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Remote Sensing and Gis Applications For Monitoring Multi- Temporal Changes of Natural Resources in Bursa-Turkey

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ABSTRACT

The main objective was to investigate multi-temporal changes of the natural resources using remote sensing and geographic information system techniques. Landsat5 TM full frame images of 16 June 1984 and 06 August 1998 were used in this study.
For this aim, three sub-scenes covering the Bursa city built-up area, Uluabat Lake and Mount Uludağ and its surroundings were extracted from the images. Geometric correction and image enhancement were made for the comparison time series remote sensing data, exact image-on-map overlay and better visual interpretation. Boundary of the Bursa City built-up area and Uluabat Lake was produced from visually interpreted image using both screen and tablet digitizing. Biomass changes of the Mount Uludağ and its surroundings were gathered from normalized vegetation index classification.
The results revealed that the Bursa City built up areas have been expanded at a rate of 142.5 % from 5089 hectares (in 1984) to 12343 hectares (in 1998). The expansions in the built-up areas have been mainly occurred in valuable agricultural lands. In addition, the coverage area of the Uluabat Lake decreased at a rate of 12 % from 133.1 km^2(in 1984) to 116.8 (in 1998) km^2 due to sediments transported by the surface water of surrounding irrigated agricultural lands, tributary streams and mainly Mustafakemalpaşa River. Moreover, we found that 26292 ha mainly forest and floral areas have been degraded in fourteen years period.

Key Word: Natural resources, temporal changes, monitoring, remote sensing, GIS.

INTRODUCTION

Turkey is a country located between Europe and Asia from 26° E to 45° E and from 36° N to 42° N with land area is 77.8 million hectares. More than half of the country is mountainous, except the Central Anatolian plateau and the coastal plains.

Soil erosion is the major land degradation hazards in Turkey and in Bursa province as well. Erosion affects 78 percent of the country's total land area. In Turkey, 73.9 percent of the land is moderately or severely steep and farming requires adequate soil and water conservation practices to prevent erosion (Dinç et al., 1993). Each year in Turkey estimated 1.2 billion tons of soil is displaced because of erosion and 500 million tons of it which is equal to 150 thousand hectares land with 25 cm soil depth runs into the lakes, reservoirs and the seas (Doğan, 1996). In addition to climatic and topographic causes, soil erosion also results from human activities such as agricultural malpractice, conversion of forestry land into temporary or permanent agricultural land, forest fires, overgrazing and deforestation.

Bursa locating between from 28°10' N to 30°00' N and from 39° 35' to 40° 40' is the second populated and industrialized city in the Marmara region. Most of the lands have mountainous and hilly terrains. The depressions have been filled with alluvial sediments at elevation between 50 and 100 m above sea level (asl). These alluvial plain covers only 17% of the total area in province (Anonymous 1995). The Uludağ mountain is the highest peak of the province with elevation 2591 m asl. The Climate of the province changes from base to top, being Mediterranean type in lower parts which are near the city of Bursa, and rainy, partially mild microthermic, with icy winter at higher altitudes (Güleryüz and Malyer, 1998). The climate may be in the first family of the East Mediterranean climatic group (Akman, 1999). According to The Mayor of the city population has increased 6.5% (overall growth rate in Turkey is 1.5 percent in 1997) and about 65000 person per year in last decade. The uneven population distribution and the increasing number of people higher than normal birth rate in industrialized areas especially in western part of the Turkey result in heavy pressure on land and its resources. Converting the most productive agricultural lands to settlement and industrial lands as a result of increasing population pressure has become increasingly important in the area surrounding the industrialized cities. According to soil survey studies of the General Directorate of Soil and Water Conservation, urbanized areas were 1925 hectares in the city of Bursa and Bursa plain in 1969. But this area increased in 1980, 1981 and 1983 to 7623, 8046 and 9082 hectares respectively due to population pressure. Finally about 5000 hectares agricultural lands went out from cultivation until 1983 (Katkat, 1984).

