Monitoring Land –Use Changes by GIS and Remote Sensing Techniques: Case Study of Trabzon

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Key words: GIS, remote sensing, urban development, land use.

SUMMARY

While determining future growing-areas of cities, monitoring city-growth, in other words, determining land-use changes has an important role in urban development. Immigration, especially emerged from improvement of industry, is an important factor causing urban land-use changes. In last 15-20 years period, collapse of Soviet Union and opening Sarp customs have contributed to considerable income for the Black Sea regional economy in Turkey. The city *Trabzon* which is the centre of the Black Sea region has been mostly affected from this economical development. Emerging of shore-trade and consequently, improving commercial activities and activating regional tourism caused to immigration from surrounding cities to Trabzon. In addition to this, increasing population density due to local population-growth caused to changes in urban land-use. In this study, in order to determine Trabzon's land-use changes in the last 40 years, required data was acquired for 31 square kilometer area, processed, analyzed and some queries were executed. In this respect, Standard Topographic Maps, produced in 1960, and in scale of 1/25.000, were digitized and required vector data was overlaid on it. Besides, four aerial photographs - 1974, Landsat 5 TM image - 1986 and Landsat 7 TM+ image - 2000 were provided. This data processed using GIS and Remote Sensing techniques.

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1. INTRODUCTION

Urban land cover types and their areal distributions are fundamental data required for a wide range of studies in the physical and social science, as well as by municipalities for land planning purposes (Stefanov, 2001). Approximately 85% of the European Community's population lives and works in urban areas (Barnsley, 2000). In Turkey, these ratios were 60% in1990 and 65% in 2000. As for Trabzon, these figures were 42% and 50% respectively (DIE). This spatial concentration of human activity has very significant environmental and economic impacts both within and beyond the immediate urban fabric arising from the need to serve it with appropriate physical resources and to dispose of the resultant waste products. In last 15-20 years period, collapse of Soviet Union and opening Sarp customs have contributed to considerable income for the Black Sea regional economy in Turkey. The city *Trabzon*, which is the centre of the Black Sea region, has been mostly effected from this economical development. Emerging of shore-trade and consequently, improving commercial activities and activation of regional tourism caused to immigration from surrounding cities to Trabzon. In addition to this, increasing population density due to local population-growth caused to changes in urban land-use.
Trabzon city is door open to Asia for West Black Sea region and Turkey, and second Center of World Trade in Turkey has just been build here. These features increase the importance of Trabzon. In addition, having an international airport and providing land and sea arrival add extra density for Trabzon city. These conditions display a face to face dense housing and commercial area demand in the future.

One of the important problems for developing countries is public improvements, and it stays behind urbanization movements. As a result of population growth, some quick development projections are usually occurred. On the other hand, administrators cannot monitor appearance of ill-shaped urban developments.

The technologies of Geographical Information Systems (GIS) and Remote Sensing have been combined to detect and control urban encroachment in a way which is easier and faster then the traditional methods of surveying the urban environment **(Da Costa, 1999).** In this study, in 1960 – 2000 years period, land-use changes in Trabzon were examined. Changes in residential areas and shoreline changes were exposed. Urban land-use characteristics were combined with some plans aiming at urban development and thus it is proposed for future land-use decisions to local authorities.

2. HISTORICAL PUBLIC IMPROVEMENTS OF TRABZON CITY

It is not known when and who was established city of Trabzon. In addition to this, it is supposed that first permanent settlements were made years of B.C. 2000. Silk Road which connect Europe and China each other, passed through city of Trabzon in middle era. Trabzon was a harbor city and a capital of the region in that time. Trabzon is a historical city and lies along Black Sea shores (figure 1). Land is mountainous and rough. So, agricultural activity is limited. Because of topographic structure, housing areas are located closely, and state road lies through shore along which the city developed mostly linear.

