ENVIRONMENTAL IMPACT ANALYSES OF QUARRIES LOCATED ON THE ASIAN SIDE OF ISTANBUL USING REMOTELY SENSED DATA

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ABSTRACT

In this study, change detection of stone quarries were determined and evaluated in the northern part of Istanbul by using Landsat TM and SPOT 5 satellite images and geographic information system. The area of quarries in 1987 and 2001 were calculated and the size and direction of expansion was determined by performing Geographic Information Systems (GIS) overlay analysis. Potential quarry areas obtained from Landsat TM images were verified using both high resolution SPOT 5 image and ground truth data. Finally, thematic maps of these areas are created by using appropriate visualization techniques and the study results are presented on these maps.

1. INTRODUCTION

After 1950s, in Turkey, especially in Istanbul, there is a rapid expansion in economic growth, cities and urban areas that resulted in complex problems with rapid urban and industrial development. Between the year of 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 Istanbul Asian side has started to be occupied by legal and illegal residential and industrial development in that era. This unavoidable overpopulation has resulted significant destruction on agricultural lands and forests in both side of Istanbul. On the other hand, surface mining activities have destroyed natural areas such as forest and green areas in the Black Sea coastal part of Istanbul. Study region was selected as an important example in order to present land cover and use changes based on mining activities and impacts of this change on environment.

Determination of the mining activities impacts on environment is a major issue in sustainable development and resources management. The conflict between mining activities and environmental protection has intensified over recent years, emphasizing the need for improved information on the dynamics of impacts at regional and local scales (Latifovica et al., 2004). Surface mining activities range from large open-cast coal and base metal mines, to much smaller aggregate (rock, gravel and sand), industrial minerals (potash, clay) and building materials (granite, stone and marble) quarries. Mapping mining activities and evaluating associated environmental concerns are difficult problems because of the extensive area affected and the large size of individual mines. Monitoring and controlling these changes have been more difficult because of the expense and time in producing reliable and up-to-date mapping. Besides, a successful monitoring approach for evaluating surface mining processes and their dynamics at a regional scale requires observations with frequent temporal coverage over a long period of time to differentiate natural changes from those associated with human activities. In order to meet such challenges, urban planners and decision makers need to have accurate and up-to-date information. Since the 1970s analog aerial photographs have been used for mapping spatial changes in mined areas (Anderson, 1977). Today, satellite remote sensing can provide this information more effectively.

Satellite remote sensing, in conjunction with geographic information systems, has been widely applied and recognized as a powerful and an effective tool in detecting land use and land cover change (Harris and Ventura, 1995; Weng, 2001; kaya et al, 1998). Integration of these technologies have often been used by decision makers as informative and visual analytical tools in order to monitor and determine the surface mining activities and their impacts on the environment in a quick and cost efficient way. On the other hand, visualization of the processed remotely sensed data by using effective tools and techniques provides significant benefits for the users from different environmental sciences. Thus, cartography takes vital role in this process for obtaining effective visual outputs. In this concept, well designed maps are used as the best communication tools while sharing the information with the users. A number of published papers (Schmidt and Glaesser, 1998; Prakash and Gupta, 1998; Wright and Stow, 1999) suggest usefulness of such techniques for detecting contamination, determining success in reclaiming open cast mined areas and for providing other relevant spatial data for assessing mining impact on the environment.

This study is conducted an assessment on land cover change of the northern part of Istanbul by means of multitemporal satellite images with the aim of identifying changes due to surface mining activities and its impacts on environment. Used method depends on comparative analysis of independently-classified two Landsat TM images in GIS environment.

2. DATASET AND STUDY AREA

1987 and 2001 dated Landsat TM images and 2002 dated SPOT 5 image were used to determine the extension and direction of quarries and land cover/use changes in the concerned area. Landsat TM and SPOT 5 images have 30 m and 5 m spatial resolution, respectively. Satellite sensor images including the study are shown in Figure 1.

