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FAHP and GIS based land use suitability analysis for agriculture in Aksaray City, Turkey

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Keywords

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ABSTRACT

As a result of rapid population growth with the developing technology, resources are used unconsciously, and the need to use these resources effectively has emerged to transfer them to future generations. Land, which is a scarce resource, is among the most critical areas of use, agricultural lands. These areas meet the basic nutritional needs of living things, therefore, determining the suitability of the lands for agriculture, increasing productivity in agriculture, sustainability of resources, and contribution to the country's economy is of great importance. In the suitability analysis of agricultural areas, it is necessary to consider the land's specific use, the physical characteristics of the land, and the socio-economic and environmental characteristics in terms of land sustainability. Land use analysis is a complex process that includes multi-criteria decision-making analyses. This study aims to determine the areas suitable for agriculture in Aksaray city with Geographic Information System (GIS) and Fuzzy Analytical Hierarchy Process (FAHP). Nine parameters were used to determine the most suitable area. These parameters are; slope, aspect, elevation, proximity to water surfaces, drainage density, soil depth, land use capability, great soil group, land use capability sub-class. Expert opinions were taken in the weighting of the criteria and an agricultural suitability map was produced.

1. Introduction

For centuries, human beings have seen nature and resources as unlimited and used them unconsciously, causing severe damage to the environment and economy. As a solution to these problems, the concept of sustainable development, which is defined as ensuring the transfer of natural resources to future generations without being wholly consumed, has emerged. Sustainable development requires new land administration infrastructures and tools (Gazibey et al. 2014). Land management is one of these tools, and with the rapid population growth, the insufficient agricultural products obtained from the land and the development of industry, the land has been seen as a socially scarce resource and the need for effective management of this resource has arisen. As in Turkey, soil and natural resources are under threat due to the wrong planning of lands in many undeveloped and developing countries. As a result of unplanned land use, erosion and erosion in the soil occur as a result of flood-flood events. To benefit from natural resources with the highest efficiency, to

ensure sustainable development in both rural and urban areas, in economic and social areas; that is, 'Land Management' and 'Land Management Systems' are used in order to produce the data needed in the preparation of policies for the efficient use of country resources (Inan 2021).

The agricultural sector has a significant role in Turkey's social, political and economic development. In the early stages of economic development, it is the dominant sector as in other societies. (Erdoğan and Erdoğan, 2000). Although the agricultural sector, which provides the most prominent primary food sources of human beings from the past to the present, is seen as a developed sector with mechanization today, its environmental damages are increasing. Therefore, sustainable agriculture has emerged to maintain productivity and benefit society in the long term. Sustainable agriculture includes the production of sufficient and quality foods at affordable costs, the economic vitality of agriculture, the protection of natural agricultural resources and the environment, and systems and practices that will improve the welfare of the world

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population (NRC 2010). With the developing technology, the need for effective use of agricultural lands has arisen due to the increase in population day by day and the noticeable decrease in agricultural lands. For sustainable agriculture to thrive, it is essential to determine suitable areas for agriculture. Identifying suitable areas for agriculture is an essential issue in ensuring the protection of resources for future generations and ensuring economic development. Suitable site selection studies require the processing of large amounts of spatial data. Processing this data about site selection with traditional methods is a time-consuming and challenging task (Bilgilioglu et al. 2021). For these reasons, additional tools called Multi criteria decision making (MCDM) have been developed so that decision-makers can work more effectively and efficiently instead of land use planning, which is widely developed with traditional methods today. MCDM consist of multiple selection criteria and a management system that produces the most helpful solution in managing the criteria (Uyan and Yalpir 2016).

This study aims to determine land-use suitability analysis for agriculture in Aksaray City, Turkey. Another goal of this study is to create a model that can be transferred to the information system for farmers engaged in agriculture in Aksaray. In this context, it is aimed to increase productivity in agriculture, reduce environmental damage and revitalize the economy. Nine criteria were used to determine the most suitable area. These criteria are; slope, aspect, elevation, proximity to water surfaces, drainage density, soil depth, land use capability, great soil group, land use capability sub-class. As a result of the analysis made by using these factors, an agricultural suitability map was created for Aksaray city.

2. Method

In decision-making problems, MCDM models are the tools that allow the best decision to be taken as quickly and efficiently as possible by evaluating more than one criterion simultaneously. The primary purpose of this study is to determine the suitable areas for agriculture in Aksaray with an MCDM model. FAHP, an MCDM model, was used for this purpose.

Fuzzy set theory, first introduced by Zadeh (1965), allows the grading of membership functions. The primary purpose of the method is to formulate linguistic variables mathematically (Zadeh 1971). However, linguistic variables obtained from experts cannot be expressed numerically according to classical set theory and methods such as AHP based on this theory cannot reflect human thinking style. To solve these problems, FAHP has emerged by combining AHP and fuzzy logic theory.

