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Use of Corona, Landsat TM, Spot 5 images to assess 40 years of land use/cover changes in Cavusbasi

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ABSTRACT: Rapid land use / cover change has taken place in Asian side of Istanbul such as Cavusbasi over the past 40 years due to rapid population growth, accelerated urbanization and degradation of forest and green areas. In this study, remote sensing and geographic information system (GIS) techniques were used in order to determine land cover change of study area using multitemporal remotely sensed data. Corona, Landsat 5 TM, Landsat 7 ETM, and Spot 5 images were used for in the study and all of these images were transformed into the UTM coordinate system. After geometric correction of this data set, Corona image was level sliced and Landsat 5 TM, Landsat 7 ETM and Spot data were classified using ISODATA technique. Obtained results were compared with each other and visualized in Geographic Information System. The results demonstrated that while the area of forest decreased around 1188 ha, area of others increased about 1192 ha between the year of 1960 and 2002.

1 INTRODUCTION

Since the 1950s, in Turkey, especially in Istanbul, there has been a rapid expansion in economic growth, cities and urban areas that has resulted in complex problems with rapid urban development. As urban centres grow, illegal development of land for housing has become apparent. Between 1975 and 2000, the population of Istanbul has increased from 3 904 588 to 10 018 735 with an annual increase rate of 6,2 %. Especially the Asian side of Istanbul has started to be occupied by legal and illegal residential and industrial developments in that period. Historic settlements and natural areas were replaced by luxury apartment blocks as demanded by high and middle income groups, and some other parts of the Bosphorus were covered by squatter areas built by low income groups. Therefore, with these drastic changes, Cavusbasi has been losing its geographical importance. Moreover, forests and green areas, which are state-owned land, have been attractive areas for the new urban development. In addition to these developments, after the construction of the two bridges that connect the European and Asian sides of the Bosphorus, in 1973 and in 1989, the most important problem started in terms of urbanization. Monitoring and controlling this growth have been more difficult because of the expense and time needed to produce reliable and up-to-date mapping. In order to meet such challenges, urban planners and decision makers need to have accurate and up-to-date information. Satellite remote sensing can provide this information very effectively.

Timely and accurate change detection of Earth's surface features is extremely important for understanding relationships and interactions between human and natural phenomena in order to promote better decision making (Lu et al., 2003). Satellite remote sensing, in conjunction with geographic information systems, has been widely applied and been recognized as a powerful and effective tool in detecting land use and land cover change (Ehlers et al., 1990; Meaille and Wald, 1990; Treitz et al., 1992; Westmoreland and Stow, 1992; Harris and Ventura, 1995; Weng 2001). Satellite imagery has been used to monitor discrete land cover types by spectral classification or to estimate biophysical characteristics of land surfaces via linear relationships with spectral reflectance or indices (Steininger 1996). Geographical Information Systems have already been used for assessing environmental problems, since they provides a flexible environment and a powerful tool for the manipulation and analysis of spatial information (Goodchild et. al., 1992) for land cover feature identification and the maps of all variables were combined to extract information to better understand analyzing (Weng, 2001). Remote sensing and GIS based change detection studies have generally focused on obtaining the information of how much, where, what type of land cover change has occurred. The method used for the purpose of the study depends on a comparative analysis of independently-classified remotely sensed images.

This project was examined to assess the land cover and land use change in Cavusbasi between 1960 and 2002 years by using classification and level slicing techniques.

2 DESCRIPTION OF THE STUDY AREA

In Istanbul, there has been rapid urbanization resulting in huge migration. Especially the Anatolian side, which is in between the European side of Istanbul and Kocaeli , which is one of most developed cities, is an important attractive area for these developments. Because of the large forest areas, the state owned nearly all the land on the Anatolian side. Cavusbasi, whose location is shown in Figure 1, is located on the Asian side of the Bosphorous. It is bounded by $41^0 07' 29''$ and $41^0 02' 51''$ in latitude and $29^0 06' 10''$ and $29^0 12' 38''$ in longitude. In Cavusbasi forests and green areas, which are state owned land, have been the attractive areas for the new urban development.

