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Determination and monitoring of land use changes by using quickbird satellite data and aerial photographs in a selected area of the Northern Adana in Turkey

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Abstract

In this study, high-resolution QuickBird satellite images of year October 2006, visual interpretation of aerial photographs of year 1989 and the land cover and changes in land use of North Adana in Turkey between 1989-2006 were monitored and analyzed. In each Picture that imported into GIS, residental areas, agricultural areas, forests, water surfaces and the other categories have been determined. The study area in North Adana in Turkey was determined first as 41.932 hectares, while in 1989 the city center residential areas were 1.351,86 hectares in 2006 they turned into 2.956,25 hectares, and showed 118,68 % increase, indistrial areas expanded from 115 hectares to 148,7 and showed 29,36 % increase. Dry agricultural lands turned from 12.442 hectares into10.728 hectares and decreased by % 13,8. The statistical data obtained from results showed the dynamics of land use and also consisted a base for future planning.

Keywords: QuickBird Satellite Image/Wiev, Remote Sensing, Geographic Information System, Land Cover/Land Use and Land Change

Introduction

Making right decisions about the geographical area on which we live, to be able to solve problems is only possible with realized, reliable and current data. With Remote Sensing (RS) and Geographic Information System (GIS) technologies current data about natural resources can be obtained. (Aronoff, 1989).

Change Analysis is observing an object or a phenomenon at different times and it is an application that includes the detection of the differences. In general the change analysis includes a number of applications that targets detection of qualitative and quantitative changes in data sets at different periods. The important applications needed in change analysis are briefly; multi-time image record, geometric and atmospheric corrections. Accurate record of multi-time spatial data is very important, otherwise the results will be unreliable. (Townshend et al., 1992; Dai and Khorram, 1998; Stow 1999; Verbyla and Boles, 2000; Carvalho et al., 2001).

Widely applied fields that use the RS techniques in land use and land cover change analysis, are; forest vegetation change, loss of forest, forest productivity, renewability (regeneration), forest fires, change of wet areas, change in the fields of topography, the changes in residential areas along with the changes in agricultural cropping patterns. (Lu et al., 2004).

A wide variety of change analysis techniques have been developed so far. Development of change analysis techniques is still an active issue and new techniques are being developed day by day. For example, spatial

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mixture analysis, Li-Strahler Kanopi Model, Transformation of Chisquare, artificial neural Networks (ANN) and integration of multi-source data are used in applications of change analysis (Lu et al., 2004).

Adana is a big city of Turkey, which is growing rapidly and expanding in every direction and on the major transportation routes connecting Europe to Asia. Due to the presence of fertile alluvial soils in the South, this development is more asked and expected to be towards the North. Indeed, significant changes in land use have been observed in the North Adana.

In this study, the production of current Land Use Maps of North Adana in Turkey is aimed and along with this purpose it is aimed to determine the changes in Land Use between the years 1989-2006 with the detection of land use. These are determined by forest vegetation change, change in wetland change in agricultural cropping patterns and almost all changes in land cover and land use, such as comparing the two cartographic data, satellite images and aerial photographs.

Material and Methods

Study Area

The study was caried out in North Adana 35 10 28 E 37 12 50 N latitude and 35 23 36 E 37 01 15 longitude, approximately 21 miles long and 41.930 hectares, starts with the Çatalan Dam and extending to the South of the Seyhan Dam Lake. This defined aresa is located within the boundaries of Sarıçam and Çukurova districts of Adana (Figure 1).

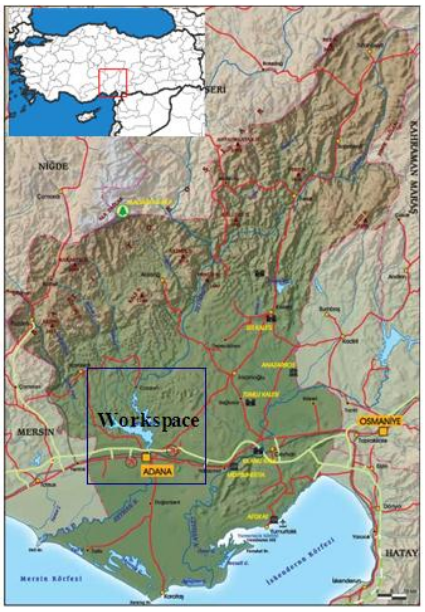


Figure 1. The Geographical Location of Study Area

1:15000 scale black and white stereoscopic aerial photographs of the study areas taken in 1989, QuickBird satellite data with high distinction power conceived in term of minimum terestrial vegetation dated October 05.2006, and 23, October 2006, digital topographic maps, geological and geomorphological maps were used as material.

