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Remote sensing and GIS applications for suitable afforestation area selection in Turkey

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Abstract: The aim of the study, the potential afforestation areas locate using remote sensing data and geographic information system. In this study, Arit and Esme-Gure forest district areas that have different site conditions, vegetation and topographic conditions was chosen. Landsat TM image was used do pixel based supervised classification and maximum likelihood classification strategy were applied. At first, the criteria that will be potential afforestation area were determined, then the training areas selected on the remote sensing images using on maps to the best classification of potential afforestation areas. Accuracy assessment was evaluated of supervised classification and the result images generated vector. The study revealed that 2032 ha is total potential afforestation forest area for Arit Forest district (overall accuracy; 81%) and 38447 ha is total potential afforestation forest area for Esme-Gure Forest district (overall accuracy; 89%). The study has demonstrated a method that can be used due to the fact that higher accuracy.

Keywords: Afforestation, classification, remote sensing, Turkey

Türkiye'de uygun ağaçlandırma alanlarının belirlenmesinde uzaktan algılama ve CBS uygulamaları

Özet: Bu çalışmanın amacı, uzaktan algılama verileri yardımıyla coğrafi bilgi sistemlerini kullanarak potansiyel ağaçlandırma alanlarını tespit etmektir. Çalışmada, topografik, bitki ve arazi kullanım durumları farklı olan Arıt ve Eşme-Güre orman işletme şefliği sınırları seçilmiştir. Her iki alana ait Landsat TM uydu görüntü verilerine kontrollü sınıflandırma metodu maksimum benzerlik algoritması uygulanmıştır. Öncelikle potansiyel olan ağaçlandırma alanlarına ilişkin kriterler belirlenerek uzaktan algılama yazılı ile kontrollü sınıflandırma metodu için bu alanlardan kontrol alanları seçilmiştir. Kontrollü sınıflandırmaya ilişkin her iki alan için doğruluk değerlendirmeleri yapılmıştır. 2032 ha toplam alanı bulunan Arıt Orman İşletme Şefliğine ilişkin genel doğruluk %81, 38447 ha Eşme –Güre Orman İşletme Şefliğine ilişkin genel doğruluk % 89 oranında gerçekleşmiştir. Bu çalışma uzaktan algılama sınıflandırma yöntemleriyle potansiyel ağaçlandırma alanlarının tespit edilebilirliğini ispatlamıştır.

Anahtar Kelimeler: Ağaçlandırma, sınıflandırma, uzaktan algılama, Türkiye

1.INTRODUCTION

To protect natural forests and biological diversity, existing productive forest should be run efficiently within the principles of sustainable forest management (FRA, 2001; FAO, 2010). In addition to, afforestation must be done in degraded stand (unproductive stand), glade and some state and agricultural land. Also to have enough of the existence of forest and land preservation is vital for the countries (Kanowski, 1997). In general terms, it is a must for sustainable development. As a result, one of the primary problems of Turkey and the world is afforestation in terms of ecological, social, cultural and economic (Diker and Inal, 1945; Saatcioglu, 1956).

The variety of vegetation types is quite different from each region and the climate. Many criteria (topography, aspect, slope, soil, etc.) act on vegetation diversity. All these criteria play an important role in the determination of afforestation area (Dilek et al., 2008). At the same time, the canopy can be a decisive factor. The afforestation area identified due to different canopy values using remote sensing techniques identified (Chaudhary et al., 2003)

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Land cover composition and change detection are important factors that affect ecosystem condition and function. These factors are frequently used to generate landscape-based metrics, to assess landscape condition and to monitor the status and the trends over a specified time interval (Jones et al., 1997). The use of satellite-based remote sensing imagery has been widely applied to provide a cost-effective means to develop land coverage’s over large geographic regions. The calculation of Normalized Difference Vegetation Indices (NDVI's) can be very useful in the generation of a land use/ land cover classification. So it can be used for determined afforestation area (Elhag, 2010). However, RS and GIS methods can be improved according to the different climate and plant species.

