Middle-East Journal of Scientific Research 11 (11): 1584-1590, 2012
ISSN 1990-9233

DOI: 10.5829/idosi.mejsr.2012.11.11.1638

Land Use Changes in Istanbul's Marmara Sea Coastal Regions Between 1987 and 2007

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Abstract: Recently, important changes in land use in the Marmara coastal regions of İstanbul have occurred due to increasing of population and consequently urban growth. The objective of the study is to determine changes in land use in the Marmara coastal region of İstanbul between 1987 and 2007. Landsat 30 m satellite images from 1987 and 2007 are used in the study. The study area is 1000 m in width from coastline to land and was analysed by the controlled classification method to classify areas into residential, agricultural, forest, free land, bush/grass and lake/pond land classes. Land use changes between 1987 and 2007 were analysed in detail. Residential areas in the Marmara coastal regions of İstanbul have increased by 45% in the two decades while agricultural areas decreased by 64%, forest areas by 97%, free land by 15% and bush and grass land by 54%. Furthermore, in this study, occupation as residential area (79%) was observed in 2007. It is probable that pressure on the İstanbul coastal regions due to migraton and rapid urbanization will continue. Therefore, it is necessary for Istanbul's Marmara Sea coastal areas to maintain a sustainable coastal management plan.

Key words: Coastal land use · Land use change · Remote Sensing · Marmara Sea Coast of İstanbul

INTRODUCTION

The coasts are preferred regions for humans because they have offered advantages during human history. Besides being attractive areas for industry, security, agriculture and tourist facilities, coasts are the most preferable location areas for humans from an aesthetic viewpoint [1-5].

Nowadays, residental areas are located on 60% of the 1 million kilometres of coastline worldwide [6, 7, 8]. In the sections of coastal areas that are transition zones between sea and land live two-thirds of the world's population [9, 10]. As it is thought that the world population will reach 8.5 billion in 2050, it is estimated that development in coastal areas will be fast [11]. Besides, the increasing population depends upon industrial facilities, settlement needs, recreation and tourism at coasts and thus many problems have occurred [3, 4, 5, 12]. With increasing population and pressure of urbanization on coasts, physical interferences with construction and filling processes have also caused biological, ecological and physical degradation at coasts [13, 14, 15].

One of the most significant cities is İstanbul, which has seen the degradation of coastal areas. İstanbul, which has approximately 6000 years of human history, has been faced with great changes in the natural landscape, especially since the second half of the twentieth century. Increasing population due to migration, unplanned urbanization and mistakes in use of land have caused environmental pollution. The Bosphorus, the Black Sea and the Marmara coasts located in Asia and the European peninsula are the regions most affected by rapid urbanization and increasing population. Because of increasing transportation, construction and tourism needs, coastal regions are changing and these changes are continuing.

The Marmara Sea coasts of İstanbul are the most densely populated areas of changing coasts due to the use of land in the coastal areas of İstanbul Sea. It is not possible to go a few kilometres from one point to another continuously along the coastline because of the constructed routes. Also it is difficult to make connections from the coast to houses and workplaces located in the inland regions, as for example, Fener-Balat to Yeşilköy coastline. So, Istanbul Municipality started to

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arrange in the rearrangement project scope by filling coasts after 1984. This study was carried out on the west Marmara coast in Fatih, Eminönü, Zeytinburnu, Bakırköy, Ataköy, Florya, Küçükçekmece, Avcılar and Büyükçekmece and on the Anatolian side in Üsküdar, Kadıköy, Maltepe, Kartal, Pendik and Tuzla. Recently, however, great changes in the Marmara sea coastal regions of Istanbul have occurred because of the increasing amount of recreation oriented filling zones [16]. Article 2634 of the Tourism Encouragement Law of 1982 and Article 2805 of the Construction Forgive Law of 1983 have had significant effect on this situation [17]. So, it is necessary to arrange effective coastal region management within the international economy with strategic Bosphorus and sea trade in order to offer the best possibilities for human usage of the natural wonders and the historical, ecological and morphological constructions around İstanbul. In order to have an effective coast region management, it is quite important to determine the changes in city coasts and use of land. Therefore, this study aims to detect the land use changes of the Marmara Sea Coast of İstanbul in order to develop a land use planning. In the study, the changes in the 1000 m study area between 1987 and 2007 were determined by the method of zoning and cutting from the coastline to the land of İstanbul Marmara Sea coastal areas.

Study Area: İstanbul, which is surrounded by the watershed of Ergene catchment in the west, the Marmara Sea in the south, the Kocaeli Mountain Range in the east and the Black Sea in the north, is located between longitudes 27° 58' and 29° 56' E and latitudes 40° 48' and 41° 36' N. The city, situated in the northwest of Turkey, lies along the Marmara Sea and İstanbul Bosphorus. The west side of Bosphorus is known as European side and the east side is known as the Anatolian side. It has 32 counties, covers a surface area of 5512 km^2 and has feature of a peninsula, being surrounded by the Marmara Sea, the Bosphorus and Haliç [18, 19]. While the city has these features, the study area has a length of 1000 m from the coastline to the land in the Marmara Sea coastal regions of İstanbul. The study was done on both sides of İstanbul and the Marmara Sea coastal areas. The study area located on the Marmara Sea coastal areas of İstanbul was separated into two portions by İstanbul Bosphorus. Silivri, Büyükçekece, Avcılar, Bakırköy, Zeytinburnu, Fatih, Eminönü and Eyüp districts are on the European side of İstanbul Bosphorus, while Üsküdar, Kadıköy, Kartal, Pendik and Tuzla districts are on the Asian side. The total area of these districts which was involved in this study was 14606 ha in 1987 and 15596 ha in 2007.