In the past, since Trabzon city was on the Silk Road, Trabzon become a continual trade center. Especially, after Soviet Union was established, the district lost its old importance. However, opening Sarp customs caused economical development (DPT, 2000). It is the most developed city in the region in such social activities as commerce, education, health care services and arrival. In a study published in 1993, the population rate coming Trabzon from surrounding cities for trade, work, educate – health and temporarily for a day determined as 1.26, 2.88, 3.72 and 3.61 respectively (Aydemir, 1993). Another factor for increasing urban density is tourism. In last years, development of tourism effected city of Trabzon. Especially, in last 10 years, as a result of collapse of Soviet Union, Trabzon city become a door which is open from Europe to Middle Asia. In 1999, 438.525 tourist visited Trabzon from independent Russian States.

Figure 1. Location of Trabzon City

Past urban land use development of Trabzon should be examined as two main title; planned period and not planned period. It is seen in Figure 2 that general housing area for city of Trabzon according to historical stages belonged to not-planned period. Firstly, city of Trabzon is established in centre (inside castle), then developed along shore. The first appearance of urbanization which brought a convenient public improvement to Trabzon city began with the plan prepared by French architect J. Lambert in 1938 (İller bankası, 1967). This plan was in force until 1967. Second plan is made in 1967 then revision public improvements are made in turn in order; 1977, 1984, 1989 and 2002. In these planning studies, urban development was not estimated and the city enlarged along shore and vertically (by increased number of floors). In other words, planning and application of plans were not been able to reach city's development speed (Report of Trabzon municipality, 2002).

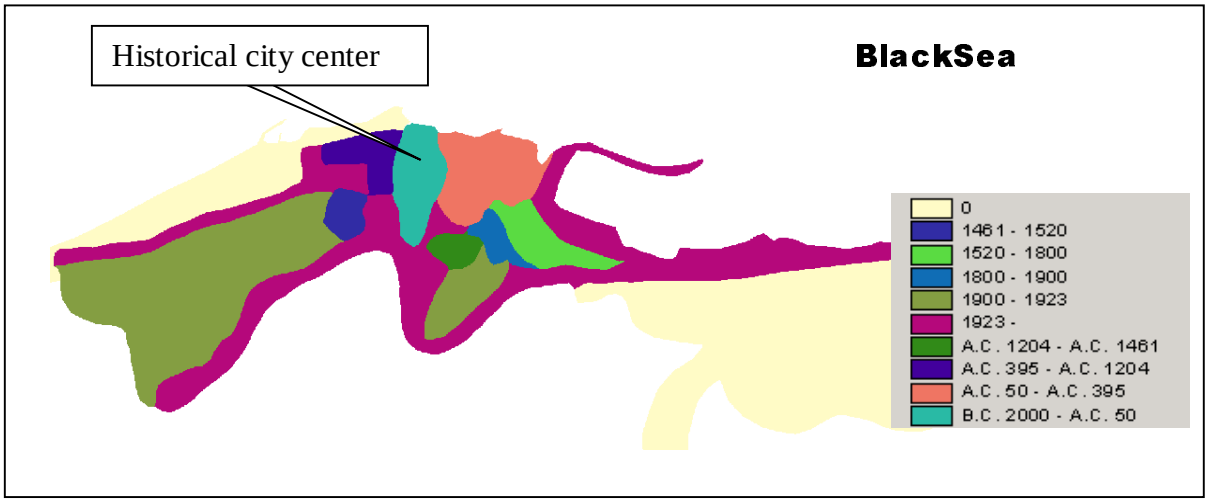

Figure 2. Trabzon city historical development

3. METODOLOGY

3.1. GIS and Remote Sensing Data Processing

In this study, in order to expose changes of settlement areas of the city in the course of time, it was used such materials as a topographic map captured in "Report of Analytical Investigation of the City Trabzon" which was published in 1960, 5 aerial photographs (1:23000 scaled) gathered in 1973, a Landsat 5 image of the year 1986 and a Landsat 7 ETM+ of the year 2000. Additionally, a new topographic map of the city produced in 2000 was used to transform raster and vector data from different coordinate systems into modified 3^o UTM coordinate system – a unique coordinate system.

