ANALYZING LAND COVER CHANGES USING REMOTE SENSING AND GEOGRAPHIC INFORMATION SYSTEMS IN AKFIRAT AND ITS SURROUNDINGS (TUZLA – ISTANBUL), NORTH-WEST TURKEY

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Abstract:

In this study, land cover changes are analyzed by using of Remote Sensing (RS) and Geographic Information Systems (GIS) in Akfirat and Its surroundings (Tuzla – Istanbul), North-West Turkey. Akfirat and its surroundings are located in Tuzla town, southeast of Istanbul. Istanbul is the most populated city in the world with 13.483.052 population according to the recent 2011 census. The city will expand the north-south and east – west direction of along the Bosporus and increasing the need for new settlement areas in Istanbul. Akfirat and its surroundings where Istanbul Park Formula 1 racing pist located in this area are interesting example from southeast of Istanbul.

For determining the land cover change in the study area, on-screen digitizing method is applied to Landsat satellite images acquired in Landsat 7 ETM+ 2003 and Landsat 5 TM 2010 using ArcMap. The method consists of three major steps: (1) determining land cover classes with unsupervised classification method (2) the establishment of land cover change classes based on CORINE land cover classification theme using on screen digitizing method (3) mapping of land cover change. According to the obtained results, it was determined that the biggest change in the land cover from 2003 until 2010 occurred with the 271 hectare and 275,4% increase in the non-continuous urban residential land.

Keywords: *Land cover change, Landsat 7 ETM+ 2003, Landsat 5 TM 2010, Akfirat (Tuzla-Istanbul-Turkey)*

Introduction

Natural and human factors covering the land surface were defined as the land cover by Anderson and others (1976). Land cover and the change in its usage happen by natural or human impact. Few of the problems like world population, destruction of forests, floods, food shortage and uncontrolled structuring are relevant directly to the land cover and its usage changes. Satellite images are used as the most effective data in determining this change (Ustaoğlu, 2012, İkiel et al., 2012, İkiel and Ustaoğlu, 2011, Reis, 2008, Sertel, et al., 2008). Satellite images show important changes in resolution and accuracy in parallel with the developing technology (Kaya and Musaoğlu, 2002). Creating land cover maps is one of the most commonly used areas of the Landsat satellite images which are used also in this study. Landsat satellite is very effective in distinguishing the variety of spectral bands and land cover types. For analyzing and evaluating the satellite images obtained through the Remote Sensing technology, Geographic Information Systems is one of the most effective means. Geographic Information Systems, which turns the geographical data into a map and analyzes these, produces new knowledge from the current knowledge, offers processed spatial information to the users, is used in creating land cover maps (Reis and Yomralıoğlu, 2004). Along with the land cover maps being both a fast and economic means in monitoring the dynamic of land cover, they are also used in preparing the mappings of the land cover changes. In order to obtain, in accordance with the technological possibilities, high accuracy land cover maps in the desired details, conducting field works and defining the land cover computationally in different dates through time are required (Genç et al., 2010). In this study named as determining the land cover changes in Remote Sensing and Geographic Information Systems in Akfırat and its surroundings (Tuzla - Istanbul) between the years of 2003 – 2010, the CORINE Land cover classification was used to determine the land cover classes. Establishing the changes in land cover usually uses spatially aligned images taken from the same area in two different times. In this study, by using Landsat 7 ETM+ 2003 and Landsat 5 TM 2010 satellite images, mappings of the land cover changes belonging to the years of 2003 and 2010 in Akfırat and its surroundings, which is a new residential area placed in the southeast of Istanbul, were determined.

The study was conducted by using ERDAS Imagine© 9.1 image processing software and ArcGIS© 9.1 software placed in the Geographic Information Systems laboratory of department of Geography in Sakarya University.

Study Area:

Akfırat that forms the research area is a neighborhood constructed on a 5.280 hectare land, 19 km north from Tuzla district in the southeast of the Istanbul city. It is placed in the southeast of Ömerli Basin. The Formula 1 Istanbul Park Racetrack and Facilities, Okan University, Okan College, Villas Region are situated in the

north and northwest of old residentials of Akfırat neighborhood. In the southwest of area, Vehbi Koç Foundation Schools founded in the year of 1988 are situated (Figure 1).

Figure 1: Location Map of the Research Area (http://maps.google.com/11 July 2012)

After building the Formula 1 Istanbul Park Racetrack and Facilities, new residential areas started to take form in the surroundings of old residential areas of Akfırat neighborhood. The most important ones of these are the new residential areas in which luxury housings named as Okan University, Okan College and Villas Region are found.

Data and Methodology

Data

In this study, to obtain cover land data these were used; Landsat 7 ETM+ 2003 and Landsat 5 TM 2010 satellite images, ground truth data, CORINE Land Cover Classes, Vector Layers, the National Land Use/ Land Cover databases.

Satellite Images

In the research, for the purpose of putting forth the change of land cover and its current condition, 08/05/2003 dated Landsat 7 ETM+ and 08/09/2010 dated Landsat 5 TM satellite images procured from USGS (United States Geological Service) were used (Table 1, Figure 2). To determine the change correctly, summer season when the weather is clear was chosen. Cloudiness rate of both images is 0%.

Ground Truth Data

To correct the satellite data geometrically, in choosing the ground points to be used in the transformation, g22-b4 screw plate of 1/25.000 scale standard topographic maps published in 2002 by the General Command of Mapping is used. Also, air photo of the year 2010 obtained from the Istanbul Metropolitan Municipality, updated Google Earth images, photos taken in the 18/09/2011 and 19/06/2012 dated field works and also GPS measurements are used as the supporting data.

