of plants, not only the water taken from the soil, but also the amount of water the plant contains is important (Kapluhan 2013). Precipitation is also a criterion used for suitability for agricultural use.

2.2.9 Temperature

Temperature is one of the most basic elements for growing plants and for efficient agriculture.

The decomposition of rocks and natural wastes occurs with the factor of precipitation and temperature. As a result of these decompositions, changes occur in the soil. While the rate of decomposition is directly proportional to the temperature, the organic matter accumulation is inversely proportional (Anonymous 2005).

It should be the right temperature for the plants. If the appropriate value is below or above, there will be difficulty in plant development, and this will damage the plant.

2.3 Best-Worst Method

Decision making is defined as the determination of one among various alternatives. Some criteria are determined for this definition. This decision making process is called multi-criteria decision making (MCDM). MCDM methods began to be developed in the 1960s, when a number of methods were deemed necessary to facilitate the decision-making process in a situation where there are many criteria. It has been used primarily in decision theory and operations research, and then it also used in financial and economic fields (Cengiz 2012). The Best-Worst Method (BWM) used in the study is one of the MCDM methods.

Compared to other multi-criteria decision making methods, BWM has fewer pairwise comparisons. Decision makers are not required to make pairwise comparisons between all criteria. The calculation process is easy compared to other MCDM methods. The Best-Worst Method is a method that is based on determining the preference of the most important criterion over other criteria and the preference of other criteria over the least important criterion and determines the criterion weights accordingly. It is carried out by determining the best and worst criteria and comparing the best and worst criteria with other criteria (Ertunc and Uyan 2022).

The steps of the Best-Worst Method are as follows:

Step 1: Determination of decision-making criteria $\{C_1, C_2, \ldots\ldots, C_n\}$.

Step 2: Determination of best and worst criteria.

Step 3: The decision-maker gives their preferences of the best criterion over all the other criteria using a number (e.g. 1 to 9) from the importance scale of Saaty (Table 2). As a result of this step, the vector called Best-Others (AB) which determines the preference from the best to the others is obtained. This vector looks like this; $A_B = (a_{B1}, a_{B2}, \ldots\ldots\ldots a_{Bn})$

Table 2. Importance degree scale (Saaty, 1987)

Importance Degree	Definition
1	Equally important
3	A little more important (less superiority)
5	Quite important (too superior)
7	Very important (absolute superiority
9	Highly important
2, 6 and 8	Intermediate values

In vector AB, a_{Bj} represents the preference of the best criterion B over criterion j.

Step 4: By using a number from the importance scale, the decision maker determines the preference rate of other criteria over the preferred bad criterion. In this step, the vector showing the preference from the others according to the worst criterion is as follows; $A_W = (a_{1W}, a_{2W}, \ldots\ldots\ldots a_{nW})^T$

a_{jW} in the AW vector indicates the preference of the j criterion over the worst criterion.

Step 5: Determining the weights of the criteria (1).

$(w_1^*, w_2^*, \ldots\ldots\ldots w_n^*)$.

$$\left|\left(\frac{W_B}{W_J}\right) - a_{BJ}\right| \; and \; \left|\left(\frac{W_J}{W_W}\right) - a_{JW}\right| \qquad (1)$$

The expression that minimizes the maximum of the differences is converted into the linear optimization/programming below (2-3).

$\min \xi$

$$\left|\left(\frac{W_B}{W_J}\right) - a_{BJ}\right| \leq \xi \,, \forall j \qquad (2)$$

$$\left|\left(\frac{W_J}{W_W}\right) - a_{JW}\right| \leq \xi \,, \forall j \qquad (3)$$

$\sum wj_j = 1; w_j \geq 0, \forall j$

Step 6: After the optimization process is performed, weights and ξ value are obtained. The ξ value is checked to check whether the criteria weights obtained are consistent. (Table 3). The consistency ratio (CR) is obtained by dividing ξ by the consistency index value (CI). The fact that the consistency ratio moves away from zero indicates that the consistency decreases.

