THE USE OF REMOTELY SENSED DATA AND GIS FOR DESTRUCTED AND INFRACTED FOREST AREA DETECTION IN ISTANBUL

Dursun Zafer Seker[1], Ugur Alganci[1], Sinasi Kaya[1] and Alper Unal[2]
[1]ITU, Civil Engineering Faculty, Department of Geomatics Engineering 34469 Maslak Istanbul, Turkey
Email: (seker, alganci, kayasina)@itu.edu.tr
[2] ITU, Eurasia Institute of Earth Sciences, Maslak 34469, İstanbul, Turkey
Email: alper.unal@itu.edu.tr

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ABSTRACT: Main focus of this study is to determine the destructions and infractions in forest areas of Istanbul, Turkey using multi-temporal Landsat satellite imagery. Analysis was mainly constructed on supervised classification of multi-temporal satellite images. Determined changes were exported to GIS and spatial overlay and intersection analyses were performed in order to demonstrate the actual situation of destructions and infractions. Results showed that 15.48% of forest area was destructed and infracted between 1987 and 2007 which is a significant change for 20 years period. Destructed forest mask was then subjected to overlay analysis with historical forest type map and destructed forest type distributions were calculated. Lastly a visual comparison between 1984 and 2015 was performed in order to present the most current situation and destruction trend of the study area.

1. INTRODUCTION

Migration from rural areas to city centers and their surroundings is an important problem of not only in Turkey but also in most of the developing countries. Together with urbanization and socio – economic problems, the industrial areas and commercial activities nearby the city centers results with a negative change in natural land cover on cities. Negative impacts of human induced activities on natural resources and land cover has been continuously increasing for decades. The main human activities that resulted with destruction and infraction of forest areas can be defined as mining activities, agricultural activities, industrial / commercial activities and urbanization (Basnet and Vodacek, 2015).

Human modification of forest habitats is a major component of global environmental change (Wimberly and Ohmann, 2004). Temporal monitoring of the changes in spatial distribution of forest areas is significantly important for effective management and planning progress. Changes can occur as spatially large destructions or small infractions. Therefore there is a need for reliable, fast and accurate data sources. At this point, satellite images proved to be a good data source for determination of the land use /cover changes with their capability of monitoring large areas with reasonable temporal resolutions (Giri and Long, 2014). Remotely sensed data have been used widely to record land cover change in general. Spectral information derived from images provides discrimination of land use/cover types from each other. It can be used to rapidly generate land use maps for assisting emergency responses for decision making and impact assessments. While remote sensing offers the capability for monitoring land surface changes, extracting the change information from satellite data requires effective and automated change detection techniques (Roy et al, 2013).

Many related studies were carried out in different aspects of forest destruction. Forest fires are one of the main reasons of forest degradation in the Mediterranean area countries. Every year, around 45,000 forest fires break out in the Mediterranean basin causing the destruction of about 2.6 million hectares (FAO, 2001).

The requirements and necessity of the quantifying and mapping of dense tropical forest for assessing carbon stocks as part of the Reducing Emission from Deforestation and forest Degradation (REDD +) process at region to country level were considered by Barbier and Couteron (2015) using high spatial resolution passive optical data.

In the study carried out by Leempoel et al, (2013), it is mentioned that implementation of better conservation and management strategies for the evaluation of the past and present status of the mangrove forest which are decreasing in the world mainly due to human induced activities are required. In this study, mangrove cover dynamics at Gaoqiao were evaluated using 1967, 2000 and 2009 satellite imageries sensors Corona KH-4B, Landsat ETM+, GeoEye-1 respectively. Even the limitations such as geometric distortion and single panchromatic band, the Corona classified images are evaluated as the invaluable for land-use/cover change detections when compared to recent satellite data sets.

In the study about the deforestation in the Brazilian Amazon, adjusting policy and resource allocation in the face of current forest destruction are presented as the key issues to understand actor-specific responsibilities with a time series of remote-sensing data covering four periods between 1986 and 2007 (Godar et al. 2012).

Arca et al, (2014) were evaluated the destruction of forest lands as one of the main disaster-producing factors in their study due to location of Turkey is prone to the risks of natural disasters like earthquake, flooding, and avalanche; a majority of the residential areas are facing these risks at various levels.

Forests have been highly exploited in recent decades also in Iran and deforestation is major environmental concern due to its role in ecosystem. For better management and preservation of forests, finding the effective parameters in deforestation can help the managers (Naghdizadegan et al., 2013).

