

Analysis of Land Use Change and Urbanization in Büyükçekmece Watershed (Istanbul, Turkey)

H.Gonca COSKUN, Guler YALCIN

Istanbul Technical University, Osmaniye Korkut Ata University

Abstract— *Rapid urbanization is one of the crucial issues of global change affecting the human dimensions. As a result of population increase, Istanbul is the largest city in Turkey with its current population. Settlement areas have extremely expanded beyond the planned urbanization program and consumed the agricultural land and other green areas leading to deterioration of the environment. Also undesired urban sprawl affects the watersheds in Istanbul. Monitoring and representation of urban sprawl in the watershed is an essential part of water resource planning and management, and water quality. The objective of this study is to describe the application of multi-temporal satellite data for monitoring the land-use changes of Büyükçekmece Reservoir Watershed along the determination of some typical characteristics and to present the findings to the decision-makers in order to inform them on the current situation of land-use distribution. Remote Sensing (RS) with computer-based Geographic Information Systems (GIS) techniques are used as a tool for monitoring the watershed area. During the analyses of urban changes in Buyukcekmece Watershed, Landsat-5 TM + SPOT-Pan and SPOT-XS +SPOT-Pan satellite data were used respectively, for years 1992 and 1993. Also Landsat-5 TM satellite data were used for years 2001, 2004, 2005 and 2006.*

Index Terms—land-use, remote sensing, urban growth, watershed.

I. INTRODUCTION

The intensive migration and natural population growth into an area cause continuous urban growth and rapid urbanization [1]. Urbanization has been a universal and important social, economic and environmental phenomenon taking place all around the world. This process has brought about fundamental changes in land-use and landscape around the globe. Rapid urbanization, especially in the developing countries, is one of the crucial issues of global change affecting the human dimensions [2]. One of many problems resulting from rapid urbanization is the environmental impact and the conversion of open or agricultural land [3] also a rapid increase of settlements, unplanned and illegal housing are determined. As a result of population increase, Istanbul is the largest city in Turkey with its current population of around 13.9 million people as stated in News Bulletin of Turkish Statistical Institute [4] and settlement areas have extremely expanded beyond the planned urbanization program and consumed the agricultural land and other green areas leading to deterioration of the environment. Also undesired urban sprawl affects the watersheds in Istanbul. Many land-use plans are developed and proposed for sustainable management of the watersheds or drinking water reservoirs

such as a case study of Omerli Reservoir [5]. Its aim was to protect Omerli Reservoir from unplanned urbanization, rapid population increase and insufficient infrastructure development and to manage a sustainable and long-term water supply because it is the most important reservoir regarding the water holding capacity, supplying 40% of the overall drinking water demand of the megacity, Istanbul [6]. The developments in the technology of remote sensing provide an opportunity to monitor ground changes periodically. There are various applications for monitoring and planning urban areas in Istanbul and its watersheds by remote sensing and geographic information system techniques. [7] Achieved settlement suitability analyses to the natural thresholds of the area. Additionally, some kinds of formations, which may limit the development of the metropolitan area of Istanbul, such as natural structures, natural structure, ecological corridors and natural hazard areas, have been defined and developed model. [8] demonstrated the use of satellite images for detection of land-use changes and integration with existing maps into GIS for Sazlıdere Dam, Kilyos-Karaburun coastline and Haliç Bay. [1] analyzed land-use changes in the Büyükçekmece district using 1984-1997 population database, multi-temporal satellite data based on administrative sub-districts and villages and remote sensing methods. [6], [9], [10] described the application of multi-temporal satellite data for monitoring the land-use changes of the Omerli Reservoir Watershed, investigated the water quality changes in the Reservoir, focused on the assessment of urbanization in relation to land-use water quality using remote sensing and GIS techniques. Urban sprawl factors in 12 surface water resource basins of Istanbul (Terkos, Büyükçekmece, Sazlıdere, Alibeyköy, Küçükçekmece, Elmalı, Ömerli and Darlık) and land-use changes are evaluated and compared by [11]. Büyükçekmece is one of the administrative districts that form the city of Istanbul and one of the main summer resort areas for the city. Büyükçekmece Lake is located in this district and it was transformed into a lake from a lagoon by constructing a dyke to provide water for Istanbul in 1985 [1]. The objective of this study is to describe the application of multi-temporal satellite data for monitoring the land-use changes of Büyükçekmece Reservoir Watershed along the determination of some typical characteristics and to present the findings to the decision-makers in order to inform them on the current situation of land-use distribution.

