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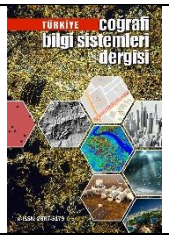

GIS-based site suitability analysis of afforestation in Konya province, Turkey

Ceren Yağcı*[1], Fatih İşcan [1]

[1]*Konya Technical University, Faculty of Engineering and Natural Sciences, Geomatics Engineering, Konya, Turkey*

Keywords
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ABSTRACT

In order for the land management to be applied correctly and effectively, importance should be given to the location selection studies. Determining the most suitable area according to the purpose and initiating studies will provide social and economic gain for the countries. As forest areas occupy large lands, it is actually a necessity to determine the areas to be afforested by site selection. In the study, suitable afforestation areas are selected by using Geographical Information Systems (GIS) and Analytic Hierarchy Process (AHP) method in Konya province, which has an arid and semi-arid climate. For this purpose, within the scope of the study, land use capability (LUC), large soil groups (LSG), rainfall, slope, aspect, and erosion were used as criteria. Using these criteria in GIS, suitable areas for afforestation map for Konya province was obtained. According to results, 15% of the study area is the most suitable area, 25.52% is suitable, 28.95% is medium, 12.76% is low and 17.77% is found very low for the afforestation. The fields obtained were presented to the public with the help of the website created. It is expected that tree planting activities will increase thanks to the website showing the suitable areas for tree planting.

1. INTRODUCTION

Technology has made a quick breakthrough into our lives since the beginning of the 2000s, and industrialization has increased. With these developments, technology and industrialization have increased the comfort of providers to human beings while increasing the damage to nature and the environment. Global warming, ozone depletion, increased environmental and air pollution, noise pollution, climate change, and increased greenhouse gas levels in the atmosphere have all begun to pose a threat to nature.

Afforestation is seen as a way to help protect the nature and environment. Although afforestation does not fix all of these significant issues, it should be utilized as one of several tools to mitigate the harmful consequences of these challenges. Therefore, some researches have been carried out under the name of afforestation studies (Bandy 1994; Zorner et al., 2008; Kantarcı et al., 2011; Kalu et al., 2014; Güner et al., 2016; Jing et al., 2021). In these studies, it was emphasized that many current problems can reduce the negative effects of urbanization and industrialization by increasing sustainability afforestation studies. Afforestation and reforestation are crucial to the sustainability of environmental stability which to large positively affects the growth of the human population, food security, and quality of life (Kalu et al., 2014). The primary goal of afforestation studies is to maintain sustainability. For successfully achieving sustainable afforestation studies Geographic Information Systems (GIS) are used. There are various studies on this subject in the literature.

Dilek in Gölbasi/Ankara in 2008, Zydroń and Bober in the Tarnovo Podgórne commune in 2013, Ateşoğlu in Western Black Sea Region and Western and Inner Anatolia Region/Turkey in 2015, Tonguç et al. in Kahta-Adıyaman in 2017, used GIS on their afforested related research. GIS identifies the priority reforestation areas in forest management planning because the selection of

* **Corresponding Author**

*(cyagci@ktun.edu.tr) ORCID ID 0000–0002–4429-7809
(fiscan@ktun.edu.tr) ORCID ID 0000-0002-0669-5830

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Research Article

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afforestation areas required to increase forest areas is quite important. It is very useful to use the GIS technique in afforestation and to plant it in suitable areas. AHP method is, however, required to search for locations, for afforestation strategies. They emphasized the necessity of using GIS and AHP together in order to make the afforestation works successfully. Some researchers have used GIS and AHP together in order to make the afforestation works successfully (Ismail, 2009; Eslami et al., 2010; Piran et al., 2013; Hashemi, 2018; Muğla & Türk, 2020). This partnership especially gives effective results in studies such as afforestation using different criteria. Furthermore, to ensure sustainability the use of GIS and AHP together is an emerging addition to conducting sustainability assessments in afforestation studies.

In this study, to determine the potential afforestation areas within Konya province by GIS and Analytical Hierarchy Process (AHP) methods are used, and among the most suitable areas to be afforested areas a questionable platform was created on the web.

