SEPARATION OF AGRICULTURAL AIMED PLANTATIONS FROM THE FOREST COVER BY USING THE LANDSAT-5 TM AND SPOT-4 HRVIR DATA IN TURKEY

Ü. Asan[a], I. Özdemir[b]

[a] I.U. Faculty of Forestry, 80895 Bahceköy, Istanbul, Turkey e-mail: asanunal@istanbul.edu.tr
[b] SDU, Faculty of Forestry, 32260 Cünür, Isparta, Turkey e-mail: ibrahim@orman.sdu.edu.tr

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ABSTRACT

Agricultural plantations consisting of citrus fruits, hazelnut, olive and tee adjacent to the forest boundaries cover very huge areas in Turkey. Since, they are seen as if forest cover on the satellite data a reliable tool, which can be used for definition of these boundaries is needed in order to get a sound statistic about the forest cover in the country. A case study accomplished in this course is introduced in this paper. Two varying areas having olive, poplar and hazelnut plantations around of Düzce and Gemlik were chosen for this purpose. Double sampling design for stratification basing on satellite images and aerial photographs was used for separation of these plantations from forest areas. For forest and non-forest classes only, overall accuracy was found as % 90.3 and Kappa Coefficient was 79.4 for the first area while producer's accuracy and user's accuracy of the classes are %79.1 and %81.0 respectively for the olive plantations. In the second area around of Düzce, overall accuracy, and Kappa Coefficient for the forest and non-forest areas were found as %95.1 and 88,6 respectively. Producer's accuracy and user's accuracy are %84.4 and %92.0 for hazelnut, and % 85.0 and %68.0 for the poplar plantations.

1. INTRODUCTION

Because of changing peculiarities continuously, monitoring of the forest existence in the country is an important gab for the foresters in all over the world. Forest statistics are updated in definite time intervals by means of suitable inventory methods.

Precise and reliable information on the situation of forests is necessary either for the large - scaled strategic forestry planning at the whole country base, or regulation of yield at the small – scaled districts base. Depending on the magnitude of inventory units, there are three hierarchic levels in forest inventory as it can be grouped i) stand base, ii) regional (planning unit) base, and iii) national base inventory (Asan 1999). .

The forest inventory covering the whole country surface is called National Forest Inventory (NFI) in forestry. Many kinds of data sources such as ground survey, aerial photos, satellite images, and so on are being used in the NFI applications depending on the conditions current in the countries involved: i) general topographic properties, ii) forest forms and distribution, iii) transportation facilities, ıv) forestry tradition, and ownership situation, v) existence of previous inventory results, vı) application level of the modern inventory methods and related technologies (Asan 1999). Satellite remote sensing technology providing a cheap data especially for the large regions is accepted as an inevitable data sources for the NFI applications in various countries.

Because of the climatic and topographic properties, Turkey has many kinds of vegetation types depending on the altitude and latitude. There are great differences among the geographical regions from the standpoint of tree species, forest forms and types. There are no definite and explicit boundaries between the forest and the agricultural aimed plantations consisting of citrus fruits, hazel-nut, olive and the tee. The agricultural plantations adjacent to the forest boundaries cover very huge areas in Turkey. They are seen as if forest cover on the satellite data because of their wood peculiarities of these plants. A reliable tool, which can be used for definition of these boundaries, is needed in order to get a sound statistic concerning the forest cover in the country (Dees et Al. 2003).

A case study accomplished in the Marmara and West Blacksea regions concerning to determine olive, hazel-nut and poplar plantations on the satellite images introduced in this paper. Double sampling design for stratification basing on satellite images and aerial photographs was used for separation of these plantations from forest areas.

2. MATERIAL AND METHODS

2.1. Study Area

Two areas in the Marmara and West Blacksea regions were chosen as the study areas. The first test site, having wide spread olive plantations and 51721 ha magnitude is located between the Universal Transverse Mercator (UTM) -35N coordinates 28° 59' 47''E / 40° 25' 01''N and 29° 29' 46''E / 40° 34'' 39''N. The second test site occurring between the UTM-35N coordinates 30° 53' 23''E / 40° 50' 21''N and 31° 14' 45''E / 40° 59''27''N has 29624 ha is occupied by the poplar and hazelnut plantations (Fig.1). Natural tree species in the study areas are *Fagus orientalis Lipsky, Quercus Ssp., Carpinus L., and Castenea sativa Mill. Pinus nigra, Pinus brutia* and *Pinus pinea* can be seen as the plantation forest too.

