LAND USE AND LAND COVER (LULC) CLASSIFICATION USING SPOT-5 IMAGE IN THE ADAPAZARI PLAIN AND ITS SURROUNDINGS,TURKEY

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Abstract:

The objective of the study is determination of land use and land cover patterns of Adapazari plain and its surroundings by image classification. The study area is located in northwest of Turkey between coordinates of 40°37′- 40°57′ N and 30°12′- 30°46′ E and approximately 140 km east of Istanbul. Plain has become by the accumulation of sediments carried by Sakarya River and its tributaries. Adapazari Plain is a fertile agricultural area because of its favourable natural conditions. However, because of its closeness to Istanbul, population stress has gradually increased, so industrialization and urbanization has been accelerated in the plain. In this study, SPOT-5 satellite image is used to determination of land use and land cover characteristics of research area. The image is analyzed by using data images processing techniques in ERDAS Imagine© 10.0 and ArcGIS© 10.0 software. Land cover nomenclature is classified according to the CORINE (Coordination of Information on the Environment) Level 2 Classification (1-Urban fabric, 2-Heterogeneous agricultural areas, 3-Forests and 4-Inland wetlands) and Level 3 Classification (1-Industrial units, 2-Roads) . Furthermore, the image analysis results are confirmed by the field research.

Keywords: Land use and land cover (LULC), CORINE, SPOT 5, The Adapazari plain.

1. INTRODUCTION

Land use and land cover (LULC) classes characterize important information of natural landscape and human activities on the Earth's surface (Gong et al. 2011). In recent decades, remotely sensed data have been widely used to provide the land use and land cover information such as degradation level of forests and wetlands, rate of urbanization, intensity of agricultural activities and other human-induced changes. More recently, imagery from high spatial resolution satellite systems such as IKONOS, QuickBird, and SPOT-5 has become available. High resolution satellite imagery offers new opportunities for potentially more accurate identification and area estimation than traditional satellite imagery (Yang et al. 2010). In this study we used SPOT-5 data with 10 meter spatial resolution. Land use/land cover classification is a time-consuming and expensive process. There are various methods that can be used in the collection,analysis and presentation of resource data but the use of remote sensing and geographic information system (RS/GIS) technologies can greatly facilitate the process (İkiel and Ustaoglu, 2011). In remote sensing technology, classification as a common image processing technique is implemented to derive data regarding land cover types. In classification process, supervised classification with the maximum likelihood method which is also used in this study has been widely used in remote sensing applications (Yuksel et al. 2008). In this study, land use and land cover classification standards of Coordination of Information on the Environment (CORINE) Land Cover were used in the process classification system. The study area, Adapazari Plain, is located in northwest of Turkey approximately 140 km east of Istanbul (Figure 1). The plain has become by the accumulation of sediments carried by Sakarya River and its tributaries (Bilgin,1984: 2). Adapazarı plain has an intensive and varied agriculture because of its favorable natural conditions (Erinc and Tuncdilek, 1952) and the largest plain in the Marmara region (Tuncel, 2005). The research area is involved in Euxine province of Euro-Siberian phytogeographical region. This region is the most important area with its forest formation (Humid-Mild Deciduous Forests) (Kilic and Ikiel 2010). However, because of its closeness to Istanbul, population stress has gradually increased, so industrialization and urbanization has been accelerated in the plain. In recent years, change has been observed in the natural land use and land cover. The objective of the study is determine the land use and land cover (LULC) patterns of Adapazari plain in 2010 using an integrated approach of remote sensing and GIS.