In the literature, only the best areas of site selection afforestation studies with AHP and GIS have been identified. However, unlike previous research, this study created a web based platform for afforestation. The platform serves to make people's access to suitable afforestation areas.

2. MATERIALS and METHODS

2.1. Study Area

The city of Konya is located at between 36.5–39.5° north latitude and 31.5–34.5° east longitude and is the largest province of Turkey with a surface area of 38,183 km2. The population of the city is approximately 850,000. Fig. 1 shows the location of Konya city. The study area is about 17.1 km wide from east to west and 25 km long from north to south, which yields a total area of 427.5 km2 (Nas, 2006).

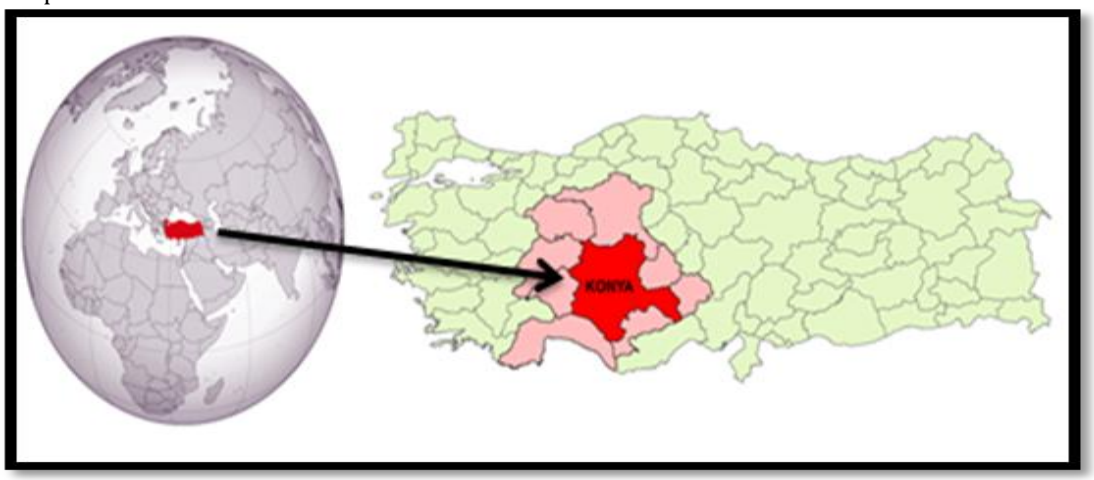

Figure 1. Study Area

2.2. Spatial Database

A database containing, LUC, LSG, rainfall, aspect, slope, and erosion layers was established (Fig.2).

Land Use Capability (LUC)

Lands are divided into 8 classes according to their ability to use. It is classified between the 1st and the 8th grades according to the decrease of their suitability for agricultural production starting from the 1st grade to the 8th grade. 1st class, 2nd class, 3rd class and 4th class areas are considered suitable for agriculture and these areas are not used legally for afforestation studies.

Large Soil Groups (LSG)

In Konya, there are five types of soil in density: alluvial soil, brown soil, brown forest soil, lime-free brown forest soil, chestnut coloured soil. An evaluation has been made among these soil groups.

Rainfall

If there is no rain and irrigation activities do not take place, the yield and growth of plants and trees will decrease. Since Konya is a region with low precipitation, the regions with 430-530 mm of precipitation where precipitation is ideal have been taken as the most suitable areas for afforestation works.

Aspect

In terms of geography, aspect is generally defined as the part of a slope, a surface facing the sun or the direction of receiving sunlight in mountainous areas. The most suitable areas for afforestation in the aspect criteria are the northeast, north and northwest directions. Northern directions on the northern hemisphere are more humid and are covered by more favourable vegetation compared to the southern hemisphere (Zare et al., 2011).

Slope

Slope is very important in terms of agricultural and afforestation works. In places where the slope is very low, it can have a negative effect in terms of drainage. When the slope of an area is not suitable, it results in limitations for afforestation operations including limited ability to work with different machineries, limited presence in the forested area, harsh climatic and environmental conditions and so on. Therefore, more gentle slopes are more desirable for afforestation. Slope

was a factor of evaluation of forestry capability (Hashemi, 2018).