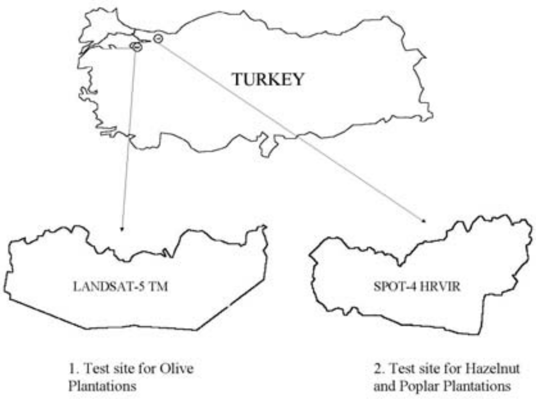
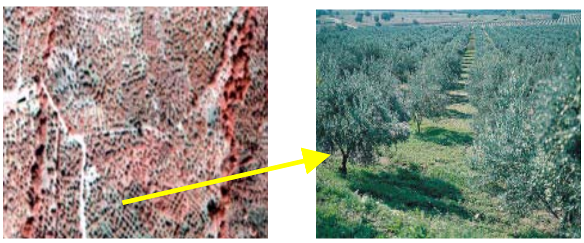


Figure 1: Study areas

2.2. Materials

Standard topographic maps rectified by means of ER Mapper Software and, management plan maps corrected geometrically with the help of Ground Control Points (GCP) were used in the study. Two groups of map 1/25000 scaled both transformed into UTM coordinate system.

Landsat Thematic Mapper (TM) imagery acquired on 26th September 1999 and, 1/16000-scaled infrared aerial photos belonging to the year 2001 were chosen in order to separate olive plantation from forest areas in the first test site (Fig. 2). SPOT-4 HRVIR data acquired on 26th September 1999 and, 1/15000-scaled infrared aerial photos taken in 1995 were used in separation of poplar and hazelnut plantations in the second test site (Fig. 3).



a b

Figure 2**:** Olive Plantation on a) Aerial Photo, b) the Ground

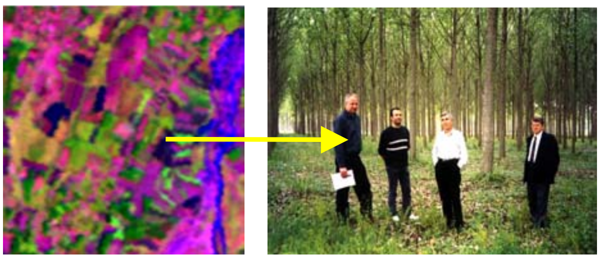


Figure 3**:** Poplar Plantations on a) SPOT HRVIR İmage, b) the Ground

2.3. Methods

2.3.1. Creation of Digital Elevation Models (DEM)

A Digital elevation model (DEM) is an ordered array of numbers representing the spatial distributions of elevations in the earth surface (Carter 1988, Musaoglu 1999). DEM was used for both geographic stratification of satellite data and orto-rectification of aerial photos in the study. The DEMs for the test sides both were created using triangulation gridding method by means of ER Mapper Gridding Wizard (Fig. 4).

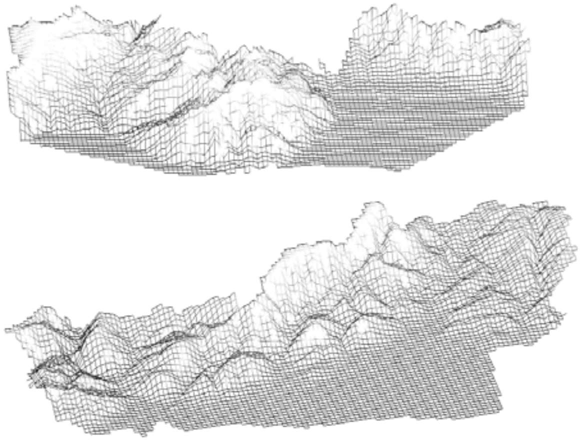


Figure 4: Digital Elevation Models for the study areas

2.3.2. Analysis procedure

2.3.2.1. Geometric Correction of Satellite Data

Geometric correction is a process by which points in an image are registered to corresponding points on a map or other image that has already been rectified (Lillesand and Kiefer 2001). In this study, satellite images were transformed into UTM co-ordinate system by geo-coded topographic maps of 1/25000 scale prior to classification. 37 and 46 GCP were used for rectification in the first and second test sites respectively.

2.3.2.2. Classification

Supervised classification and the maximum likelihood algorithm were applied for the classification of Landsat TM image pixels. 85 training areas identified in both stand types map and fieldwork were used for supervised classification of Landsat TM data. On the analysis, seven different land cover classes were considered: water, broadleaved forest, coniferous forest, degraded forest, agricultural and other open land, olive plantation, and residential areas. In order to eliminate the influence of different illumination conditions, and to make use of some ecological rules in classification (Jensen 1996), the first test site was stratified into two height classes (up to 500 m and 500 m and higher) and two illumination classes (lighting and shadow areas) according to the sun azimuth angle, resulting in 4 strata altogether.
In this test site, four stratified data set consisting of TM7, TM4 and TM3 bands were classified into seven classes using

maximum likelihood algorithm independently. Then, classified four data were integrated to the one image (Fig. 5).