To benefit the high spatial resolution of image and the spectral characteristics of sensors were developed and used by appliying 0.61m resolution QuickBird panchromatic channel, resolution matching/overlaying (pansharpening) instead of the first main component (2.44m resolution) QuickBird's four spectral channels.

Process of Land Evaluation

Geographical corrections of satellite images were made in reference to topographic images. Then, mosaic images of data have been obtained by using the Erdas Imagine 8.4 Professional Program. Aerial photographs were interpreted under the stereoscope by eye, then land use was identified and so the geographic adjustments were made and the photographs were digitized. Then the land use was determined by eye interpretion as it was with aerial phtographs by image enhancement on QuickBird satellite data (Şenol and Dinç, 1994), and with eye interpretion on the enriched image (Sesören, 1998).

These interpretions were controlled and selected from different places in test areas, so the interpretion errors/mistakes were corrected. At the end the aerial photographs of the year 1989 together with the land use map of 2006 that identified by satellite imagery by using ArcGIS 9.2 Software changes in land use were determined. In the sudy the pros and contras of both carthographic materials in determining land use were identified. The flowchart of this research is presented in Figure 2.

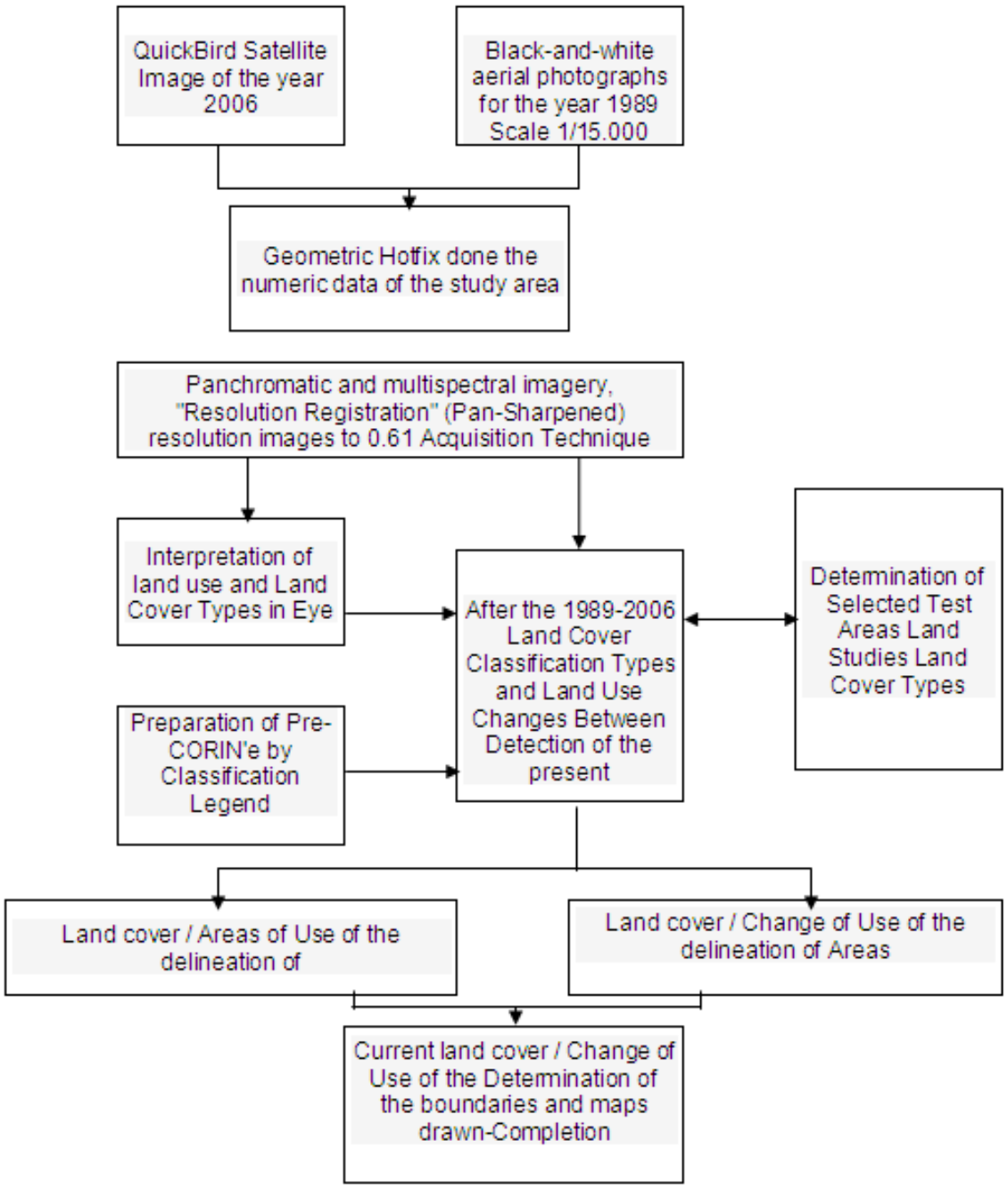


Figure 2. The Flowchart of Study Method

In this study the land cover changes and land use of North Adana in 2006 and the land cover- and land use changes took place from 1989 untill 2006 examined. For this purpose 14 units 0.6m high resolution QuickBird satellite imagery of 2006 and 150 units 1:15000 scale aerial photographs of the year 1989 were used and so by the method based on CORINE (Coordination of Information on the Environment), which is stil in force in the European Union, Land Cover/Land Use, Land Cover/Land Use Changes have been obtained.

Results

Existing Land Cover/Use of the Study Area

Based on CORINE land cover/land use classification system four levels were identified in land use types of study area. There are four main categories in Level1 identified in the study area. According to CORINE these are; Aritificial Surfaces, Agricultural Areas, Forest Areas and Water Surfaces. There are 10 main topics in