In the study, carried out by Seker et al, (2010) Landsat satellite imageries were used to examine the temporal impact of rapid urban growth on forest cover in the mega city of Istanbul. The authors used VIS model to differentiate urban land from rural land and to conduct urban morphology of the developed areas under three basic components of vegetation, impervious land and soil.

As being the megacity of Turkey, Istanbul has been facing a huge migration for the last 30 years and effects of urbanization and other human based activities over forest areas are significant. In this study, the spatial distribution of land use and changes that have occurred throughout the megacity of Istanbul within years were analyzed via Landsat 5 TM images belonging to years 1987 and 2007. Then a visual comparison was performed between the dates 1984 and 2015 determination of the current situation and trend of destruction in the study area.

2. STUDY AREA AND DATA USED

In this study, city of Istanbul was selected as study area. The city of Istanbul, which is located between Asia and Europe, is the largest city of Turkey with a population of over 14.5 million in the year of 2014. Its population expected to reach 20 million by 2030. The north of the city towards the Black Sea is mostly covered by protected forest patches, and the expansion of the city in that direction is mostly confined to along the Bosporus. The most densely populated parts of the city lie in the south along the Sea of Marmara.

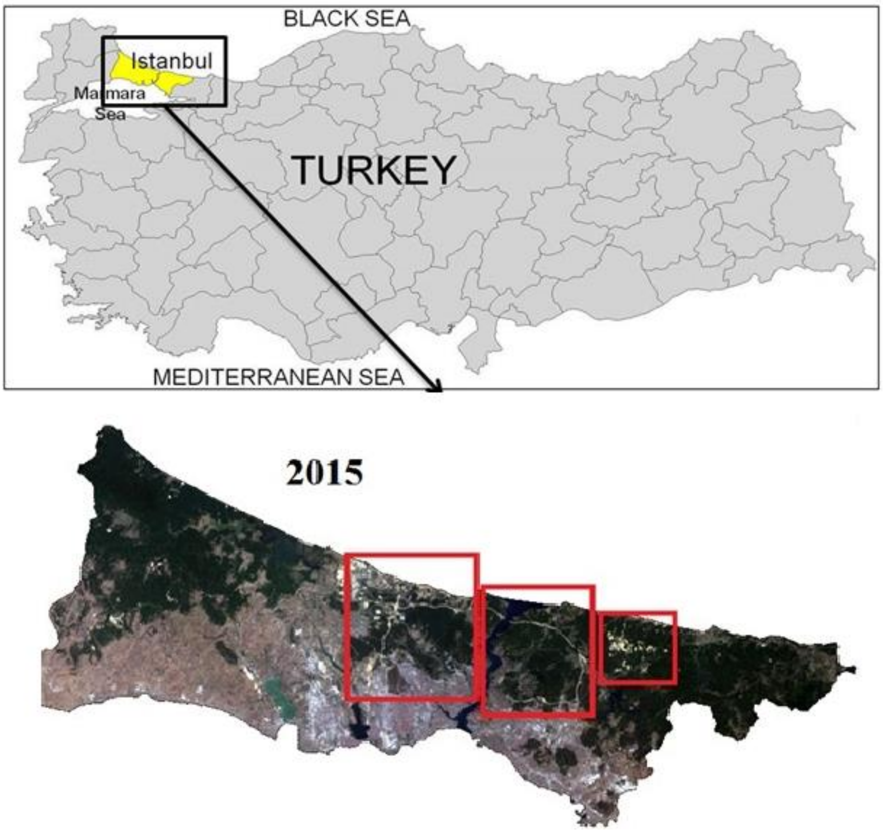

Figure 1. 1984 and 2015 dated Landsat satellite data of metropolitan Istanbul (red squares indicate current destructions)

In this study, 4 different Landsat satellite images that cover the borders of Istanbul province were used. Imaging sensors and acquisition dates were 1984, 1987 and 2007 dated Landsat 5 TM and 2015 dated Landsat 8 OLI. Imaging period was selected as summer – beginning autumn in order to delineate the different land use/cover information and broad leaved forest area successfully.

3. METHODOLOGY USED

3.1. Pre-Processing

Landsat series satellites are delivered as Level 1T terrain corrected imagery by USGS. Thus these images mostly do not need to be geometrically corrected. However, radiometric calibration was applied to images and they were converted to TOA reflectance in order to minimize the illumination effects in multi-temporal dataset. Satellite images were then mosaicked and subset to acquire the images of Istanbul borders.

