MONITORING SPATIAL AND STRUCTURAL CHANGES OF FOREST COVER IN YENICIFTLIK WATERSHED WITH MULTITEMPORAL SATELLITE DATA

M.INAN[a], **K. ERDIN**[a]

İstanbul University, Forestry Faculty, 34473 Bahçeköy, İstanbul, Turkey – (inan, erdink)@istanbul.edu.tr

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ABSTRACT:

Recent surveys indicate that changes in forest cover and land use have a direct and enormous effect on wildlife, water quality, climate and carbon cycling. The forest ecosystem is threatened constantly by both human impacts like forest fires, air pollution, clearing for agricultural uses, illegal cutting and also natural phenomena like storms and droughts. The monitoring and control of this dynamically structured forest ecosystem give the best usage possibilities for the sustainable operation and protection of forest resources. In this study, the land use of Yeniciftlik watershed located in Beykoz-Istanbul- Turkey, and spatial and structural changes of forest cover are investigated by using the monitoring system with Landsat MSS, TM and ETM^+ images evaluated with the data of ten year time periods belonging to the years of 1974, 1984, 1994 and 2001. In addition, the combined uses of GIS and remote sensing tools have been highlighted with respect to their advantages in forestry applications.

1. INTRODUCTION

At present, change detection and land use mapping studies are important because false land use decisions and deforestation have caused negative impacts on soil erosion, run-off and flooding, CO2 concentration and climate changes. Change detection is the method used to highlight or extract differences through imagery acquired from different epochs time (ERDAS, 1997). Satellite data has become the major data source in the change detection of diverse applications including forest cover changes, because of the its advantages in fast, cost effective, synoptic, accurate, flexible and up to date properties and digital data acquisition characteristics.

There are several methods for the determination of change detection, but basically, there are two main approaches: Comparative analysis of independently-produced classifications and simultaneous analysis of multi-temporal data (Sing 1989).

The method of post-classification comparison provides complete change information reduces the impact of atmospheric and environmental differences to a minimum and make it possible to the classify images recorded at different time periods.

This study covers the analysis of the changes in land-use preferences over a 30 year time period in Yeniçiftlik Watershed and determination of structural and area changes in the forest covers by using the Landsat satellite data belong to the years 1974, 1984, 1994 and 2001.

2. STUDY AREA AND DATA SET

The study area is located in Turkey, roughly between latitudes 41º 09' - 41º 03' N and longitudes 29º 10' – 29º 09' E. The total area is 22.86 km^2 and average height of the area is 152.04 m. The main data used in this study is Landsat MSS/TM/ETM^+ images recorded on 31st June 1975 (MSS), 24th June 1984 (TM), 02nd July 1984 (TM) and 16th July 2001 (ETM^+). Additionally, tabular data derived from Forest Management Plans made in the relevant years and the map of these plans were used to compile the terrestrial data to be used as supporting data for the study.

3. METHODS

Figure 1 illustrates the flow chart of land use change detection associated with forest cover change detection. The multi-temporal Landsat images were geometrically rectified and registrated into UTM projections. All Landsat images were atmospherically and topographically corrected with ERDAS Imagine ATCOR 2.1.Modules.

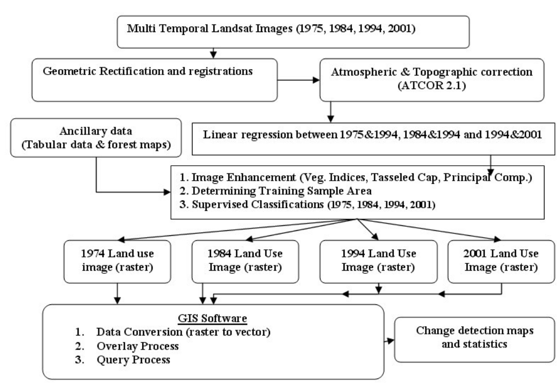

Figure 1. Flow chart for classification and change detection

The atmospheric and topographic correction models eliminate or reduce the effect caused by sun zenith angle, solar radiance, atmospheric scattering and absorption, but they cannot eliminate the reflectance difference among the multi-temporal images caused by different environmental conditions such as soil moisture (Lu D. at all. 2002).

Therefore, 1994 Landsat TM images were chosen as reference and other images (1974, 1984, and 2001) as predicted and linear regression models were set up for each band in multi-temporal images. Consequently, the disparities in images caused by environmental differences were normalized.