Table 1: Characteristic Features of the Images Used in the Study

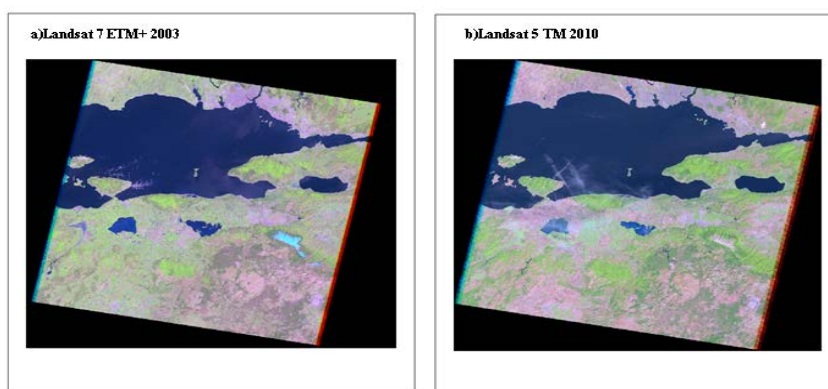| SATELLITE	RESOLUTION		DATE	SOURCE
	Spatial (s)	**Radiometric**		
LANDSAT 7 ETM+	30	8 bit	08.05.2003	USGS
LANDSAT 5 TM	30	8 bit	08.09.2010	USGS

Figure 2: The Images Used in the Study, a) Landsat 7 ETM+ 2003 b) Landsat 5 TM 2010

CORINE Land Cover Classification

In this study, CORINE land usage/ land cover classes were used to determine the land cover classes. CORINE, which is Coordination of Information on the Environment, means Coordination Project of Environmental Information. The CORINE Project is one of the important land projects within the context of the Global monitoring program for the European Union GMES (Global Monitoring for the Environment and Security) (Çivi et al., 2009). The CORINE Project Land Cover Classification consists of 3 hierarchical levels determined by the European Environment Agency (EEA, 2008). In the first level;

- Artificial Surfaces,
- Agricultural Areas,
- Forest and Semi-natural Areas,
- Wetlands,
- Water Bodies

There are 5 main groups as stated above, 15 in the second level and 44 must-be used sub-classes in the third level. As it's known, our country has a very different climate and plant characteristics because of its geographical location. For this reason, as addition to the 44 sub-classes determined by the European Environment Agency, 12 more codes were developed. 5 different classes in the research field within the CORINE Land Cover Classification were established from the satellite images used in this study. These classes are; Road and Rail Networks and Associated Land, Non-continuous Urban Residential Land, Non-irrigated Arable Land, Mixed Forests, Sport and Leisure Facilities (Table 2).

Table 2: CORINE Land Cover Classes Determined in the Work Field

Code	Class
1.2.2	Road and Rail Networks and Associated Land
1.1.2.1	Non-continuous Urban Residential Land
2.1.1	Non-irrigated Arable Land
3.1.3	Mixed Forests
1.4.2	Sport and Leisure Facilities

Vector Layers

In the study, while determining the classes on the land cover through satellite images, air photo and Google earth images according to the CORINE Land Cover Classification system, vector layers for cover land classes were formed by using ArcGIS$^{©}$ 9.1 software with the digitizing method through screen (Figure 3). These layers identified on the land cover and the formed characteristic classes are as follows:
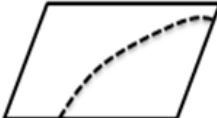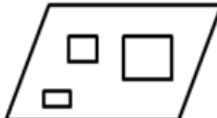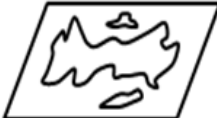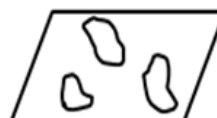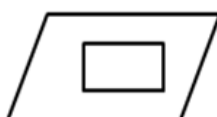
Layers		Class Attribute
	Road and Rail Networks and Associated Land	line
	Neighborhood Border	line
	Non-Continuous Urban Residental Land	polygon
	Mixed Forests	polygon
	Non-Irrigated Arable Land	polygon
	Sport and Leisure Facilities	polygon

Figure 3: Vector Layers Formed in the Work Field

The National Land Use/Land Cover databases

To verify the land cover map that we obtained in the study, land cover maps of the years of 1990, 2000 and 2006 that were created according to The National Land Use/Land Cover databases that are run by Turkish Republic Ministry of Forestry and Water Affairs and mappings of land cover changes of the years 1990-2000, 2000-2006 were used. These maps were created in accordance with the CORINE Land Cover Classification system. In the maps, 63 Landsat satellite images of the year 2000 with the 30 m resolution that contain Turkey, SPOT 4-5 and IRS images of the year 2006 with the 20 m resolution that contain Turkey; Quickbird, Ikonos, Landsat, IRS, SPOT images within the ministry of environment and forestry within the context of environment plans, 1/100.000 and 1/25.000 topographic maps were used as data (Figure 11,12,13,14) (http://aris.ormansu.gov.tr/crn/

Methodology

In order to determine the temporal and spatial changes taking place in the land cover, the data used in the study was analyzed with the methods complementing each other in a systematic way (Figure 3). For this reason, primarily;

➢ The borders of the work field were established from 1/25.000 topographic maps. And, as accordance with the borders of the work field, the borders the satellite images to-be used in the study were organized by using Data Preparation Subset Image Tool in ERDAS Imagine$^{©}$ 9.1 software (Figure 4).

➢ Secondly, by determining ground control points, air photo of the year 2010 of the satellite images to-be used in the study and the geometric correction of the Google Earth images were made. For this, 1:25,000 scale standard topographic maps were used. The geometric correction process and the satellite images are referenced according to the UTM (Universal Transverse Mercator) projection system (36. round). During this process, the quadratic mean error was found under ±1 pixel for all the satellite data.