Table 3. Consistency index value

a_{Bw}	1	2	3	4	5	6	7	8	9
TE	0.00	0.44	1.00	1.63	2.30	3.00	3.73	4.47	5.23

2.4 Preparation of data and determination of weights

In order to determine the suitability of Ankara province lands for agricultural use, criteria and the weights of these criteria should be determined. By using decision-making methods, it is stated how important the criteria are for agricultural use. As a method, weights were calculated with the Best-Worst Method and maps were created with the Scoring Method. Comparisons are made between the importance values of the criteria. These criteria used in the study were evaluated by experts (consisting of 3 Agricultural and 5 Survey Engineers). Then, maps were created for 9 criteria with the Scoring Method. As a result, a map indicating its suitability for agricultural use was prepared.

The steps taken to determine the suitability of Ankara province lands for agricultural use are listed as follows;

1. Collection of data related to the study area,
2. Determination of criteria determining the suitability of lands for agricultural use for multiple decision making,
3. Obtaining expert opinions according to the Best-Worst Method,
4. Creating matrices and determining weights with the Best-Worst Method,
5. Obtaining the maps of the study area for each criterion by the Scoring Method,
6. Production of suitability for agricultural use map which is the final map
7.

it was aimed to determine the most appropriate area by determining the importance levels with BWM in determining the suitability of agricultural land for agricultural use in Ankara province.

It was ensured that the best and worst of the 9 criteria, which were effective in determining the suitability of agricultural lands for agricultural use, were determined by the decision makers. As a result of the determination of the best and worst criteria, firstly, it was ensured to determine the importance levels from the best to the others, with the evaluation matrix rated from 1 to 9, then from the others to the worst, the importance levels were determined by the evaluation matrix. The criteria used in the study are shown in Table 1.

After the criteria were determined, the best and worst criteria were determined by taking expert opinions. Then, the preference of the best criterion according to the other criteria, followed by the preference of the other criteria according to the worst criterion was evaluated. Table 4 includes the evaluations. After the evaluation made by the decision makers, a linear programming was established using the MS Excel solver add-on. Weights were determined (Table 5).

After the weights were determined, the consistency index was calculated according to the dominance ratio of the best criterion to the worst criterion to calculate the consistency ratio. For this, land use capability (T2), which is the best criterion, is 8 times more important than the worst criterion (T9) (Table 5). Accordingly, the consistency index value is determined as 4.47. The consistency ratio was calculated by dividing the ξ value by the consistency index value (4).

$$CR = \xi/CI \text{ and } CR = 0.08 / 4.47 = 0.018 \quad (4)$$

Consistency Rate: CR, Consistency Index Value: CI

Table 4. Evaluation by decision makers

Best–Worst Step 2: Determining Best and Worst Criteria									
The Best Criteria	T2		**The Worst Criteria**		T9				
Best–Worst Step 3: Best to Other Evaluation (Finding A_B vector)									
	T1	T2	T3	T4	T5	T6	T7	T8	T9
From the Best Criterion (**T2**), The Preference Ratio According to Other Criteria	2	1	3	5	5	5	4	7	8
Best–Worst Step 4: Worst Rating From Other Criteria (Finding A_W vector)									
	T1	T2	T3	T4	T5	T6	T7	T8	T9
Preference Rate According to the Worst (**T9**) Criterion from Other Criteria	8	9	7	6	4	4	5	3	1

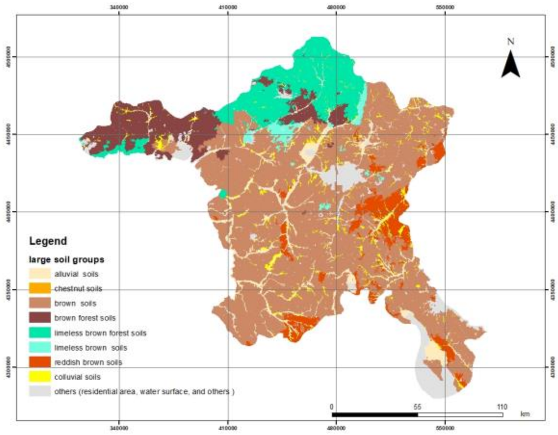
Table 5. Optimal weight values of the criteria

