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Analyzing land cover changes of Osmancik (Corum, Turkey) basin with landsat TM images

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Abstract

This research involves land cover changes of Osmancik Basin. The basin, is located in the northern part of Turkey, between 40° 48' - 41° 40' north latitudes and 34° 41' - 35° 04' east longitudes. The aim of this study is to research the permanent effects of human activities on natural land cover change. For this purpose, satellite images which enclose 1987 - 2010 periods are used as data. Erdas Imagine 10.0 software was used to analyse these images by using data images (Landsat TM) processing techniques. Land cover change nomenclature is made due to Corine (Coordination of Information on the Environment) Class 2 (Urban fabric, Forest, Shrub and/or herbaceous vegetation association, Heterogeneous areas, Inlands wetlands) and Class 3 (Rice fields). All images were independently classified using the supervised classification method of maximum likelihood algorithm. As a result, a period of over 20 years deforestation was calculated 62 % from 66663, 1 to 25266, 2 hectares between 1987 and 2010. In the same period, urban fabric changing was observed 190 % from 1949, 8 to 5671, 8 hectares. On the contrary, Inland wetlands have increased from 429, 4 to 1641, 6 hectares because of the built up new big dam named Obruk.

Keywords*:* Land cover change; Corine; Landsat TM; remote sensing (RS); Osmancik Basin

1. Introduction

The study area, Osmancık Basin, is located in the western part of the Black Sea Region of Turkey, Osmancik district of Corum Province (Fig. 1). Osmancik Basin, where the tectonic process is effective, was formed by accumulation of sediments brought by Kizilirmak river. Osmancik plain with an area of 300 square kilometers is located at the bottom of the basin. Study area has a complex evolutionary history. Tectonic movements, volcanic activities and erosional and sediment transportation processes have played an important role in its evolution.

Osmancik Basin is located on the North Anatolian fault zones which are the major tectonic structures of Turkey. Due to this, seism and volcanism played an important role in the formation of Osmancik Basin. On the other hand, fluvial processes also have an important role in shaping the basin. This area lies on the transition zone between Black Sea climate zones from the north and continental climate zone from the south [1]. Average annual precipitation is 385 mm, temperature is 13, 5 ^{0}C. The study area is characterized by semi-arid climate according to Thornthwaite climate classification.

Natural vegetation is involved in the Euxine province of Euro-Siberian phytogeographical region [2, 3]. In this area, land cover was changed due to the population growth, urbanization and industrialization.

Major economic activities in the study area are farming, livestock and industry, respectively. Rice farming is very important on the alluviums near the Kizilirmak River. On the other hand, the city also has some factories, such as brick-tile, rice and textile. In terms of the urban settlement, the city is expanding because of the migration to the city from the neighbouring villages. For this, agricultural areas have opened for the urban settlement. According to the Turkish Statistical Institute [4], between 1980 and 2011, while the urban population has been increasing, rural population has been decreasing in the same period (Table 1). As a result, agricultural areas have opened for the urban settlement in the city of Osmancik.

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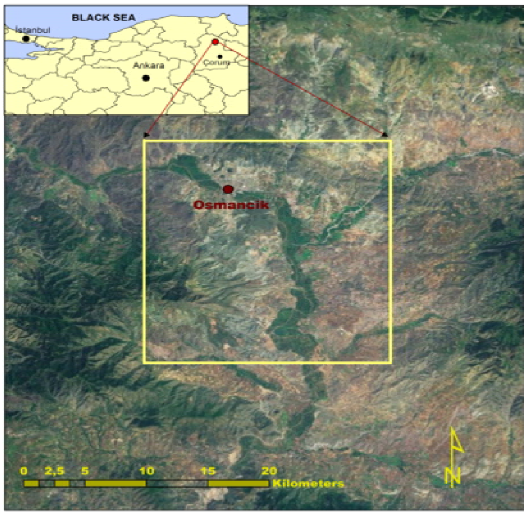