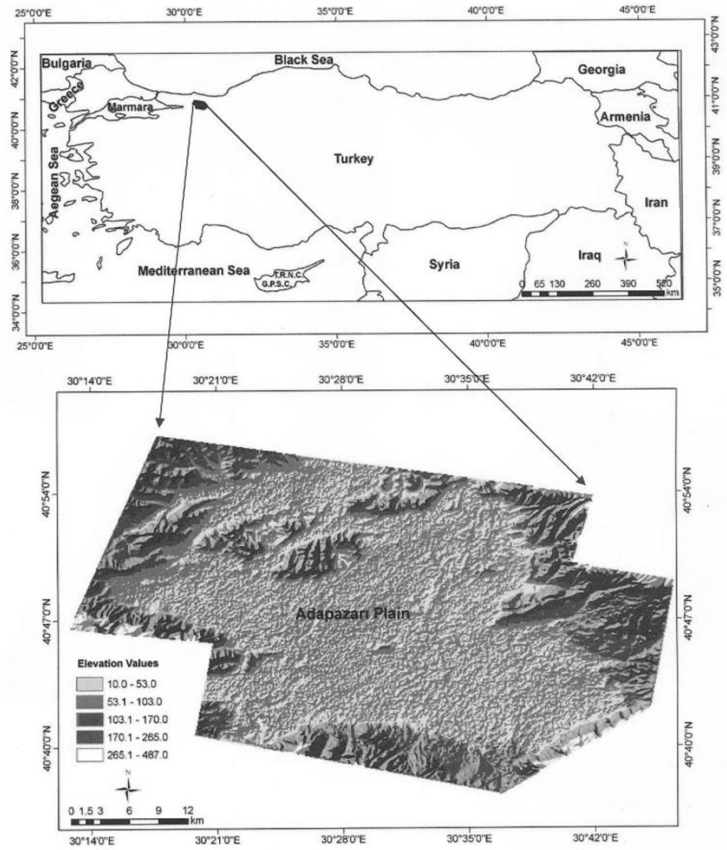

Figure 1: The Location map of study area.

2. DATA AND METHOD

2.1 Data

A Spot 5 image acquired on December 7, 2010 with 10 meter spatial resolution and four spectral bands: B1 (green: 0.50–0.59 μ m), B2 (red: 0.61–0.68 μ m), B3 (near infrared NIR: 0.79–0.89 μ m) and B4 (short-wave infrared SWIR: 1.58–1.75 μ m) was used to classify the land use land cover (LULC) in our study area. The image was provided by a commercial data provider. The image was also required to have less than 20 % cloud cover. With thiscriteria the image was cloud cover of 0 %. The characteristics of the image data are presented in Table 1. The other data used in this study for reference and analyses mainly include: (1) topographic maps at a scale of 1/100.000; (2) detailed vegetation map obtained from TR Forestry and Water Affairs Minister belongs to 2002; (3) detailed environment plan obtained from Sakarya Metropolitan Municipality; (4) ground reference data obtained from land survey with hand held GPS (5) demographic data of Sakarya from 1990 to 2010 which obtained from TurkStat, Turkish Statistical Institute (6) ERDAS Imagine© 10.0 and ArcGIS© 10.0 software were used for image classification and data analyses.

Type of imagery	Date	Spatial resolution (m)
Spot 5	07.12.2010	10

Table 1: Characteristics of the satellite data used for land cover change mapping in the study area.

2.2 LULC classification and mapping

LULC classification and mapping was performed in four stages: 1) Preprocessing of the images 3) Determination of land cover types 3) Supervised classification of the image into LULC classes 4) Accuracy assessment. These applications were performed using ERDAS Imagine 10.0 software. This research primarily used theory and methodology from geography, remote sensing and geographic information science to analyze the land cover dynamics in the study area.

2.2.1 Preprocessing of the images

Image was clipped out according to the location map by using subset function (Figure 2). The radiometric corrections, systematic errors and SPOT 5 geometric correction were carried out by data set providers. The image was geo-referenced into the Universal Transverse Mercator-UTM, WGS-84.