Turkey is one of the rare countries in terms of natural conditions in the world. The three main types of climate are observed (Emberger, 1952; Gaussen, 1954). Turkey is located in different ecosystems due to the different properties of physical geography (Atalay, 2002; Kantarcı 2005). As a result, afforestation areas are also varying. Afforestation areas in Turkey are degraded and unproductive stand, partially *maquis* land, glade land and other areas (drainage basin, steppe land, dune fixation etc.). For the detection of these areas, the site survey (Generally site conditions, performance capacity of site, vegetation survey) is necessary. But, especially in field studies of soil profiles for soil survey are increase cost and labour.

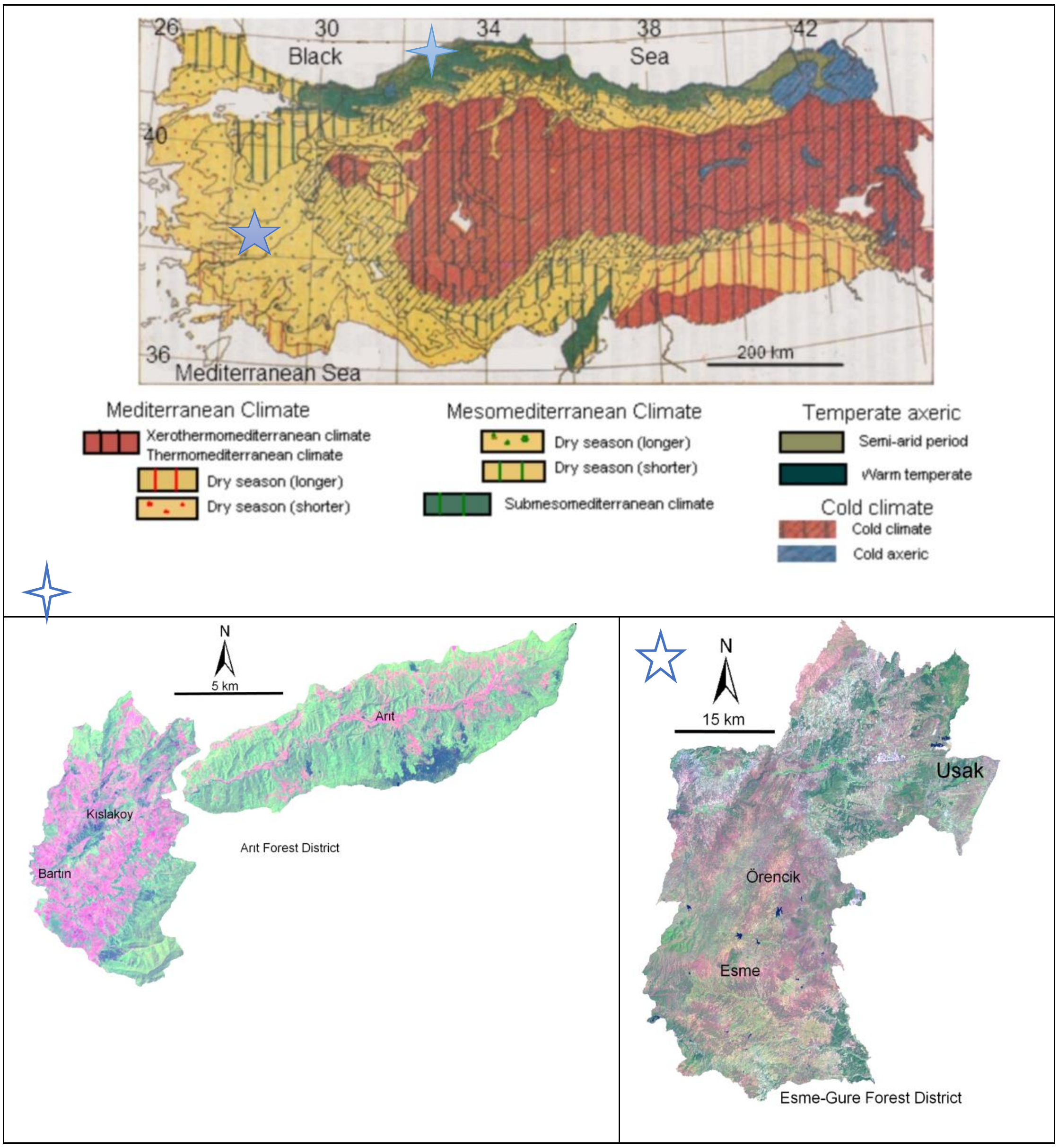
The purpose of this study, the potential afforestation areas were to determine using Landsat TM that satellite image data is most widely used, which allows retrospective study and classification method that the most commonly used in two different types of Turkey in different temperature regimes.