	KRİTERLER	**KRİTER AĞIRLIKLARI**
T1	Large Soil Groups	0.187
T2	Land Use Capability Classes	0.292
T3	Soil Depth	0.125
T4	Erosion Degree	0.075
T5	Elevation	0.075
T6	Slope	0.075
T7	Aspect	0.093
T8	Precipitation	0.053

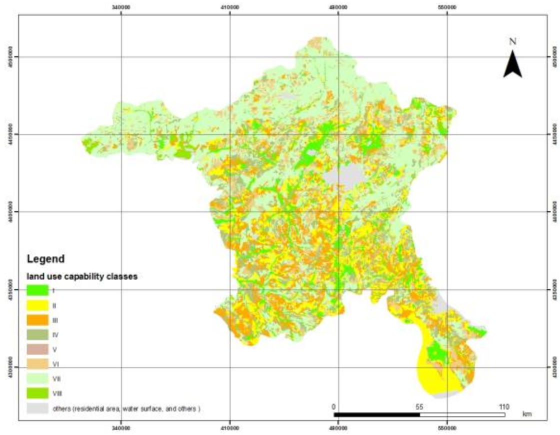
T9	Temperature	0.026

3. Results

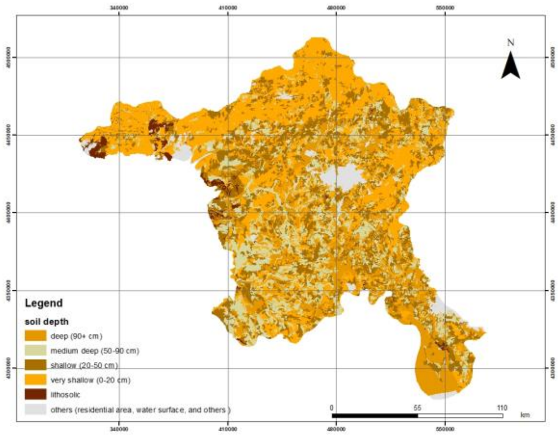
Within the scope of the study, 1/25 000 scaled digital base maps obtained from the General Directorate of Maps was used. Large Soil Groups, Land Use Capability Classes, soil depth and erosion degree maps were produced by using soil maps with ArcMap 10.5 for the application. Then, the Digital Elevation Model of the study area was created. In this context, slope, aspect and elevation maps were created. Finally, temperature and precipitation maps were created using climate data. Maps in vector format were first converted to raster format and classified between 0-100 (Table 6).



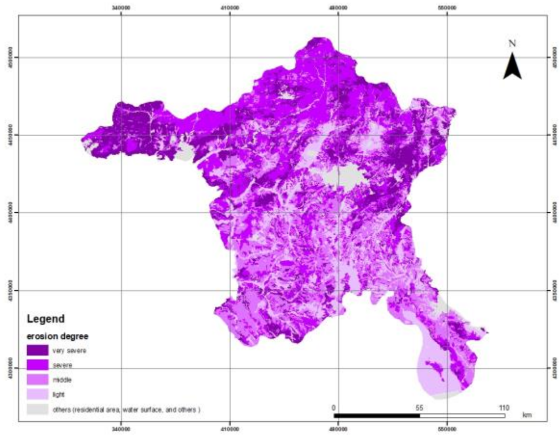
(a)



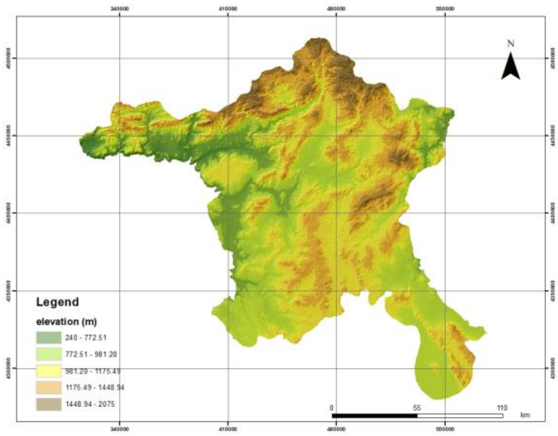
(b)



