

SPATIO-TEMPORAL ANALYSIS OF URBANIZATION RELATED LAND USE/COVER DYNAMICS USING SATELLITE IMAGERY: CASE STUDY ANTALYA, TURKEY

Ugur ALGANCI, Dursun Zafer SEKER, Elif SERTEL, Sinasi KAYA

ITU, Istanbul Technical University Civil Engineering Faculty Department of Geomatics
34469 Maslak Istanbul, Turkey
e-mail: alganci, seker, sertele, kayasina@itu.edu.tr

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Abstract: Antalya is the ninth largest city in Turkey with the area of around 20 815 km² and a population of 1 978 333 (2010). In 1985, the population was only 891 1437; however, it has more than doubled in the last 25 years. The city is one of the most popular and important tourism centers of the country. Thus, there are significant land use/cover changes due to rapidly increased population and tourism activities. In this study, the effects of urban sprawl over land use/cover dynamics of Antalya were investigated in terms of spatial and areal changes using multitemporal satellite imageries. Landsat 5 TM images for 1984, 2001 and 2010 were used to quantify the land use/cover changes with unsupervised classification process. Topographic parameters such as aspect and slope were produced from ASTER GDEM data. Classified images were converted into the vector format and relationship between land use/cover changes and spatial-topographic characteristics of the area was determined. Classification results showed that settlement areas heavily increased towards to the northwest of the city within the 25 year period resulting in conversion of agricultural areas into urban. In addition to these changes considerable coastline changes were also determined.

1. INTRODUCTION

Increased urbanization is one of the major problem and a form of environmental change having direct impacts on the daily lives of people. The world is undergoing the largest wave of urban growth in history. After the year of 2008, for the first time in history, more than half of the world's population became living in towns and cities with the (UNFPA, 2007). Understanding and managing the changing urban environment is a prerequisite for addressing sustainability, an increasingly important issue across a range of disciplines (Newman and Kenworthy, 1999; Chen, 2002; Wu and Murray, 2003; Kaya and Curran, 2006).

Population census data is one of the main data source for the investigation of urban dynamics. Remotely sensed data have been widely used to determine land cover changes. Satellite remote sensing has been extensively applied and recognized as a powerful and effective tool for the detection of land-use and land cover changes. Remotely sensed data can provide information that is at a finer temporal frequency compared to population census but these data are related only indirectly to a count of population (Kaya and Curran, 2006). The land-use /cover changes are quite difficult to grasp as they occur incrementally. Recently, temporal mapping from satellite data has successfully demonstrated the utility of integrating maps with remotely sensed data. The rapid population growth induced urbanization in developing countries mostly affect the metropolitan cities causing changes in land use/cover (LULC) dynamics that mostly results with decrease in natural resources such as forests or pastures and farmlands. In the last decade, a common population growth is observed all over Turkey with increase at 66 provinces out of 81. Antalya is one of the cities of Turkey that exposed to unplanned urban sprawl. The population of the city was ranked as 29th based on 1927 census data whereas the population was ranked as 9th of the country according to 2010 census results. According to "9th Progress Report" issued by Ministry of Development, Antalya is the city that exposed to the fastest population growth with a rate of %0, 48 during 1990-2000 in Turkey.

Main reasons of the rapid urbanization in Turkey are; rapid population increase and migration from rural areas to urbanized areas. This essentially unplanned, and therefore, uncontrolled urbanization results typically in the destruction of green (e.g., agricultural) areas and water resources (Goksel et al., 2001). Satellite sensor imagery is a potentially useful source of land cover information and urban land covers have been identified and mapped using remotely sensed data with a fine spatial resolution (Tapiador and Casanova, 2003; Yang, 2002; Madhavan et al., 2001; Ridd and Liu, 1998; Jensen, 1996). Remotely sensed data is used to monitor temporal changes over urban areas. Antalya is the most popular touristic city of the Turkey, with its 650 km of coastline, suitable climatic conditions, historical and natural beauties. Its population has increased due to employment facilities and migration related to tourism. It is also an important agricultural center with its fertile soil and rainy climate. Development in industry and building trade also results with continuous development and rapid urbanization. Main effects of population growth and related urbanization are; significant changes in watersheds, forests and agricultural lands

into settlement in an irregular and uncontrolled way and urban sprawl. To conduct effective urbanization analysis, it is important to determine spatial distribution and trend of urbanization, its impact on other land cover types and relationship between urbanized areas and topographic parameters. To this end, spatial and topographic information derived from satellite imagery can be used as main data resources. Since satellite images could be obtained rapidly and for large areas, these data source is essential for monitoring temporal land cover changes. Spatial, spectral and temporal resolution capabilities of different satellites should be considered based on the aim, scale and extent of the study. Spatio-temporal analysis of satellite images provides valuable information about changes in LULC dynamics.