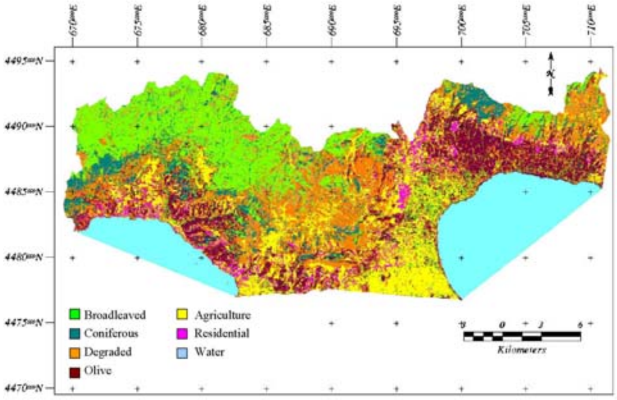


Figure 5: Classification map for first test site

In the other test site, new data groups were created using the ratio images, which are the Normalized Difference Vegetation Index (NDVI) and XS3 / XS4 band ratio in order to reduce effects of different illumination conditions (Lillesand and Kiefer 2001). The SPOT data set consisting of NDVI, XS3 / XS4 band ratio and XS1 bands were classified into seven land use classes using 56 training areas. Maximum Likelihood Classification Algorithm was employed for classification of SPOT HRVIR data too. Stratified land use classes in the study are water, broadleaved forest, coniferous forest, hazel-nut plantation, poplar plantation, agricultural and other open land and residential areas. Classified satellite map are shown in Fig. 6 .

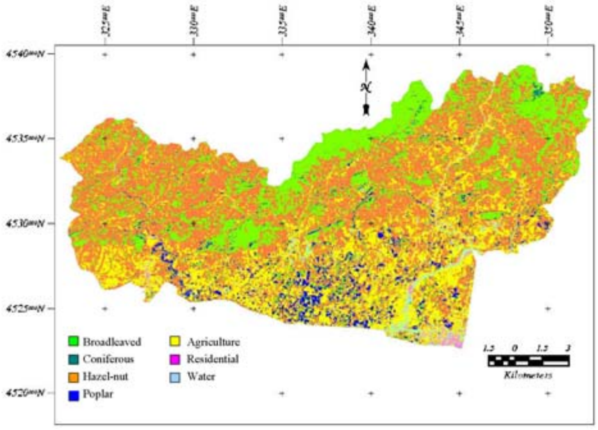


Figure 6: Classification map for the second test site

2.3.3. Accuracy Assessment of Classification

Assessment of classification accuracy is controlled with the help of error matrix and Kappa Analysis technique, and, reference test pixel data (Richards and Jia 1999; Mather 1987 ; Jensen 1996). In the error matrix, the columns indicate the reference data, while the rows represent the classification generated from the satellite-derived map data. Kappa analysis technique basing on K statistic is applied by means of the formula given below:

$$K = \frac{N\sum_{i=1}^{r} x_{ii} - \sum_{i=1}^{r}(x_{i+} \times x_{+i})}{N^2 - \sum_{i=1}^{r}(x_{i+} \times x_{+i})}$$

where r = number of rows in the matrix,

x_{ii} = number of observations in row and column

x_{i+} = the marginal totals for row

x_{+i} = the marginal totals for column

N = the total number of observations

In this study, aerial photos, management plan maps, and groun data were used as references data (Fig. 7).

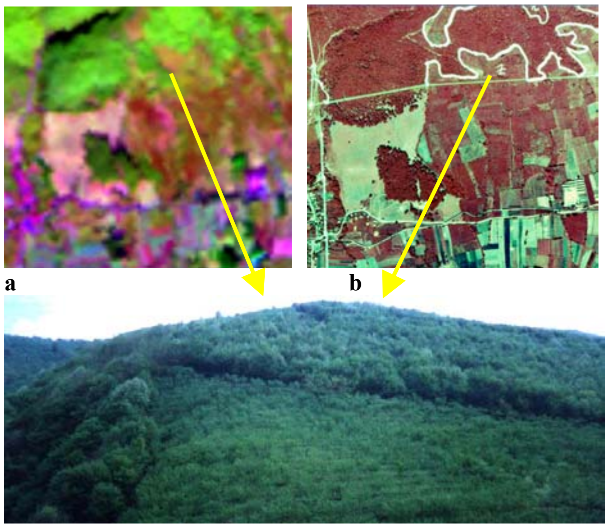


Figure 7: Hazel-nut Plantation on a) SPOT XS, b) Aerial Photo, c) Ground

350-reference test pixels are selected randomly for filling the error matrix in the test sites both. The results are shown in the tables 1- 2 for the first, 3 – 4 for the second study area.