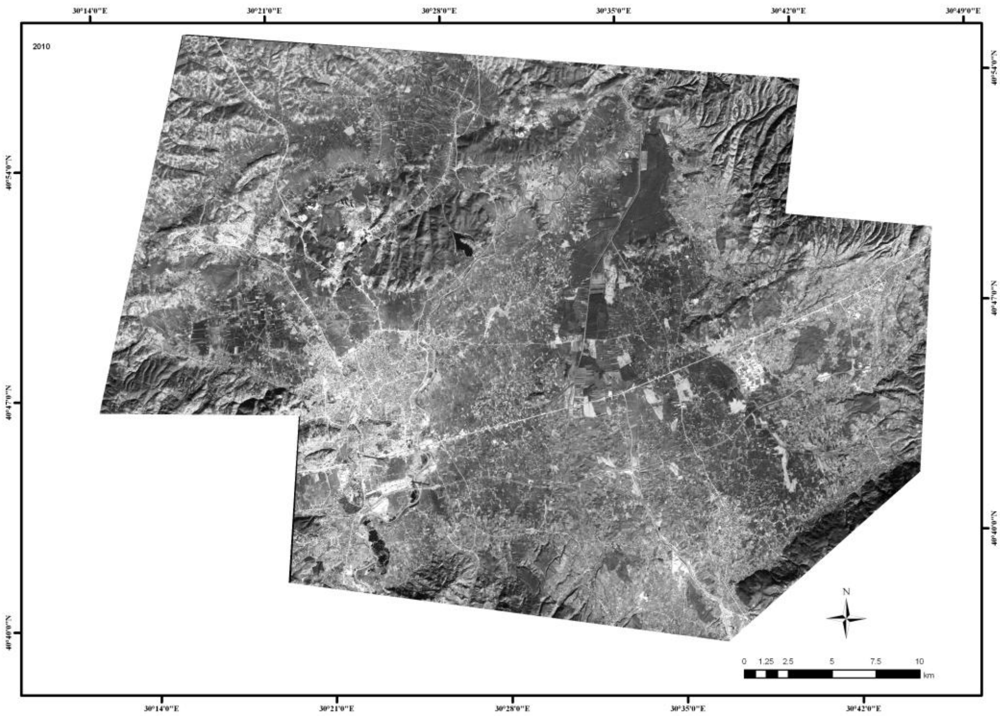

Figure 2: SPOT 5 satellite image with 10 meter resolution (07.12.2010)

2.2.2 Determination of land cover types

The CORINE land cover nomenclature/ classification system was chosen and referred for the classification system for this study. The field work supported the image interpretation of land cover types defined in the classification. The Coordination of Information on the Environment (CORINE) land cover determination program, which is mainly operated by member countries of the European Union, was started by the European Commission of the Union and can be summarized as ‘environmental knowledge formation’. The legend of the CORINE land cover nomenclature/ classification is standard for the whole of Europe, which as a result is quite extensive with 44 classes describing land cover (and partly land use) according to a nomenclature of 44 classes organized hierarchically in three levels (Sonmez et.al, 2009). In this study land cover legends include six classes. Some of those are classified at level 2 (1-Urban fabric, 2-Heterogeneous agricultural areas, 3-Forests and 4-Inland wetlands) and others are classified at level 3 (1-Industrial units, 2-Roads).

2.2.3 Supervised classification of the image into LULC classes

A good knowledge of the study area was achieved by a suitable image enhancement and related literature. Furthermore Richards and Jia (1999) suggest fieldwork that develops knowledge of the area with interviews, photography of characteristic surfaces, ground truth data in order to validate a classification. In this study, all images were independently classified using the supervised classification method of maximum likelihood algorithm. Although many different methods have been devised to implement supervised classification, the maximum likelihood is still one of the most widely used supervised classification algorithms (Jensen, 1996). In supervised classification, spectral signatures are collected from specified locations in the image by digitizing various polygons overlaying different land cover types. The spectral signatures are then used to classify all pixels in the scene. “user defined polygon” were selected from the whole study area by drawing area of interest (aoi). In supervised classification process, .aoi function reduces the chance of underestimating class variance since it involved a high degree of user control. After the classification process, all signature sample points were grouped as a class by “recode” function according to the determined land cover classification types in this study. In this study, the supervised classification method detected over 50 homogenously distributed sample areas from 6 classes in total according to the maximum likelihood algorithm (aoi).

2.2.4 Accuracy assessment

Accuracy assessment tool was performed to evaluated of the accuracy of the classified images. It is based on random sampling method which selected the points from referenced map. After the application, obtained a report which show error matrix of the results. Error matrix is in the most common way to present the accuracy of the classification results. Overall accuracy, user's and producer's accuracies, and the Kappa statistic were then derived from the error matrices. The overall accuracy and a KAPPA analysis were used to perform classification accuracy assessment based on error matrix analysis. Using the simple descriptive statistics technique, overall accuracy is computed by dividing the total correct (sum of the major diagonal) by the total number of pixels in the error matrix. KAPPA analysis is a discrete multivariate technique used in accuracy assessments. KAPPA analysis yields a Khat statistic (an estimate of KAPPA, equation 1) that is a measure of agreement or accuracy (Jensen, 1996, Guler et al, 2007). The Khat statistic is computed as:

$$\frac{N\sum_{i=1}^{r} x_{ii} - \sum_{i=1}^{r}\left(x_{i+}x_{+i}\right)}{N^2 - \sum_{i=1}^{r}\left(x_{i+}x_{+i}\right)} \qquad (1)$$