II. STUDY AREA

Istanbul, located in the northern West of Turkey, is the most crowded city with a population of about 14 million. It is also a world renowned tourist destination with unique historic and aesthetic sites lying on two continents. The geographical coordinates of the project area that covers the Bosphorus and the water basins are 40° 60' - 41° 70' north latitude and 28° 00' and 30° 00' east longitude. Study area, Buyukcekmece Watershed, covers the third largest drinking water source of Istanbul, Buyukcekmece Lake [12]. Buyukcekmece Lake is located in a suburban area, which is located 30 km away from the city center [13]. This lake covers 27.5 km² area and lies in a 620 km² watershed. In this watershed Karasu, Hamza, Tahtakopru Rivers and other creeks flow into Buyukcekmece Lake [12]. The location of Buyukcekmece Watershed within the borders of Istanbul is shown in Fig.1 [14].

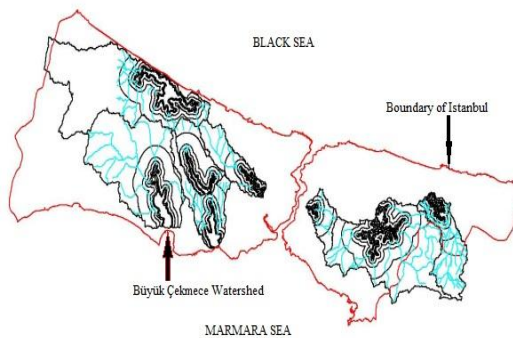


Fig 1. Location of Buyukcekmece Watershed.

III. DATA AND METHOD

Remote Sensing (RS) with computer-based Geographic Information Systems (GIS) techniques are used as a tool for monitoring the water basin area. ERDAS Imagine as image processing system, MapInfo as a GIS software and NETCAD for 3D modeling are used. During the analyses of urban changes in Buyukcekmece Watershed, Landsat-5 TM + SPOT-Pan and SPOT-XS +SPOT-Pan satellite data were used respectively, for years 1992 and 1993. Also Landsat-5 TM satellite data were used for years 2001, 2004, 2005 and 2006. Both 1:25000 and 1:5000 scaled digital maps cover the study area and orthophotos derived from 1:5000 aerial photographs were used as ground truth information in rectification of satellite imagery. Some of the vector data was merged using GIS software. After the digital satellite data set are transformed into Universal Transverse Mercator (UTM) coordinate system using the digital 1:5000 digital topographic maps in order to achieve the necessary geometric registration, taking 50 ground control points from the maps with registration accuracy about ±0.1 and ±0.5 pixels root mean square error (RMSE) the images are geometrically corrected before applying image merging and classification. The Supervised Maximum Likelihood Classification algorithm is used with 13 classes for the rectified and merged images. These classes were verified using pattern recognition,

referring to the ground truth data and fieldwork. In the classification the colors that are assigned: magenta for settlements, tan for empty area, yellow for uncultivated field, green for forest and trees, black for asphalt road, dark grey for dirt road, blue for water. The classification results only for years 1992 and 2006 are shown in Fig.2 and Fig.3. These classified images show visual differences of the land cover.

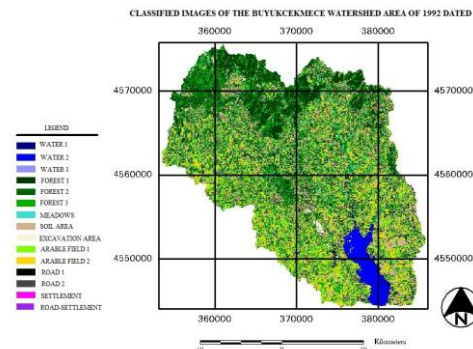


Fig.2: Classified images of the Buyukcekmece Watershed area of 1992 dated merged Landsat-5 TM and SPOT-Pan as georeferenced UTM coordinate system.