In the last decade significant land use changes and land degradations have been observed in the entire province, but detailed information have not been produced and there is no long term planning and

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management practices to prevent land degradation. Deforestation due to illegal timbering, fire and mostly conversion of forestry land to agricultural land and soil erosion are the main land degradation processes in the Bursa province. In the province, 84.8 % of the land is moderately (13.1 %) to severely (58 %) - very severely (13.7 %) eroded (Anonymous, 1995). According to mentioned situation of the province, there is an urgent need for more detailed information on our resources and for establishment of an information network to communicate nationally and internationally. In addition, we need to know the quantity and quality of our natural resources, and consider environmental impact, economic viability, biodiversity and social justice to sustainability of agriculture in the future.

GIS and remote sensing have an important place in this process. Recent advances in remote sensing technology and rapid development of microcomputer systems have made these technologies readily available at relatively low cost, for a wide range applications. The development of images processing facility (lPF) and the Geographical Information System (GIS) have provided new and powerful tools for serving natural resource planners and decision makers to get easily accurate information and to use them effectively for natural resource development and conservation. GIS has shown to be very effective tool in the handling of remotely sensed data (Bocco and Valenzuela, 198l). A GIS the capability of transforming remotely sensed digital imagery into useable and shareable data.

Introduced case study was carried out using GIS and Remote Sensing in order to investigate multi-temporal changes of natural resources for making decision in the future. ILWlS (Integrated Land and Water Information System) GIS Software (Valenzuela, 1988; Itc, 1993), developed by the ITC computer department The Netherlands, was used for this purpose. ILWlS combines conventional GIS procedures and Remote Sensing Capabilities with a relational database management technology.

The objectives of the study were:

- To introduce basic GIS and remote sensing applications on monitoring natural resources,
- to take attention on land degradation hazard in the Bursa province
- to monitor situation of natural resources in the Bursa province
- to eradicate decision makers for establish long term planning and management practices on the basis of sustainability

MATERIALS AND METHODS

Material

To rich goals of the study mentioned above, three sub scenes situated in between from 4425000 m to 4480000 m N and 620000 m to 690000 m E were created from the raw data (Figure 1). These are Bursa city, Uluabat Lake, Uludağ Mountain and their surroundings.

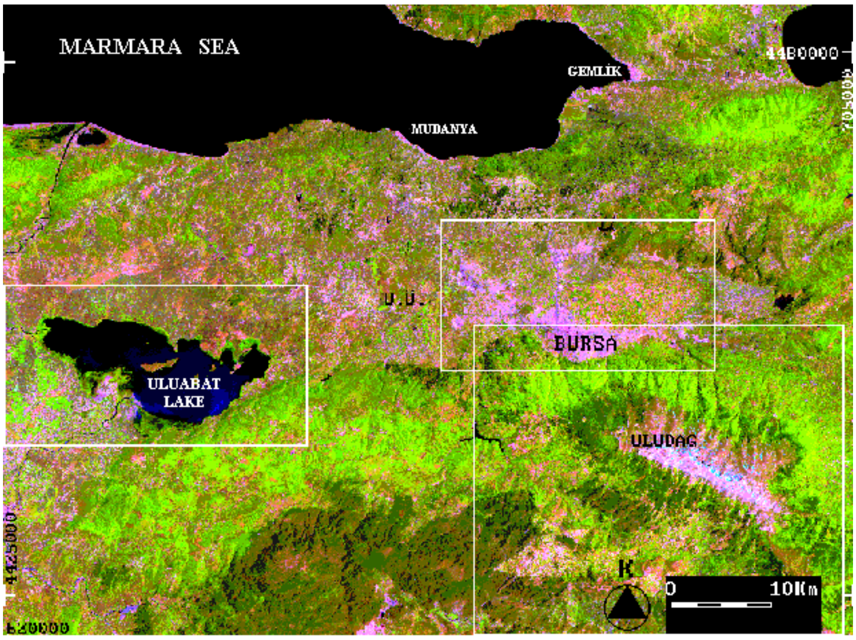

Figure 1. Geographic location of the selected sub scenes on PNCC of landsat 5 TM images.

Material Inputs

In this study used reference maps, digital data and software program were given as below, respectively;

-Topographic maps of Bursa Province, Scale: 1/100.000, 1984.