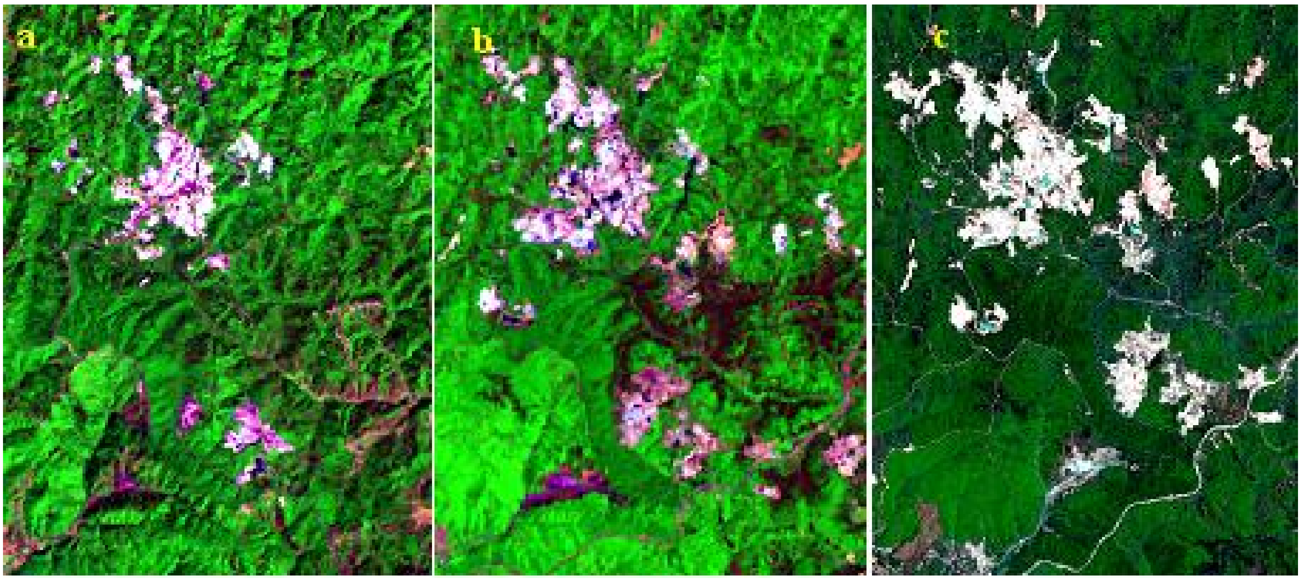

Figure 1. Satellite sensor images used in the study.
(a)September 1987 Landsat 5 Tm image, (b) May 2001 Landsat 7 ETM image, (c) May 2002 SPOT 5 Pan Sharpened Image.

Ground photographs were taken and field survey was performed in the study region in order to provide ground truth data for further analyses. Moreover, aerial photographs and topographic maps were used in rectification and classification process.

In this study, the northern part of Istanbul, which has faced with expansion of stone quarries, a kind of surface mining activity was selected as study area. The region represented in Figure 2 is located between Black Sea and northwest of Istanbul and comprises approximately 8323.65 ha area. This area has changed considerably in a twenty years period because it includes potential sites for mining activities.

3. METHODOLOGY

Rectification, classification, GIS integration and presentation were applied to dataset in order to perform aim of the study in an accurate way. Moreover, all processes in the methodology were supported by ground truth data and topographic maps. Methodology applied in the study is mentioned in the following parts.

3.1. Image Processing

In the rectification process, the mathematical relationship between the addresses of pixels in an image and the corresponding coordinates of those points on the ground is established using geometric model (Richards and Jia, 1999). Coordinates of Ground Control Points (GCPs) were obtained from topographic maps and first order polynomial equations were used as geometric model. Root Mean Square Errors (RMSE) of rectifications were 0.52 and 0.51 for 1987 and 2001 Landsat TM images, respectively. RMSE of SPOT 5 image rectification was 2.22 pixels. After the rectification, all images were cut in a common boundary including the border of study site.