In this study, the spatial distribution of urbanized areas and their changes for 25 year period occurred inside Antalya city boundary were analyzed using Landsat images obtained in 1984, 2001 and 2010, respectively. Forest, agriculture, urban, barren and water are considered as the five main land cover classes throughout the study. The areal extents of urbanized regions were extracted and corresponding census data of the related years were analyzed simultaneously to understand the impact of urbanization and population growth on the land use/cover changes. The main objectives of the study were to discuss and evaluate the LULC changes between 198 and 2010 by using the satellite images of Landsat 5 TM with a spatial resolution of 30 m.

2. DATA AND METHODOLOGY

In this study, Antalya is selected as the study area since it is one of the biggest city of Turkey located in southwest of Turkey with high touristic and historical potential (Figure 1). Because of the archaeological and natural richness of the area, Antalya is also known as the Turkish Riviera. The 630 km shoreline of the province is liberally scattered with ancient cities, harbors, memorial tombs and beaches, secluded coves and lush forests, many of which are easily accessible from the city. It is an important touristic destination for foreign and local tourists. Area of Antalya is about 20,815 km² and population is 1,978,333 in the year of 2010. Being one of the most popular and important tourism center, there have been significant land use/cover changes due to rapidly increased population and tourism activities in the city for the last few decades. While the average population increase in Turkey calculated as 18.28% between the year of 1990 and 2000, this ratio is raise up to 21.43% in Mediterranean Region and 41.79% in Antalya (http://en.wikipedia.org/wiki/Antalya_Province). Population growth rate is approximately 30.07% in the year of 2010 (TSI, 2010).

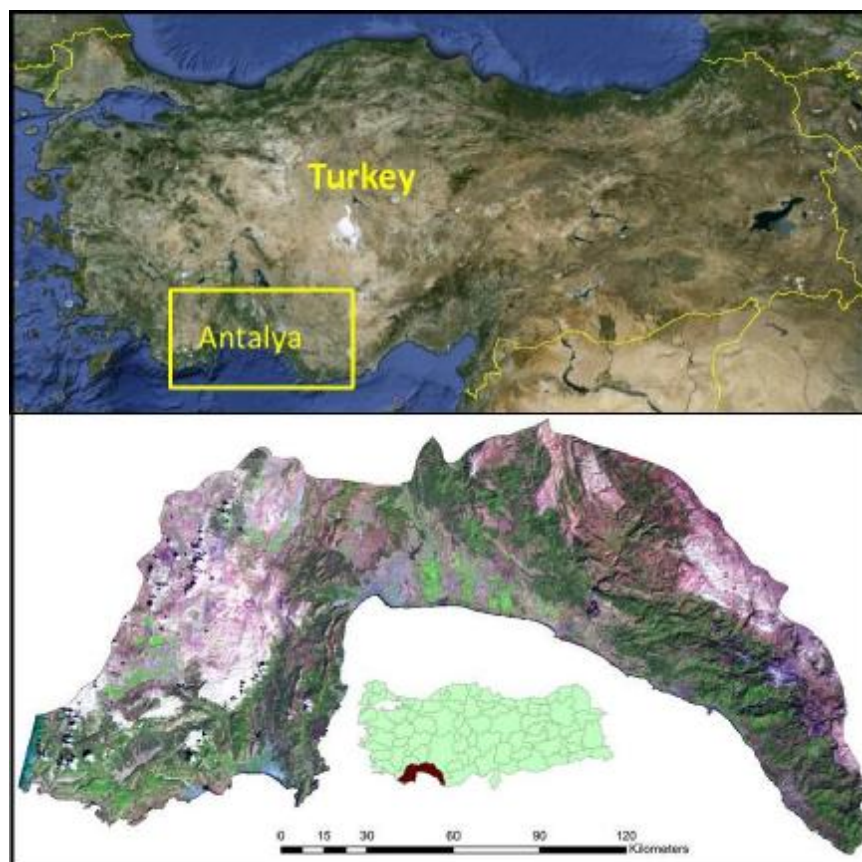


Figure 1: The Study Area

The population of Antalya has been increased significantly from the 1985 to 2010 due to heavy immigration from the other part of Turkey to this region. It is the ninth largest city in Turkey with the area of around 20 815 km². The population of the city was 1 978 333, 1 719 751, 891 1437 in 2010, 2000 and 1985, respectively. The population of the city has reached to 2.043.482 in 2011.