-Soil Maps of Bursa Province, Scale 1/25.000 and 1/100.000, 1995

-Landsat5 TM, 16 June 1984 and 06 August1998 full frame.

-Integrated Land and Water Information System (lLWIS, 1997)

Methods

The necessary information for monitoring multi temporal changes of natural resources were gathered and complied using remote sensing and GIS techniques such as creating pseudo natural and false color composite images, enhancement, geographic correction, digital elevation model and ratio images.

Image Processing Applications

The available satellite data from Landsat5 TM was converted to ILWIS format. The individual spectral band information was geo-referenced through ILWIS program by selecting tie points from topographic maps and subsequently enhanced using a 3*3 laplacian edge-enhancement filter and linear stretching for improving the visual aspect of the images (Rosenfeld and Kak, 1976).

The color composites were prepared by different band combinations of extracted Landsat5 TM bands. The band combinations which are prepared using band 7, 3 ,2 and 5, 4, 3 as a Red, Green, Blue were selected due to optimum discrimination for multi- temporal changes of urbanized areas and UIuabat Lake, respectively. Visual interpretation was made due to color, texture, pattern, shape, size, tone differences of urbanized areas and Uluabat Lake on the selected color composite images for to produce their segment maps in 1984 and 1993 (Sabins, 1987; Lillesand and Kiefer, 2003). The False Color Composite (FCC) images used for urbanization changes in 1984 and 1998 was given as a sample images (Figure 2).

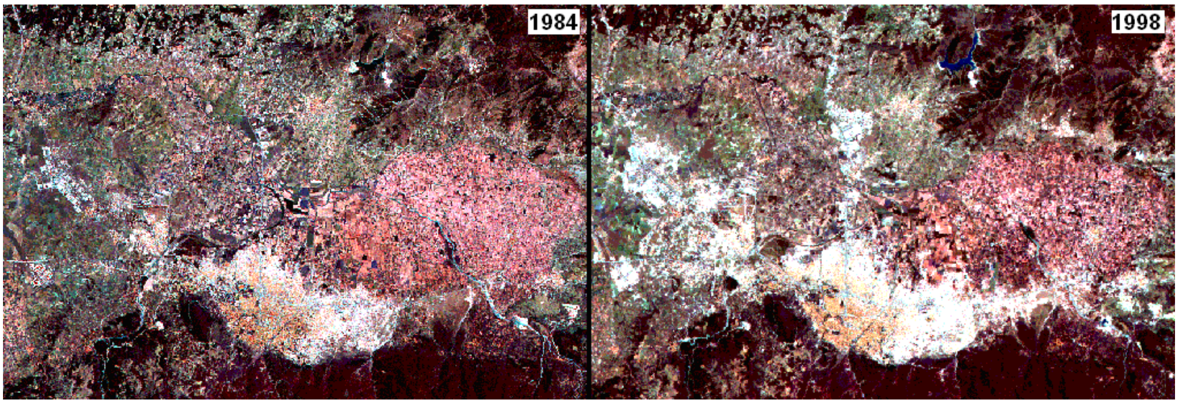

Figure 2. Landsat 5 TM images of Bursa city in 1984 and 1998
(built-up areas in whitish color; bands 7,3,2 as RGB)

The first investigations into vegetation indexes concerned the NIR (near infrared)/ R (red) ratio by Rouse et al. (1973, 1974). They also used the normalized vegetation index (NVI= [NIR-R]/[NIR+R). Often, this type of vegetation index is called the normalized difference vegetation index (NDVI) (Clevers, 1993). Green Vegetation Index gives the information on the amount of green vegetation on the ground. It can be used for crop canopy cover, forest cover and can also be related to crop harvest estimate. Normalized vegetation index NVI= ([NIR-R]/[NIR+R] 127+128 in case of Lansat5 TM: ([4-3]/[4+3]*127)+128 was applied to produce Biomass Changes of Uludag and its surroundings (127 and 128 are the scaling factors to avoid impracticable negative values and to convert output into a byte range) (Itc, 1993). The color density slicing technique was applied to the data provided by the normalized vegetation index images in order to codify the classes and compare vegetation changes of the Uludag and its surrounding in 1984 and 1998. The normalized vegetation index images of Uludag in 1984 and 1998 were classified into four density classes using by density slice classification module of the ILWIS 2.1 software program. As a result, Vegetation Cover density classes' maps were produced comparing changes in 1984 and 1998. The Figure 3 shows the vegetation index map of the Uludağ Mountain and its surroundings in 1984 and 1998.