➢ In the next phase, unsupervised classification was conducted with the ISODATA method in the ERDAS Imagine$^{©}$ 9.1 software.

➢ The land cover data was formed by taking CORINE land usage / land cover classification system into account. In GIS environment, land classes were determined, by using the satellite image data, with the on screen digitizing method. For this reason, "vector layers" were formed for each class. The areas these classes take up were calculated separately. ArcGIS$^{©}$ 9.1 software was taken benefit for GIS applications used in this phase.

➢ For the verification of the Land cover classes determined with Remote Sensing and Geographic Information Systems; field works was carried out in different dates, updated Google Earth images were used, an elaborate literature review about the work field was conducted and sample studies were taken as reference and at the same time, interviews were carried out in the work field. Beside this, information of Land Use / Land Cover

Database being run within the context of National Land Monitoring Systems projects, which is run by Turkish republic ministry of forest and water affairs, was used.
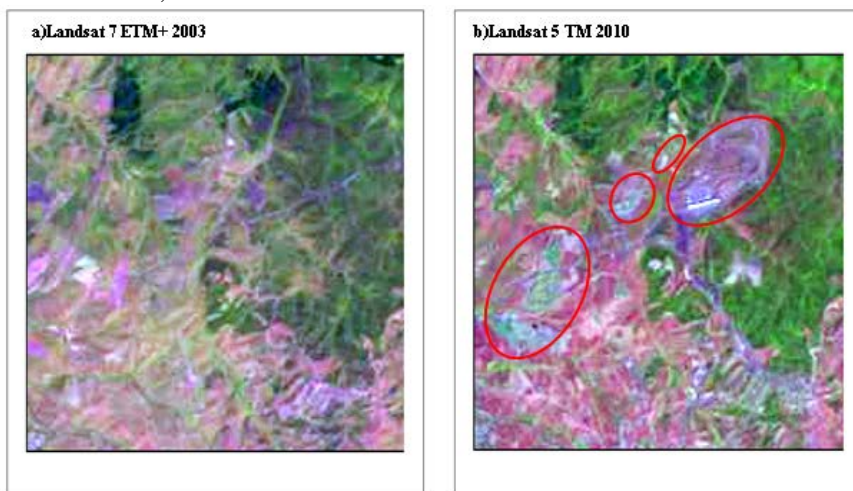

Figure 4: Determining the area cut from satellite images by doing "subset image" and the change through raw image a) Landsat 7 ETM+ 2003 b) Landsat 5 TM 2010
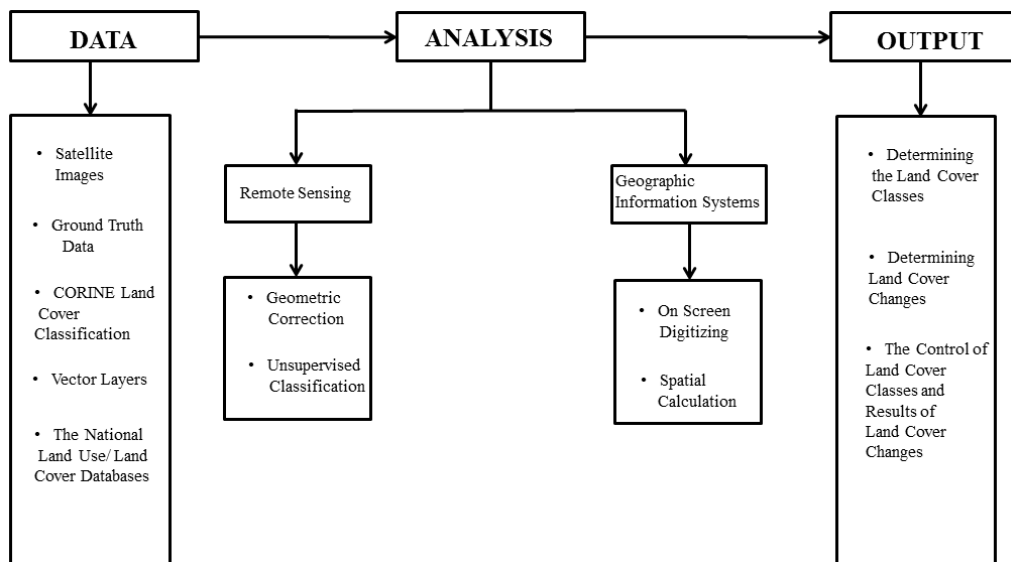

Figure 5: The Work Flow Diagram Used in the Analysis of the Data

Discussion and Results

Determining the Land Cover Classes

Land cover classes for the years of 2003 and 2010 were determined according to the CORINE land cover classification, with the on screen digitizing method in ArcGIS$^©$ 9.1 software with Geographic Information Systems of Landsat 7 ETM+ 08/05/2003 and Landsat TM 08/09/2010 dated satellite images (Table 3, Figure 6; Table 4, Figure 7).