MATERIALS AND METHODS

Nowadays, many different methods are used to determine changes of land use in coastal regions due to technological developments. The following natural environment and changes in time can be determined by comparison with past data and updated so it is quite important to obtain images showing correct and up to date information when making comparisons between old and new aerial photos and satellite images of the selected area. So, the most effective method for determination of land use changes in a region is by use of remote sensing [20, 21, 22, 23, 24, 25].

In the remote sensing method, satellite images are subjected to a controlled and uncontrolled classification process to compose the land use classes. The objective is to compose land use classes by separation of pixels located on a satellite image according to spectral reflectance values [26]. The controlled classification method is preferable to the uncontrolled method in the production of land cover maps due to the high truth values [27]. So, Landsat 30 m satellite images from 1987 and 2007 used in the study were analysed by the ERDAS Imagine program by applying the controlled classification process with the help of present reference data. Classification results were transformed to vectors using the program ArcGIS by editing to prepare them for analysis in the GIS medium.

The study area is composed of a zone 1000 m in length from the coastline to the land in the Marmara Sea coastal areas of İstanbul. The creation of the study area is based on the 1987 Landsat satellite image coastline. All of the classification process and analysis were done in a buffer region which is determined as 1000 m from the coastline to the land. General classes used in the classification are urban area, agriculture, bush/grass, lake/pond, forest and cloud/land classes. An area of approximately 8 ha in the 1987 Landsat image was shown under the heading “cloud” because it lay under cloud.

The next step is accuracy assessment to complete the land cover maps after classification of satellite images [28]. The accuracy ratio is obtained by dividing the total number of cells classified as true by the total number of reference pixels. The kappa statistic is used to measure the difference between classified data and reference data [29, 30]. Accuracy analysis was done with ERDAS 9.1 software in this application. First, 100 points were dropped randomly with the help of software in proportion to the zones which occurred after classification. Each point is controlled manually with ground reality knowledge and the accuracy analysis is

completed. Ground reality knowledge was obtained from the Landsat image natural band combination. At the end of these processes the resulting data were obtained and the changing area of land classes in the 1000 m study area were established with the help of ArcGIS software.

RESULTS AND DISCUSSIONS

Land use changes along the coast of İstanbul were analysed in a 1000 m zone from coastline to land by means of 1987 and 2007 Landsat data. The land use groups relevant to both years were evaluated according to six different classes in these coastal areas. They are: urban areas, agricultural areas, forests, bare soils, bush/grassland and lakes/ponds. Approximately 8 ha were not classified because they were covered by clouds in the 1987 satellite image, so it is shown under the heading "cloud" in the 1987 land use classification.

In the study area, 12346 ha are used as residential area, 492 ha as agriculture area, 15 ha as forest area, 1521 ha as free area and 979 ha as bush area (2007). The surface area of lakes was 243 ha in 2007. Up to 2007, an increase in residential area along with decreases in forest, bush and free lands were seen (Table 2). While constructions can be observed at the back of the coast line in 1987, we can see the same constructions at the back of the way and parks by fillings done in 2007.

As can be seen from Table 2, residential areas covered the largest part, with 8471 ha, representing 58% of the total of 14606 ha of coastal areas in 1987. Also it can be seen that urbanization and the increasing population of İstanbul coasts were too great in 1987, (Table 2). The densest residential areas were Üsküdar, Maltepe, Kadıköy and Kartal district coasts on the Anatolian side and Zeytinburnu, Bakırköy, Avcılar, Küçükçekmece and Büyükçekmece coasts on the European side (Figure 2).

As can be seen from Table 2, bush/grassland was the second largest land use class in the study area in 1987. All of the grass and bushes are shown in this class. The total area of bush/grassland was 2136 ha in 1987, representing 15% of the total area. Bush/grassland is generally dense around the forest areas due to destruction of forests in the process of construction.

One of the land classes covering large areas is called "bare soil", which means naked land surfaces. In 1987, this land class covered 1798 ha of the study area, representing 12% of the total land in that year. The bare soil class is denser on the Silivri and Büyükçekmece coasts of İstanbul, (Figure 2).