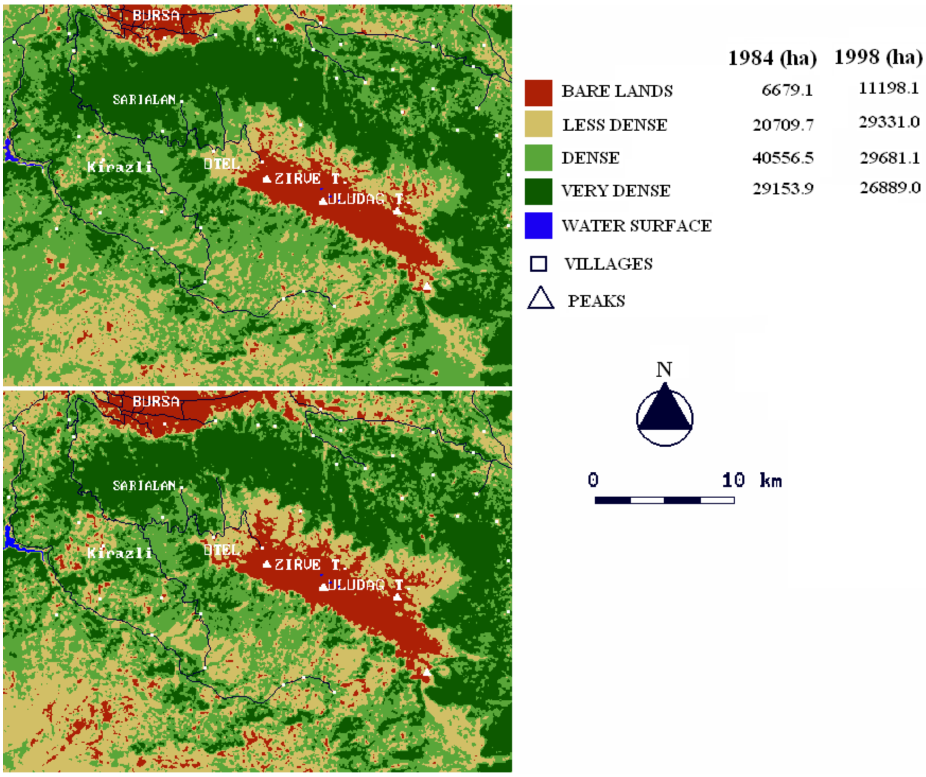

Figure 3. Vegetation index map of the Uludağ Mountain and Its surroundings.

GIS Applications

The data structures (raster and vector) in ILWIS package offered versatile user friendliness in the preparation of various databases like thematic, topographic, soils, land cover and land use maps as well as attribute databases. Some of the important capabilities of the ILWIS package which are reclassifying, overlaying and digitizing were used in this part of the procedure given below.

The maps of urbanized areas for the city of Bursa and the maps of shoreline changes of the U1uabat Lake were derived from visually interpreted Landsat5 TM images using digitizing and rasterizing procedures (Figure 4 and 5). The Figure 4 shows urbanization growth map of the city of Bursa from 1984 to 1998 in three dimensional views. Soil-map was digitized and rasterized. Consequently the Land Capability Classes (LCC) maps of the urbanized areas of the city of Bursa for 1984 and 1998 were produced from rasterized soil map with reclassification procedure.