Level 2 like City Structure, Indutrial, commercial and transport units, mine discharge and construction sites, Suitable Areas for Agriculture, Continuous Products, Forests, Shrubs, Dam Lake, Stream, Dam Lake Mirror. In Level 3 eleven main categories were examined; continuous urban structure, Industrial Zones, Highway, Places received from Raw Materials, Bare Lands, Dry Agriculture Lands, Irrigated/Wet Agriculture Lands, Fruit Orchards, Olive Orchards, Dense Forests and Sparse Forests. In Level 4; detail classes of land cover were collected under three main headings as creating and defining third level sub-classes of CORINE database. These are; City Center Residential Areas, Rural Settlement Areas and Villa Type Residential Areas. Current land cover/use maps in 2006 and the land cover/ land use changes occured between the years 1989-2006 were collected totally in 30 threadeers in the form of 1/20.000 scaled maps.

As of 2006, the Land Cover/Land Use Map of Northern Adana was given in Figure 3 and spatial data of these given in Table 1. Considering the size and scale of the study area the detailed classess seem very diffuse (to avoid confusion) thy were only shown in the first and second levels in Figure 3.

Table 1. The General Surface Measurement Rates of Research Area and the Changes Rates and the Areas Covered by Form of Land use for the Years 1989-2006

Level	Land Use Type	Covered Area		Change (ha)	Change (%)
		1989 (ha)	2006 (ha)		
1.1.1.1.	Settlement Areas of City Centre	1.351,8622	2.956,25	+1.604,38	+118,68
1.1.1.2.	Rural Settlement Areas	208,2865	208,32	+0,03	+0,02
1.1.1.3.	Villa Type Settlement Areas	8,6902	99,43	+90,74	+1044,15
1.2.1.	Industrial Zones	114,9551	148,70	+33,75	+29,36
1.2.2.	Highway	-	134,05	+134,05	+100,00
1.3.1.	Places Imported Raw Material	149,87	160,42	+10,55	+7,04
1.3.2.	Bare Lands	562,89	512,15	-50,74	-9,01
2.1.1.	Dry Agriculture Lands	12.442,47	10.728,41	-1.714,06	-13,78
2.1.2.	Irrigated Agricultural Lands	6.171,64	6.183,89	+12,25	+0,20
2.2.2.	Fruit Orchards	427,54	541,44	+113,90	+26,64
2.2.3.	Olive Orchards	147,27	327,12	+179,85	+122,12
3.1.1.	Dense Forests	5.740,59	5.845,86	+105,28	+1,83
3.1.2.	Sparse Forests	3.273,05	3.002,27	-270,78	-8,27
3.2.	Shrubs Covers	4.170,78	3.899,86	-270,92	-6,50
4.2.	Rivers	258,32	258,32	0	0
4.3.	Dame Lake Mirror Covers	2.435,58	2.454,65	+19,07	+0,78
	Other Ways	809,47	840,54	+31,07	+3,84
	Total:	**38.273,24**	**38.301,68**		