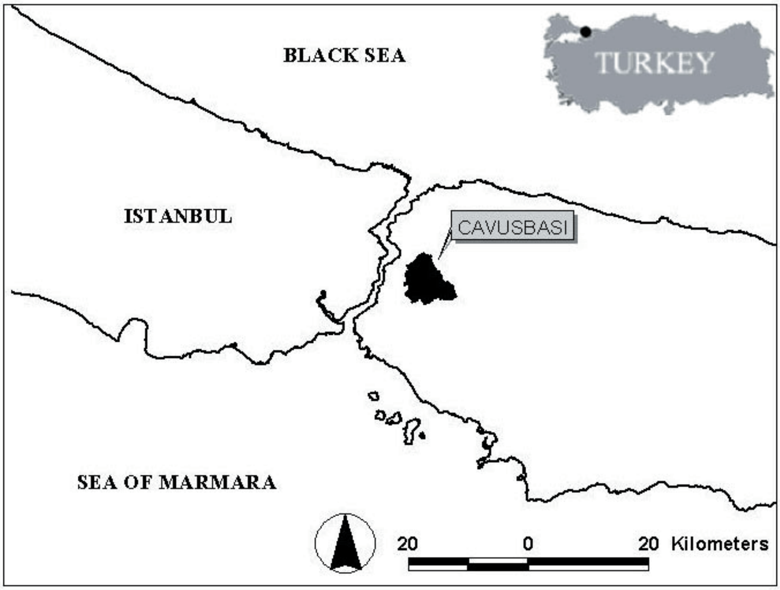

Figure 1. The location of the study area

3 METHODOLOGY USED

3.1 *Data sources*

In this study, Landsat 5 TM, acquired in June 1984, Landsat 7 ETM acquired in May 2001, Spot 5 acquired in May 2002 satellite images and 1960 dated Corona satellite photograph were used as main data. Together with these remotely sensed data, 1/25000 and 1/5000 scale topographic maps and 1996 dated orthophotos were used.

3.2 *Image processing*

3.2.1 *Geometric correction*

Remote sensing data are distorted by the Earth's curvature, relief displacement and the acquisition geometry of the satellites (i.e. variations in altitude, aspect, velocity, panoramic distortion). The intent of geometric correction is to compensate for the distortions introduced by these factors so that the corrected image will have the geometric integrity of a map (Lillesand and Kiefer 2000). Rectification is the process of projecting the data onto a plane, and making it conform to a map projection system. Satellite images are rectified to the Universal Transversal Mercator (UTM) projection system with 0.5 pixel RMS accuracy.

3.2.2 *Classification*

The purpose of digital land cover classification is to link the spectral characteristics of the image to a meaningful information class value, which can be displayed as a map so that resource managers or scientists can evaluate the landscape in an accurate and cost effective manner (Weber and Dunno 2001). The ISODATA classification technique was applied to classify the remotely sensed images. Three land cover types for the study site were identified and used in this study, such as water, forest and others (urban or built-up land, barren land etc.).

In this study, accuracy assessment of classification was calculated using an error matrix which showed the accuracy of both the producer and the user. Accuracy assessment is an important feature of land-cover and land-use mapping, not only as a guide to map quality and reliability, but also in understanding thematic uncertainty and its likely implications to the end user (Lillesand and Kiefer, 2000). To assess the accuracy of the classification, random points were generated on the classified images and compared with ground truth data. The ground truth data of the study region was obtained from the high resolution satellite images, orthophoto maps and *in situ* data. The overall accuracy and Kappa coefficient values based on error matrix analysis were calculated in the classification accuracy assessment process.

3.2.3 *Level Slicing*

Level slicing is an enhancement technique whereby the DNs distributed along the x axis of an image histogram are divided into a series of analyst-specified intervals or slices. It involves the grouping of image regions with similar DN. All of the DNs falling within a given interval in the input image are then displayed at a single DN in the output image (Lillesand and Kiefer, 2000).

In this study, DNs of the Corona image were read and intervals of DNs for forest and non-forest were determined. The Corona image was divided into two slices which showed the boundary of forest and non-forest areas. Boundary of water basin in the site was digitized on the screen and this digitized section was added to the level sliced Corona image. The final image that has three land cover classes (forest, water and others) was obtained by means of density slicing and digitizing techniques.

4 RESULTS AND CONCLUSIONS

The temporal changes in land use/ land cover of Cavusbasi due to human activities and their impact on the environment were observed effectively using satellite sensor data and displayed in Figure 2. The overall accuracy of the classification for 1987 and 2001 was determined to be 90.48 % and 96.19 %, respectively. The Kappa coefficients were calculated as 0.82 for the year of 1987 and 0.93 for the year of 2001.