Fig 1. The location map of study area

Table 1. Demographic Changes in Osmancık District from 1980 to 2011

Years	1980	1985	1990	2000	2008	2010	2011
Urban	15.477	18.014	21.347	28.423	25.227	26.388	26.837
Rural	47.541	46.923	31.143	25.335	19.825	18.475	17.849
Total	63.018	64.937	52.490	53.758	45.052	44.863	44.686

The observed biophysical cover of the earth's surface, termed land-cover, is composed of patterns that occur due to a variety of natural and human-derived processes [5]. In other words, land cover is defined as the bio-physical features one can observe on the surface of the earth [6]. On the other hand, land-use refers to human activity on the land influenced by economic, cultural, political, historical, and land-tenure factors [7]. Remotely-sensed data (i.e., satellite or aerial imagery) can often be used to define land-use through observations of the land-cover [1].

Remote sensing is a powerful tool to derive accurate and temporal information on the spatial distribution of land use/land cover changes over large areas [8-10]. There are numerous studies about land cover changes using remotely sensed data in Turkey [11-15].

Over the past few decades, land cover change has taken place around the study area. During this process, many rural lands, such as forests and wetlands, have been transformed to human settlements. Initially, forest areas were afforested rather than converted to agriculture areas, however, agricultural areas finally opened for urban settlements.

In this study, land cover changing of Osmancik Basin and its surroundings was examined by using remotely sensed data from 1987 to 2010. During the study, Landsat Thematic Mapper (TM) images were used. Because previous studies show that Landsat Thematic Mapper (TM) images with the spatial resolution of 30 m are sufficient to accurately classify a large variety of landscapes from the homogeneous tropical landscapes to the heterogeneous Mediterranean landscapes [5]. Landsat Multispectral Scanner (MSS), Thematic Mapper (TM) and Enhanced Thematic Mapper Plus (ETM+) data have been broadly employed in studies towards the determination of land cover since 1972, the starting year of Landsat program, mainly in forest and agricultural areas [16].

2. Data

Nowadays, there is a wide range of satellite-based remote sensing data providing very high temporal and spatial resolution (approximately 1 to 100 m) that is suitable for detecting and monitoring land cover changes. Generally, investigators are interested in monitoring land dynamics using moderate spatial resolution imagery such as Landsat, Spot and Aster etc. [17]. In this study two different Landsat Thematic Mapper (TM) images acquired on July 27, 1987 and other Landsat TM image acquired on August 27, 2010, both with 30 meter spatial resolution were used to assess the land cover changes in the study area. All of these images were dowloaded at USGS (United States Geological Survey) [18]. The images were chosen to be as close as possible to the same date. The images were also required to have less than 20 %

cloud cover. With these criteria all images had cloud cover of 0 %.

3. Methodology

In this study image processing was performed using ERDAS Imagine, version 10.0 software. All images were clipped out according to the study area by using “Subset” function. Landsat TM images were corrected using linear polynomial method based on 1/100.000 scaled topographic map (produced by the General Directorate of Mapping) with 8 control points and an RMS error of less than 0.5 pixels. All images were geo-referenced to the common Universal Transverse Mercator (UTM) projection system, WGS-84 datum.

The CORINE land cover nomenclature/ classification system was chosen and referred for the classification system for this study. This methodology developed by the Joint Research Center, a center affiliated with the European Union, utilizes Landsat TM as its main database [18]. It was established by the European Commission to create a harmonized Geographical Information System on the state of the environment in the European Community. 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 partial land use) according to a nomenclature of 44 classes organized hierarchically in three classes. The first class (five classes) corresponds to the main categories of the land cover/land use (artificial surfaces, agricultural areas, forests and semi-natural areas, wetlands, water bodies). The second class (15 classes) involves the subclasses of the first class. The third and last class is composed of 44 classes and is formed by the sub-classes of the second class [19, 20]. In this study land cover legends include five classes at the Class 2 (Urban fabric, Heterogeneous agricultural areas, Forests, Heterogeneous agricultural areas and Inland wetlands) and one class at the Class 3. The field work supported the image interpretation of land cover types defined in the classification.

A good knowledge of the study area was achieved by suitable image enhancement and related literature. Furthermore Richards and Jia [21] 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 [22]. 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. Over 100 “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 involves 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.