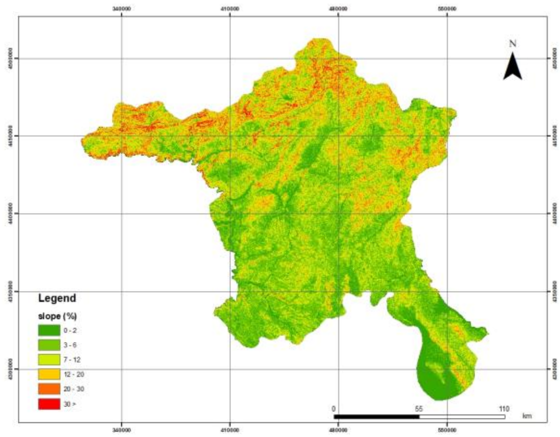
(c)



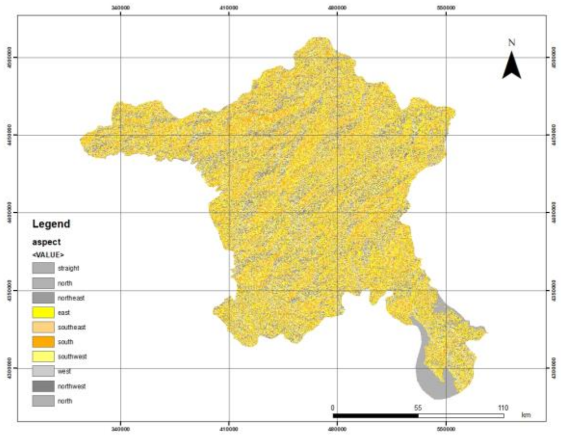
(d)



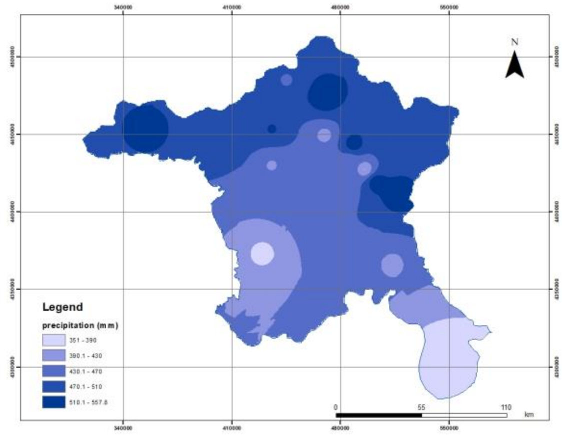
(e)



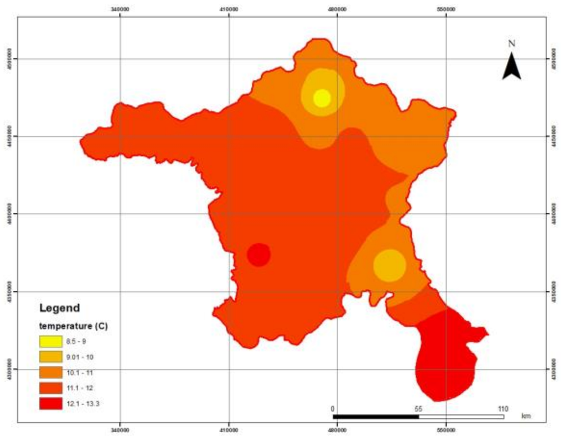
(f)



(g)



(h)



(i)

Figure 2. *Maps of the criteria used in the study; a) Large soil groups map b) Land use capability classes map c) soil depth map d) erosion degree map e) Elevation map f) Slope map g) Aspect map h) Precipitation map i) Temperature map*

In this last layer, a map of suitability for agricultural use was produced (Figure 3). In other words, suitability for agricultural use map has been reached by using the weights of the criteria affecting the suitability for agricultural use and the scores assigned to the criteria by the Scoring Method. The resulting map was prepared using four sub classes. These were determined as very suitable (4), suitable (3), not suitable (2), and not suitable at all (1). We can say that the most influencing criterion is the Large Soil Groups. We can see that Kızılcahamam, Çankaya and Mamak districts of Ankara are not very suitable for agricultural use, but the other districts are generally suitable for agricultural use.