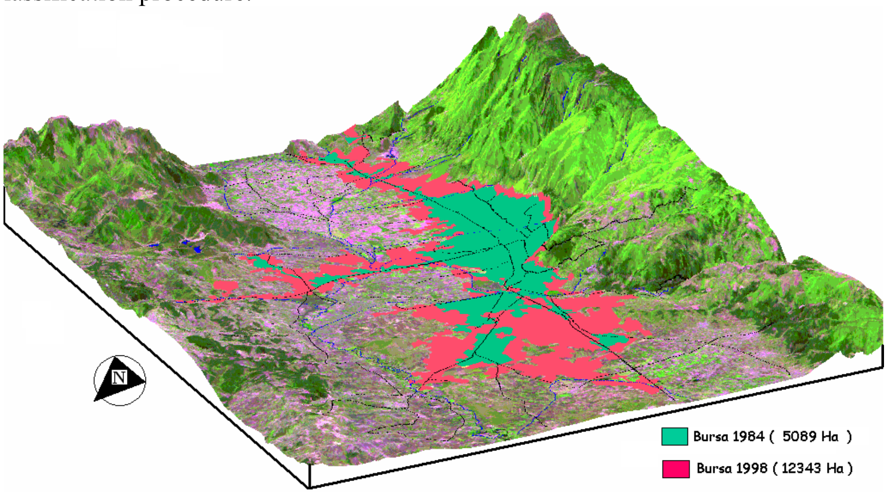

Figure 4. Urbanization growth maps on landsat 5 TM images in 3DV

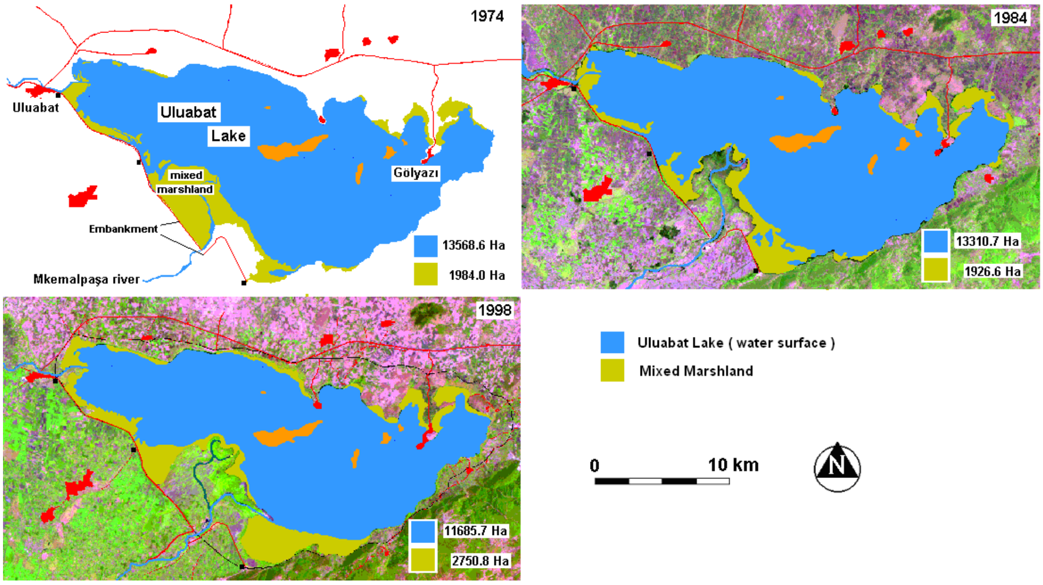

Figure 5. Shoreline Changes Maps of Uluabat Lake and Landsat TM images.

RESULTS AND DISCUSSION

Results gathered form statistical analysis of urbanized areas maps, show that 7244 ha of the land have been urbanized due to population pressure and industrialization in the fourteen years period. The conversion agricultural land to urbanized land occurred mostly close to main and secondary roads and along from Bursa to Ankara (to the east direction), Istanbul (to the north direction), and Izmir (to the west direction). Urbanization incline can clearly be seen in the Figure 4. These roads proved very attractive areas for building, housing and factories that are geared towards the Yalova-Istanbul, Izmir and Ankara markets. In Bursa, first automobile factory (Renault) was constructed in the 1972 and the second (Fiat-Tofaş) in the 1976. Consequently, these were followed by the textile industries. Due to construction of labor-intensive industries, the members of people living in the city of Bursa have amazingly been increased. As a result of population increase and industrial development, 6373 ha agricultural lands which have land capability classes of I, II, III and IV have been converted to urban land at a rate of 148.9 % (Table 1). It can be seen in the Table 1 that high proportion of urbanization has been occurred in good-quality agricultural land with a land capability classes of I and II.