Erosion

Two types of erosion have been investigated, namely water erosion and soil erosion. Separate classification has been made for erosion degrees and wind erosion.

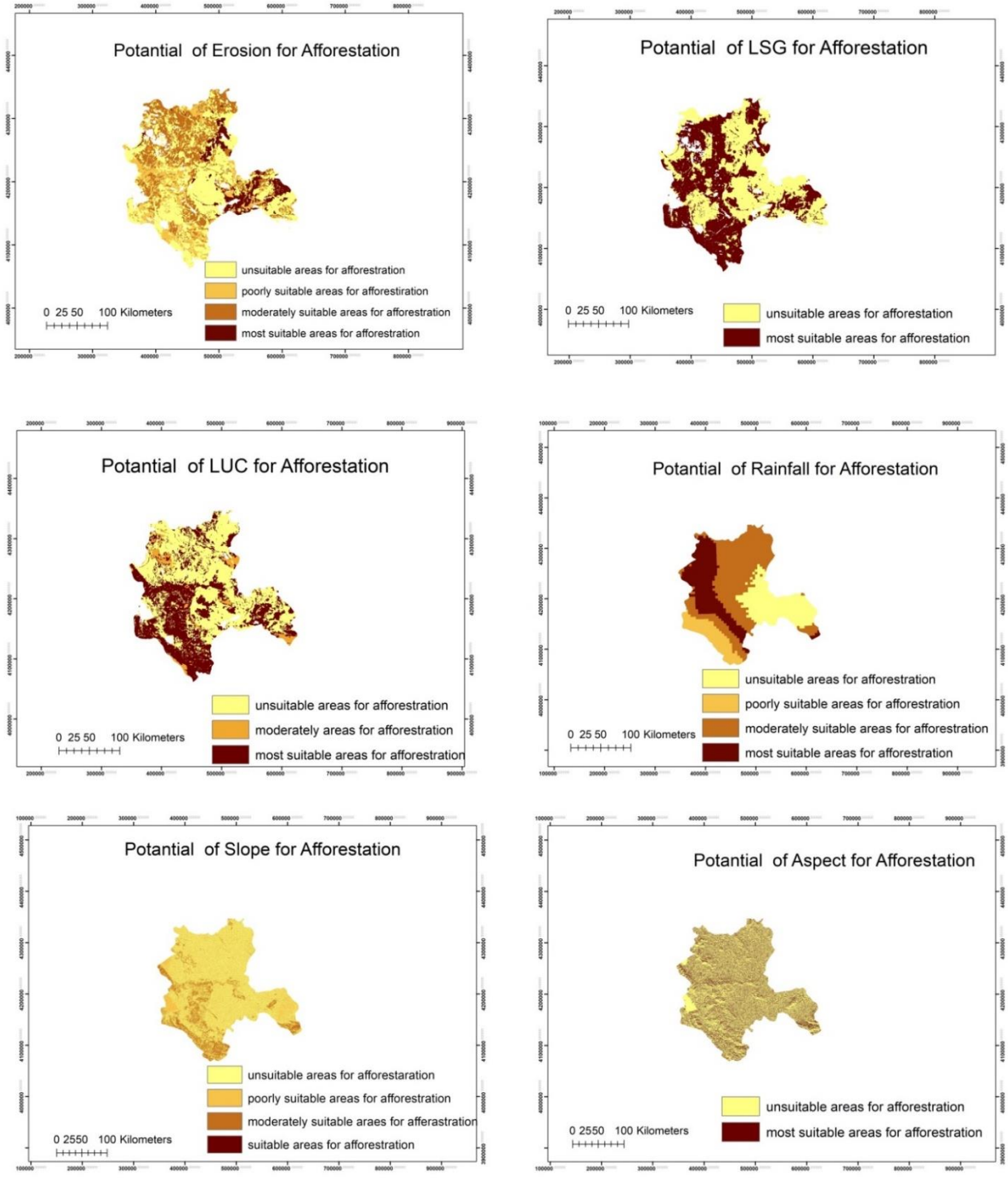

Figure 2: Potential Areas of Afforestation According to Layers

2.3. Determination of the most suitable areas to be afforested using AHP method

The AHP (Saaty ,1980) has found its way into various decision areas. It compares alternatives pair-wise, finds a complete ranking of the alternatives, and provides an overview of the complex relationships between decision elements (i.e., criteria and alternatives) by structuring them into hierarchies. An important step in this method is the construction of an evaluation matrix for each criterion, within which the values of the attributes of the different alternatives are compared amongst each other in pair-wise fashion. Each comparison is based on a verbal or numerical (ranging from 1 to 9) scale. According to this scale, 1,3,5,7 and 9 is respectively defined as equally important, a little more

important, quite important, much more important, definitely more important, and 2, 4, 6, 8 as intermediate values. In the application of the AHP method, the matrices created with the data obtained from the expert opinions are evaluated by combining with the geometric mean. Consistent answers of decision-makers when making binary comparisons are important in solving the problem in terms of the reliability of the study (Saaty, 1980).

As part of the research, the literature (Ismail 2009; Eslami et al., 2010, Piran et al., 2013; Hashemi, 2018; Muğla & Türk, 2020) and expert opinions were used to generate pairwise comparison matrices and determine parameter weights.

Table 1. Comparison matrix and weights of layers

LAYERS	1	2	3	4	5	6	WEIGHTS
LUC	1						0.36
(LSG)	1	1					0.36
Rainfall	1/5	1/5	1				0.14
Aspect	1/7	1/7	1/5	1			0.05
Slope	1/9	1/9	1/7	1/3	1		0.03
Erosion	1/7	1/7	1/3	3	5	1	0.08
(CR)				0.08459			

The weights of each criterion (Table 1) were calculated using the paired comparison matrices created. The weight of the parameters was calculated after the comparison matrix. The consistency ratio was found as CR = 0,085. which is the highest value determined for the correct execution of the study, there was no need to repeat the pairwise comparison method (Saaty, 1980) The map of the study area was produced by collecting all weighted layers by using the weighted sum overlay method in ArcGIS software with the obtained weights (Fig. 3).