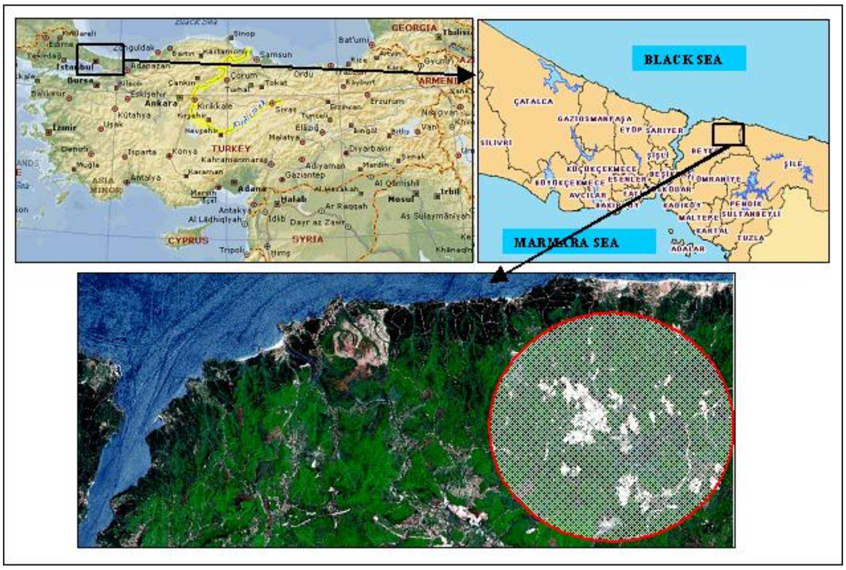

Figure 2. Study area.

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). ISODATA (Iterative Self Organizing Data Analysis Technique) unsupervised classification technique was applied to classify the remotely sensed images.

The number of clusters was chosen as 50 for both of the images, the convergence threshold was set as 0.98 and the number of iteration was 20. Four land cover types for study region were evaluated and used in this study. These are water, forest, stone quarry and others (urban or built-up land, barren land etc.). Figure 3 shows the statistical results of classified images in 1987 and 2001.

Classes	1987		2001	
	ha	%	ha	%
Forest	7161,03	86,03	6478,38	77,83
Water	7,56	0,09	15,21	0,18
Stone Quarry	393,39	4,73	1080,45	12,98
Others	761,67	9,15	749,61	9,01
Total	8323,65		8323,65	

Figure 3. The statistical results of classified images in 1987 and 2001

3.2. GIS Integration and Presentation

GIS can be defined as an organized collection of computer, hardware, software, geographic data and personnel to efficiently capture, store, update, manipulate, analyze, and display all forms of geographically referenced information (Clarke, 2002). Geographic Information Systems provides not only a medium for combining spatial data but it is also a powerful technology for the quantitative analysis of land use changes and map updating (Treitz et.al., 1992). Its capabilities on manipulation and analysis of spatial information make GIS an indispensable vector based solution for assessing environmental problems. On the other hand, presentation tools, which are used for communication of the information obtained as a result of the analysis in GIS, add another dimension to this technology for being so popular.

In this study, GIS is used for analyzing and visualizing the classification results obtained by remote sensing technology. Classification results of the remotely sensed images dated 1987 and 2001 in vector format were imported to the GIS in to two different layers including land cover classes -water, forest, stone quarry and others- as the sub layers (see Figure 4). Overlay analyze was executed on these layers for detecting the changes of the quarry areas. Visualization of the analyze results was considered as another important issue in this study. Thematic maps emphasizing the changes in the quarry areas and showing the direction of the extension of the mining activities were designed to better understand the results of study.