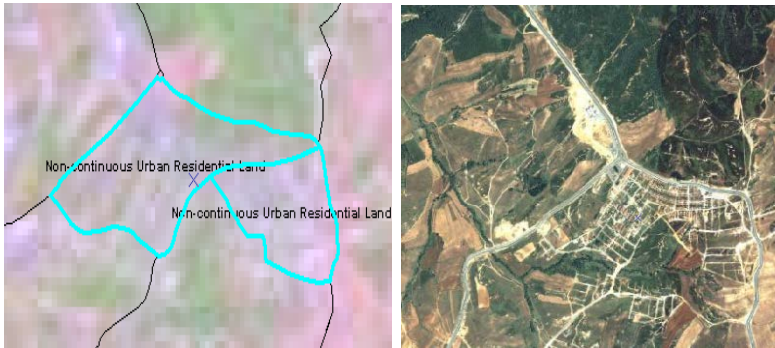According to this, land cover classes;

- ➢ Road and Rail Networks and Associated Land,
- ➢ Non-continuous Urban Residential Land,
- ➢ Non-irrigated Arable Land,
- ➢ Mixed Forests,
- ➢ Sport and Leisure Facilities

Consist of 5 classes as stated above. The year 2003 land cover composes of Road and Rail Networks and Associated Land, Non-continuous Urban Residential Land, Non-irrigated Arable Land and Mixed Forests. The year 2010 land cover composes of Road and Rail Networks and Associated Land, Non-continuous Urban Residential Land, Non-irrigated Arable Land, Mixed Forests and Sport and Leisure Facilities. In terms of area the year 2003 land cover classes contained in itself, the biggest portion was taken by Non-irrigated Arable Land with 2162.6 hectare. Secondly, Mixed Forests with 1739.2 hectare and thirdly, Non-continuous Urban Residential Land with 98.4 hectare take place (Table 3, Figure 6).

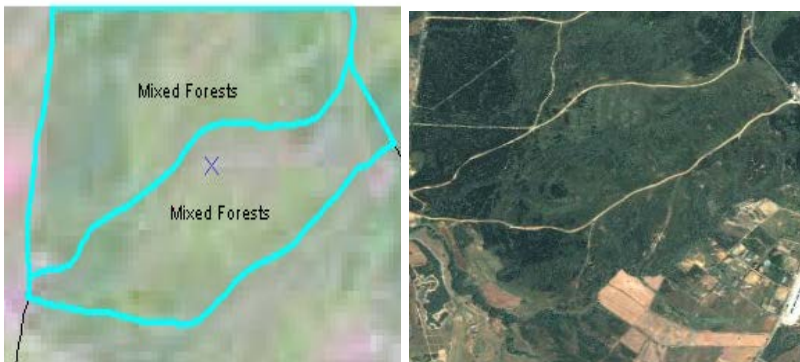**Road and Rail Networks and Associated Land**

Non-continuous Urban Residential Land

Non-irrigated Arable Land

Mixed Forests

Sport and Leisure Facilities

Table 3: 2003 Land Cover Classes of Akfırat and Its Surroundings (ha) (%)

Land Cover	Area (ha)	Area (%)
Non-continuous Urban Residential Land	98.4	2
Non-irrigated Arable Land	2162.6	44
Mixed Forests	1739.2	54
Total	4000.2	100

In terms of area land cover classes covered in the year 2010 land cover, it is aligned as; Non-irrigated Arable Land with 1927.5 hectare, Mixed Forests with 1508.1 hectare, Non-continuous Urban Residential Land with 368.6 hectare and Sport and Leisure Facilities with 195.6 hectare (Table 4, Figure 7).
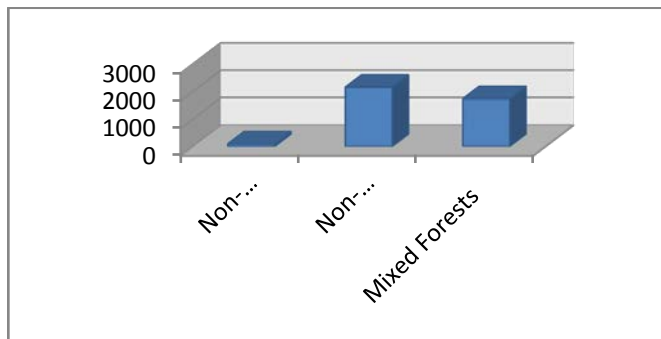
Figure 6: 2003 Land Cover Classes of Akfırat and its Surroundings (ha)

Table 4: 2010 Land Cover Classes of Akfırat and Its Surroundings (ha) (%)

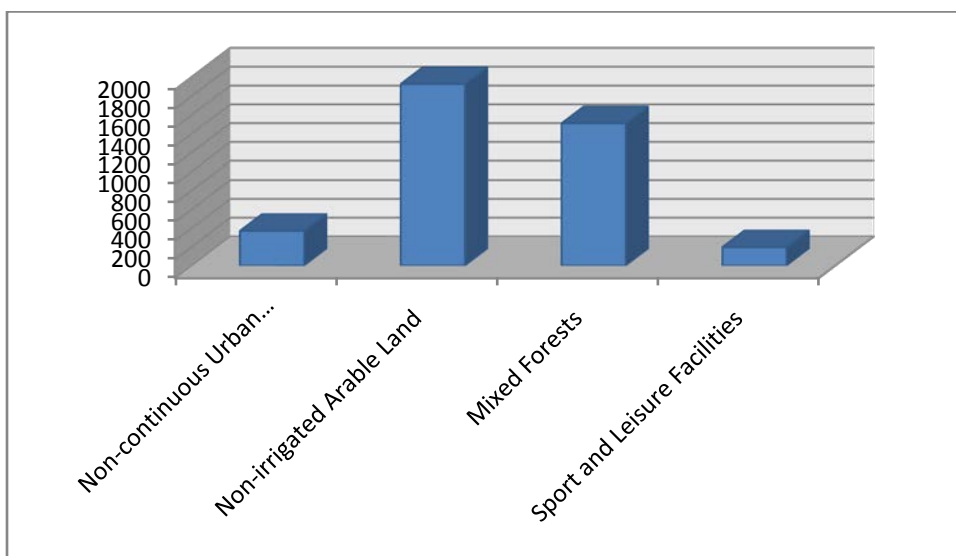| Land Cover	Area (ha)	Area (%)
Non-continuous Urban Residential Land	369.4	9
Non-irrigated Arable Land	1927.3	49
Mixed Forests	1508.1	37
Sport and Leisure Facilities	195.4	5
Total	4000.2	100

