INTEGRATING GIS AND REMOTE SENSING FOR EVALUATION AND MONITORING OF OMERLI REGION, ISTANBUL

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ABSTRACT

The purpose of this study is to determine land use changes in an area using remotely sensing and GIS data. The analysis of the remotely sensed imagery and its integration with digital spatial data consisted of four major steps: 1) Landsat TM and SPOT P data were referenced to UTM projection System; 2) SPOT P and Landsat TM images were merged to provide high resolution land use/land cover information; 3) Unsupervised and supervised classification techniques were applied to the images to establish a land use and land cover GIS database, which was subsequently used for change detection analysis, and 4) An accuracy assessment was applied to the classification results to determine the overall accuracy of the study. For classified images of 1992, overall classification was 83.3 percent and for the classified images of 1997 was 80.3 percent. Finally the raster data were converted to vector data and were used in a GIS

1 INTRODUCTION

Urban land-use planning can help to guide urban development away from vulnerable ecosystems. All governmental units have a continuing requirement to form and implement laws and policies that directly or indirectly involve existing or future land-use. Uncoordinated development can lead to inefficient and undesirable environmental, social, and economic conditions (Campbell, 1996). Urban planners and policy makers need to have access to up-to-date maps and systematic information on the land-use patterns, environmental problems, and infrastructure facilities. Traditional techniques are time-consuming, costly, and unmanageable. Remote Sensing technique, which is used in urban planning, cost effective and time efficient. The extraction of land use/land cover information from remotely sensed data has received considerable attention over the last fifteen years and has become almost common practice in many application areas (Canters, 1997). The integration of remote sensing and geographic information systems GIS is essential for monitoring, evaluating and planning.
The aim of this study was to determine land-use change in Omerli Water Basin using remote sensing and GIS data. In the study different types of data were collected from various sources. The satellite images, aerial photographs, standard topographic maps, and various thematic maps and several photographs have been used as data sources of the study.

2 STUDY AREA AND DATA SOURCES

2.1 Characteristics of the study area

Istanbul's drinking water is provided by surface water resources through seven water dams. Omerli Dam Water Basin is one of the major water dams which supplies 40% of the drinking water of the city and approximately covers an area of 620 square kilometers. The basin is located Anatolian side of Istanbul. The reservoir capacity of the water basin is 270 000 000 m^3 and the daily capacity is 750 000 m^3 per day (Orhon, 1991)

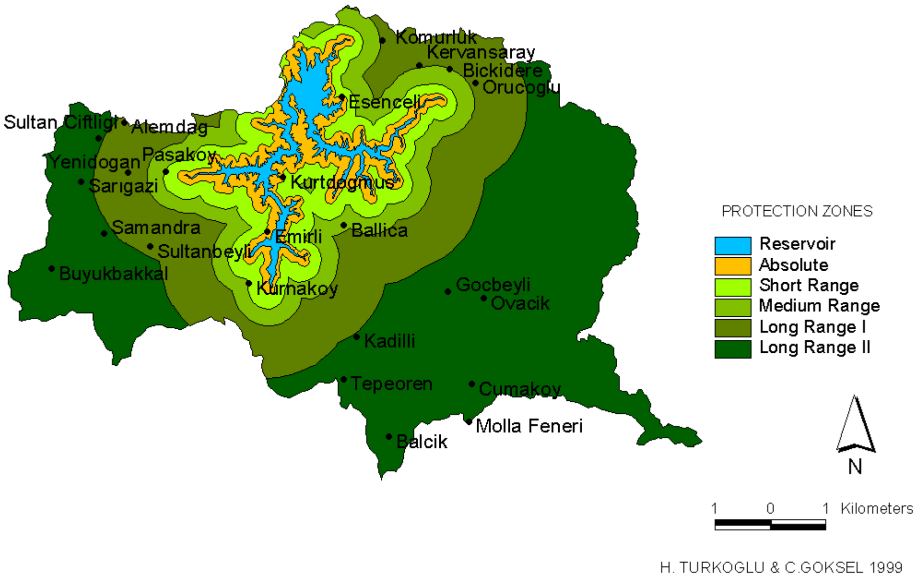

Figure 1: Protection zones of Omerli Water Basin Area

Population in the basin has shown a drastic increase since 1985(population: 36860) to 1997(population 257204). While the rate of population increase for Istanbul was around 5.3% the same rate for the total water basin were 26.76% for the period of 85-90.