2.MATERIALS AND METHODS

Two study areas, which have different site, climate and vegetation, have been selected (Şekil / Figure 1). The first study area is situated in the Western Black Sea Region in Turkey where located a field of approximately 180 km^2 and it is located in temperature climate. The geographical location of the first study area is between latitude 41º33´ and 41º42´N and longitude 32º24´ and 32º44´E. It is covered by forest community (*Fagus orientalis, Castenae sativa, Carpinus betulus, Abies bornmülleriana*, partially *Quercus sp., Pinus sylvestris, Pinus nigra* are formed mixed forest) with the rest being pseudo-maquis land (Atesoglu and Tunay 2010). The Second study area is situated in the Western and Inner Anatolia Region in Turkey where located a field of approximately 2000 km^2 and it is between located in Mediterranean and Mesomediterranean climate. The geographical location of the first study area is between latitude 38º12´ and 38º50´N and longitude 28º47´ and 29º25´E. It is covered by forest community (*Pinus sylvestris, Pinus nigra, Quercus sp.,*) with the rest being Mediterranean *maquis* land (Atalay, 2008).

Data for GIS were based on existing available in Turkey that include topographic maps of 1:25000 scale, forest cover type maps of 1:25000, CORINE (EEC, 1995) classification maps of 1:25 000 scale in 2011 (General Directorate of Forestry, Republic of Turkey). In addition to, multiple resource uses data were collected during the field trips and were used as bases in the selection of training areas. Old records concerning forest cover type maps were collected from forest general directorate and local people. Landsat TM images were used acquired on 13 June 2010 and 25 August 2010. Image processor for the analysis was PCI Geomatica and GIS analysis was made using ArcView/ESRI software.The selected areas as afforestation areas were identified using management plans and CORINE land management. Result digital maps were created using PCI Geomatica 9.1 and ArcMap 9.3 software.For classification procedure, supervised classification was chosen. In the training stage, it was identified representative training areas and developed a numerical description of the spectral attributes of each land cover types, especially afforestation areas. Supervised classifications were carried out the ground truth or so-called training areas (collected during field investigation) were regions of terrain with known properties or characteristics. Next, in the classification stage, each pixel in the image data set was categorized into the land cover class it most closely resembles. After the entire data set was categorized, the results are presented in the output stage (Lillesand et al., 2004). Maximum likelihood classification was found to be most useful for discriminating the category of interest.

Each test area that regionally in itself contains similar climatic and soil properties, existing land use patterns climatic conditions. For potential afforestation class, selection of training areas has been selected image on the basis of the existing base maps (Tablo / Table 1) and investigation and supervised classifications were carried out. This item of the nomenclature covers land units identifiable by characteristic spectral responses which distinguish them from their environment.