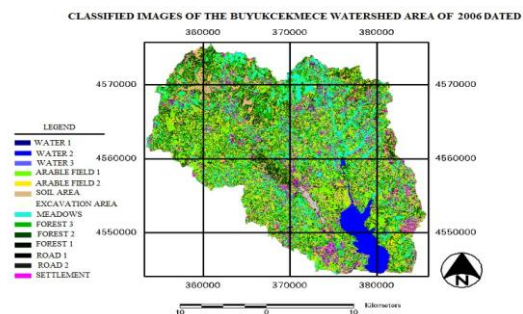


Fig.3: Classified images of the Buyukcekmece Watershed area of 2006 dated Landsat-5 TM as georeferenced UTM coordinate system.

The land use changes of the watershed are determined according to the protection zones. In Greater Metropolitan Istanbul, the watershed regulation declared by Istanbul Water and Sewerage Administration (ISKI) have led to the establishment of four protection zones around reservoirs; absolute (0-300 m), short range (300-1000 m), medium-range (1000-2000 m) and long-range (2000 m- the watershed boundary [15]. While Table 1 shows urbanized area in the protection zones within years Table 2 shows it as percentage. On the other hand Fig.4, 5, 6 and 7 show the graphical presentation of urban expansion analysis. From these analyses, it is clearly observed that there is an increase in urbanized areas in whole watershed within years.

Table 1: Urbanized areas within years.

	1992	1993	2004	2005	2006	watershed
whole	330,1	723,5	3518,4	4150,0	3843,0	60574,5
out	150,0	313,6	1418,4	2064,7	2187,6	37218,7
long	107,4	249,9	1058,8	1339,1	1133,4	13146,1
medium	32,4	69,2	320,2	404,0	293,8	4571,3

short	22,6	44,1	205,1	243,5	166,7	3537,3
absolute	18,7	48,9	131,1	128,8	92,5	2257,2

Table 2: Urbanized areas within yeras as percentage.
((settlement + %70(road settlement)) / whole watershed)).

	1992%	1993%	2004%	2005%	2006%
whole	1,9	1,2	6,4	6,9	7,8
out	1,5	0,8	4,1	5,6	6,9
long	2,6	1,9	9,0	10,2	11,2
medium	2,4	1,5	7,9	8,8	8,3
short	2,3	1,3	6,6	6,9	5,8
absolute	3,4	2,2	0,1	5,7	5,0

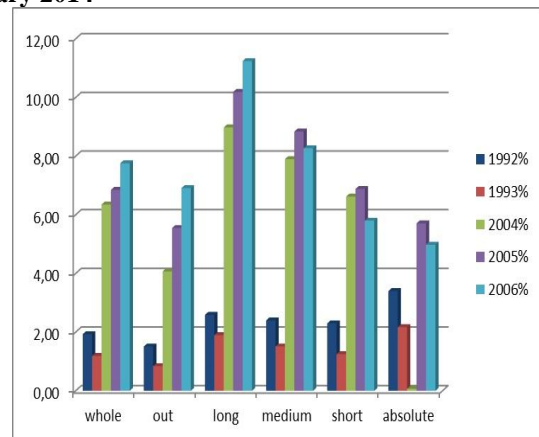


Fig.7: Percentage of urbanization in protection zones in years.

IV. CONCLUSION

Istanbul, with more than 14 million population at present, is the biggest city of Turkey drawing an important amount of migration. Along its well-developed settlement and industrial areas it also has the striking examples of unplanned urbanization as a result of high population increase rate. Uncontrolled growth of cities has resulted in various infrastructure and environmental problems. One of the most prominent examples of this situation is Buyukcekmece Watershed facing rapid and unplanned development in Istanbul. Buyukcekmece Lake constitutes one of the most important drinking water resources of Istanbul. The main purpose of this study is to investigate the rapid urbanization and the land use variations in the study area and to indicate the threat of uncontrolled development on the Buyukcekmece Watershed. In this context, the land use characteristics and the process of the land use changes in the study area are examined regarding the Buyukcekmece Watershed protection zones based on the satellite images belong to 1992, 1993, 2001, 2004, 2005 and 2006. At the end of the study, the temporal and spatial variations of the land use of the study area are introduced. Monitoring of environmental protection areas of the watersheds by urban planners implies the collection of updated systematic information on land-use. RS and GIS techniques are important tools for determining and updating land-use variations at the watershed areas. RS and GIS methods are applied to monitor urban changes in the protection zones of Büyükçekmece Watershed. As seen in Table 1 and Table 2 there is an increase in urban areas between years, especially on agricultural and forest areas. The urban area increased by 3512,88 ha between 1992 and 2006. This difference equivalent to a 7,76% increase in total watershed area. Also this land-use increase extends to rural areas such as agricultural and forest areas. This study shows that high resolution satellite data combined with GIS provides efficient and timely control of new settlement areas. It is possible to protect the forest and agricultural areas from their destruction. Urban sprawl is considered a significant and growing problem that entails a wide range of social and environmental costs. It is obvious that rapid, uncontrolled and illegal urbanization brings out social, environmental,