The study area is 41.932 hectares, city structures with 7.75 % have 3.264 hectares in total area. From these, City Center Settlement Areas constitute with 2.956,25 hectares 7,05 % of total study area, Rural Settlement Areas with 208,32 hectares 0,5 %, Villa Type Settlement Areas with 99,43 hectares 0,2 % total of teh study area. Industrial, commercial and transport units are 282,75 hectares and they cover 0,7 % of total area. While in 148,70 hectares area the Industrial Zone constitute 0,4 % of total area, the highway covers 134,05 hectares with 0,3 % . Mine, Excretion and construction Ares are 672,57 hectares and represent 1,6 % of the total area. From these areas the raw material places correspond 0,4 % of total area and have 148,70 hectares field. Bare lands cover 1,2 % of total area and have 512,15 hectares area. The 16.912,3 hectares area corresponding 40,3 % of total study area (41.932 hectares), constitutes Agricultural Fields. Irrigated/wet agriculture is made only on 6.183,89 hectares of this area, and on the area of 10.728,41 hectares is made Dry Agriculture. Irrigated/wet Lands constitue 14,7 % of total area and also the dry agriculture areas 25,60 % of the total area. Climatic conditions, existence and use of water resources, factors such as presence of agricultural land and convenience of it, have significiant influence on agricultural industry.

Continuous Products with 868,56 hectares cover 2,1 % of total study area. Of these products; Fruit Orchards constitute 1,3 % of total study area with 541,44 hectares and Olive Orchards constitute 0,8 % with 327,12 hectares. Forest Lands are 12.748 hectares and they cover 30,45 % of total area. Dense Forests cover 14 % of the total study area with 5.845,86 hectares, Sparse Forests again with 3.002,27 hectares cover 7,15 %, and Shrubs cover 3.899,86 hectares and 9,3 %. Water Surfaces are totally 6.343,63 hectares and they cover 15,1 % of the study area. In total study area the Dam Lake covers 8,65 % with 3.630,66 hectares, Streams cover 0,60 % with 258,32 hectares and the Dam Lake Mirror covers 5,85 % with 2.454,65 hectares. And the other ways are 840,54 hectares and they correspond to 2 % of the total study area.