Figure 7: 2010 Land Cover Classes of Akfırat and Its Surroundings (ha)

Determining Land Cover Changes

The mappings of land cover changes of the years 2003-2010 were determined according to the CORINE land cover classification with the unsupervised classification ISODATA method in the ERDAS Imagine[©] 9.1software with Remote Sensing and with the on screen digitizing method in the ArcGIS[©] 9.1software with Geographic Information Systems (Figure 9, 10). According to this, Villas Region,

Okan University Campus and Okan College in the Non-continuous Urban Residential Land are determined clearly. Beside this, the Formula 1 Istanbul Park Racetrack and Facilities included in Sport and Leisure Facilities were also established in the land cover map (Figure 9, 10). When the areas of land cover classes of the years 2003 – 2010 are statistically calculated, the biggest change was seen in Non-continuous Urban Residential Land with 271 hectare and 275,4% increase (Table 5, Figure 8). Contrary to this situation, a decrease close to each other was determined with a drop of -235.3 hectare and -10,8% in Non-irrigated Arable Land and a drop of -231.1 hectare and -13,3% in Mixed Forests (Table 5, Figure 8). A class named as Sport and Leisure Facilities was added to the land cover in the year 2010. This situation is the clearest indicator of change in the land cover (Table 5, Figure 8).

The increase seen in Non-continuous Urban Residential Land also caused the emergence of Sport and Leisure Facilities. Reason for this can be given as the Formula 1 Istanbul Park Racetrack and Facilities racetrack being located in Akfırat and its surroundings. Realization of the Formula 1 Istanbul Park Racetrack and Facilities project was accepted in the 24 July 2002 with the council of ministers decision. In November 2002, Istanbul was elected as the place where the Formula 1 events will take place. In choosing Akfırat and its surroundings for the building of the racetrack in Istanbul; the area where the racetrack was to be built being the calmest district, it being connected to the TEM and E5 highways and it being close to the Sabiha Gökçen Airport, which wasn't started to being used in that era, were taken as grounds (Dönmez, 2009). Hence, Akfırat and its surroundings gained the privilege of being a very popular area as of 2003. After the building of the Formula 1 Istanbul Park Racetrack and Facilities racetrack as Sport and Leisure Facilities, number of Non-continuous Urban Residential Land increased with the building of the new housing projects in the work field. Before choosing the location of the Formula 1 Istanbul Park Racetrack and Facilities, while no change was seen in Akfırat neighborhood and its neighbor Tepeören neighborhood and its surroundings, after choosing the location, they became neighborhoods where important and fast transformations took place especially in terms of surroundings. When looked at the mapping of the land cover changes, areas where changes took place can be seen very clearly. The most important ones of these are; Istanbul Park Facilities Formula 1 Racetrack, whose building was decided to be constructed in the north of Akfırat in 2002, Okan University Campus that was opened in 2006-2007 school year in the south of Akfırat and again in the south of Akfırat, Okan College that was opened in 2011-2012 school year and new residential areas where luxury housings take place that are known as the "Villas Region", whose construction was started in the west and northwest of Akfırat. Among these villas, Arkeon Houses in 2003, Ville Housings in 2006 and F2 Houses in 2008 were started to be constructed as being considered prominent projects by us during the field works.

Table 5: Temporal Variation of Cover Lands in Akfırat and Its Surroundings (ha, %) (2003-2010)

Land Cover	2003		2010		Land Changed	
	ha	%	ha	%	ha	%
Non-continuous Urban Residential Land	98.4	2	369.4	9	271	275,4
Non-irrigated Arable Land	2162.6	44	1927.3	49	-235.3	-10,8
Mixed Forests	1739.2	54	1508.1	37	-231.1	-13,3
Sport and Leisure Facilities			195.4	5	195.4	
Total	4000.2	100	4000.2	100		