For the purpose of the classification of the images obtained in the years of 1974, 1984, 1994, 2001 and change detection, 4 different land use classes were determined, namely deciduous forest, coniferous forest, settlement areas and other non-forest usage. These main classes include many sub-classes. Representing these classes, 42 training areas were selected for each of the images and the same training areas were used in all images. Forest Management Plans and charts were referred to for the determination of the training areas and the terrestrial data .was checked.

The training areas were first subjected to signature analysis and the investigation of the brightness (reflection) values and relevant curves of these classes were conducted. Decisions were made on the most appropriate band combinations after the investigation of the tables and graphics showing the reflectance values of the training areas belonging to these classes with respect to bands. The appropriate band combinations were NDVI, VI (MSS4 - MSS3), Tasselled Cap (Greenness) for the year 1974 and 3-4-5th band of TM and ETM^{+}, NDVI, VI (TM4-TM3) and Tasselled Cap (Greenness) for the years 1984, 1994, and 2001. Afterwards, the classification of the sub-classes and the band combinations were made. The classification was done using the "Maximum Likelihood" method.

4. RESULT AND DISCUSSION

To determine land use changes, classificated images belonging to the 4 main land use classes were recoded and converted into vector layers with ArcInfo software and geographic information covers for the years 1974, 1984, 1994 and 2001 were used. After the query of the overlay process, the land use changes between the years of 1974 and 2001 were examined.

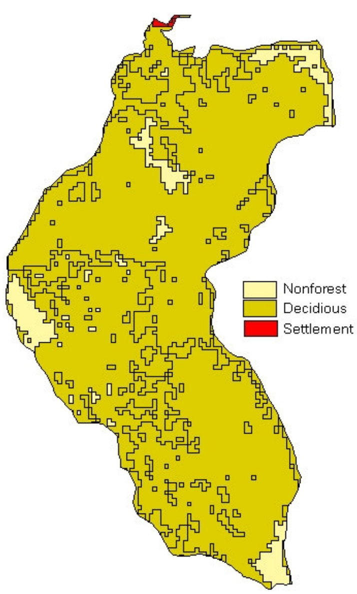

Figure 2. Land use map of 1974

Class	Area (ha)	Area (%)
Settlement	3.04	0.13
Non-forest	142.36	6.23
Deciduous	2141	93.64
Coniferous	0.00	0.00

Table 1. Area distributions of land use class for 1974

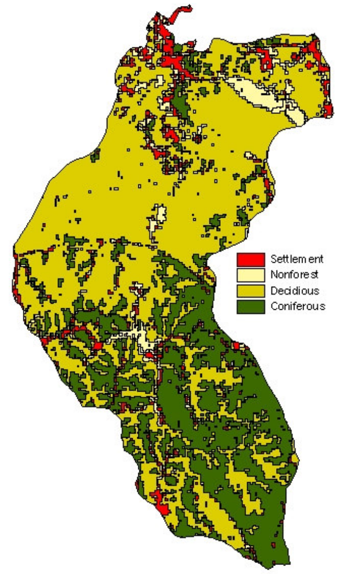

Figure 3. Land use map of 1984

Class	Area (ha)	Area (%)
Settlement	166.81	7.30
Non-forest	96.66	4.23
Deciduous	1357.83	59.39
Coniferous	665.10	29.09

Table 2. Area distributions of land use class for 1984

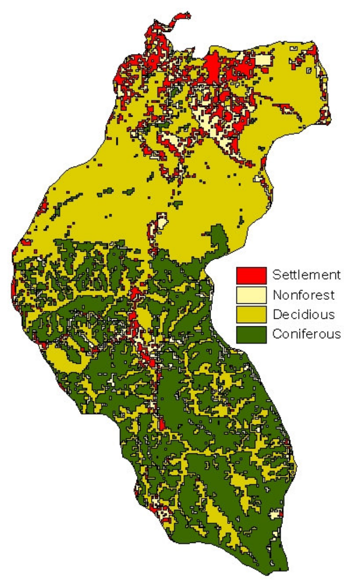

Figure 4. Land use map of 1994

Class	Area (ha)	Area (%)
Settlement	189.31	8.28
Non-forest	128.75	5.63
Deciduous	1132.44	49.53
Coniferous	835.90	36.56