2.1. Website design

After the determination of the areas to be afforested in Konya 10 area of most suitable areas were selected and these was displayed on the website. For this website "html code" created using the blogger website. Then the location of the most suitable areas, the capacity of the fields, the suitable type of saplings for planting, and the beginning of planting were integrated in this website. In this way, the map of dynamic afforestation areas on the web is made available to users on the internet. This platform is made available to everyone at https://konyagac.blogspot.com/. In addition, information about the transition to the websites of the General Directorate of Forestry and TEMA (The Turkish foundation for combating erosion reforestation and the protection of natural habitats) and the sapling planting stages were shared with the public in order to get information on the site (Fig.4)

3. RESULTS AND DISCUSSION

Afforestation studies have gained importance in recent years in order to reduce the negative effects of industrialization and urbanization on the environment in cities. While the impact of technology on the environment has been highly negative, the concept of environmental technology could save our planet from the harm

One of these environmental technology tools is GIS. It is a powerful tool for environmental data analysis and planning. in the study, the combined AHP and GIS methodology which consists of stages such as structuring AHP hierarchy, describing evaluation criteria, doing pairwise comparisons, and preparing criterion maps and suitability maps of afforestation has been applied. From the weights derived from the AHP method, it can be seen that LUC and LSG were strong factor in a multi-criteria evaluation in Konya. However, the slope factor had the lowest value, because in the study area slope is very low all over the Konya. But in in Malaysia Ismail's study, the slope factor had the highest value, in Sivas/Turkey Muğla and Turk's study slope factor is a middle value. This shows the importance of expert opinion in a pairwise comparison, and the effect of any of these parameters is different in dissimilar areas based on our research objective (Hashemi, 2018). The research must be evaluated accordıng to the characteristics of the study area. Because the study area lacked a large-scale afforestation area inventory map, the accuracy of the model was determined by examining the proper identification of the parameters and their effects on the value.