Initially, the topographic map of 1960 scanned and the map transferred to the digital form. This raster data digitized on the screen using Arc/Info GIS software and settlement areas were determined in vector form. In the second step, making use of the digital topographic map of 2000, 5 aerial photographs rectified and combined using mosaicing method in ErMapper software. On this combined image model, settlement areas were determined manually. After that, rectification of Landsat 5 and Landsat 7 ETM+ images were realized similarly. Using this two images, to determine residual areas, it was used 432 RGB false composite images. Settling areas and vegetation areas were determined under two main classes using ArcView Image Analysis software.

3.3. Monitoring Urban Residential Growth

The studies of monitoring urban residential growth of Trabzon city were first started with a topographic map prepared in 1960 (Figure 3). Comparing this topographic map with the map in Figure 2 showing historical development of the city, it is understood that the ancient historical structure of the city was preserved up to 1960. In the city, residential production was quite restricted until 1960`s. After those years, constructional activities increased

depending on population growth. Residential growth in Trabzon developed through such aspects as being filled gaps in residential areas due to the topographical barricades, renewing and spreading residential areas in necessary circumstances. Housing areas were intensified in the city-centre. In those dates, the population of the city was 65.000. When aerial photographs of 1973 are examined, it seems a growing inclination from the city-centre to outer areas (Figure 4). In addition to this, it is also seen some rare housing in future growing areas of the city. Especially, with the construction of airport and establishment of the university, an increasing residential construction was determined through the aerial photographs.