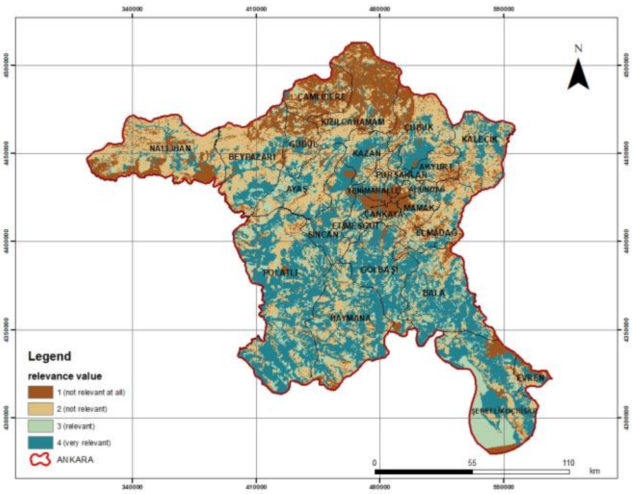


Figure 3. Agricultural suitability map of

Table 6. Weights of study criteria and scores of sub-criteria

CRITERIA	W	SUB CRITERIA	PUAN	CRITERIA	W	SUB CRITERIA	PUAN
		Alluvial and Colluvial Soil	100			Straight (%0-2)	100
(T1)	0.187	Brown and Brown Forest Soils	80			Light (%2-6)	80
		Reddish Brown and Limeless Brown	70	**(T6)**	0.075	Middle (%6-12)	60
		Limeless Brown and Forest Soils	60			Steep (%12-20)	40
		Chestnut Soils	40			Very Steep (%20-30)	20
						Precipitous (>%30)	10
		I, II,	100			Straight	100
		III IV	80			South, Southeast,	80
(T2)	0.292	V VI	40	**(T7)**	0.093	Southwest	60
		VII,	20			East,	40
		VIII	10			West	20
						Northeast,	
						Northwest North	
		Deep (90+ cm)	100			510.1-557.8 mm	100
		Medium Deep (50-90 cm)	80			470.1-510 mm	80
(T3)	0.125	Shallow (20-50 cm)	60	**(T8)**	0.053	430.01-470 mm	60
		Very Shallow (0-20 cm)	40			390.1-430 mm	40
		Lithosolic	20			351-390 mm	20
		Light	100			12.1-13.3 C^0	100
		Middle	80			11.1-12 C^0	90
(T4)	0.075	Severe	40	**(T9)**	0.026	10.1-11 C^0	80
		Very Severe	20			9.01-10 C^0	70
						8.5-9 C^0	60
		240-500 m	100				
		500-1000 m	80				
(T5)	0.075	1000-1500 m	60				
		1500-2000 m	40				
		>2500 m	20				

Table 7. Values of suitability for agricultural use in terms of area

Suitability Value	Area(ha)
1	454797.33
2	864434.63
3	290903.55
4	941518.33

A literature review about the study was made and the studies were examined. It has been seen that successful results will be obtained with the land use plan made to determine the areas suitable for agriculture. It proves that doing this with expert opinions will increase the success for efficient land use. The criteria used in the studies differ according to the regions examined. As indicated in Table 7, the province of Ankara has a large area suitable for agricultural use.

4. Discussion and conclusion

GIS is actually a combination of a wide variety of technologies, processes and methods. By transferring the data used in the study to the Geographic Information System, information pollution is minimized. Thus, access to information becomes even easier.

The decision of location selection is of great importance in a long-term investment project of an enterprise. Site selection for the use of lands has become difficult nowadays. Appropriate site selection is a complex structure in which many criteria must be evaluated. In order to make a correct analysis, it is necessary to investigate the work to be done in detail and to determine the affecting criteria correctly. In such studies, the quality, data type and scale of the spatial data belonging to the criteria are important. The location-based criteria discussed in this study come from different data sources; It was obtained as raster, vector and position-based feature data. Raster and vector maps were arranged on the provincial border of Ankara, which is the study area, and data were obtained from the most appropriate scales.