Data

Landsat 5 TM data for 1984, 2001 and 2010 were used to determine the Land Use/Cover (LUC) dynamics of the study area. Administrative boundaries of Antalya could be covered with 4 Landsat scenes, so totally 12 images were processed for 3 different years. Images were acquired at same seasonal periods for all years. Some acquisition properties of processed images are given in Table 1.

Table 1. Landsat 5 TM image acquisition parameters.

Name	Date	Path	Row
LT51780341984198AAA05	16.07.1984	178	34
LT51780351984198AAA05	16.07.1984	178	35
LT51770341984239XXX02	26.08.1984	177	34
LT51770351984239XXX02	26.08.1984	177	35
LT51770342001160MTI00	09.06.2001	177	34
LT51770352001160MTI00	09.06.2001	177	35
LT51780342001212MTI00	31.07.2001	178	34
LT51780352001212MTI00	31.07.2001	178	35
LT51780342010237MOR00	25.08.2010	178	34
LT51780352010237MOR00	25.08.2010	178	35
LT51770342010262MOR00	19.09.2010	177	34
LT51770352010262MOR00	19.09.2010	177	35

Methodology

Image processing

Landsat 5 TM images were obtained at Level 1T processing level that terrain correction has already performed. Images of 1984 and 2001 were registered to 2010 dated images in order to achieve necessary geometric association and integration to GIS. Registration processes of all scenes were performed with homogeneously distributed Ground Control Points with Root Mean Square error below 0.5 pixels. After registration process, images belonging to same year were mosaicked to form a single image. Only histogram matching was applied to the overlapping areas as scenes were obtained at same season. After mosaicking operation images were subjected to subset operation using province's administrative boundary shape file.

Classification

Classification process is a conventional method to derive LUC information from the satellite images to create areal and spatial distribution of different classes especially when a change detection observation with multi temporal images to be carried out. Pixel based classification algorithms traditionally separated under two categories as supervised and unsupervised. In this study, ISODATA unsupervised classification algorithm was used due to the lack of ground truth information. Using the six optical bands of the Landsat 5 TM images, ISODATA classification using 50 iterations – 0.99 convergence threshold parameters, was performed over multi temporal images to form 80 clusters. Then, clusters were examined and labeled to related class category. Labeled clusters are recoded to form the final LUC classes that are forest, agriculture, urban, barren and water.

Post Classification

Classified images were subjected to median filtering in order to minimize the speckle effects. Then, a raster to vector conversion with bend simplification was performed and class vectors were produced. Areal information of classes was derived from produced vector files.

3. RESULTS

Results of this study provided valuable information for observing the land cover (LC) changes in an important touristic city of Turkey, Antalya. City faced important changes from 1984 to 2010. Figure 2 presents the classification results of multi temporal images and Table 2 presents the area information derived for each class from classification results. According to classification results, there are noticeable increases in urban, agricultural area and barren land. Increase trend of these classes showed a continuous pattern for selected time periods. Moreover, these increases resulted with an important decrease in forest class.

Spatial analysis of the changes indicates that increase in urban and agriculture occurred as a permeation of existing urban and agriculture locations while barren lands grow with relation to forest boundaries. Most of the urbanization occurred through the shore line and condense at the bays with a south to north direction. Agriculture increase shows a complicated spatial pattern that growing both between and extends of urban areas. This situation was a result of greenhouse style farming activities. In addition, zonal analysis performed with class vectors and digital elevation model indicated 78% of the urban and agriculture increase occurred in flat areas where elevations are between 1 and 100 meters. Figure 3 shows the elevation characteristics of the study area.