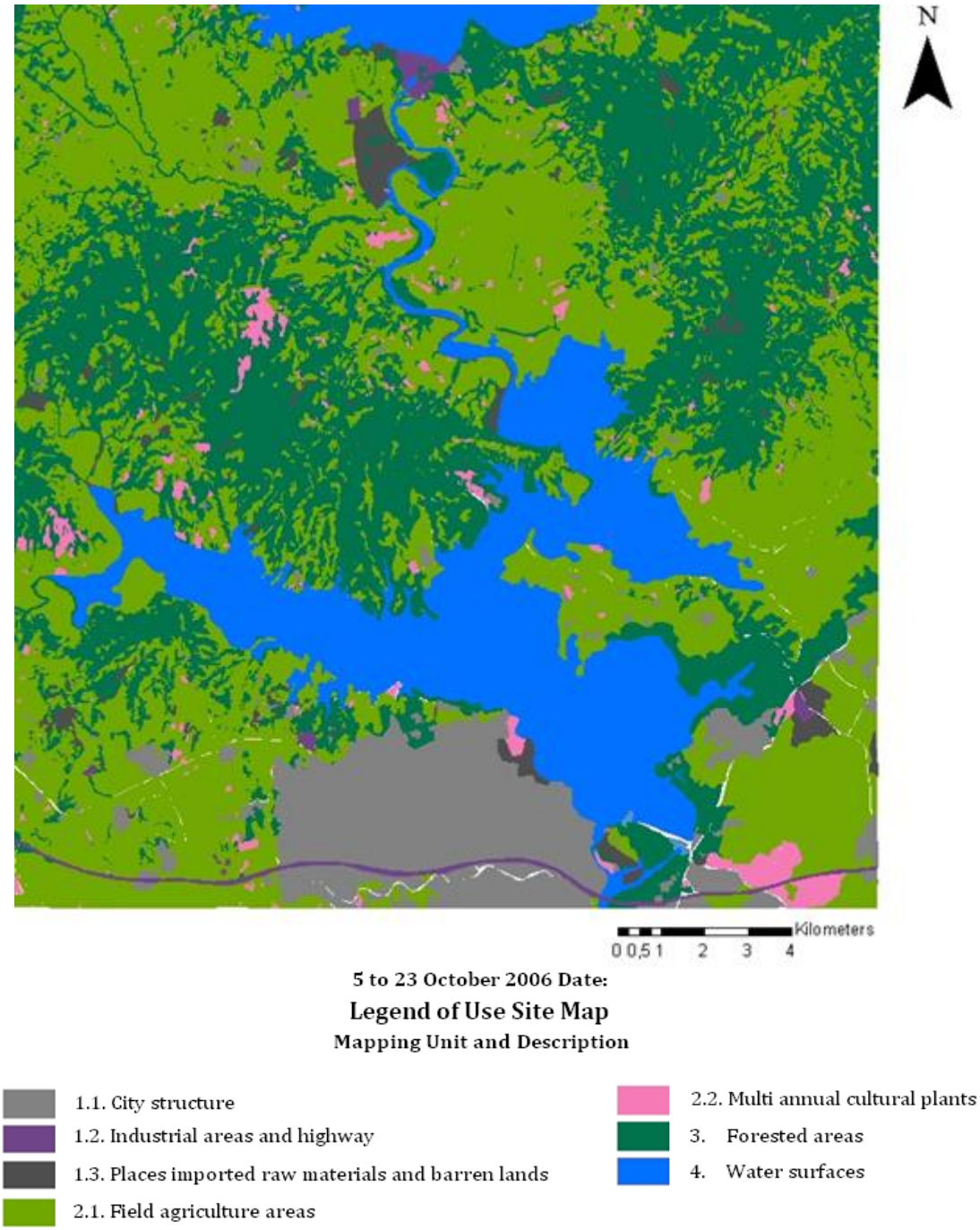
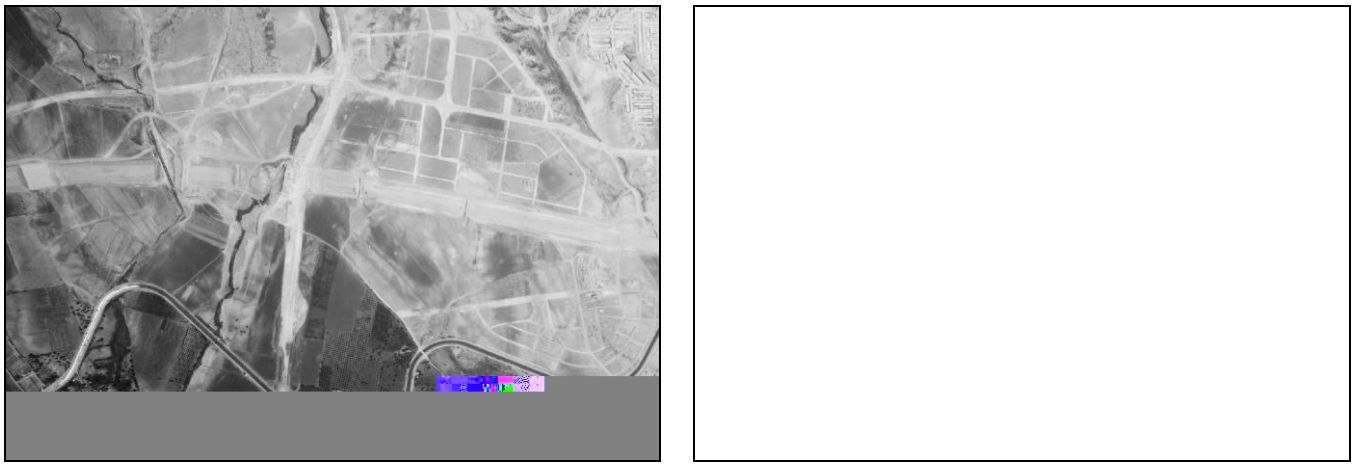


Figure 3. North Adana Land Cover/Use Map of the Year 2006

Existing Land Cover in the Study Area/ Its Change in Use

Land use and cover change in urban areas and their surrounding areas, monitoring and detection of these changes and the rapid population increase in recent years and as a result of this it has gained importance for the optimal use of natural sources (Small and Miler, 1999). Uncontrolled industrial and urban development can cause losses that can not be recovered. Many problems can arise such as; using fertile agricultural lands as industrial areas, the destruction of forest areas for use as agricultural land, structuring the residential areas on inappropriate surfaces. In order to prevent and monitor unplanned development, temporal changes should be identified required plans should be made. In recent years with the change in tracking techniques using the satellite data to obtain the desired results more successfully than short time and conventional methods (Tunay and Ateşoğlu, 2004). The changes in existing land use of study area that occured between 1989-2006 have been determined.