Accuracy assessment was applied for 1987 and 2010 land cover maps, and was utilized to evaluate the accuracy of the classified images (Table 2, 3). It is based on random sampling method which selected the points from the referenced map. After the application, a report showing error matrix of the results is obtained. Error matrix is 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 [23, 24]. Kappa analysis yields a Khat statistic (an estimate of Kappa) that is a measure of agreement or accuracy [13, 25, 26].

The Khat statistic is computed as Eq (1):

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

where:

r: Number of rows in the error matrix. xii: Number of observations in row i and column i.

xi+: Total observations in row i. x+i: Total observations in column i.

N: Total number of observations included in matrix.

4. Results and Discussions

4.1. Accuracy Assessment Results

The satellite images used in the study are classified into 6 classes depending on the CORINE land cover classification. All of them, except rice fields, are classified as Class 2 (Urban fabric, Heterogeneous agricultural areas, Forests, Shrub and/or herbaceous vegetation association, Inland wetlands). Rice fields are classified as Class 3 (Table 1).

The supervised classification method detected over 100 homogenously distributed sample areas from 6 classes in total according to the maximum likelihood algorithm (aoi).

Accuracy analysis was applied to the classified satellite images (1987-2010) with an aim to confirm the accuracy of the classification. To do this, over 100 random reference control points were identified on the study area map for 6 classes. The point distributions were arranged in proportion to the field distributions of the classes.

Error matrices were used to assess the classification accuracy for the two-period Landsat TM images. 85 pixels were identified for the land cover change map of 1987. Total accuracy rate (total number of accurate pixels/number of pixels taken as reference) was detected 94.12 % and kappa coefficient agreement of 0.9292 (Table 2).

Table 2. Accuracy assessment of 1987 classified land cover map

Class Name	Reference Totals	Classified Totals	Number Correct	Producers Accuracy(%)	Users Accuracy(%)
Forests	15	15	13	86.67	86.67
Heterogeneous Agricultural Areas	14	15	14	100.00	93.33
Shrubs and/or herbaceous vegetation association	18	15	15	83.33	100.00
Inland wetlands	14	15	14	100.00	93.33
Urban fabric	10	10	10	100.00	100.00
Rice Fields	14	15	14	100.00	93.33
Totals	85	85	80		
Overall Classification Accuracy = 94.12% Overall Kappa Statistics = 0.9292					

85 pixels were identified for the land cover change map of 2010. Total accuracy rate was detected 95.29 % and kappa coefficient of the agreement of 0.9433 (Table 3).

Table 3. Accuracy assessment of 2010 classified land cover map

Class Name	Reference Totals	Classified Totals	Number Correct	Producers Accuracy(%)	Users Accuracy(%)
Forests	16	15	13	93.75	100.00
Heterogeneous Agricultural Areas	16	15	15	93.75	100.00
Shrubs and/or herbaceous vegetation association	16	15	14	87.50	93.33
Inland wetlands	14	15	14	100.00	93.33
Urban fabric	9	10	9	100.00	93.33
Rice Fields	14	15	14	100.00	93.33
Totals	85	85	81		
Overall Classification Accuracy = 95.29% Overall Kappa Statistics = 0.9433					

4.2. Land Cover Changes Detection

The kappa statistics value obtained from the accuracy analysis over statistically proved 85 % accuracy of the implemented classification. As a second step, area values in hectares, obtained during the classification operation using the classified satellite images (area/hectare), and change ratios of these values in years in Tables and graphics were transformed into percentages (%).

The results produced are land-cover data for Osmancik basin and its surroundings for the years of 1987 and 2010. According to Table 4, Fig. 2 and 3, over a 23-year period, the most significant change was observed on forests which have faced a rapid decrease. Deforestation within this period was calculated 62 % from 66663, 1 to 25266,2 hectares between 1987 and 2010. On the contrary, Inland wetlands have increased from 429, 4 to 1641, 6 hectares because of the newly constructed big dam named Obruk (Table 4).