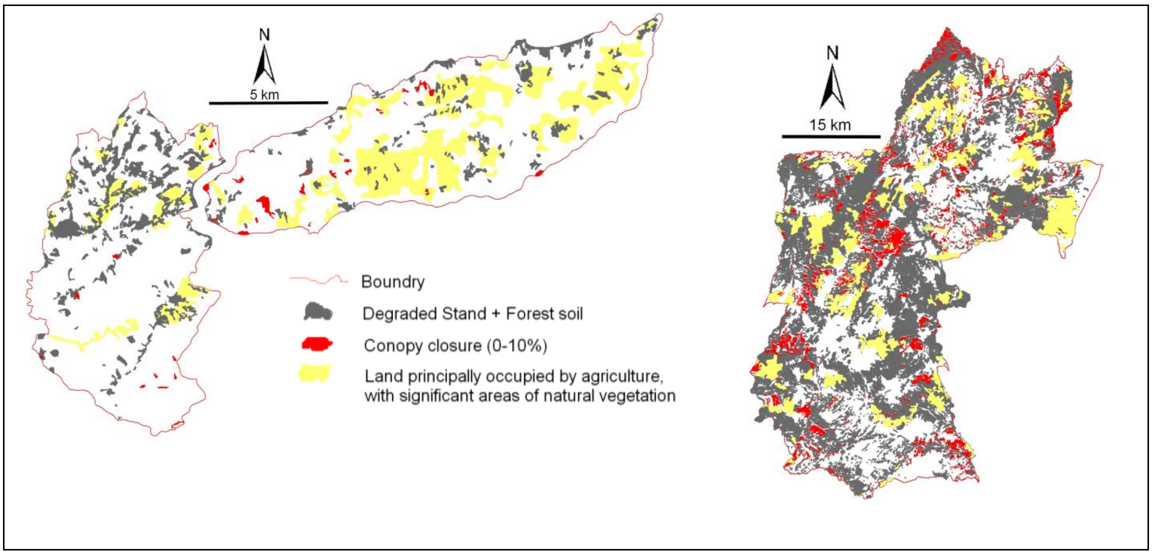
Şekil 1. Türkiye ve çalışma sınırlarındaki bioklimatik bölgeler ((Urgenc, 1998).
Figure 1. Bioclimatic zones (Urgenc, 1998) in Turkey and the study sites

Tablo 1. Seçilen kontrol alanlarının özellikleri
Table 1. Properties of the selected training areas

Data	**Criteria**
Forest cover type maps	Canopy closure (0-10%) Degraded stand (unproductive stand) Glade land
CORINE classification maps	2.4. Heterogeneous agricultural areas 2.4.3. Land principally occupied by agriculture, with significant areas of natural vegetation
Analyst	Observation and investigation

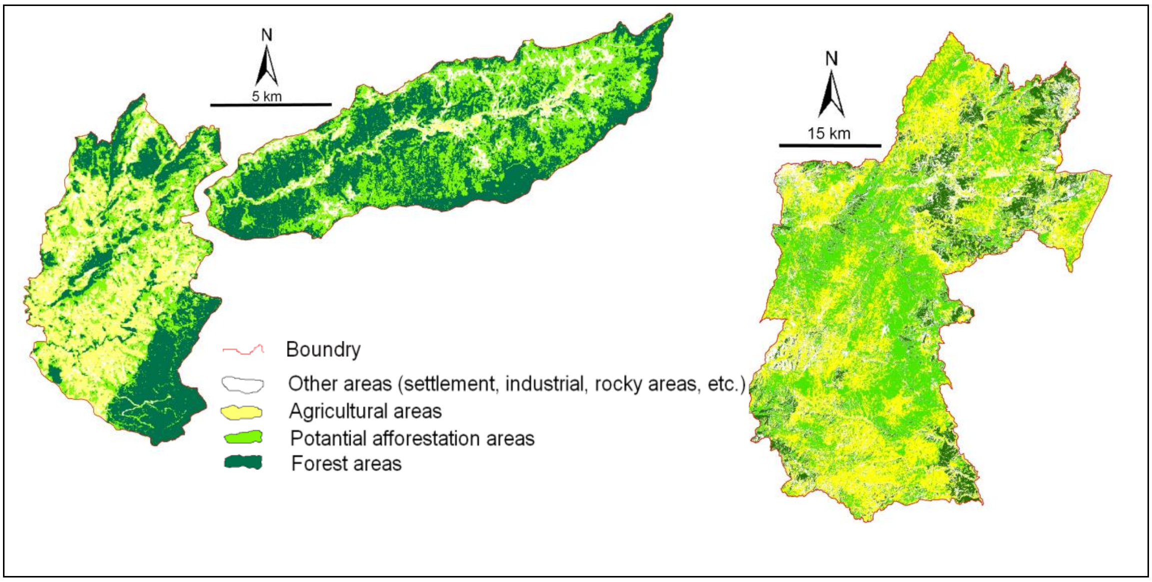
3.RESULTS AND DISCUSSION

Each test area has a diverse climate and site conditions. Although criteria of the selected training areas were same, spectral responses were different in terms of both radiometric resolution and land cover. The selected training areas according to table were extracted as a vector (Şekil / Figure 2).