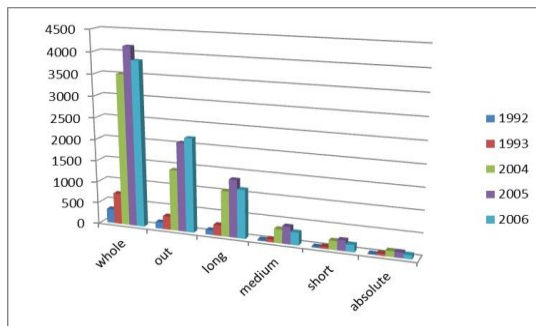


Fig.4: Urbanizatin in protection zones with years

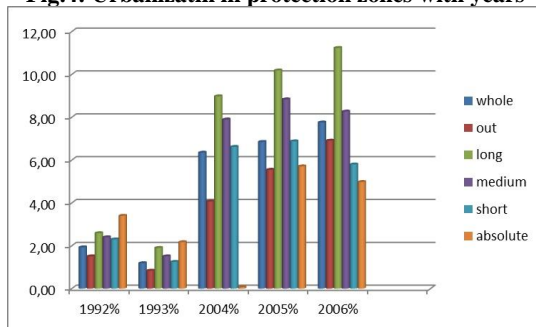


Fig.5: Percentage of urbanization in years with protection zones

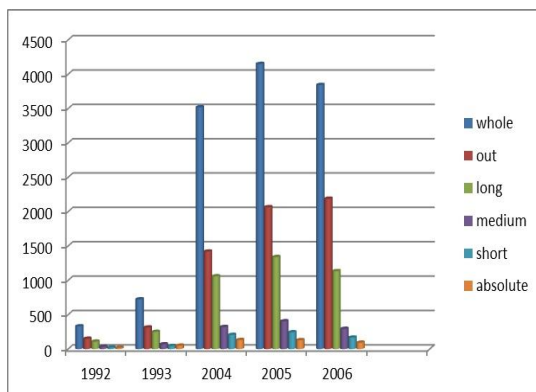


Fig.6: Urbanization in years with protection zones

economic and infrastructure problems. To minimize the negative impacts there is a need for accurate, reliable and up to date data at regular intervals. RS and GIS technology form an adequate tool to obtain the necessary information. Land-use plans should be based on an accepted analysis of land use variations to support decision making for sustainable development. These plans should be prepared in accordance with a protection strategy. Local governments, relevant administrations, municipalities, planning and environmental protection agencies must cooperate with universities and scientific organizations; work in harmony under good co-ordination, rather than attempting isolated solutions on an individual basis. Protection strategy for the watershed areas requires certain, urgent and short-term measures. The irreversible land-use changes and land-use activities should be kept under control for future generations.

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AUTHOR'S PROFILE

H.Gonca COSKUN obtained her bachelor's degree, master science degree and doctorate degree at Geomatics Engineering Department in Istanbul Technical University. She is presently working as Prof. at Geomatics Engineering Department in Istanbul Technical University. She is interested in remote sensing and geographic information systems.

Guler YALCIN had bachelor's degree at Geomatics Engineering Department in Istanbul Technical University, master science degree at Department of Geodetic and Geographic Information Technologies in Middle East Technical University and doctorate degree at Social Environmental Sciences in Ankara University. She worked at General Directorate of Land Registry and Cadastre for 15 years. She is presently working as Assist.Prof.Dr. at Department of Geodesy and Photogrammetry Engineering in Osmaniye Korkut Ata University. Her areas of interest include in land registry, cadastre, land administration, geographic information systems, and environmental problems.