Detection of Spatial-Temporal Changes of Development Potential of Aksaray City Using Remote Sensing and GIS

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Key words: Access to land; Remote sensing, Land use change; aerial photos; GIS; remote sensing; urban expansion

SUMMARY

This paper presents an integrated study of urbanization trends in Aksaray City of Turkey based on Geographical Information Systems (GIS) and remote sensing tools. The study explores the temporal and spatial characteristics of urban expansion and land use/cover change (LCLU) between 1987 and 2001. The administrative status of Aksaray was changed from district to province in 1989. Therefore, the study of urban expansion for Aksaray covers two different period of time during which the status of the city was different. The changes of land use/land cover in the city are spatially analyzed for these time periods. As the result of analyses, it has been determined that after the status of the city was changed to province, there has been 410 % of increase in the number of buildings especially in the urbanized regions, in 16 years between 1984-2000, as a result of the parceling. During this time period, the maximum increase in neighbor provinces of Aksaray is 120 %. This indicates that Aksaray gained a great development potential after its status was changed to province. This study also projected LCLU change using supervised classification for the next 14 years. The relationships of urbanization-landscape change and urbanization-population growth are also observed. For Aksaray, substantial LCLU changes were detected for the time period of 1987 - 2001. The LCLU conversion relationship implies that these changes are caused and leaded by urban expansion that produces a driving force for land use changes resulting in a higher return. The major factors influencing urban expansion and LCLU change are also discussed. Overall major factors influencing the urban expansion are detected to be the population, traffic conditions, industrialization, and politics.

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1. INTRODUCTION

Aksaray is one of the major cultural centers and the fastest growing cities in Turkey (DPT, 1999). In the last 25 years, comparing to the other middle size cities in the region, there has been a rapid growth in the city of Aksaray in terms of urbanization and special expansion. Despite the lack of infrastructures, there is still an ongoing urbanization trend in Aksaray. After Aksaray became a province, it was declared as a privileged region in development, and this resulted in increase in the amount of state, KOBİ and KOSGEB supports to the investors in the region. The number of the industrial facilities in the city was 20 in 2003 while it was 7 in 1989. The economic activities in the region also have been moving from agriculture and stock breeding to the other industrial sectors. While the proportion of the agricultural sector in the economy of the region was 57,7 % in 1995, it was 31.3 in 2001, which is a significant decrease proving the move to the other sectors (Aksaray Valiliği, 2005).

The aim of this study is to analyze land use/cover changes and the dynamics behind the urban expansion of Aksaray city. The specific objectives are, using multi-temporal Landsat data to create time series for two terms for urban growth between the years 1987–2001, detecting the urban spreading directions of the city and land use conversions occurred within Aksaray, examining the scope and rate of urban expansion using classification method; and analyzing the driving forces and factors influencing the urban expansion. To achieve these objectives, Landsat Thematic Mapper (TM) and Enhanced Thematic Mapper plus (ETM+) data acquired on June 1987 and May 2001, were used.

2. URBANIZATION OF AKSARAY CITY

In turkey there has been a rapid increase in the population of cities comparing to the increase of population of the villages. Between 1990 and 2000, while the rate of the increase of population per year in the cities was 2,68 %, it was 0,42 % for the villages. The population of the downtown are, projected as 34.4 million for 1995, reached to 44 million in 2000 in Turkey, which is 66,9 % of the total population (DPT, 1999). Aksaray was a district of a neighboring city called Nigde until 1989, and then the administrative status of Aksaray was changed to province. After the status of the city was changed, investments done by public or private sector in the city were increased profoundly. Transportation is always important in terms of the development of a city, and since Aksaray is established on one of the important intersections of Turkey, the development of the city was positively contributed by this situation.

After Aksaray became a province, A rapid urbanization processes was started. In this process, the constant application of reconstruction plans in areas which have development potentials had a big positive affect on the speed of the urbanization of the region. In Turkey, after preparing the reconstruction plans, the regulation for the land and building land are implemented, and qualified reconstruction parcels are created. Thus, the infrastructures of the cities such as square, park, parking lot, playground, road, channels, green area, were constructed according to the reconstruction plans without charge. (Atasoy et al, 2004).