Şekil 2. Kontrol alanı seçilebilecek uygun alanlar
Figure 2. The suitable training areas can be selected control areas

After determining training areas, pixel based supervised classification was applied. The study areas were classified into four groups; agricultural areas, forest areas, potential afforestation areas, other areas (settlement, industrial, rocky areas, etc.) (Şekil / Figure 3) and calculated accuracies (Tablo / Table 2). Due to the fact that the study areas were different size, accuracy assessment was made using reference pixel that 1/1000 of the total area pixel number.



Şekil 3. Sınıflandırma sonuçları
Figure 3. Classification results

For Arit forest district; Overall accuracy was calculated 81% (Overall Kappa Statistic: 73.9%). For the purposes of this study, producer's accuracy of “potential afforestation areas” class was calculated 69.6%. That means, 69.6% of selected pixels for “potential afforestation areas” class was defined correctly for this class. Although overall accuracy of classification is high level, accuracy of “potential afforestation areas” class is low. For Esme-Gure forest district; Overall accuracy was calculated 89% (Overall Kappa Statistic: 83.9%) and producer's accuracy of “potential afforestation areas” class was calculated 79.9%.

Tablo 2. Doğruluk değerlendirmesi*
Table 2. The accuracy statistics*

Class Name	Producer's Accuracy (%)	User's Accuracy (%)
Other areas (settlement, industrial, rocky areas, etc.)	97.1	86.8
Agricultural areas	70.2	92.9
Potential afforestation areas	69.6	76.5
Forest areas	88.4	77.2

**Arit Forest District: Overall Accuracy: 81% (95% Confidence Interval); Overall Kappa Statistic: 73.9%*

Class Name	Producer's Accuracy (%)	User's Accuracy (%)
Other areas (settlement, industrial, rocky areas, etc.)	97.7	76.9
Agricultural areas	91.9	87.5
Potential afforestation areas	79.9	92.5
Forest areas	99.3	92.7

**Esme-Gure Forest District: Overall Accuracy: 89% (95% Confidence Interval); Overall Kappa Statistic: 83.9%*

The analysis of the error matrix, “potential afforestation areas” class was the most mixed with “forest areas” class in Arit forest district. But, “potential afforestation areas” class was the most mixed with “Agricultural areas” class in Esme-Gure forest district (Tablo / Table 4.). The reason for the Arit forest district, the vegetation has reached a certain maturity and covered the soil. Therefore, the spectral response values (digital number) of the forest areas and this area were close each other and were difficult to distinguish. Similarly, the reason for the Esme-Gure forest district, due to following land, “potential afforestation areas” class was the most mixed with “agricultural areas” class.