City Center Residential Areas, the majority of the land consists of buildings and transportation Networks. Buildings, roads and artificial areas cover a large part of the total area. This class consists of apartments, houses, streets, and parks. Land use can change depending on years. It was found that in 1989 the dry agricultural land use structure turned in 2006 into continuous city structure. This evident is clearly seen in Figure 4. Satellite images and aerial photographs of the same area at different dates (1989-2006). Rural Residential Areas are seperated from other settlements by the presence of vineyards, orchards and cultivated agricultural areas. Furthermore they are a type of remote settlements to the city center. There are 33 villages in the study area. Villa Type Residential Areas are villa style residential areas that located near the city center and also include the certain city parts in rural areas. Villa type settlements cover 99,43 hectares. In 1989 this value was determined to be 8,69 hectares. It is found taht ther is 1044,15 % increase in villa type residential areas. Especially heavily expanding of residential areasis quite remarkable (Table 1 and Figure 4).

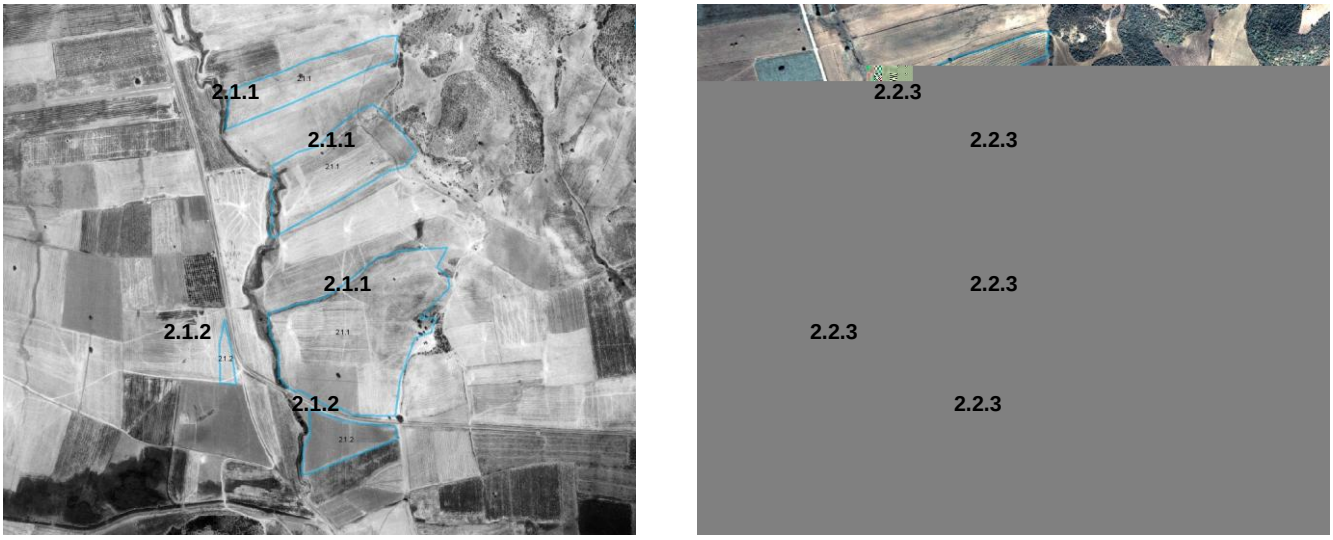


(a) (b)

Figure 4. Aerial Photograph of the Year 1989 (a) and QuickBird Satellite Image, dated October 2006, A Section from Areas that turned to City Center Settlement (b)