Figure 8: Temporal Variation of Cover Lands in Akfırat and Its Surroundings (ha) (2003-2010)
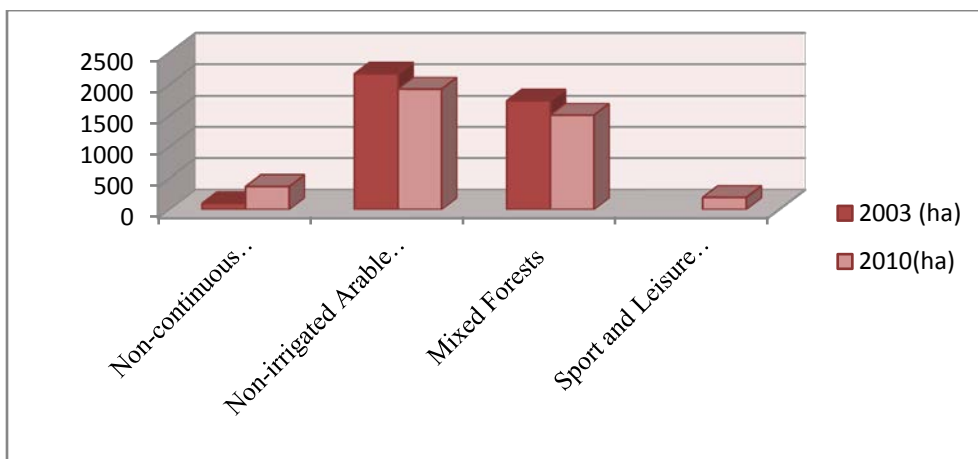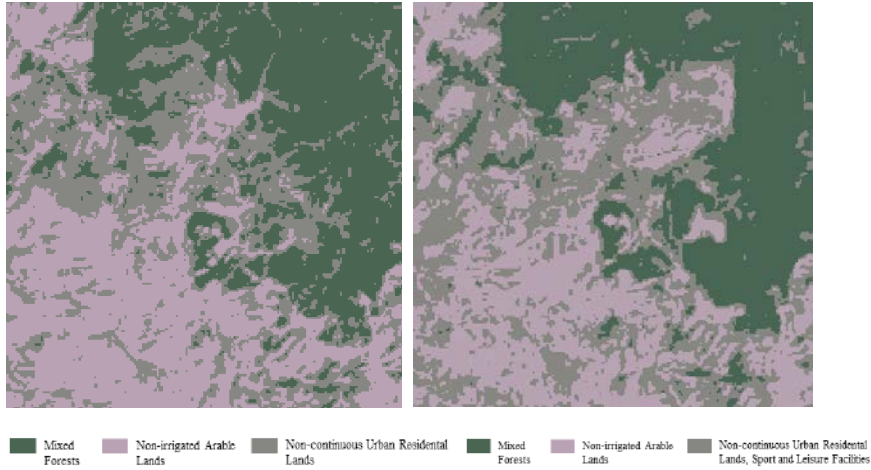
Figure 9: Unsupervised Classification of the Satellite Images a) Landsat 7 ETM+ 2003
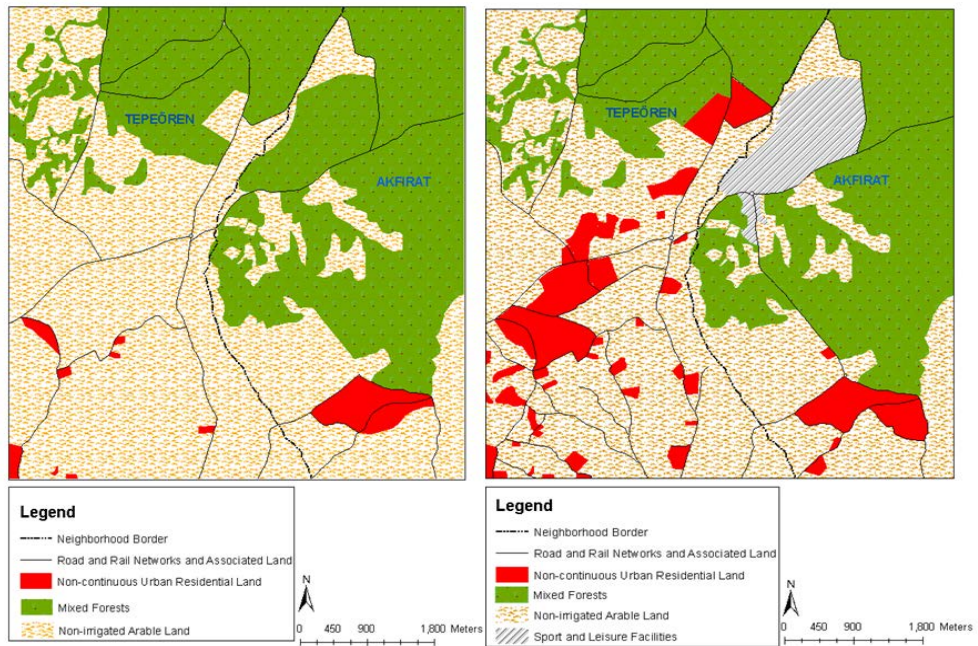
b) Landsat 5 TM 2010

Figure 10: Temporal and Spatial Detection of the Changes Occurred in the Land Cover by Using Satellite Images

The Control of Land Cover Classes and Results of Land Cover Changes

In order to verify the accuracy of mappings of land cover changes obtained by unsupervised classification and on screen digitizing methods in the years 2003 and 2010, mappings of CORINE Land Cover and Land Cover changes of the years 1990 – 2000 – 2006 acquired from the National Land Use / Land Cover Databases were used (Figure: 11, 12, 13, 14). According to this, the year 2003 land cover map (Figure: 10) shows coherence with the 2000 land cover maps obtained from the National Land Use/ Land Cover Databases (Şekil: 11). Land cover classes in both maps cover the shared areas about the same. These similarities were determined more clearly in mappings of CORINE Land cover changes of the years 1990 – 2000 and 2000 – 2006 that were obtained from the National Land Use / Land Cover Databases (Figure: 13, 14). The Formula 1 Istanbul Park Racetrack and Facilities, which was constructed after the year 2002, caused vital changes in land cover. This situation can be observed clearly in the year 2006 National Land Use / Land Cover map. In this map, the area named as Villas District under the name of Non-continuous Urban Residential Land and the Formula 1 Istanbul Park Racetrack and Facilities under the name of Sport and Leisure Facilities were determined. Still no land cover map of the year 2010 exists in National Land Use/ Land Cover maps. Hence, because Okan University and Okan College we determined in the land cover map of 2010 were constructed after 2006, they don't take place in the mapping of change of 2000-2006.
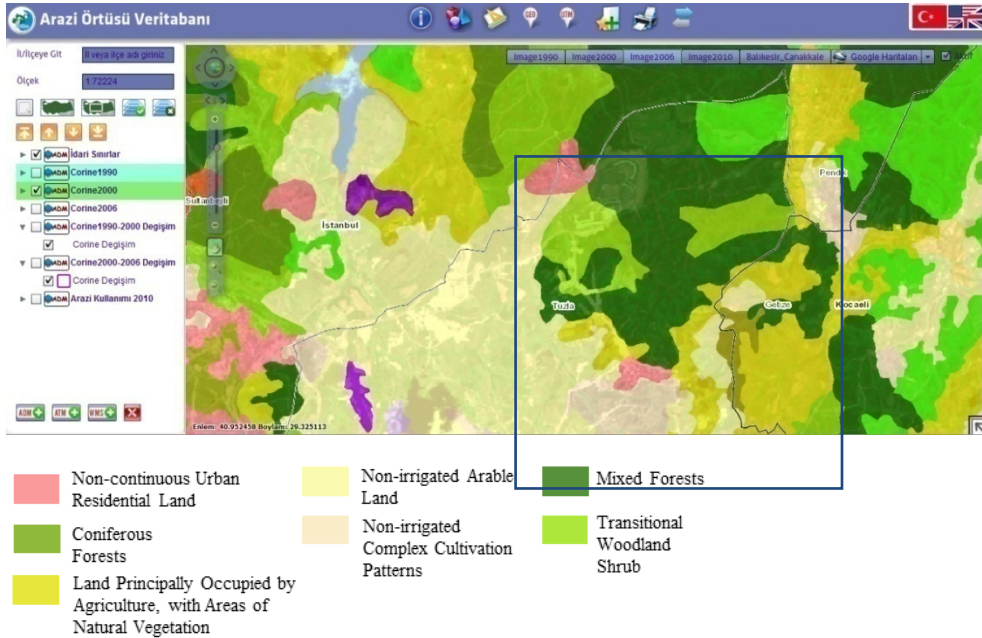