3.2. Classification

In the second step, 1987 and 2007 dated Landsat TM images were subjected to Maximum Likelihood supervised classification process. Samples were selected from in situ data, standard topographic maps of the city and satellite image itself. Results were evaluated and clusters were reduced to maintain 5 LULC classes that are Water, Urban, Bareland /Agriculture, Forest and Excavation using recode algorithm (Figure 2).

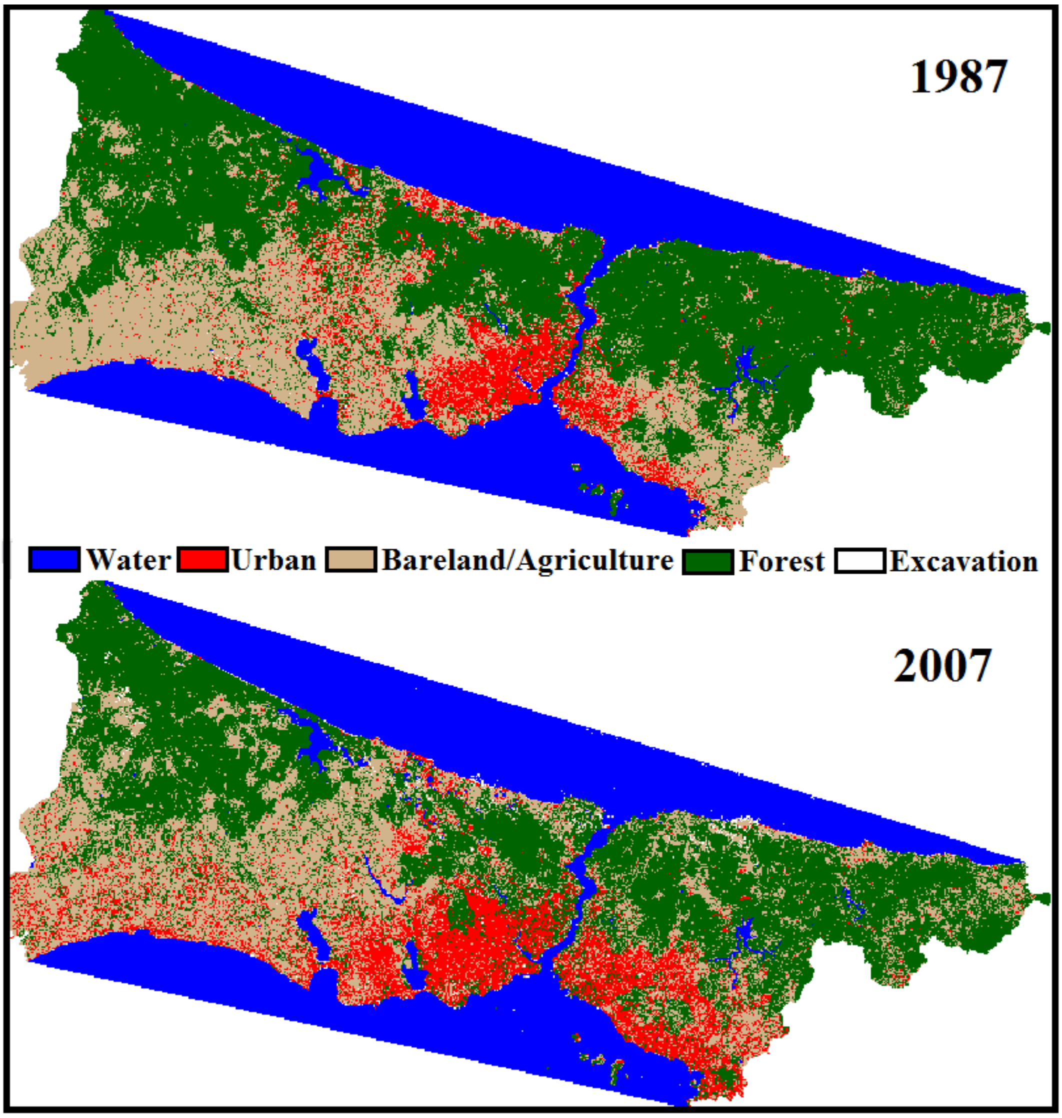

Figure 2. Supervised classification results of 1987 and 2007 dated Landsat TM satellite images.

3.3. Spatial Analysis

Classification results were converted to vector files and spatial analysis were performed on GIS environment. Firstly, forest areas belonging 1987 were extracted from vector data and it is intersected with 2007 classification vector. This process enabled to measure the total destructed forest area patches and their new LULC class information. Areal changes and “from forest to LULC” distribution between 1987 and 2007 is given in Table 1.