Where r is the number of rows in the matrix, x_{ii} is the number of observations in row i and column i, x_{i+} and x_{+i} are the marginal totals for row i and column i respectively and N is the total number of pixels. Independently classified images were compared with each other to determine the changes of land cover types. Accuracy levels of more than 80 % are considered adequate enough for reliable classification of land cover types (Alrababah and Alhamad, 2006).

3. RESULTS AND DISCUSSIONS

The supervised classification method detected over 50 homogenously distributed sample areas from 6 classes in total according to the maximum likelihood algorithm (aoi). Accuracy analysis was applied to the classified satellite image (2010) with an aim to confirm the accuracy of the classification. To do this, over 50 random reference control points were identified on the study area map for 6 classes. The point distributions were made in proportion to the field distributions of the classes. Total accuracy rate (total number of accurate pixels / number of pixels taken as reference) was detected 94.00% and kappa statistics value was 92.30%. Both Producer's accuracy and User's accuracy (accuracy rate generated by the user) are over 80% in all classes (Table 2). According to the high accuracy assessment results up to 80%, LULC classification is correct statistically.

Class Name	Reference Totals	Classified Totals	Number Correct	Producers Accuracy (%)	Users Accuracy (%)	Kappa (%)
Heterogenous agricultural areas	20	20	19	95,0	95,0	91,6
Forests	5	5	4	80,0	80,0	77,7
Urban Fabric	6	5	5	83,3	100,0	100,0
Industiral Units	5	5	5	100,0	100,0	100,0
Inland Wetlands	5	5	5	100,0	100,0	100,0
Roads	4	5	4	100,0	80,0	100,0
Totals	50	50	47			78,2
Overall Classification Accuracy: 94.00 %	94,00%		Overall Kappa Statistics =	92,30%		

Table 2: Results of accuracy assessment of the 2010 land use and land cover classification map produced from SPOT 5 data.

The highest classification accuracy was obtained in industrial units and inland wetlands due to their homogenous character. Structural character of the land (homogeneous-heterogeneous) and spatial resolutions of the satellite image put a direct effect on the obtained result. According to LULC classification results, land cover distributed as heterogeneous agricultural areas 78.4 %, forests 14.8%, urban fabric 5.1%, industrial units 0.3%, inland wetlands 0.5% and roads 0.9%. Based on the results, heterogeneous agricultural area is the largest land use and land cover classes in the plain (Table 3). Major agricultural areas and industrial units are located around the settlements according to the map (Figure 3).

Class Name	Area (hectare)	Area (%)
Heterogenous agricultural areas	145798	78,4
Forests	27476	14,8
Urban Fabric	9419	5,1
Industiral Units	609	0,3
Inland Wetlands	1014	0,5
Roads	1671	0,9
Totals	185987	

Table 3: Results of the land use and land cover classification table for 2010 image showing area of each class.