Tablo 4. Hata Matrisi*
Table 4. Error (Confusion) Matrix*

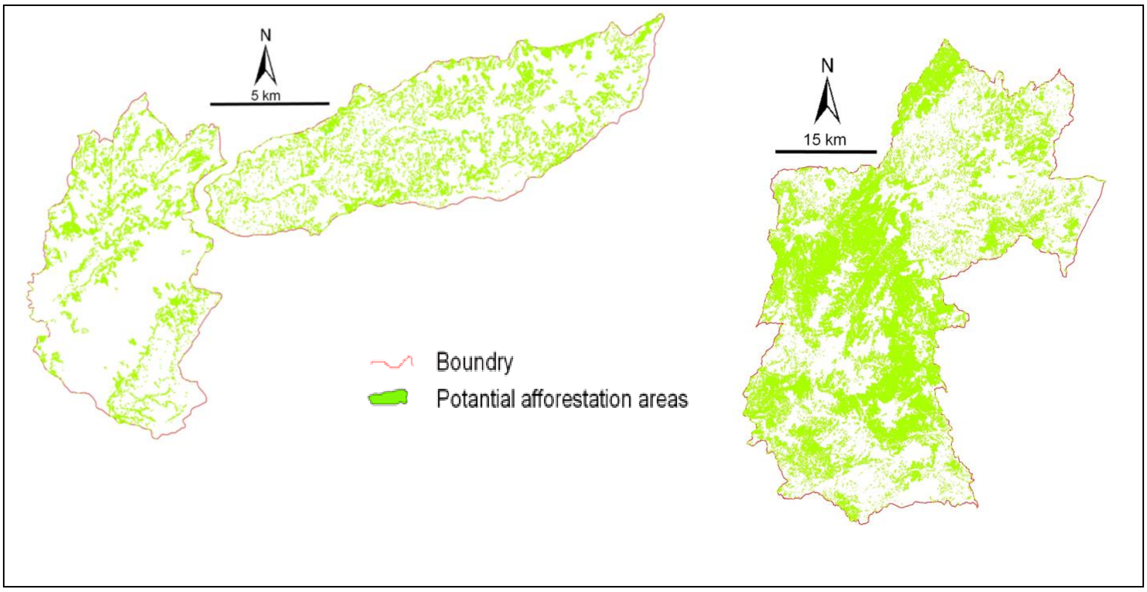
Classified data	A1	A2	A3	A4	Total
Other areas (settlement, industrial, rocky areas, etc.); A1	33	4	**1**	-	38
Agricultural areas;A2	1	26	**1**	-	28
Potential afforestation areas;A3	**-**	**4**	**39**	**8**	**51**
Forest areas;A4	-	3	**15**	61	79
Total	34	37	**56**	69	196

** Arit Forest District*

Classified data	A1	A2	A3	A4	Total
Other areas (settlement, industrial, rocky areas, etc.); A1	87	23	**3**	-	113
Agricultural areas;A2	2	698	**98**	-	798
Potential afforestation areas;A3	**-**	**38**	**497**	**2**	**537**
Forest areas;A4	-	-	**24**	306	330
Total	89	759	**622**	308	1778

**Esme-Gure Forest District*

Potential afforestation areas identified as a result of classification was overlaid with cadastral maps using GIS. After removal of ownership lands, it was calculated only afforestation areas (Arıt forest district; 2032 ha, Esme-Gure forest district; 38447 ha) (Şekil / Figure 4).



Şekil 4. Potansiyel ağaçlandırma alanları
Figure 4. Potential afforestation area

Dilek et al., 2008, in his study, are needed permeability of the soil structure, permeability of the geological structure hence vegetation, slope etc. for for identification of areas of afforestation. Thus, the corrected data produced and field work is required. Although the results of high accuracy, this study is not optimal with regard to time, cost and labor. However, these criteria can be minimized using remote sensing. Elhag, 2010, in his study, used remote sensing data, Landsat TM images. Two temporal Landsat images acquired in 1984 (Landsat TM-5) and 2006 (Landsat ETM-7) were used to generate Normalized Difference Vegetation Index (NDVI) change detection map. Multi Criteria Analysis (MCA) is used for compromising conflicts.At the same, these criteria are geo-soil, vegetation, NDVI change detection and DEM. The result maps (afforestation areas) were created as a result of statistical algorithm. The future studies will increase the accuracy of classification using different vegetation indices. Models manufactured by statistical methods will be used in national or regional (Chaudhary et. al., 2003; Hossain et. al., 2008). The afforestation suitable areas can be identified change detection studies based on past (Ivanov et al., 2007). The classification can be used to control the validity performed. Turkey has different climate types due to location and seas around. The bedrock and soil properties are different as well as climate types. Therefore, in the purposive classifications, the knowledge of the site conditions, vegetation and topographic conditions by analysts is very important. The training areas should been selected different spectral responses in the different afforestation areas. Especially, it should be suggest from experts to determine training areas and should be identified in the field.

As a result, considering the physical conditions Turkey, the identification and quantity of afforestation are important. For determination of afforestation areas, remote sensing and Geographic information system are the most appropriate method in terms of time, cost and labor. This study is exhibits as a simple and effective method with regard to rehabilitation the protection of forests that national wealth. It is important to study spread throughout Turkey. Besides, in terms of increasing accuracy, it will determine to different techniques and modeling studies that based remote sensing and Geographic information system.

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