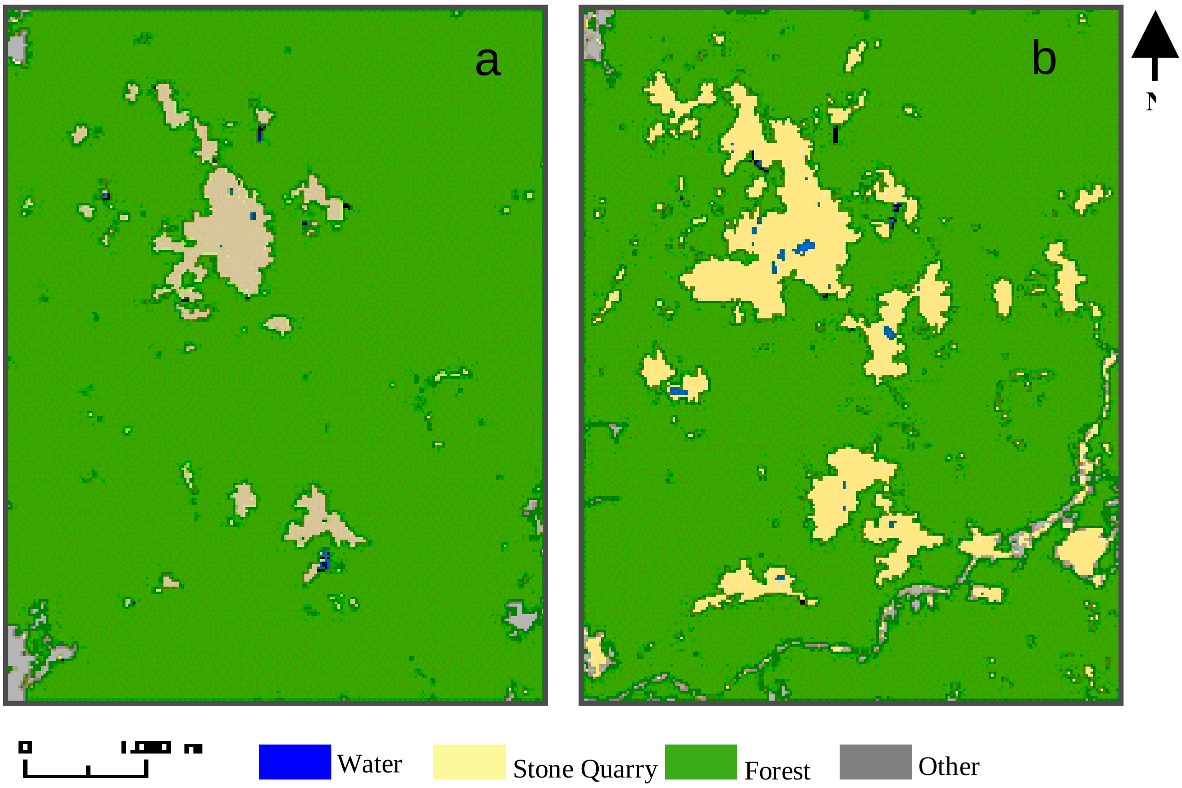

Figure 4. a) Classification results of 1987 b) Classification results of 2001

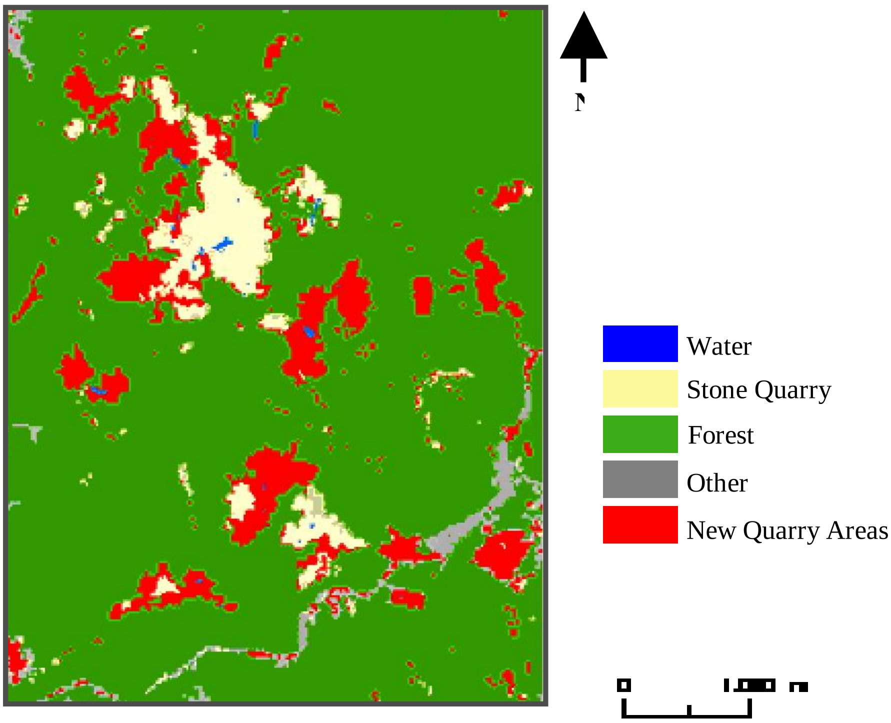

Figure 5. New quarry areas in 2001

4. RESULTS

This paper indicates that how remote sensing and GIS techniques are integrated in order to establish land cover changes in the northern part of Istanbul between the year of 1987 and 2001. As it is seen in Figure 3, there have been considerable land cover changes in the study region during the 14 years period as a result of surface mining activities. It was found that the area of stone quarries was 393,39 ha in the year of 1987, this value has notably increased to 1080,45 ha in the year of 2001. The area of forest decreased to 6478,38 ha from 7161,03 ha in 14 years period. This means that the forest area was decreased about % 8 between the year of 1987 and 2001. However, the area of others was 761,67 ha in the year of 1987, this value decreased 749,61 ha in the year of 2001. On the other hand, in the field surveys it is seen that the change in the water area is derived from the mining activities as a result of the large mining holes filled by water. These significant results show that the study area has not affected by the urbanization yet and the most of the forests in the study area destroyed as a result of the mining activities. The statistical results of classification obtained by using RS technology verified visually in GIS environment (see Figure 4). Thematic maps designed for visualizing the results of the overlay analysis show that mining activities have increased for 14 years in the study area. While the amount of the water bodies has been increasing in expansive stone quarries, forests were cut up drastically. Besides as it is seen in Figure 5 mining activities have expanded 687,06 ha through southern part of the study area.

5. CONCLUSION