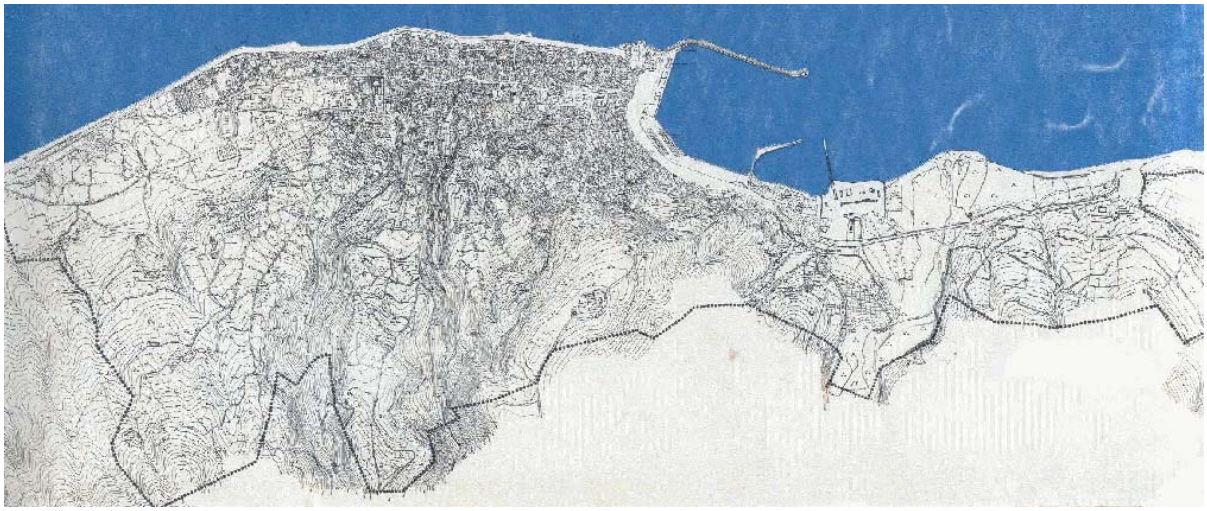

Figure 3. The Topographic Map of Trabzon in the year of 1960

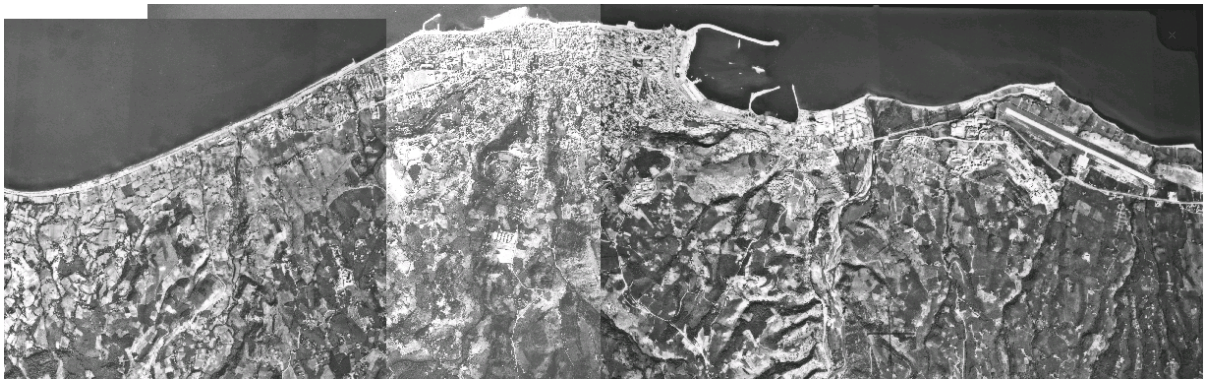

Figure 4. Aerial Photographs of Trabzon in the year of 1973

The clearest changes determined through Landsat 5 images of 1986 are especially appearing of light industry alongside the *Değirmendere* valley and, in consequence of this, increasing housing areas of the region (Figure 5). In addition to this, in surrounding areas of the university and the airport, continuing improvement of residential construction started in 1970`s. It is also seen an increasing settlement activity alongside the other roads that lies in south direction. The population of the city in those dates was about 130.000.

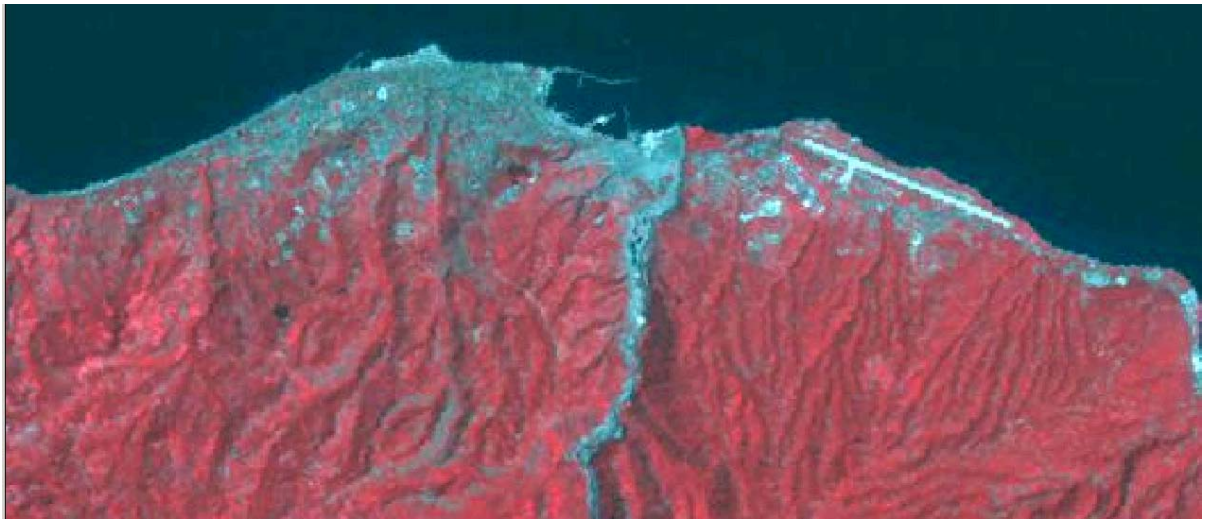

Figure 5. Landsat 5 satellite image of the year 1986.