Table 4. Results of the land cover classification for 1987 and 2010 images showing area of each class, class percentage and area changed

Year	1987		2010		1987-2010	
Class Name	Land cover (Ha)	Land cover (%)	Land cover (Ha)	Land cover (%)	Area Changed (Ha)	Area Changed (%)
Forests	66663.1	35.4	25266.2	13.4	41396.9	62.1
Heterogeneous Agricultural Areas	81274.2	43.2	90651.1	48.2	9376.9	11.5
Shrubs and/or herbaceous vegetation association	34982.1	18.6	61967.53	32.9	26985.4	77.1
Inland wetlands	429.4	0.2	1641.6	0.9	1212.2	282.3
Urban fabric	1949.8	1.0	5671.8	3.0	3722.0	190.9
Rice Fields	2910.6	1.5	3011	1.6	100.4	3.4
Totals	188209.2	100.0	188209.2	100.0	0.0	0.0

Heterogeneous agricultural areas were increased, but this condition could be dependent on converting forests to the opened agricultural areas in the rural settlements. In fact, in the city, arable lands have been disappearing day by day because of the settlements. Especially, rice farming areas near the Kizilirmak River have been opening for the new construction areas. Thus, in the same period, urban fabric area has increased more than twice.

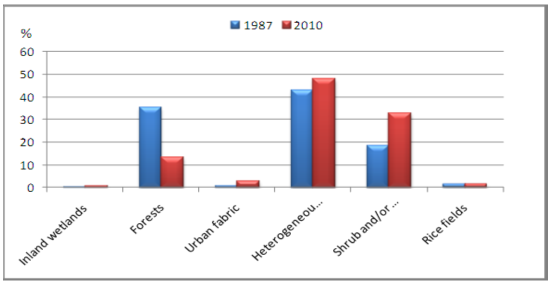

Fig. 2. Land cover change ratio (%) throughout the study period (1987-2010)

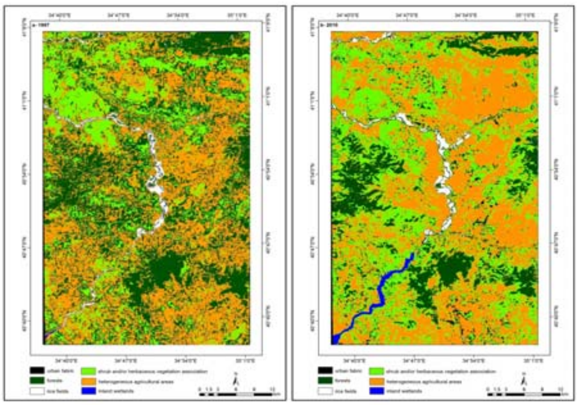

Fig. 3. Land cover classification maps for each time step (1987-2010) according to the Corine Land Cover Nomenclature

5. Conclusions

This study analyzed land cover changes and urban expansion in the Osmancik Basin, Turkey, between 1987 and 2010 using satellite images. In this context, several types of image processing were applied to two Landsat TM images collected over time (1987, and 2010) that provided recent and historical land cover conditions for the study area.

It was observed that the urbanization and the expansion of roads as a result of the urbanization were the major reasons for the land cover changes. It was determined that over a 20 year period deforestation within this period was calculated 62 % from 66663,1 to 25266,2 hectares between 1987 and 2010. In the same period, urban fabric changing was observed 190 % from 1949,8 to 5671,8 hectares. On the contrary, Inland wetlands have increased from 429, 4 to 1641,6 hectares because of the newly constructed big dam named Obruk.

The study area has experienced land cover change as a result of increasing population and industrialization. A considerable increase in urban settlements has taken place as well as a huge increase in agricultural lands. The area of natural vegetation and agriculture has decreased considerably.

The results presented that Landsat image can provide accurate information for mapping and analysis in land cover studies. Results of the analysis can be used for urban and natural resource management. Using Landsat images provides quick monitoring of large areas with no cost data, however, using higher resolution images for monitoring urban areas will provide more accurate results for applications. In order to have a sustainable development and future investigation, monitoring of the nature of land is essential.

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