There are many suggested BAHPs in the literature. In this study, the order analysis method, developed by Chang (1996) and frequently preferred in site selection studies, was used to solve MCDM problems.

Aksaray city was chosen as the study area. Agriculture is an essential source of livelihood in the study area. The region has a total area of 7626 km². The study area is shown in Figure 1.

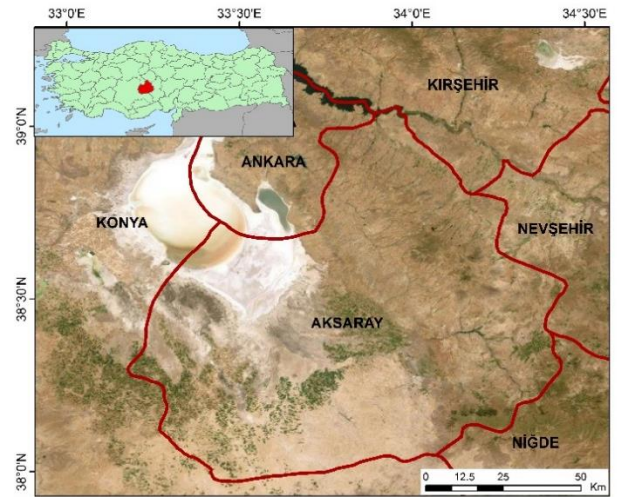


Figure 1. Study area

Different criteria have been determined as a result of the literature research to determine the agricultural land use suitability (Akinci et al. 2013; Pramanik 2016; Yalew et al. 2016; Memarbashi et al. 2017; Tashayo et al. 2020). These criteria are; slope, aspect, elevation, proximity to water surfaces, drainage density, soil depth, land use capability, great soil group, land use capability sub-class.

3. Results and discussion

The pairwise comparison matrix was created through interviews with experts and a literature study. In order to understand whether the pairwise comparisons created for the criteria are consistent or not, consistency analysis was performed and the results of the calculations; The consistency ratio (TO) = 0.0412 was calculated. It has been understood that the comparisons made are consistent since the obtained CTR value is less than 0.10. The criteria weights calculated with BAHP are shown in Table 1.

Table 1. Weights of criteria

Criteria	Weights
Slope	0.084
Aspect	0.072
Elevation	0.025
Prox. To water surfaces	0.124
Drainage density	0.118
Soil depth	0.096
Land use capability	0.162
Great soil group	0.173
Land use capability sub-class	0.146

All data collected from different sources were converted to raster data with a pixel size of 20 m in the UTM (36-3) projection coordinate system. Criteria with different values are normalized in the range of "0-1" to be compared. A suitability index of "0" indicates that those regions are unsuitable, and "1" indicates that those regions are highly suitable. Maps of the criteria are shown in Figure 2.