The last data used in monitoring residential areas is Landsat 7 ETM+ image of 2000 (Figure 6). It is understood through this image that the impact on construction continues due to the attraction of the area around the university and the airport beginning in 1980`s. It is also seen that the construction alongside the roads which lies in south of the region continues similarly to the previous years. Apart from these, two important application raised after 1990`s have considerable effect on the growing areas of the city. The first of them is some development plan applications realized in agricultural areas in the west of the city. The second one is a main route planned parallel to the present main shore-road in 1960`s, started to construct after 1990 and continuing at present. The main aim of this road in planning stage was dragging the residential construction around the new road in south of the city. However, through four stage of this study, it is determined that the new road couldn`t reach the planning aim, at all.

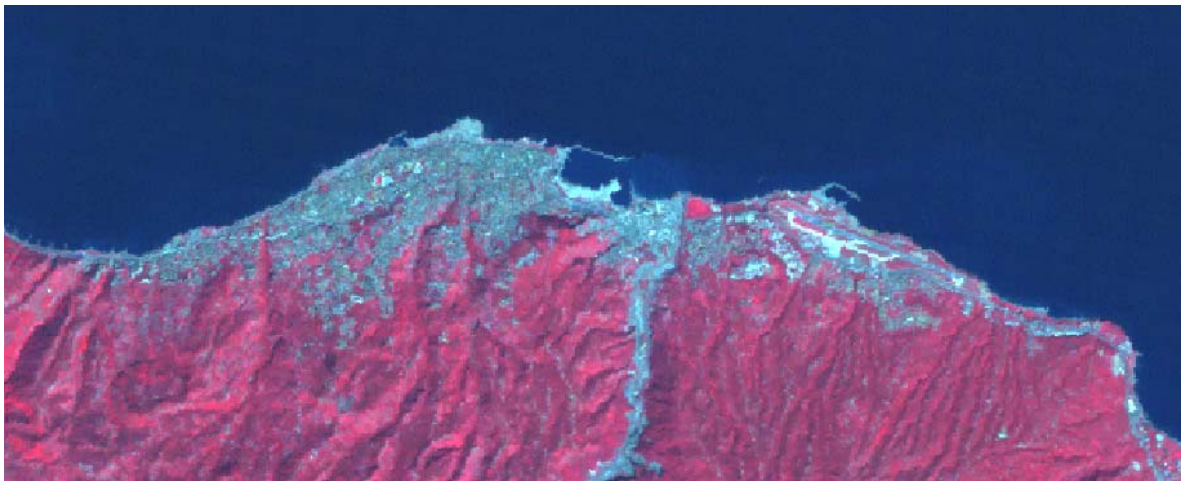

Figure 6. Landsat 7 ETM+ image of the year 2000

4. DISCUSSION

Using different types of data in monitoring urban development makes the study difficult. The main problem encountered during the study is using the data in different coordinate systems (scale, screwing, etc.) and structure (raster, vector). The changes on residential areas obtained via aerial photographs and satellite images between 1960 – 2000 as periods, using effective analyze techniques of GIS (Figure 7).

When *Figure 7* is examined, it can be seen that the city has been growing systematically along the shore-state road and from the city-centre to outer areas in south direction. Growing areas were shorter than that estimated especially between 1980 –2000 years. The reason of this is that some decisions about increasing density and/or storey numbers of housing areas in the city-centre were made in this period (Report of Trabzon municipality, 2002). On the other hand, when *Table 1* showing population information of the city is examined, it is seen that the population of the city increased to the number of 150.000, that is, multiplied by about four between 1960 – 2000 years. In addition to this, while the amount of the settlement areas was about 400 hectares in 1960, it is 1400 hectares in 2000. In this stage, it is seen that the aerial growing factor of the settling areas increased 3.5 times. That the population growth and physical growth of the city has a close rational does not indicate that the city has a regular development scheme. Because, while the housing areas increased, the residual naked areas didn`t increase in the same rate. On the contrary, the naked areas as well as the agricultural areas were transferred into housing areas. This changing stage can be determined through satellite images.