The Best-Worst Method, which is in the multi-criteria decision-making approach, is one of the methods used to make these analyzes. The use of agricultural suitability analysis together with the GIS enables us to reach real values more reliably and quickly. In addition, a database system is created, and old information is accessed. Necessary inquiries are made. Analysis of developments in the region can be carried out. When people want to invest in land, they can reliably buy it. In the study, a database is created by transferring soil properties to the computer environment with GIS. Thus, access to information becomes easier and healthier.

As a result of the analyzes made for the province of Ankara, the most suitable land use map was created based on the natural abilities and capabilities of the lands. In this study, nine criteria were examined and studied with the Best-Worst Method. In the resulting map, it has been determined that the northern and northwestern parts of Ankara and the central region are not very suitable for agricultural use. By determining the suitability of agricultural lands for use, natural resources are protected, agricultural productivity and quality increase. Such studies ensure the sustainable use of agricultural resources.

In order to deal with the study in more detail, verification can be made from the land (appropriate use of agricultural land) based on the most suitable land use map. In addition it can be helped to keep agricultural activities or urban areas under control by working on larger-scale maps by increasing the criteria with the opinions of the experts of the region.

5. References

Aghaloo, K., and Chiu, Y. R., 2020. Identifying optimal sites for a rainwater-harvesting agricultural scheme in iran using the best-worst method and fuzzy logic in a GIS-based decision support system. *Water*, **12(7)**, 1913.

Akıncı, H., Özalp, A. Y., Özalp, M., and Turgut, B., 2015. Büyük barajların tarım arazileri üzerindeki etkilerinin incelenmesi ve Artvin'de CBS ve AHP yöntemi kullanılarak alternatif tarım arazilerinin belirlenmesi. TMMOB Harita ve Kadastro Mühendisleri Odası, 15. Türkiye Harita Bilimsel ve Teknik Kurultayı, Ankara.

Al-Ghobari, H., and Dewidar, A. Z., 2021. Integrating GIS-based MCDA techniques and the SCS-CN method for identifying potential zones for rainwater harvesting in a semi-arid area. *Water*, **13(5)**, 704.

Albaji, M., and Alboshokeh, A., 2017. Assessing agricultural land suitability in the Fakkeh region, Iran. *Outlook on Agriculture*, ***46*(1)**, 57-65.

Alevkayalı, Ç., and Tağıl, Ş., 2020. Edremit Körfezi'nde Tarımsal Arazi Kullanımı Uygunluk Düzeylerinin Değerlendirilmesi. *Coğrafya Dergisi*, **40**, 135-147.

Anonymous 2005. Toprak ve Arazi Sınıflaması Standartları Teknik Talimatı,
https://www.mevzuat.gov.tr/MevzuatMetin/1.5.5403.pdf (Access Date: 16.04.2020) (in Turkish)

Atta, C., and Micheels, E. T., 2020. Identifying risk in production agriculture: an application of best-worst scaling. *International Food and Agribusiness Management Review*, **23(2)**, 283-299.

Cengiz, D., 2012. Çok kriterli karar verme yöntemleri üzerine karşılaştırmalı analiz. Yildiz Teknik Üniversitesi Fen Bilimleri Enstitüsü, Yüksek Lisans Tezi, İstanbul, 114.

Dağlı, D., and Çağlayan, A., 2016. Analitik geliştirme süreci ile optimal inceleme incelemesi: Melendiz Çayı bölümü örneği. *Türk Coğrafya Dergisi*, **66 (2016)**, 83-92.

Demir, M., Yıldız, N. D., Bulut, T. Y., Yılmaz, S., and Serkan, Ö., 2011. Alan kullanım planlamasında potansiyel tarım alanlarının ölçütlerinin Coğrafi Bilgi Sistemleri (CBS) yöntemi ile belirlenmesi (Ispir Örneği). *Journal of the Institute of Science and Technology*, **1(3)**, 77-86.