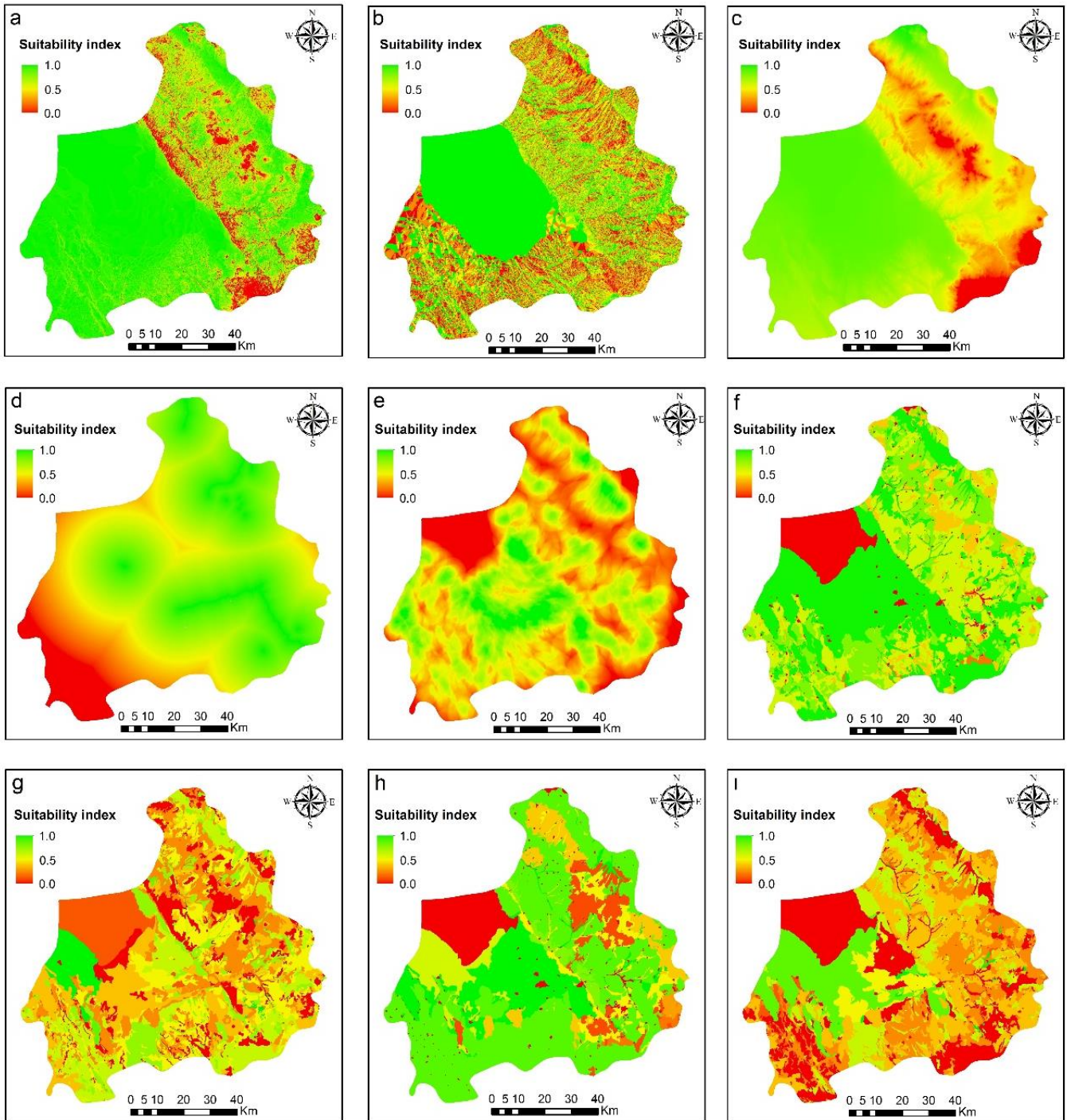


Figure 2. a: Slope b: aspect c: elevation d: proximity to water surfaces e: drainage density f: soil depth g: land use capability h: great soil group i: land use capability sub-class

Nine criteria, which were normalized after being obtained, were combined using weighted linear combination overlay analysis in ArcGIS software, taking into account the weight values given in Table 1, and the suitability map shown in Figure 3 was produced.

The criterion weights show the relative importance of these criteria at the suitable site selection. In this context, it has been determined that land use capability, great soil group, land use capability sub-class are more effective in the agricultural land use suitability analysis, while the elevation and aspect are less effective.

4. Conclusion

In this study, a model that can be evaluated effectively and quickly has been developed by integrating GIS and FAHP methods to determine the suitable areas for agriculture in Aksaray city. For this purpose, considering the characteristics of the study area, nine criteria were selected according to the expert opinions and the results of the literature study, their weights were calculated, and a suitability map was created with overlay analysis. It is thought that these results can be accepted as reasonable and applicable by managers and decision-makers, especially by farmers. Within the scope of sustainable agriculture, it is crucial

to determine the most suitable areas in terms of economy and productivity. For this reason, the criteria to be used must be determined very carefully and by experts. It is thought that the criteria used in this study will also be used in future studies in the Central Anatolian region.

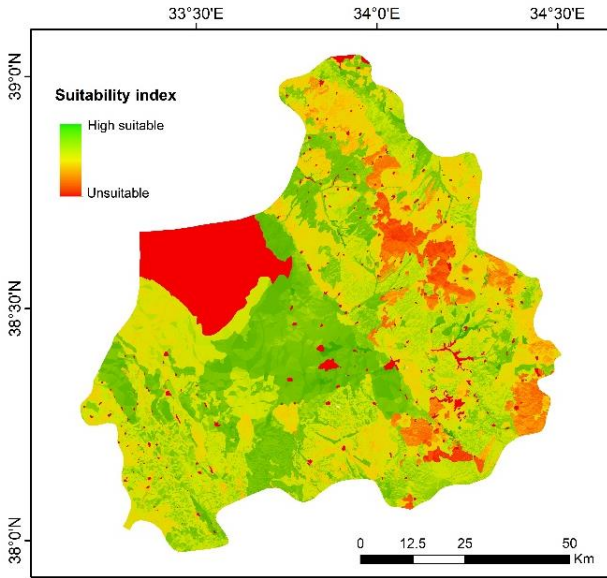


Figure 3. Agricultural land use suitability map

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