Industrial districts, are non-vegetated artificial areas (cement, asphalt, bituminous, slag, graul, etc.). Mostly buildings and/or plants are present in this class. Industrial areas can be distinguished on images by their structure and texture. Its typical tissue is heterogeneous (such as mixture of large buildings, car parking areas). This class includes the roads and car parking areas within commercial and industrial areas. University areas, commercial centers outside of urban areas are in this class. Industrial districts cover 148,70 hectares. It was appointed that in 1989 industrial areas were 111,955 hectares and now there is 29,36 % increase in indurtrial zones, repectively. Highway includes Gaziantep-Adana-Ankara Highway, which is wide and passes through the study area,_Highway covers 134,05 hectares. In 1989, this highway was not any highway yet. The areas of raw material includes some areas such as; extraction area of construction materials, stone and sand quarres or other quarries, limekin. They include quarries ofgravel that are formed by flood. Working or abandoned in near time and non-vegetated quarries are in this class. Highways and dams under construction take place in this class. Bare lands are defined as areas without natural plant cover, on which there is not any agricultural activity due to the lack of natural soil. These areas were determined by using aerial photograph and satellite imagery with land survey. Dry Agriculture Lands are areas where field crops such as cereals, fodder, sunflower, cotton cultivated. Plowed areas cultivated by processing and also the temporary and artificial pastures under rotation are included in this class. It was found that the dry agricultural lands 12.442,47 hectares in 1989, now there is 13,78 % decrease rationally. The decrease is because of the transition of irrigated agriculture and fruit orchards facility and usually by means of shipping ton on-agricultural uses. Irrigated farm areas are lands where cultivation of single year products are made by means of drainage network or continuous/periodic irrigation canals products such as watermelon, corn, peanut, potatoe, pepper, eggplant are grown in these areas. 0,20 % increase is determined in irrigated agricultural lands and this increase is thought to be as a result of the development of techniques used for irrigation. Fruit orchards are places where there are fruit orchards. They can be found in the form of single sor tor mixed fruit orchards. Citrus, loquat, apricot, nectarin, date, prunes and pomegranate orchards. An important part of this use consist of citrus and pomegranateorchards. Fruit orchards, where a few/several types of trees are grown, classified under class 2.2.2. Olive orchards are areas where there are

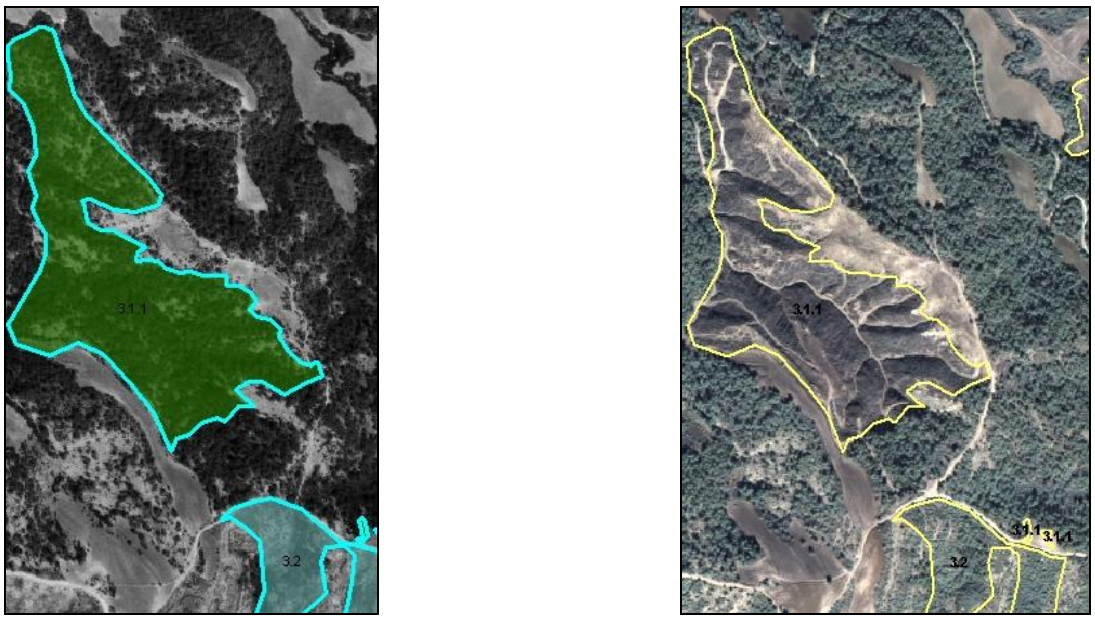
olive trees. In 2006 olive orchards cover 327.12 hectares. It is determined that this value was 147,27 hectares in 1989, and there is 122,12 % increase between 1989-2006 (Table 3 and Figure 5).



(a) (b)

Figure 5. Aerial Photograph for the year 1989 (a), High-Definition QuickBird Satellite Image for the year 2006 (b)

Dense Forests are areas where tehre are red pine forest dominantly. Eucalyptus planted areas that the edges of water or wet areas are included in this use in general. Sparse forests, where areas in high places covered with scattered vegetation are also in this class. They are places that dominantly coniferous trees and the plant structure formed by there are nurseries. Sparse forest cover 3.002,27 hectares. It is determined that it was 3.273,05 hectares in 1989, and there is 8,27 % reduction in the sparse forests. It is found that the reduction in sparse forests is caused by opening the forest areas for agriculture, turning them into settlement areas or because of the forest fires (Table 3 and Figure 5, 6).