Table 1. Agricultural land losses and land capability classes in Bursa, 1984-1998

Land Capability Classes (LCC)	Coverage area of LCC in 1984 (ha)	Coverage area of LCC in 1998 (ha)	Agricultural Land Losses (ha)	Rate of Agricultural Land Losses (%)
I	665	2145	1480	222.6
II	2117	4780	2553	125.8
III	905	2677	1772	195.8
IV	1180	1638	458	38.8
I, II, III, IV	4877	11240	6363	148.9
VI	4	255	251	6278.5
VII	218	838	620	284.6
VIII	-	10	10	-

Lacks of urgent land security and economic alternatives have been forced land user in Uludağ Mountain and its surrounding to continue illegal timbering and converting forestry land to agricultural land. In addition to this practices, to construct hotel for winter sports, to built summer houses, over grazing and air pollution are also have serious effects on forest degradation. As a result of these practices, Uludağ Mountain and its surroundings have dramatically been degraded. The vegetation mosaic around the first Center of Tourism Development (Güleryüz et al. 1998) and the second Center of Tourism Development (Arslan et al. 1999) in Uludag (Bursa) was determined using aerial photographs and Geographical Information Systems (GIS) techniques. In these studies it is stated that the vegetation characteristics of the area were composed by dwarf shrub formation. Both researchers (Güleryüz et al. 1998 and Arslan et al. 1999) also stated that there were some environmental problems caused by misuse of the area and the ruderal formation was dominant on the disturbed lands.

The Figure 3 shows the vegetation density changes in Uludağ Mountain and its surroundings from 1984 to 1998. It can be clearly seen that 26292 ha vegetative cover mainly forested areas have been degraded in fourteen years period and 13152 ha dense–very dense forested land have become bare or less dense forest cover. Therefore 8621.3 ha and 4519.1 ha lands of them have become less dense and bare land, respectively. Forest degradation mainly occurred on the land that near the upland settlement areas due to illegal timbering and conversion of forests and bushes lands to agricultural land. So coverage of bare lands increased at a rate of 67.6% and has become 11198.2 ha in the 1998 while it was 6679.1 ha in the 1984.

Shoreline changes maps for the years of 1974, 1984 and 1998 showed that decrease of the coverage of the lake is in continuing (Figure 4). It can be clearly seen that the coverage area of the Uluabat Lake have been decreased at a rate of about 12 % from 133.1 to 116.8 km^2 due to sediments transported by the surface water of surrounding irrigated agricultural land, tributary streams and mainly Mustafakemalpaşa river in a fourteen years period. If we consider Uluabat Lake coverage areas gathered from topographical map, the rate of decline will be about 14 %. In spite of this situation, the coverage of the delta has been increased as a rate of 75 % from 2135.8 ha to 3747.6 ha in the same period. The proportion of the agricultural lands in the delta has also been increased from 578 ha to 1737 ha due to conversion of the reed areas to agricultural lands.

CONCLUSIONS

Recently, the monitoring, investigating and recording quantity and quality of natural resources in a quick and accurate way have become more important than ever before for sustainable use of the land and to consider environmental impact, economic viability, biodiversity and social justices are the corner stone for the long term planning and management practices to prevent land degradation or sustainable use of natural resources.

Revealed results show that we urgently need to produce more detailed and recent information on our natural resources using new technologies and to establish local, regional and national land use plan and law in sustainable bases to prevent degradation.

The research also showed that GIS and remote sensing technologies have an important place in this process. Recent advances in remote sensing technology and rapid development of microcomputer systems have made these technologies readily available at a relatively low cost, for a wide range of applications. The development of images processing facility (lPF) and the Geographical Information System (GIS) have provided new and powerful tools for serving natural resource planners and decision makers to get easily accurate information and to use them effectively for natural resource development and conservation.

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