In the developing countries such as Turkey, real estate is the lowest risk carrier among the investment tools. Even though the investment takes years it has always a higher return comparing to the other investment tools. Since Aksaray is a new developing city, there are more real estate and building investments comparing to the other similar size cities. One of the reasons for having more of this investment is that there are many workers working abroad in the countries such as Germany, France, and Holland etc. These workers invest mostly on real estates and building sector. Even though the population of the city was increased at same rate, the urban expansion was bigger comparing to the other cities. The reason behind this growth is that, the public investments of the region were increased comparing to the other cities after the status of the city was declared as province. Another reason is that the workers working in Europe invest on building sector.

3. STUDY AREA

Aksaray is located in Kızılırmak section of Central Anatolian region where North and South Anatolian Mountains move away from each other. It is between the north parallels 37-38 and east meridians 33-35 in the north hemisphere. The province is surrounded by Nevşehir in the east Niğde in south east, Konya in the west, Ankara in the North, and Nevşehir in the north east. It has 7722 square km of land. There some volcanic mountains called Hasandağı, Melendiz Mountains and Ekecik Mountain, and some Plato formed by lava. In the west, a big part of the Konya flat is also in the boundaries of Aksaray. Uluırmak starting from Melendiz Mountains and fall in to Tuz Lake, form a large plato. The important mountains of Aksaray are Hasandagı (3268), Small Hasandag (3040), and Ekecik Mountain (2033). The altitude of Aksaray is 980 m.

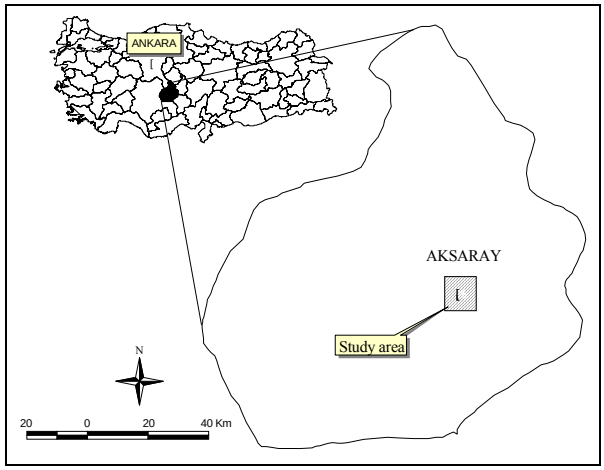


Figure 1. Study area

4. DATA AND METHODOLOGY

Landsat 5 Thematic Mapper (TM) data and Landsat 7 Enhance Thematic Mapper (ETM+) were used in this study. Data acquired are for 25 June 1987 and 22 May 2001. Besides, a 1m resolution IKONOS pansharpened image for 2003 and aerial photos for 1987 are used to rectify and classify the Landsat satellite images.

Table 1. Characteristics of the satellite data used for land use/cover change mapping in the Aksaray province.

Date	Type of imagery	Path/Row	Nominal Spatial resolution (m)	Sun elevation (^{0})	Sun azimuth (^{0})
25.06.1987	TM	176/33	30	61.32	113.79
22.05.2001	ETM+	176/33	30	63.53	127.93

The Landsat 5 TM and Landsat 7 ETM+ images were geo-referenced to the digitized map of the corresponding area using first-order polynomial transformation and nearest neighborhood resembling. 15 location control points were used for this operation. The georeferenced operations for both images are conducted with an RMS error smaller than 1 pixel. After this operation, 11x11 square km study area overlapping with Aksaray city center is cut out of the original image and a sub-image was created.

There are many change detection approaches developed for remotely sensed images. Among these digital change detection techniques, the post-classification comparison method is particularly attractive because the nature of change can be identified clearly. (Hung and Wu, 2005; Muttitanon and Tripathi, 2005). In this study too, Land use/cover change detection has been done by using post-classification method change detection. All of these application and GIS analysis were carried out using the Ermapper 6.3 and Arcview 3.2 software.

Unsupervised classification was carried out using the six bands of the multi-date image in order to classify the image into 20 clusters and to identify the type of potential changes. Land cover types considered were open forest cover, pasture land, barren land, agriculture, water and urban area. It can be noticed that some spectral classes corresponded to various covers with spectral similarities. These spectral classes were then assigned to the land cover which was more important.