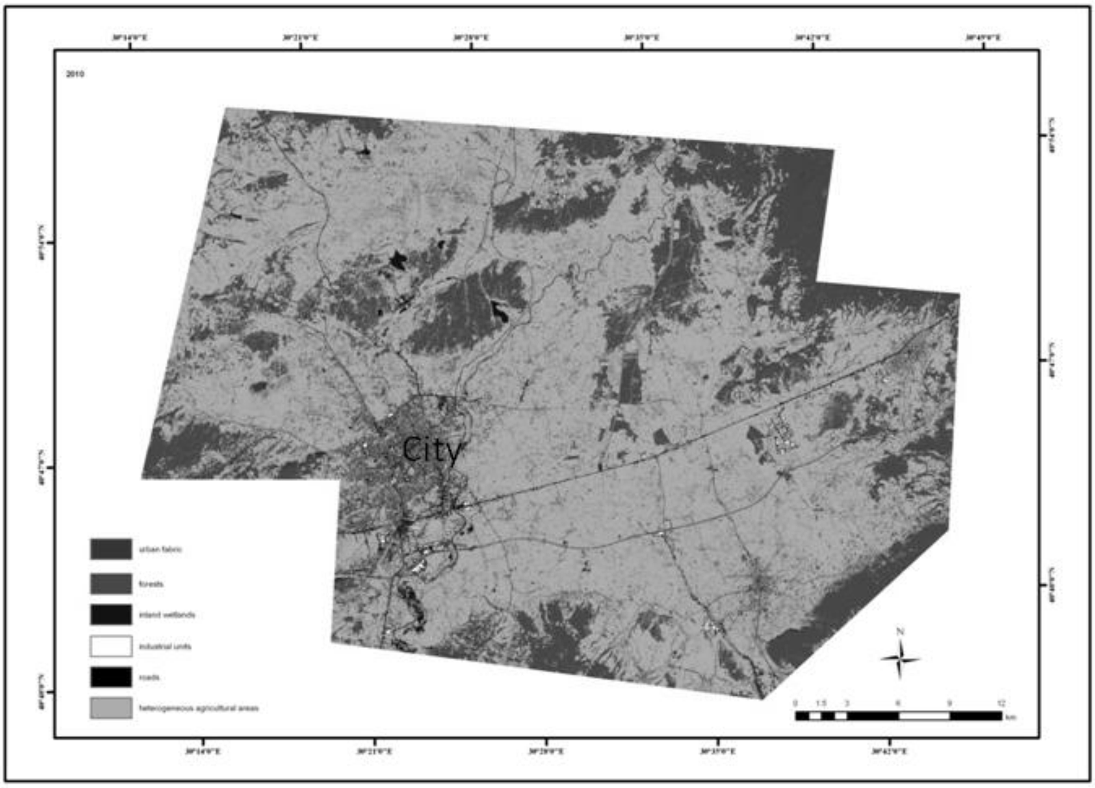

Figure 3: Land use and land cover (LULC) classification map (2010) derived from SPOT -5.

Adapazari plain is close to major roads every period of history. Because of this advantage geographic positon, settlements on the plain have developed up to now (Doldur, 2006). Today the city of the Adapazari consisted of the expansion of settlement around the old Adapazari area. Other settlements are Hendek and Akyazı which are the town center in the plain.

Years	Total Population	Accrual	Population Growth Rate (%)
1990	683,061		
2000	756,168	73,107	10,7
2007	835,222	79,054	10,5
2008	851,292	16,070	1,9
2009	861,570	10,278	1,2
2010	872,872	11,302	1,3

Table 4: Population growth of the Sakarya city between 1990 and 2010 according to TurkStat 2011.

Therefore, the population is increasing in Adapazari which has become a center of attraction for the near and far around (Table 4). Particularly urban population has greater share increasing in this population. For example, while the central town of Adapazari according to 1955 census, 74% of the population living in villages (İnandık, 1956), this ratio decreased 5.1% while the urban population ratio increased % 94.9 according to the results the 2010 census calculation of the data obtained from

TurkStat, Turkish Statistical Institute (Table 4). Therefore, urban fabric is changing and urban settlements area is growing continuously.

4. CONCLUSIONS

We obtained classified land use and land cover classification in the Adapazari Plain, Turkey (2010) with analysing SPOT-5 satellite image. According to LULC classification results, land cover distributed as heterogeneous agricultural areas 78.4 %, forests 14.8%, urban fabric 5.1%, industrial units 0.3%, inland wetlands 0.5% and roads 0.9%. Based on the results, heterogeneous agricultural area is the largest land use and land cover classes in the plain. Although industrialization and urbanization is increasing in the study area, the Adapazari Plain is still an important agricultural area in Turkey. As a results of this study, high accuracy of land use and land cover classification map was obtained. Relatively homogeneous structural character of the plain and high spatial resolutions of the SPOT-5 with 10 meter put a direct effect on the obtained result. Accurate LULC maps can play an important role in aiding land use and land cover management as well as helping in deciding what sort of lands are best suited for sustaining land use and land cover and in what manner this land use and land cover should be practiced.

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