Table 3. Area distributions of land use class for 1994

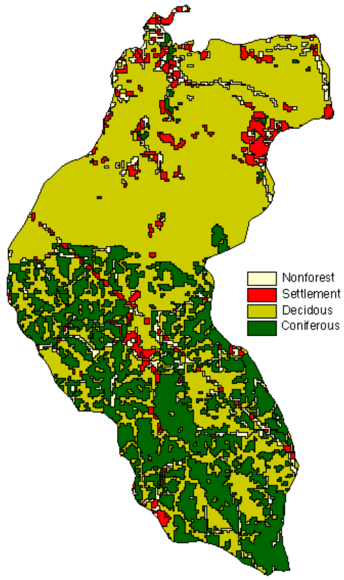

Figure 5. Land use map of 2001

Class	Area (ha)	Area (%)
Settlement	221.30	9.68
Non-forest	129.32	5.66
Deciduous	1304.54	57.06
Coniferous	631.24	27.61

Table 4. Area distributions of land use class for 2001

The spatial distribution of main land-use classes is provided in Tables 1, 2, 3, and 4; land use maps belonging to the years 1974, 1984, 1994 and 2001 are shown in Figures 2, 3, 4 and 5.

Images recorded at ten year intervals were compared to determine the direction of change. The major change between the years of 1974 and 1984 was the planting of coniferous trees in place of deciduous trees. Additionally, there was a great increase in settlement areas. The increase in coniferous trees and settlement areas continued between the years of 1984 and 1994. In 2001, the areas of settlement have increased and the areas of coniferous trees started to decrease, and creating gaps. Table 5 and Figure 6 summarize the area change rates and direction of change in the study area.

Accuracy assessment is very important for a better understanding of the developed result and use of result making decisions. In this study, 50 ground control points were used for the accuracy analysis of the classification. Ground truth data were obtained from forest maps and tabular data. In the event that the ratio of the accuracy of the estimations to be obtained through remote sensing is 80% or above, then the classification is assumed to be accurate and reliable (Swan and Davis, 1978). Ratios of accuracy of the classification for all classes belonging to the years 1974, 1984, 1994, 2001 were 89%, 88%, 90% and 86% respectively.

Change direction	Area change between 1974-1984		Area change between 1984-1994		Area change between 1994-2001	
	Area (ha)	Area (%)	Area (ha)	Area (%)	Area (ha)	Area (%)
Settlement	163.77	7.16	22.50	0.98	31.99	1.40
Non-forest	-45.70	-2.00	32.09	1.40	0.57	0.02
Deciduous	-783.17	-34.25	-225.39	-9.86	172.10	7.53
Coniferous	665.10	29.09	170.80	7.47	-204.66	-8.95

Area change (ha) = post date of area – prior data of area
Area change (%) = 100 * area of land use class / total area

Table 5.Area change rate between 1974 and 1984, between 1984 and 1994, and between 1994 and 2001

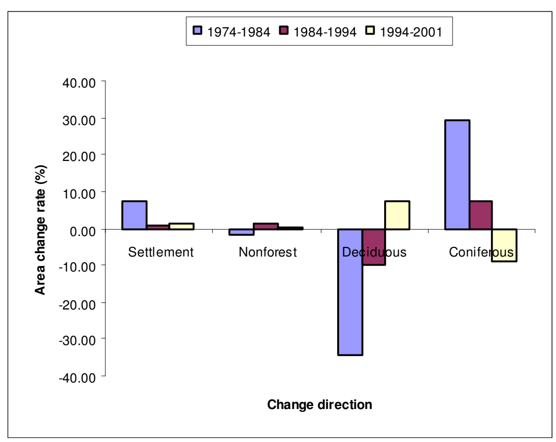

Figure 6.Comparison the rate and direction of area change in land use

5. CONCLUSIONS

The data with high degree of accuracy can be obtained via remote sensing over vast areas. On the other hand, the evaluation of data compiled within geographical information system facilitates various spatial analyses. In this way, it is possible to determine change over time especially spatial and temporal.

In this study, a monitoring system was designed for the determination of the land use and forest cover changes in Yeniciftlik watershed by using multi-temporal Landsat images and change-rate and change-direction were examined between the years of 1974 and 2001.

It has been observed that the accuracy level (86-90%) achieved is well above the generally accepted threshold (80%) for such works.

6. REFERENCES

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