When reached the year of 2000, in view of urban residential activities, it is determined that it is reached to the turning points in east-west and south directions of the city. As long as this turning points aren`t broken, the city continues its growing in existing areas in vertical direction. Additionally, it is a fact that the local authorities may encounter some requests to use public areas as housing requirements. In some studies realized to determine probable settling areas of the city, it was also determined that the city completed its linear growth and residential construction activities have arisen and increased continuously in south of the city (Nişancı, 2001; Sancar, 2000).

Another change has emerged along the shore through the years 1960-2000. In this areas, in order to meet public requirements (roads, green areas, recreation areas, etc.), it has been struggled to gain some land by filling the sea.

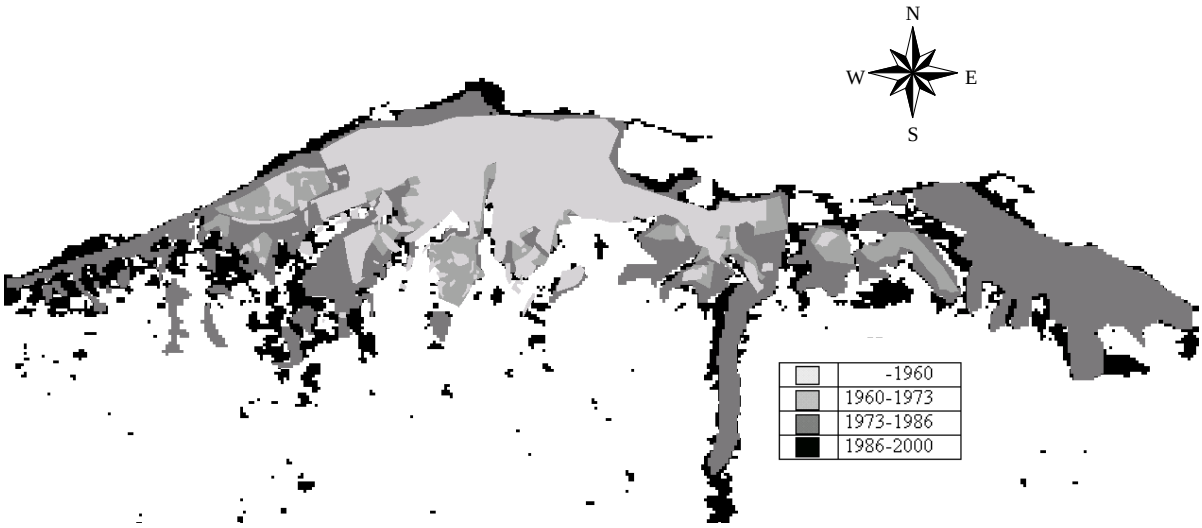

Figure 7. Urban development areas between 1960-2000

Table 1. Population information of the Trabzon city

Year	*Population*	*Growth-Ratio (%)*
1940	32.000	
1950	34.000	6,3
1960	53.000	55,9
1970	81.000	52,8
1980	108.000	33,3
1985	142.000	31,5
1997	182.000	28,2
2000	218.000	19,8

5. CONCLUSIONS

The main purpose of this study is to assist in choosing future urban residential areas by revealing the city growth in the course of time. When the improvement of the Trabzon city is observed from historical time to the present, it is seen that there is a physical growth from the city-centre to outer places. As a result of this inclination, surrounding green fields of the city have been exposed to adverse effect of constant urban growth.

The city Trabzon had a stable development stage until 1920. Between 1920-1960 years, an outer spread of urban residential growth started gradually. And between 1960-1985 years, with a considerable population growth, spreading of residential growth gained a considerable speed. Especially in 1985-2000 years period, this spreading continued with an increasing inclination. In the event that the required precautions are not taken, this urban development regime will continue increasingly. In monitoring the city that have a rapid changing characteristic, that analyzing broad areas with satellite images is far more easy and fast than the classical surveying methods, especially for administrators, provide a high level approach

chance to the urban improvement in total. Urban growing areas should be channeled under the control of local authorities, using GIS and Remote Sensing techniques especially in planning stages and monitoring urban areas.

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