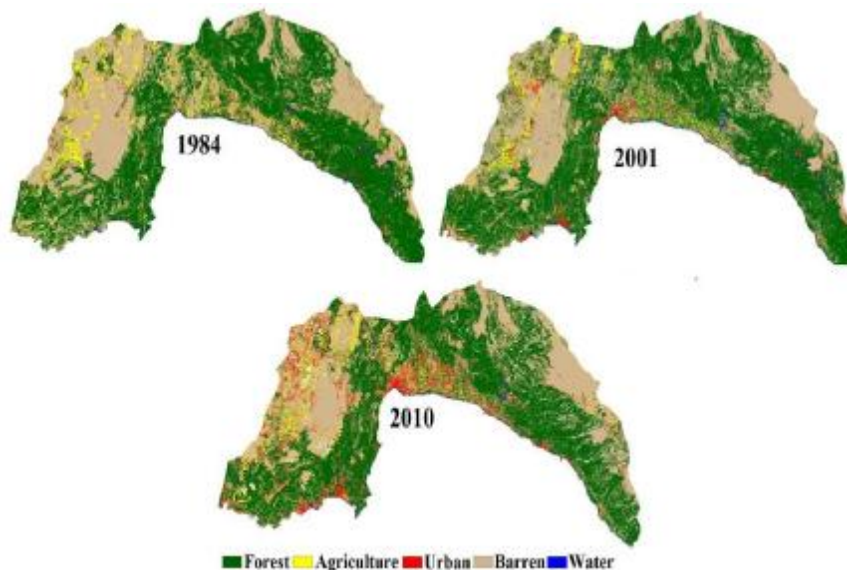


Figure 2. Classification results of multi temporal images for 1984, 2001 and 2010.

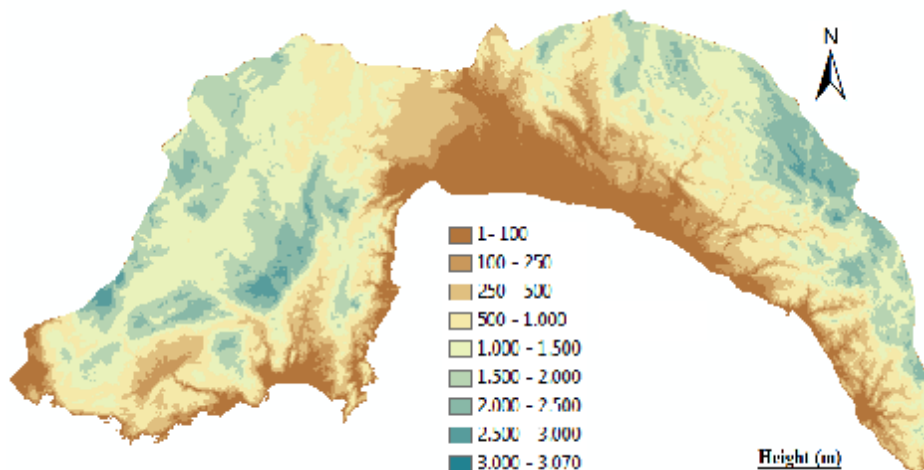


Figure 3. The height characteristics of the study area

Table 2. Areal information derived from classification results,

	1984 (ha)	2001 (ha)	2010 (ha)	2001 – 1984 (ha)	2001 – 1984 (ha)	2010-1984 (ha)
Forest	1,095,199	1,035,439	950,964	-59,760	-84,475	-144,235
Agriculture	92,755	111,826	128,778	19,071	16,952	36,023
Urban	56,891	76,762	134,139	19,871	57,377	77,248
Barren Land	774,048	792,820	805,405	18,772	12,585	31,357
Water Bodies	15,698	17,803	15,371	2,105	-2,432	-327
Total	2,034,591	2,034,650	2,034,657			

When the Table 2 is examined, it is clear that forestry area decreased around 144,235 ha between 1984 and 2010. Agricultural area increased by 36,023 ha between the 1984 and 2010. Barren land increased 31,357 ha between 1984 and 2010. Water bodies almost remained unchanged between the 1984 and 2010. The urban area increased by 19,871 ha between 1984 and 2001 and by 57,377 ha between 2001 and 2010. When the population increase examined there is no direct relationship between population growth and urban sprawl was realized. The main reason of this increase in the urban sprawl can be considered as the immigration from rural part of Antalya to the urbanized part and increases on secondary houses.

4. CONCLUSIONS

Internal migration has had a great impact on population dynamics of Turkey for decades. Population of **Antalya** is growing rapidly due to internal immigration. Moreover, millions of tourists are visiting **Antalya** every year. These effects increased the demand of urban areas especially in the shorelines and center of the province.

Significant land cover change on the city of Antalya was exposed using classification of Landsat 5 TM images. In the study area, particularly the urban area increased by around 77,248 ha in 26 years period between 1984 and 2010 parallel to the population increase. Study demonstrated that the advantage of using the remotely sensed and census data together to explore the land use/cover management problems. The future studies with finer spatial resolution images will hold the opportunity of a more detailed and precise analysis of LULC changes.

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