Table 1. Areal distribution of new LULC classes for the forest destructed and infracted areas between 198 and 2007.

Class (LULC)/Date	**1987 (km2)**	**2007 (km2)**
Water	0.00	9.89
Urban	0.00	102.13
Bareland + Agriculture	0.00	348.72
Forest	3095.61	2616.15
Excavation	0.00	18.72
TOTAL	**3095.61**	**3095.61**

As a further step of spatial analysis, destructed forest area mask derived with subtraction of 2007 forest vector from 1987, was overlaid on a historical forest type map in order to determine the types of destructed forest lands. According to analysis results it was found that mainly affected forest types were pastures with sparse trees, pinus and other broad – leaved, all three covers above 15% of the destructed forest lands. Quercus, Fagus, Scrub and Castenea types are also significantly affected from destruction with a contribution between 4% - 7% to the total destructed forest lands (Table 2).

Table 2. Commission of forest types that affected from destruction and infraction.

Destructed Forest Type	**Percentage (%)**
Pasture with sparse tree	27.93
Pinus	27.52
Other Broad-leaved	17.89
Quercus	6.95
Fagus	6.04
Scrub	4.92
Castanea	3.96
Marshlands	2.54
Carpinus	0.74
Tilia	0.44
Acacia	0.38
Cedrus	0.32
Tree -nurseries	0.21
Alnus	0.07
Fraxcinus	0.05
Juglans	0.05
TOTAL	100.00

3.4. Visual Comparison

A drastic decrease of forest lands in 2007 leads the need of evaluating the current status of urbanization trend in Istanbul. In this study just a visual comparison was given to express the important and continuous deforestation progress due to human induced activities related to urbanization and its complementary activities. In Figure 4, forest destruction due to a) third airport construction, b) third bridge and its related highways construction and c) mining activities and new settlement area – agricultural area occurrences can be easily detected with multi-temporal image set.

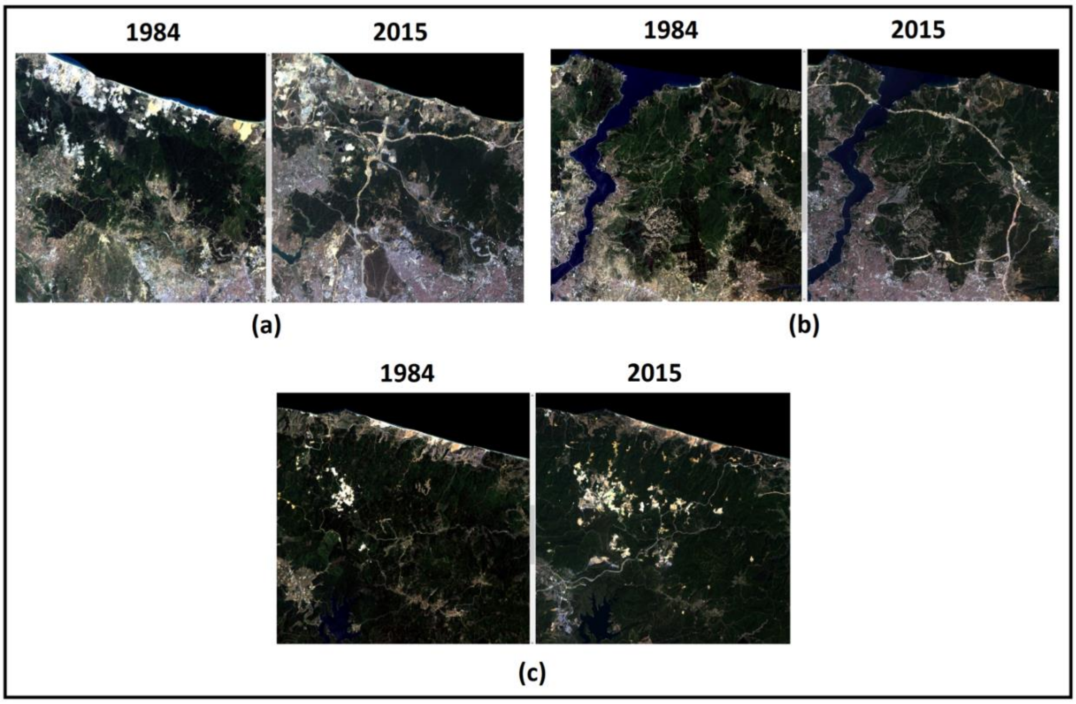

Figure 4. Visual comparison of 1984 dated Landsat TM image with 2015 dated Landsat 8 OLI image (a –b – c respectively corresponds to red boxes in Figure 1 from left to right)