Figure 11: CORINE Land Cover Maps of the Year 2000 Obtained from the National Land Use / Land Cover Databases
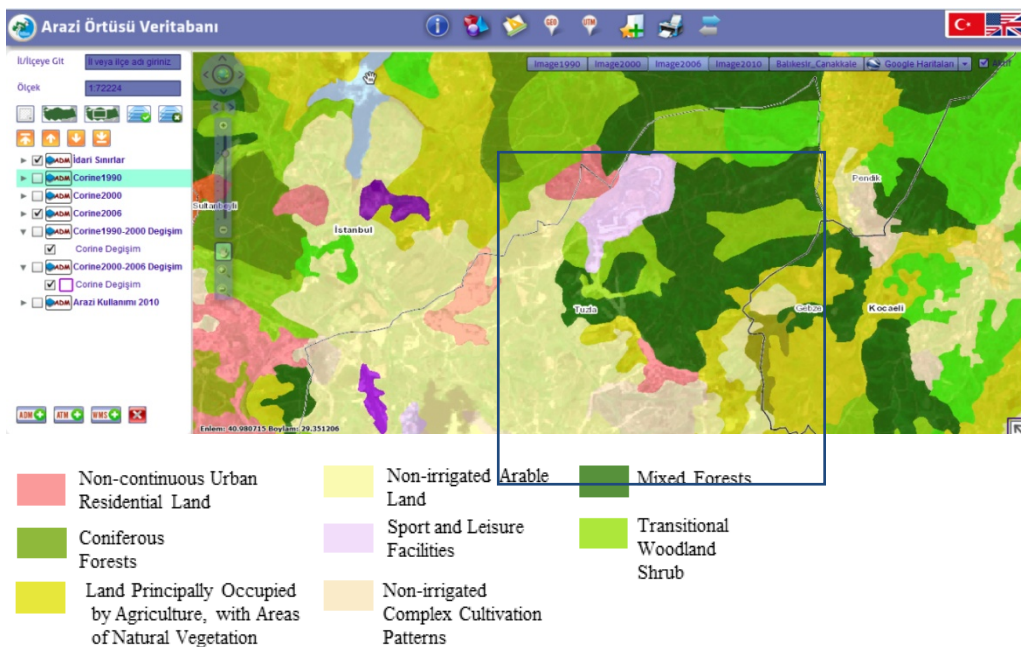
Figure 12: CORINE Land Cover Maps of the Year 2006 Obtained from the National Land Use / Land Cover Databases
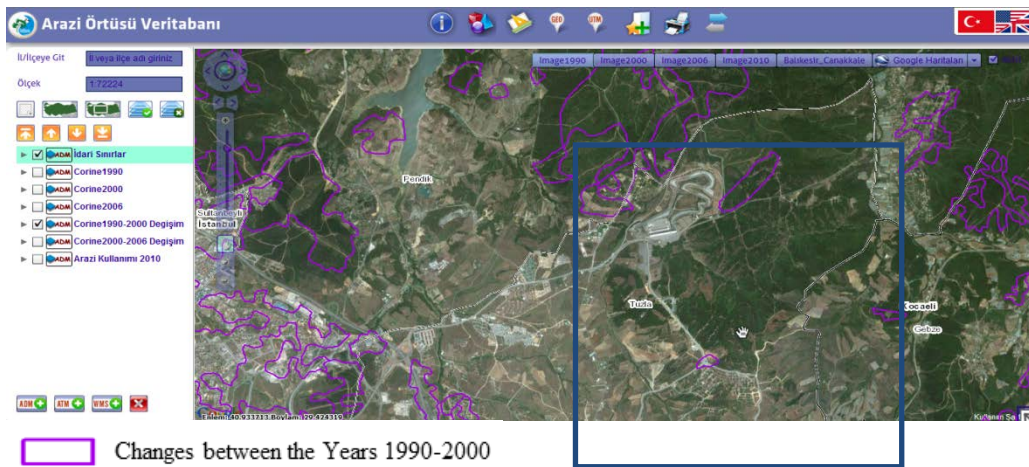