The forest area covers 320 square kilometers. The forest area are covered pine trees (18%) and leafed trees (generally oak trees) (82%). Existing forest area is not very efficient in terms of plant materials, therefore is open to erosion.
The Watershed has been divided several administration zones. First of all the area located in two cities Istanbul and Kocaeli. Istanbul Greater Municipality boundary has divided the area into two parts. Out of the Greater Istanbul Municipal boundary there are several independent municipalities (Sarýgazi, Yenidogan, Alemdag, Sultan Ciftligi and Samandra) and even a sub-districts (Sultanbeyli) . Industries are scattered and have not been segregated from the residential zones. 340 industries have located in the basin .

The quality of water sources has been controlling and monitoring by the Water Board Authority of Greater Istanbul Municipality. The Water Board Authority of Istanbul applied a regulation for the whole drenage area. According to this regulation the watershed has been divided to protection zones such as Absolute (0-300m), Short (300-1000m) Medium (1000-2000m) and Long Range Protection zones (2000m-Borders of water basin area). Protection zones of Omerli Basin are shown Figure 1.

2.2. Characteristics of Database

In the study many kinds of data were collected from various sources. The satellite images, aerial photographs, standard topographic maps (scale 1:25000), and various thematic maps and several photographs have been used as data sources of the study. The vector data has been provided by digitizer. The boundary of the watershed, rivers and protection zones and roads has been digitized. Thematic maps such as geology, soil and land-use maps were drawn as vector data by using Arc-View (v.3). For analyzing land-use changes for different period remote sensing data is used. The characteristics of the satellite images have shown in Table 1.

Image	Date	Resolution	Number of bands
SPOT P	13.6.1993	10x10m	1
Landsat TM	09.06.1984 06.09.1992 18.07.1997	30x30m	7

Table 1: The characteristics of satellite images

The satellite data was examined using standard image processing software, ERDAS (v. 7.5) and ERDAS IMAGINE, and the results of the digital processing were presented with ARC VIEW (v.3). The image processing was performed in Remote Sensing Laboratory (Department of Remote Sensing) and Urban Planning Department at Istanbul Technical University.

2.3. Remote Sensing Data and Image Processing of Omerli Water Basin

The analysis of remote sensed imagery and its integration with digital spatial data consisted of four major steps. First Landsat TM and SPOT P data were referenced to a known map coordinate system. Second SPOT P and Landsat TM images were merged to provide high resolution land use land cover information. Third, unsupervised and supervised classification technique applied images for to use to establish a land-use and land cover GIS database which was subsequently used for change detection. Fourth step accuracy assessment were applied for the classification results. Each step is discussed below:

2.3.1.Georeferencing

A registered image should be labeled with information base map and number of Ground control points RMS error or standard deviation, and, if necessary resampling method (Jansen and Vander Well, 1994). The image data sets were geometrically corrected to the Universal Transverse Mercator System (UTM) coordinate system involved the following steps:
* Digitized of ground control points coordinates from standard topographic 1/25000 scaled maps. Twenty ground control points used in this step. Computation of least square methods solution for a first order polynomial equation required to register the image data sets.
* For the resampling method of geometric correction using nearest neighbor algorithm.
* Total root mean square (RMS) error is equal to 0.49 pixel (1.47m) for the Landsat TM images and 0.55 pixel (5.5m) for the SPOT P image.