A post-classification analysis procedure was carried out using supervised classification. Both images were classified into 8 thematic classes (dense forest, open forest, vegetation, Barren land, agricultural area, water, urban area and fen). As a following step, dense forest, open forest and vegetation were grouped into a single `vegetation' class. Barren land and fen were also grouped into a single `barren land' class. Finally, there have been 5 land cover classes called forest, urban, barren land, agricultural area and water. Classified images of 1987 and 2001 were then overlaid in order to generate an image change and the accuracy was determined. In order to determine the accuracy of each image change, random samples of the points were selected within the study area. Overall accuracy for both of the two supervised classification is more than 80 %.

5. RESULTS

The land-use and land-cover maps of the study area, derived from multi-temporal Landsat TM and Landsat ETM+ data, for the time period of 1987-2001 are depicted in Figure 2. As evident from the figure, there has been a significant increase in the urban area during the time period 1987–2001 (Figure 3). While an estimated 1503 hectare (11,6 %) of land was urban during 1987, it increased to 3414 hectare (26,3 %) during 2001 (Table 2). When these data are evaluated it is seen that Aksaray is expanded bigger than two times of its original area in 15 years. The expansion generally occurred through the empty areas of the city. It is because the value of real estates is less in these areas, and there is a high density in the area close to the city center.