Within the framework of this study, for the detection of possible land cover change in the concerned region using Landsat TM data was realized. 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 mining activities. Results of the study show that mining activities have significant effects on the environment. Especially in Turkey these effects have not seriously taken in to consider. Although mining activities should be organized by terms of sustainable development, mining activities have been executed illegally. In this concept, the distribution and expansion of these activities should be monitored, their environmental damages should be determined; mitigation studies against these damages should be performed, and regular inspections should be executed to keep these activities under control. Modern technologies should be used to obtain more effective results from these studies. Although monitoring the changes in large areas by using conventional method is very difficult, remote sensing is the most convenient technique to collect a large amount of data for this kind of areas. With the ability of satellite data, it is possible to detect and analyze the magnitude and spatial changes of natural environment which is significant for resource managers. Additionally, GIS technique is used to summarize changes in the spatial distribution of land cover classes by overlaying map 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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7. BIOGRAPHY

Ahmet Ozgur Dogru was born in 1979 in Aydın-Turkey. He attended to the Istanbul Technical University (ITU) Geodesy and Photogrammetry Engineering in 1997. He has started Geomatic Engineering Over Graduate Program in ITU Institute of Science and Technology in the year of 2002. He started to work in Istanbul Technical University, Cartography Division (Department of Geodesy and Photogrammetry Engineering) as a research assistant in the same year. After he had finished over graduate program he started his PhD in the same university. He is still working on navigation systems in terms of the map design for navigation purposes. Moreover he is working on GIS.