Table 1: The Error Matrix for the first Test Area (Landsat-5 TM)

CLASSIFI-CATION	REFERENCE DATA							
	Water	Broadleaved forest	Coniferous forest	Degraded forest	Agricultural and open land	Olive plantation	Residential areas	Row Total
Water	10							10
Broadleaved Forest		114	2	6	3	2		127
Coniferous Forest			28	4	1			33
Degraded Forest		5	13	32	3	3		56
Agricultural and Open Land		3	2	2	45	4	3	59
Olive Plantation				4	4	34		42
Residential Areas				3	3		17	23
Column Total	10	122	45	51	59	43	20	350
Overall Accuracy = % 80.0 , **Kappa Coefficient** = 74.7								

Table 2: Producer's Accuracy and User's Accuracy of classes for Landsat-5 TM

CLASSES	Producer's Accuracy (%)	Omissio n error (%)	User's Accuracy (%)	Comission error (%)
Water	100	0	100	0
Broadleaved Forest	93.4	6.4	89.8	10.2
Coniferous Forest	62.2	37.8	84.8	15.2
Degraded Forest	62.7	37.3	57.1	42.9
Agricultural and Open Land	76.3	23.7	76.3	23.7
Olive Plantation	79.1	20.9	81.0	19.0
Residential Areas	85.0	15.0	73.9	26.1

Only For Forest and Non-forest classes, Overall Accuracy was % 90.3 and Kappa Coefficient was 79.4.

Table 3: The error matrix for the Second Test Area (SPOT-4 HRVIR)

CLASSIFICATION	REFERENCE DATA							
	Water	Broadlea-ved Forest	Conifero-us Forest	Hazel-nut	Poplar	Agricultur-al Land	Residen-tial Areas	Row Total
Water	12							12
Broadleaved forest		89		5		3		97
Coniferous forest		3	8					11
Hazel-nut		5		92		3		100
Poplar		2			17	6		25
Agricultural land		2		12	3	56	2	75
Residential areas	2					6	22	30
Column Total	14	101	8	109	20	74	24	350

Overall Accuracy (%) = 84.6 and **Kappa Coefficient (%)** = 80.1

Table 4: Producer's Accuracy and User's Accuracy of classes for SPOT HRVIR

CLASSES	Producer's Accuracy (%)	Omission error (%)	User's Accuracy (%)	Comission error (%)
Water	85.7	14.3	100	0
Broadleaved forest	88.1	11.9	91.8	8.2
Coniferous forest	100	0	72.7	27.3
Hazel-nut	84.4	15.6	92.0	8.0
Poplar	85.0	15.0	68.0	32.0
Agricultural and open land	75.7	24.3	74.7	25.3
Residential areas	91.7	8.3	73.3	26.7

Only For Forest and Non-forest classes, Overall Accuracy was % 95.1 and Kappa Coefficient was 88.6.

3.CONCLUSIONS

Determination of hazelnut, poplar and olive plantation areas by means of satellite images is the main purpose of this study. According to the results of the tables 1-4, this gab can be done successfully with a satisfied confidence level. As it can be seen at the Table 1, 42 pixels were classified as olive plantation on the image, although 34 of them olive in actually. The user's accuracy was calculated as % 81,0 (Table 2). On the other hand, 43 pixels are olive plantation in actually, but 34 of them could be separated as the olive areas on the image. Thus, producer's accuracy was calculated as % 79,1 (Table 2).

Overall accuracy was calculated as % 90.3 . Kappa Coefficient was found as 79.4 respectively for the forest and non-forest classification in the first study area.

As to hazelnut plantation, 100 pixels were classified as hazelnut areas on the image, although 92 of them really hazelnut areas (Table 3). The user's accuracy was calculated as % 92,0 (Table 4). On the other hand, 109 pixels are hazelnut plantation in actually, but 92 of them could be separated as hazelnut on the image. The producer's accuracy was calculated as % 84,4 for the hazelnut (Table 4).

The results for poplar plantations are 17 / 25 and, 17 / 20 (Table 3). Therefore the user' accuracy and the producer's accuracy were calculated as % 68,0 and % 85,0 respectively (Table4).

Overall Accuracy and Kappa Coefficient were found as % 95.1 and % 88.6 respectively for the forest and non-forest classification in the second study area.

The results found in this study show us that, separation of hazelnut, poplar and olive plantation areas by using satellite images is an easy and reliable way in the practise of NFI. Separation of these plantations from the forest areas will reduce the inventory expences by saving time and money before beginning the ground measurements.

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