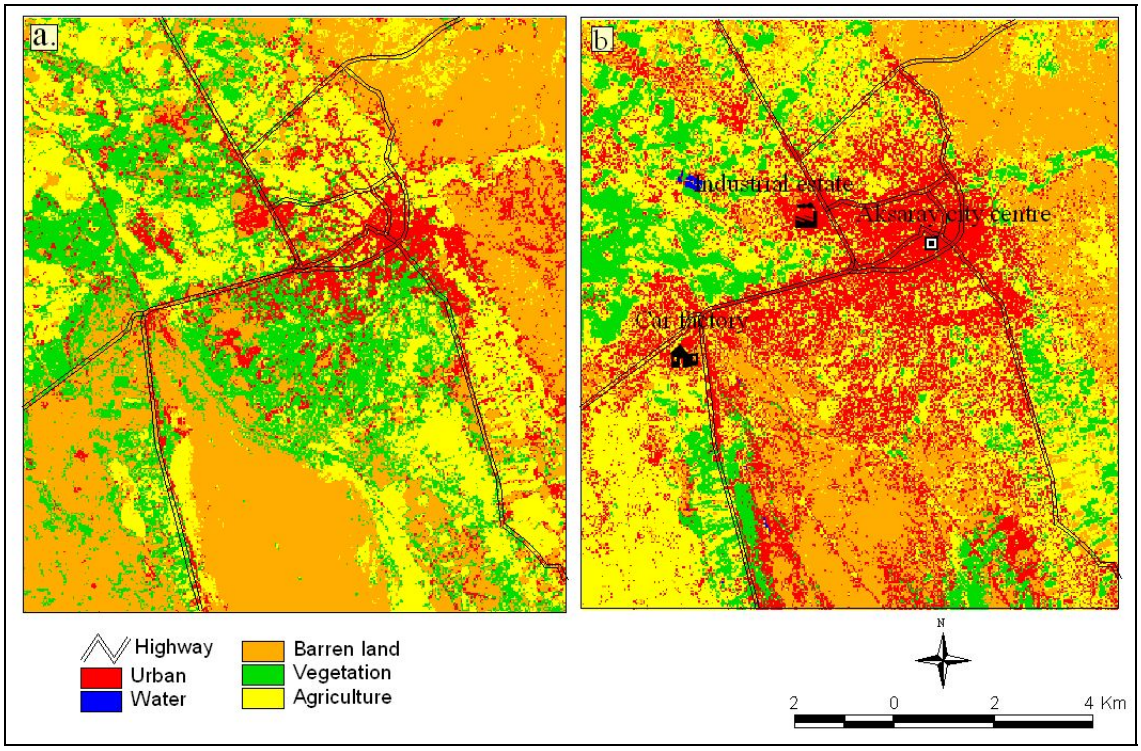


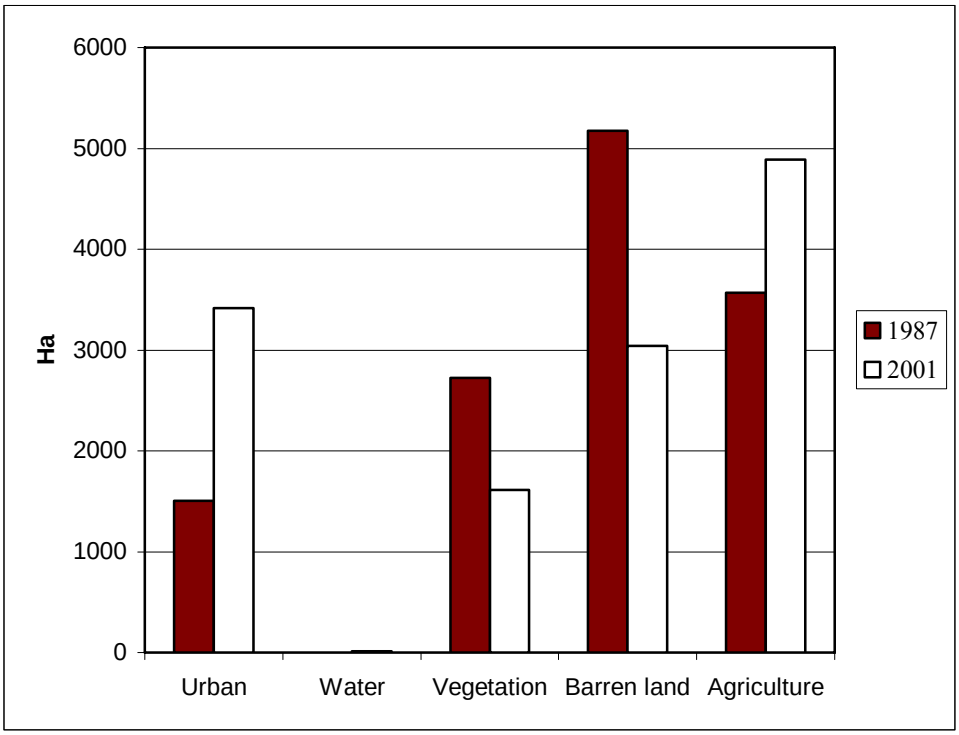
Figure 2. Land use/cover change during the period a) 1987 and b) 2001

The agricultural area increased from 3568 to 4889 he, during the time period 1987–2001. In contrast, the area of barren land and vegetation decreased from 5172 he to 3041 he and 2723 he to 1612 he respectively during the same time period. While the rate total barren land was 39,9 % in 1987, it was decreased down to the rate 23,5 % in 2001. This shows that some barren lands were changed in to residential and agricultural areas in the course of time. As a result Aksaray was brought to the foreground with its agricultural areas.

Table 2. The areas of the Land use/cover change from 1987-2001

LULC	1987		2001	
	Hectare	%	Hectare	%
Urban	1.503	11,6	3.414	26,3
Vegetation	2.723	21,0	1.612	12,4
Barren land	5.172	39,9	3.041	23,5
Agriculture	3.568	27,5	4.889	37,7
Water	0	0,0	12	0,1

Figure 3. Trends in land use/cover changes from 1987-2001



6. CONCLUSION

As a result of this study it is determined that Aksaray lived a rapid development after its status was changed to the province. In this rapid urbanization process, mostly, barren lands were changed in to residential areas. There is also significant increase in the amount of agricultural areas in the city. Moreover, some infrastructures investments for irrigation and public investments are rapidly increased after Aksaray became a province. This further increased the areas assigned for agricultural use. Also, providing some easiness in fiscal requirement of the companies resulted in more industrial facilities to be established in the empty areas of the city.

Like developing countries, Aksaray is one of the cities that grow rapidly in a healthy manner in terms of fast urbanization, and building the necessary infrastructure for the expansion areas Because of this there hardly is shanty problems. Furthermore, the study has demonstrated the potential of multi-temporal Landsat data in studying land-use/land-cover dynamics in an area with human interventions.

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BIOGRAPHICAL NOTES

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Mustafa Atasoy works at the Department of Geodesy and Photogrammetry Engineering at Aksaray University, Turkey. He graduated from the Department of Geodesy and Photogrammetry Engineering at KTU in 1993. He received his MSc degree with thesis "Investigating the problems of applications modifying post-cadastre parcel ownership" in February 1997. He began PhD in September 1997. He has studied on "Investigating of the property and cadastre (land tenure) problems of the villages located in or around the forested areas in Turkey" as his PhD thesis. His research interests are cadastral systems and forest cadastre and digital photogammetry.

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