(a) (b)

Figure 6. 1989 Aerial Photograph for the year 1989, Change in Forest Areas (A), QuickBird Satellite Image for the year 2006, Change in Forest Areas (b)

As shown in two different cartographic materials of the same area (one is in 1989, the other is in 2006) the areas that previosuly covered with trees and areas masked with green are disappeared. It is seen that this area turned into bare and dry agriculture lands (Figure 6.). This is particularly due to the removal of prennial trees for various reasons over the years. Shrubs are pastures with low productivity. Mostly they are lands,

where there are rugged, scattered, on uneven surfaces, partly rocky areas, thorny wild bushes a member of scrub group, bushes and hedges dominantly located. Generally they are slopy and unsuitable for agricultural processing. Dam Lake, the reservoirs of Seyhan and Çatalan Dam's are in this use. There is little seasonal change by coasts and they are constantly covered by water. They are seperated by a piece of land vby coasts or seperated with a similar topography of lake and spreading fresh water areas. Dam Lake covers 3.630,66 hectares. It was 2.884,14 hectares in 1989, it is found that ther is 125,90 % increase in Dam Lake. The source of these increase is from the work area within the new built Çatalan Dam Lake's (Table 3.) Rivers are waterways serving as water drainage channels, and also artificial and natural spreading ways of water. They include rivers and canals. Dam Lake Mirror, areas that are under water when the water level reaches its highest code in spring, on the other hand areas on which grazing an deven agriculture made, areas in dam lake whose water height change seasonally, and areas such as river banks have been included in this class. Dam Lake Mirror covers 2.454,65 hectares. This value was 2.435,58 hectares in 1989 and there is 0,78 % increase in dam lake mirror. It was found that this increase is because of seasonal water use and rainy or dry seasons, and also, because of the new Çatalan Dam (Table 3). In the study area except for the highway, other transportation Networks are defined under the name of the Other Roads and in total they cover 840,54 hectares. In 1989 it was 809,47 hectares, so the increase is found to 3,84 % (Table 3).

Discussion

While for the year 1989 aerial photographs were used, in 2006 the QuickBird satellite data was used in determining the land cover/use. North Adana land cover / use in determining the total area of the magrin of error using QuickBird satellite data is very clase the zero. There is not any scale mistake in Studies made with high definition Satellites like QickBird, also the error rate in defining the boarders and calculating the areas is quite low, while all of the earth objects seen clearly. In this study, where the changes in land cover/use between 1989-2006 determinated, the cause of the 0.07 % difference in total area are the different cartographic materials used in both studies.

Conclusion

Nowadays in many working fields applications that oriented first of all towards environment in RS, CBS, City Planning and in cartography applications, there is a great need for the geographical data of Land Cover/Use and Land Cover Use Change. In the extent of the study, the Features of Land Cover Detail Class' had been determined., the Land Use Types had been described, the Land Cover and Land Use Changes existied between the years 1989-2006 had been found and their hierarchical tables were created.

By using 2006 land uses QuickBird satellite data, the boarders were determined on monitor with eye interpretion and by comparing with the aerial photograph of 1989, the changes in last 17 years had been determined. It has been succesfully proved that the QuickBird satellite views can be used in mapping of land use and land cover types and partly in land controlling.

While the satellite data multiple banded is and it can be continued to study with the desired scale (like 1:1.000–1:5000), it is easier to distinguish earth objects. When the aerial photographs are used for the same purpose, problems can be experienced. For example; geographic correction of each aerial photograph and then converting them into mosaic is quite time consuming and an high error rating process. The scale errors in aerial photographs are more than in satellite views. It can be required to use a lot of aerial photographs instead of satellite view, and that can increase the cost. Despite this, aerial photographs is a very important data for searching temporal land cover/use changes. Compared to aerial photographs, the colored satellite views are superior and due to the IR feature they facilitate in determination of land cover. Sattelite data can be processed easily and the updates can be made without difficulty. The old dated aerial photographs and current satellite views are of the most important cartographic materials that can be used in land cover/use change determination. At the end of the study with high scale like 1:2000 and 1:5000, because of the large study area there could be problems in big scale printing and duplicating experienced, by producing the land use and land change maps of North Adana with 1/20.000 scale the field information for each land cover/use type was easily obtained.

In this study it has been proved that the possible changes in land cover and use can be determined with RS data and aerial photographs. It has been determined that there is a rapid structural change from 1989 till 2006 in city center residential areas, and because of this change; forest areas, scrubs and agricultural areas exposed to reduction. The development has been opposed to forest areas and agricultural areas. This unconscious and unplanned development is an important problem continuousness of natural resources.

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