Figure 13: Mappings of CORINE Land Cover Changes between the Years 1990-2000 Acquired from the National Land Use / Land Cover Databases
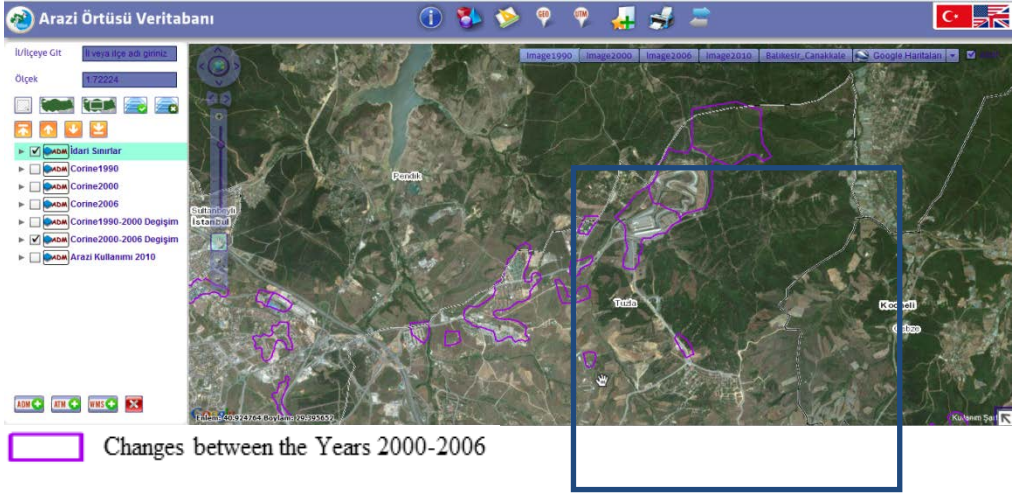
Figure 14: Mappings of CORINE Land Cover Changes between the Years 2000-2006 Acquired from the National Land Use / Land Cover Databases

Conclusions

This study was conducted for the purpose of determining the land cover change between the years of 2003 and 2010 in Akfırat and its surroundings, which is one of the new residential areas placed in the southeast of Istanbul. In the study, Landsat 7 ETM+ 2003 and Landsat 5 TM 2010 satellite images, ground truth data, CORINE land cover classes, Vector Layers and National Land Use / Land Cover Databases were used as data. In the study, Unsupervised Classification method in the ERDAS Imagine© 9.1 software and On Screen Digitizing method in the ArcGIS© 9.1 software were applied. Finally, spatial calculation of land cover as hectare was performed and the amount of change of land cover was calculated statistically. And accordingly, results in below were procured:

➢ Land cover classes for the years of 2003 and 2010 were determined according to the CORINE land cover classification, with the on screen digitizing method in ArcGIS© 9.1 software with Geographic Information Systems of Landsat 7 ETM+ 08/05/2003 and Landsat TM 08/09/2010 dated satellite According to this, land cover classes;

- Road and Rail Networks and Associated Land,
- Non-continuous Urban Residential Land,
- Non-irrigated Arable Land,
- Mixed Forests,
- Sport and Leisure Facilities

- In Akfirat and its surroundings, the year 2003 land cover composes of Road and Rail Networks and Associated Land, Non-continuous Urban Residential Land, Non-irrigated Arable Land and Mixed Forests.
- The year 2010 land cover composes of Road and Rail Networks and Associated Land, Non-continuous Urban Residential Land, Non-irrigated Arable Land,Mixed Forests and Sport and Leisure Facilities.
- In terms of area the year 2003 land cover classes contained in itself, the biggest portion was taken by Non-irrigated Arable Land with 2162.6 hectare. Secondly, Mixed Forests with 1739.2 hectare and thirdly, Non-continuous Urban Residential Land with 98.4 hectare take place.
- In terms of area land cover classes covered in the year 2010 land cover, it is aligned as; Non-irrigated Arable Land with 1927.5 hectare, Mixed Forests with 1508.1 hectare, Non-continuous Urban Residential Land with 368.6 hectare and Sport and Leisure Facilities with 195.6 hectare
- When the areas of land cover classes of the years 2003 – 2010 are statistically calculated, the biggest change was seen in Non-continuous Urban Residential Land with 271 hectare and 275,4% increase. Contrary to this situation, a decrease close to each other was determined with a drop of -235.3 hectare and -10,8% in Non-irrigated Arable Land and a drop of -231.1 hectare and -13,3% in Mixed. A class named as Sport and Leisure Facilities was added to the land cover in the year 2010. This situation is the clearest indicator of change in land cover.
- In order to verify the accuracy of mappings of land cover changes obtained by unsupervised classification and on screen digitizing methods in the years 2003 and 2010, mappings of CORINE Land Cover and Land Cover changes of the years 1990 – 2000 – 2006 acquired from the National Land Use / Land Cover Databases were used. According to this, the year 2003 land cover map shows coherence with the 2000 land cover maps obtained from the National Land Use/ Land Cover Databases. Land cover classes in both maps cover the shared areas about the same. These similarities were determined more clearly in mappings of CORINE Land cover changes of the years 1990 – 2000 and 2000 – 2006 that were obtained from the National Land Use / Land Cover Databases. The Formula 1 Istanbul Park Racetrack and Facilities, which was constructed after the year 2002, caused vital changes in land cover. This situation can be observed clearly in the year 2006 National Land Use / Land Cover map.
- The event that started the change of land cover can be said to be the Formula 1 Istanbul Park Racetrack and Facilities racetrack being located in Akfirat and its surroundings in 2002.
- Not being able to solve the conflict occurred with the Bernie Ecclestone, which as of 2011 has the trade rights of the Formula 1, in the meetings during the Turkey Grand Prix, caused the Turkey foot of the race to be ended. After this, 11-13 May 2012 FIA European Truck Racing Championship and 22-24 June 2012 Eastern Europe Motorcycle Racing were carried out. Akfırat and its surroundings, which is included in Non-

continuous Urban Residential Land, continue to pursue its development with new projects as being one of the new residential areas of Istanbul.

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