Elbeih, S. F., 2021. Evaluation of agricultural expansion areas in the Egyptian deserts: A review using remote sensing and GIS. *The Egyptian Journal of Remote Sensing and Space Science*. **24 (3) 2**, 889-906.

Ertunç, E., Uyan,M., 2022. Land valuation with Best Worst Method in land consolidation projects. *Land Use Policy*, **122**, 106360.

Everest, T., Sungur, A., and Özcan, H., 2022. Applying the Best–Worst Method for land evaluation: a case study for paddy cultivation in northwest Turkey. *International Journal of Environmental Science and Technology*, **19(4)**, 3233-3246.

Kapluhan, E., 2013. Türkiye'de kuraklık ve kuraklığın tarıma etkisi. *Marmara Coğrafya Dergisi*, **(27)**, 487-510.

Kurtener, D., Torbert, H. A., and Krueger, E., 2008. Evaluation of agricultural land suitability: application of fuzzy indicators. In International Conference on Computational Science and Its Applications, Berlin, Heidelberg, 475-490.

Mercan, Y., Yılmaz, E., Sezgin, F., and Ünal, H. B., 2017. Tarımsal işletme yeri seçiminde coğrafi bilgi sistemi destekli çok ölçütlü karar analizi uygulamaları. *Gaziosmanpaşa Bilimsel Araştırma Dergisi*, ***6*****(Özel Sayı**), 88-102.

Saaty, T., L. 1987, The Analytic Hierarchy Process – What It is and How It is Used, *Mathematical Modelling*, **9(3-5)**, 161-176.

Saykili, I., Birdal, A. C., and Tarık, T., 2017. En Uygun Arazi Kullanım Planlarının CBS ile İncelenmesi: Sivas İli Dikmencik Köyü Örneği. *Geomatik*, ***2*****(3)**, 126-134.

Smith, M., Lal, P., Oluoch, S., Vedwan, N., and Smith, A., 2021. Valuation of sustainable attributes of hard apple cider: A best-worst choice approach. *Journal of Cleaner Production*, **318**, 128478.

Tarım ve Orman Bakanlığı, 2020. Tarım Arazileri Değerlendirme (TAD) Portalı, http://tad.tarim.gov.tr/

Turhan, Ş., 2005. Tarımda sürdürülebilirlik ve organik tarım. *Tarım Ekonomisi Dergisi*, ***11*****(1-2)**, 13-24.

Turan, İ. D., and Dengiz, O., 2019. Parametrik ve hiyerarşik modelsel yaklaşımla samsun ili arazilerinin tarımsal arazi uygunluk sınıfların belirlenmesi. *International Journal of Geography and Geography Education*, **40**, 490-506.

Ustaoglu, E., Sisman, S., and Aydınoglu, A. C., 2021. Determining agricultural suitable land in peri-urban geography using GIS and Multi Criteria Decision Analysis (MCDA) techniques. *Ecological Modelling*, **455**, 109610.

USGS, 2022. The United States Geological Survey, https://www.usgs.gov/centers/eros/science/usgs-eros-archive-digital-elevation-shuttle-radar-topography-mission-srtm-non.

Vasu, D., Srivastava, R., Patil, N. G., Tiwary, P., Chandran, P., and Singh, S. K., 2018. A comparative assessment of land suitability evaluation methods for agricultural land use planning at village level. *Land use policy*, **79**, 146-163.

Wang, F., 1994. The use of artificial neural networks in a geographical information system for agricultural land-suitability assessment. *Environment and planning A*, **26(2)**, 265-284.

WorldClim, 2021. Global climate and weather data[Data set]. https://www.worldclim.org/data/index.html.

Yegizaw, E. S., and Ejegu, M. A., 2021. Geospatial technology with the integration of MCDA to identify potential irrigation site for agricultural land management in Wanka watershed, Northwestern Ethiopia. *Journal of Degraded and Mining Lands Management*, **9(1)**, 3027.

Yousefi-Babadi, A., Bozorgi-Amiri, A., and Tavakkoli-Moghaddam, R., 2021. Sustainable facility relocation in agriculture systems using the GIS and best–worst method. *Kybernetes*, **51(7)**, 2343-2382.