4. RESULTS AND CONCLUSIONS

With respect to the areal change analysis of this study, it can be strongly asserted that forests of Istanbul faced a dramatic destruction and infraction phenomenon between 1987 and 2007 with a reduction of 15.48% in forest areas. When the new LULC status of destructed areas were analyzed it is obvious that destructed areas mostly turned into agricultural lands and urban areas which is suitable with regular "forest –agriculture – urban" progress chain. Excavation sites also increased in that period due to mining activities and water class increased due to level rise and reservoir enlargement in natural and artificial lakes. Visual comparison results indicates that both Asian and European parts of Istanbul faces rapid deforestation due to urbanization and also due to new transportation facility constructions such as third bridge with related highways and third airport.

As interest to urban environment has increased, some standards of biophysical parameters are required apart from land-use distribution regarding the ecological assets. Digital multi-spectral satellite technology provides valuable opportunities for qualifying and comparing urbanized areas in the world. The direction of the changes in forest areas enables to have an idea on the future possible urbanization trend. When the findings of the study are analyzed, it is observed that rapid urbanization within a period of 20 years has a negative impact on forests and within this period loss of forests have become significant on the contrary to urbanization. If this trend continues in future and if no precautions are to be taken, severe threat will be expected to occur on the forests of Istanbul. Moreover deforestation shows a scattered structure and continues inside big forest land patches, its negative effect on ecology may be much more than expected. A detailed fractal analysis of the spatial distribution with high resolution data will help better to understand such relations.

References

Arca, D., Citiroglu, HK., Kutoglu, HS., Kemaldere, H., Mekik, C., Sarginoglu, S., Arslanoglu, M., 2014. Unsustainable urban development for Zonguldak metropolitan area (NW Turkey). International Journal of Sustainable Development and World Ecology, 21 (5), pp. 398-405.

Barbier, N., Couteron, P., 2015. Attenuating the bidirectional texture variation of satellite images of tropical forest canopies. Remote Sensing of Environment, 171, pp. 245-260.

Basnet, B., Vodacek, A., 2015. Tracking land use/land cover dynamics in cloud prone areas using moderate resolution satellite data: a case study in Central Africa. Remote Sensing, 7 (6), pp. 6683-6709.

FAO 2001. State of the World's Forests 2001. URL: http://www.fao.org/docrep/003/y0900e/y0900e00.htm.

Giri, C., Long, J., 2014. Land cover characterization and mapping of South America for the year 2010 using Landsat 30m satellite data. Remote Sensing, 6 (10), pp. 9494-9510.

Godar, J., Tizado, EJ., Pokorny, B., 2012. Who is responsible for deforestation in the Amazon? A spatially explicit analysis along the Transamazon Highway in Brazil. Forest Ecology and Management, 267, pp. 58-73.

Leempoel, K., Satyanarayana, B., Bourgeois, C., Zhang, J., Chen, M., Wang, J., Bogaert, J., Dahdouh-Guebas, F., 2013. Dynamics in mangroves assessed by high-resolution and multi-temporal satellite data: a case study in Zhanjiang Mangrove National Nature Reserve (ZMNNR), P. R. China. Biogeosciences, 10 (8), pp. 5681-5689.

Naghdizadegan, M., Behifar, M., Mirbagheri, B., 2013. Spatial deforestation modeling using cellular automata case study: Central Zagros Forests. International Archives of the Photogrammetry Remote Sensing and Spatial Information Sciences, 40 (1-W3), pp. 289-293.

Roy, DP., Lewis, PE., Justice, CO., 2002. Burned area mapping using multi-temporal moderate spatial resolution data - a bi-directional reflectance model-based expectation approach. Remote Sensing and Environment, 83 (1-2), pp. 263-286.

Seker, DZ., Kaya, S., Tanik, A., 2010. Temporal impact of urbanization on forests in the mega city Istanbul. The 1st International Symposium on Turkish & Japanese Environment and Forestry, 4-6 November, Trabzon, Turkey.

Wimberly, MC. and Ohmann, JL., 2004. A multi-scale assessment of human and environmental constraints on forest land cover change on the Oregon (USA) coast range. Landscape Ecology, 19 (6), pp. 631-646.