2.3.2.Merge

Rapid advances in computer image analysis have allowed for greater flexibility and the use of new techniques for combining and integrating multiresolution and multispectral data such as the 10m single-band SPOT P image data with the 30m image data from the reflective bands of the Landsat TM data (Sunar and Musaoglu, 1998). In this study, three bands of Landsat TM data (7.4 and 1) were used and transformed into IHS domain. The digital numbers of 10m. SPOT Panchromatic data were then substituted for the intensity component and the IHS values transformed back into the RGB domain. Merge images were used to get an enhanced details about Omerli region.

2.3.3.Classification

Before the supervised classification one of the unsupervised classification process ISODATA (Iterative Self Organizing Data Analysis Technique) has been applied image data sets for the preliminary information was required of the Omerli region. Isodata algorithm produced 40 spectral clusters which, after generalization on field work, were aggregated to seven land-use land cover classes. Forest, bare soil, settlement, road, industry, wetland and water. Statistics from the clustering were than used as input to the supervised classification. Supervised classification process can be divided into the following sections: fieldwork, classification and accuracy assessment. Fieldwork was an integral part of this project. Many kinds of reference data, field map and photographs were used in this section (Fig.2)

Figure 2. Photographs of rural and urban areas

Before the classification, test areas were selected in order to make visual analysis. In the classification procedure the Landsat TM data sets are classified into seven classes using the conventional supervised Maximum Likelihood Classification Algorithm. Figure 3 show classification results and statistical results of the classified images for settlement, roads, industry, forest, bare soil, wetland and water for the water basin area are tabulated in Table 2.

Description	*1992 (Ha)*	*1997 (Ha)*
Water	1785.33	1825.29
Forest	39169.17	35140.23
Road	360.99	439.86
Industry	164.43	351.63
Settlement	6009.21	6391.26
Wetland	2143.89	1103.13
Bare Soil	11817.99	16198.96
Total	61451.02	61451.02

Table 2: Results of classified images

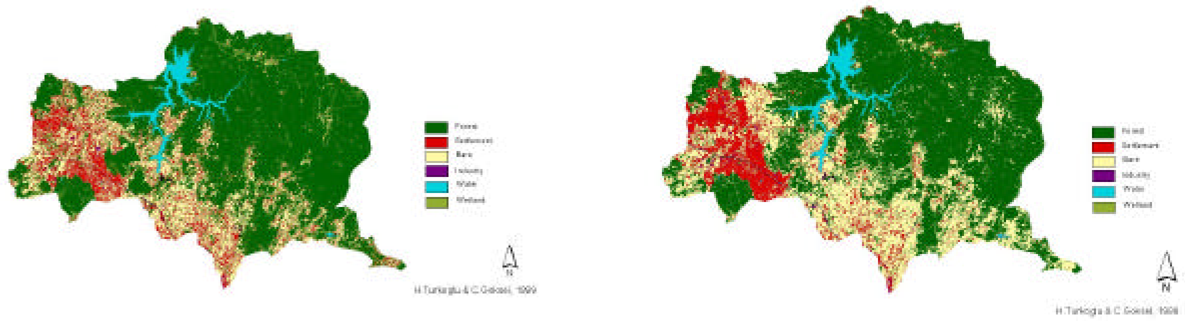

Figure 3. Classified Images of 1992 and 1997

2.3.4. Accuracy Assessment

Overall accuracy is simply the sum of the major diagonal divided by the total number of pixels or samples in the error matrix. This value is the most commonly reported accuracy assessment statistics. Producer's and user's accuracy's are ways of representing individual category accuracy's instead of just the overall classification accuracy (Congoltan et al, 1991).

The error matrix, the established standard for reporting remotely sensed data classification accuricies was used in this project. For the accuracy assessment, 300 pixel were randomly selected from the ground-truth coverage for comparison, and error matrix were calculated. Table 3 shows accuracy assessment results for 1992 and Table 4 accuracy assessment for 1997.