In the evaluations of the areas that can be afforested area for Konya province, it has been determined that 15% of the study area is the most suitable for the afforestation area, 25.52% is suitable, 28.95% is medium, 12.76% is low and 17.77% is very low. The map showing these determined areas and the boundaries of Konya district were overlapped (Fig. 2) and the distributions of the areas that can be afforested in the districts of Konya were determined. Derebucak, Ahırlı, Bozkır, Hadim, Akören, Derbent districts, south of Seydişehir, south of Seydişehir, south-east of Karapınar and north-facing areas of Ereğli were found to be suitable for afforestation. In the central districts, it was observed that the west of the Selçuklu district, the north and north east of the Meram district were suitable for afforestation, and the Karatay district was moderately suitable and unsuitable for afforestation.

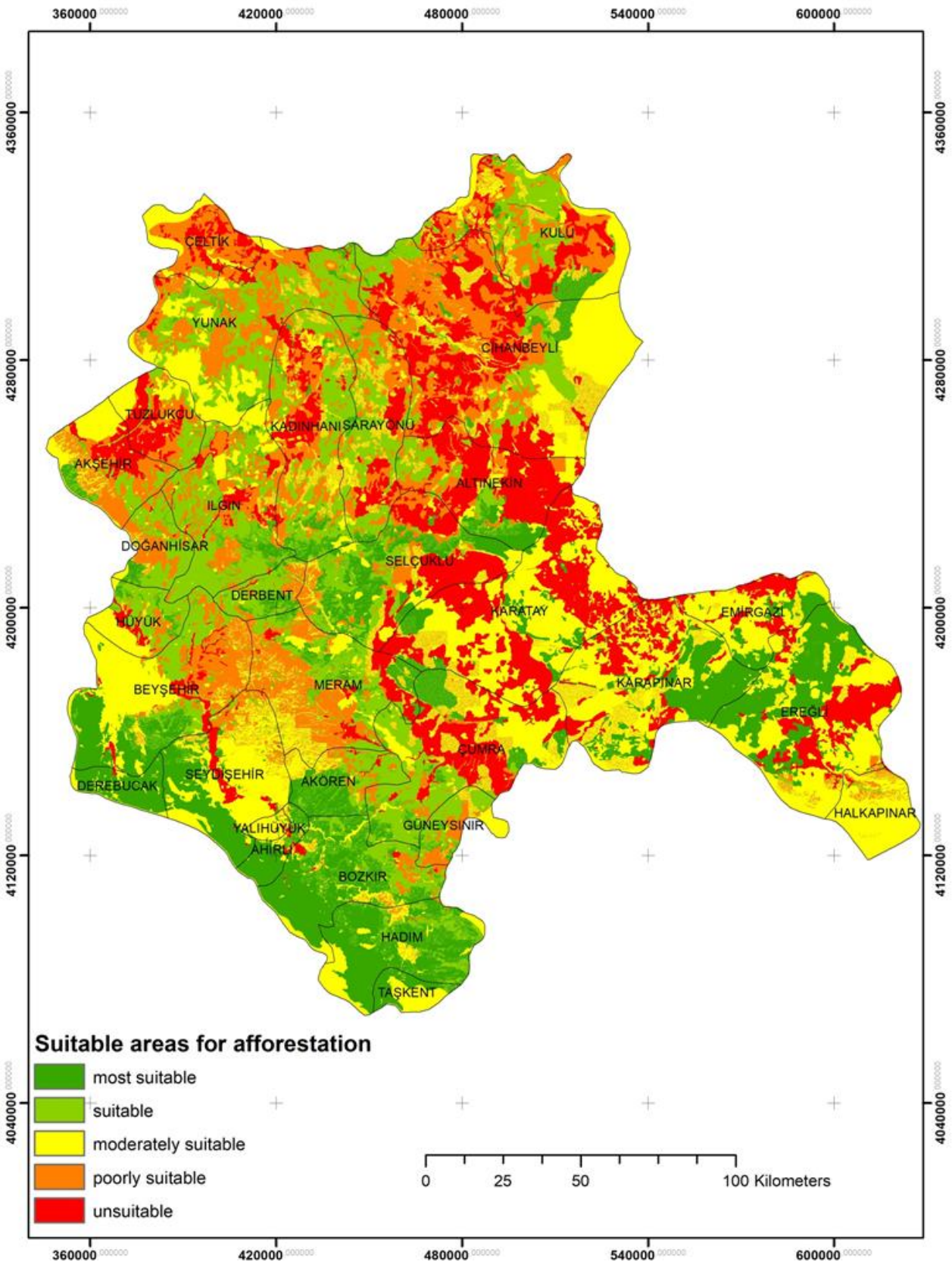

Figure 3. Suitability map of afforest area

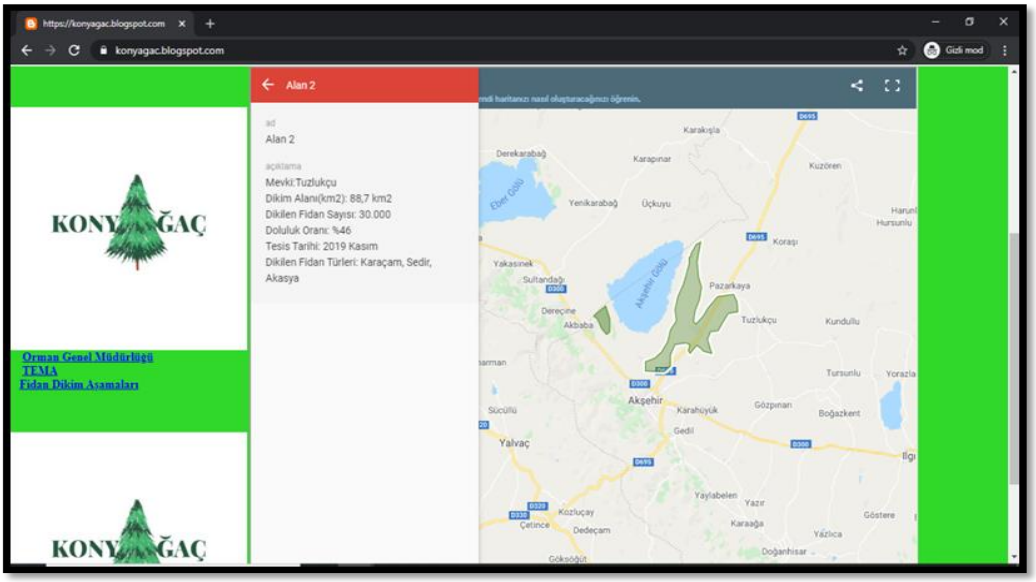

Figure 4. Sample view from the website

By determining the areas to be afforested, and combining the information of the sample areas among the areas deemed appropriate positionally, a platform open to everyone was created on the web. With this platform, which is broadcast on the internet, it has been ensured that different users can access other services and other platforms simultaneously. A web map is more than just any map because it makes GIS more accessible, more affordable and more common.

4. CONCLUSION

AHP with GIS provides an ideal tool for modelling with flexibility and the ability to conduct spatial modelling operations for site suitability assessments. In this study, the suitability map of afforested areas in Konya province was produced with GIS and AHP methods. The map was created from, land use capability (LUC), large soil groups (LSG), rainfall, erosion, aspect and slope layer and it was classified in 5 categories as "most suitable, suitable, moderately suitable, poorly suitable and unsuitable areas. As a result of the study, it was observed that the south and south west of Konya are more suitable for afforestation. In the second stage of the study, to identify the most suitable areas for users on the internet 10 different areas determined from suitability map of afforest area. This area was presented to those who wanted to plant trees on the internet. It is thought that this pilot application theme can be further developed with the participation of the Ministry of Forestry and local people in such studies.

Author Contributions

The contributions of the Authors of this article is equal.

Statement of Conflicts of Interest

There is no conflict of interest between the authors.

Statement of Research and Publication Ethics

Research and publication ethics were complied with in the study.

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