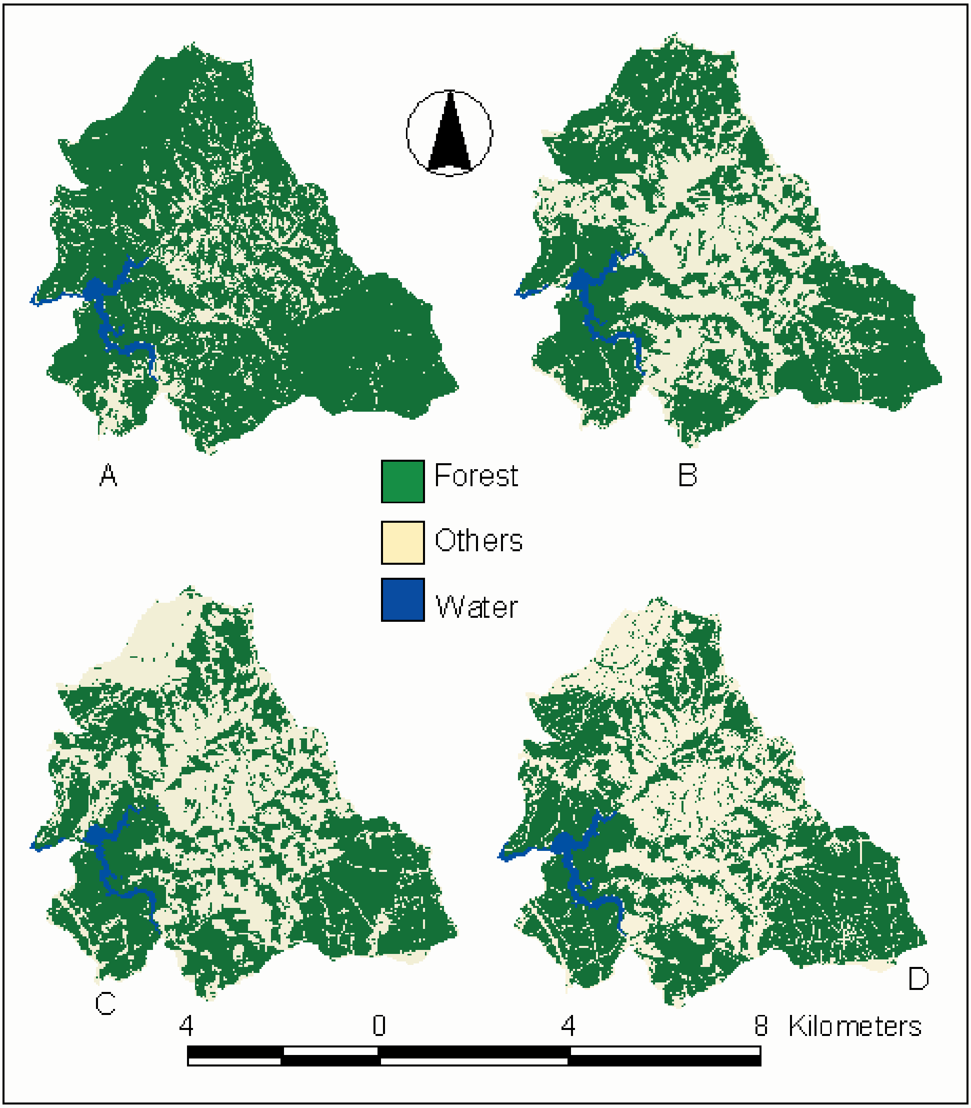

Figure 2. A) Obtained results of 1960 dated Corona image by means of density slicing and digitizing techniques. B) Classified 1984 dated Landsat TM image C) Classified 2001 dated Landsat TM image D) Classified 2002 dated Spot 5 image.

Table 1 shows the statistical results of classified images. When we compared the obtained results according to the table, it is clear that there has been a considerable change during the 40 year period. The area of forest was 3635.38 ha in the year of 1960, this value decreased to 2446.93 ha in the year of 2002. Between the year of 1984 and 2001 the forest area decreased by about 10 % while the area of others increased by 18 % . While the area of others was 692.67 ha in the year 1960, this value increased to 1885.17 ha in the year 2002. Results show that forest areas were transformed to urban areas.

Table 1. Results of classified images

Year	Sensor	Forest (ha)	%	Others (ha)	%	Water (ha)	%	Total (ha)
1960	Corona	3635.38	82	692.67	16	64.95	2	4393
1984	Landsat 5 TM	2685.51	60	1629.51	37	78.43	3	4393
2001	Landsat 7 ETM	2400.93	54	1925.10	44	67	2	4393
2002	Spot 5	2446.93	55	1885.17	43	60.90	2	4393

Within the framework of this study, Corona, Landsat TM and Spot 5 data were used to detect possible land cover changes in Cavusbasi. The digital image classification conducted with GIS has proved its ability to obtain comprehensive information on the direction, magnitude, and location of land cover changes as a result of human activities such as rapid population growth, expansion of built up areas, and degradation of forest and green areas.

Remote sensing is the most convenient technique to collect a large amount of data for large areas. It is possible to detect and analyze the magnitude and spatial changes of the natural environment by using satellite images. Additionally, GIS technique is used to visualize changes in the spatial distribution of land cover classes by overlaying maps of different dates and analyze their spatial coincidence for helping in decision making process in order to project future land development.

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