Class Name	*ReferenceTotals*	*Classified Totals*	*Number Correct*	*Producers Accuracy %*	*Users Accuracy %*
Water	9	9	9	100.0	100.0
Forest	169	174	160	94.7	92.0
Road	2	1	1	50.0	100.0
Industry	2	1	1	50.0	100.0
Settlement	40	29	25	62.5	86.2
Wetland	12	11	7	58.3	63.6
Bare Soil	19	24	14	73.7	58.3
Bare Soil	26	33	21	80.8	63.6
Green Area	21	18	12	57.1	66.7
Total	300	300	250		

Overall Classification Accuracy: 83.33334%

Table 3: Classification accuracy report (1992)

Class Name	*ReferenceTotals*	*Classified Totals*	*Number Correct*	*Producers Accuracy %*	*Users Accuracy %*
Water	8	9	8	100.0	88.9
Forest	162	172	150	92.6	87.2
Road	0	0	0		
Industry	7	2	2	28.6	100.0
Settlement	32	31	22	68.7	71.0
Wetland	11	5	4	36.4	80.0
Bare Soil	34	31	22	64.7	71.0
Bare Soil	46	50	33	71.7	66.0
Total	300	300	241		

Overall Classification Accuracy: 80.33334%

Table 4: Classification accuracy report (1997)

3 DATA INTEGRATION

GIS technology provides a suitable environment for the integration and analysis of image , spatial, and statistical data. The integration of GIS and Remote Sensing must deal with different data representation and must provide geometric correspondence or registration between the different data sets (Goodenough, 1988). The data sets(Landsat TM digital classification results of two different times, zoning data, geology, topography, and erosion, flora, demographic structure) various forms (raster and vector)were imported into Omerli GIS system. In this study the three main processing steps were applied. (1) Extract and process the Omerli GIS data, (2) Analyzing the integration products, (3) Updating Geographic Information. All data sets provide a good information source for land use as well as unplanned development activities.

4 RESULTS AND RECOMMENDATIONS

After 1985 Omerli Water Basin faced very fast urban expansion and population growth. Although the forest area is located in the north eastern part of the basin, the thematic maps show us south western part of the basin is sensitive to environmental problems according to the natural characteristics

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The result of the remote sensing analysis is two fold. First the classification results of remote sensing data obtained in this project have shown that the Landsat TM data which was resulted with the high geometric and high thematic correction can be effectively used for measuring the land-use change.

Second, from the comparison between remote sensing data of 1992 and 1997, it has been seen that increases of the building density in south western part of the basin where main urban development happened after 1985, is the characteristics

Administrative boundaries of the basin create a divided basin management. Independent municipalities (Sarigazi, Yenidogan, Alemdað and Samandra) and a subdistrict out of Istanbul Greater Municipal Boundary (Sultanbeyli) make more difficult to protect the basin and application of the basin regulations. A total basin management system and planning would be very helpful to protect the basin.

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REFERENCES

Campbell J. B,.1996. Introduction to Remote Sensing, The Guilford Press, Newyork, USA

Canters F.,1997. Evaluating the Uncertainty of Area Estimates Derived from Fuzzy Land cover Classification -PE&RS Vol.63,No,:4pp 403-414.

Congaltan R., 1991 A review of assessing the accuracy of classifications of remotely sensed data, Remote Sensing and Environment, Vol:37, pp. 35-46.

Goodenough D., 1988. Thematic Mapper and SPOT Integration with a Geographic Information System, Photogrammetric Engineering and Remote Sensing,_,_PE&RS,Vol.54, No,:2, PP 167-176.

Jansen L.F. and Vander Well, J.M., 1994. Accuracy A Review, Photogrammetric Engineering and Remote Sensing, PE&RS. pp.419-425.

Orhon D,.1991, Istanbul’da su toplama havzalarinda endustriyel kirlenmenin boyutlari, Su Toplama Havzalarini Koruma Stratejileri Uluslararasi sempozyumu,Ý.E. Goknel; D.Orhon; O.Buyuktas; N.Saripinar; S.Tokta (Eds), Istanbul:ISKI, s.254-272

Sunar, F.and Musaoglu, N. 1998, Merging multiresolution SPOT P and Landsat TM data: The effects and advantages, International Journal of Remote Sensing, vol: 19, no:2 pp.