Table 1: Accuracy Mapping Assessment

	User Accuracy (%)		Kappa Kappa Statistics	
Class Name	1987	2007	1987	2007
Urban areas	71.43	85	0.6825	0.8203
Lake/Pond	100	100	1.0000	1.0000
Clouds	100	-	1.0000	-
Forest	69	75	0.6569	81.31
Agricultural areas	83.33	83.73	0.7942	0.7463
Bare soil	83.33	78.57	0.8188	0.7318
Bush/ Grassland	76	84.62	0.7218	74.96
Overall accuracy	79.00	83.50	-	-
Kappa atatistic	-	-	0.76	0.81

Table 2: Land Use Changes of Marmara Coasts between 1987 and 2007

	1987		2007		Change	
Class	ha	%	ha	%	ha	%
Urban Area	8471	58	12346	79	3875	45
Agricultural Areas	1345	9	492	3	858	-64
Forest	670	4	15	0,1	655	-97
Bare Soil	1798	12	1521	9	277	-15
Bush/Grassland	2136	15	979	6	1157	-54
Lake/Pond	183	0,1	243	1,5	60	32
Cloud	2	0.04	-	-	-	-
Total	14606	-	15596	_	990	7

When we look at the land use classes of Marmara Coast in 1987, (Table 2), we can see that agricultural areas covered 1345 ha and 9% of the study area. Agricultural areas were considerably denser on the north side of Büyükçekmece and Silivri (Figure 2).

Forests covered 4% of the area, or 670 ha, in 1987. In this year, the districts that had denser forest areas were Silivri and the north side of Büyükçekmece, (Table 2 and Figure 2). Due to urbanization on the Marmara Sea coasts of İstanbul, it is not possible to see many forest areas.

The section shown as the lake/pond land use class in the study area forms parts of Büyükçekmece and Küçükçekmece Lake study area. These sections had a surface area of 183 ha and formed 0.1% of the study area in 1987, (Table 2).

An area of approximately 2 ha was not classified because it lay under cloud in the 1987 satellite image. Therefore it is shown under the heading "cloud" in the 1987 land classification.

As can be seen from table 2, while residential areas generally increased, bush/grassland and forest areas decreased from 1987 to 2007. In terms of area, the most significant loss was observed in bush/grassland areas. In two decades, they decreased by 1208 ha and 54% compared to 1987. Although they cover 6% of the study area, they decreased due to the presence of too much residential area.

Fig. 1: Location of Study Area

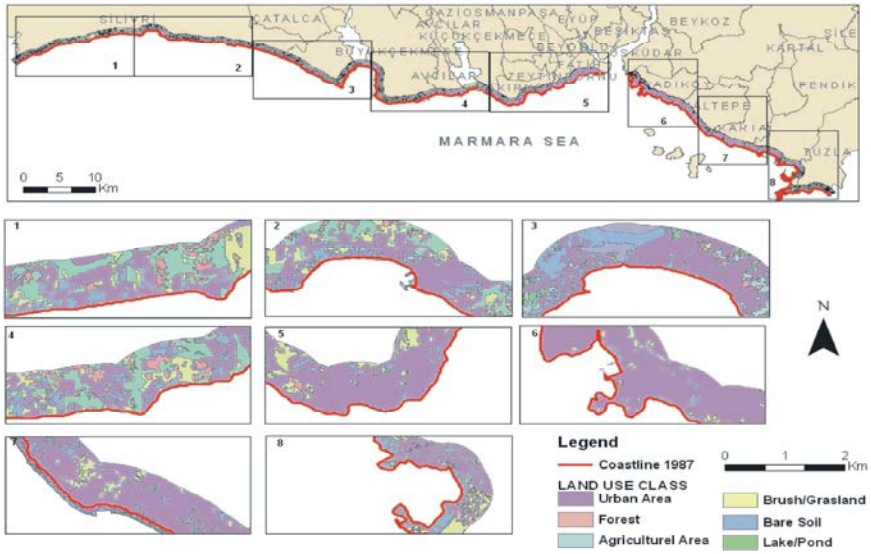

Fig. 2: Land Use of Marmara Sea Coasts of İstanbul in 1987 (Image: 4 May 1987)

After the bush/grassland areas, the most important loss of hectares occurred in agricultural areas. While agricultural areas covered 1345 ha in 1987, they decreased by 868 ha and 64% in the period up to 2007. There is an important decrease in agricultural areas due to the increase in residential areas (Table 2). The greatest decreases were seen in the Büyükçekmece, Silivri and Avcılar coasts.

While forests covered 670 ha in 1987, they decreased by 655 ha during the period up to 2007. In this case, forest areas decreased by 97% in 20 years (Table 2). Forests decreased from 4% to 0.1% in this period of time. The greatest decreases in forest cover occurred in Maltepe, Kartal and Büyükçekmece districts (Table 2, Figure 2).

In 2007, residential areas covered 15596 ha and 79% of the 12346 ha of land on the Marmara Sea Coast. Residential areas increased by 3875 ha and 45% in comparison with 1987 (Table 2). The densest residential areas are the Maltepe, Kadıköy and Kartal district coasts on the Anatolian side and Avcılar and Büyükçekmece coasts on the European side from 1987 to 2007 (Figure 3).

As can be seen from Table 2 and Figure 3, the coverage of the bare soil land class decreased by 15% between 1987 and 2007. While bare soil covered 12% of the study area in 1987, it decreased by approximately 277 ha in the period up to 2007. Bare soil covered 9% (15596 ha) of study area. The bare soil class was the

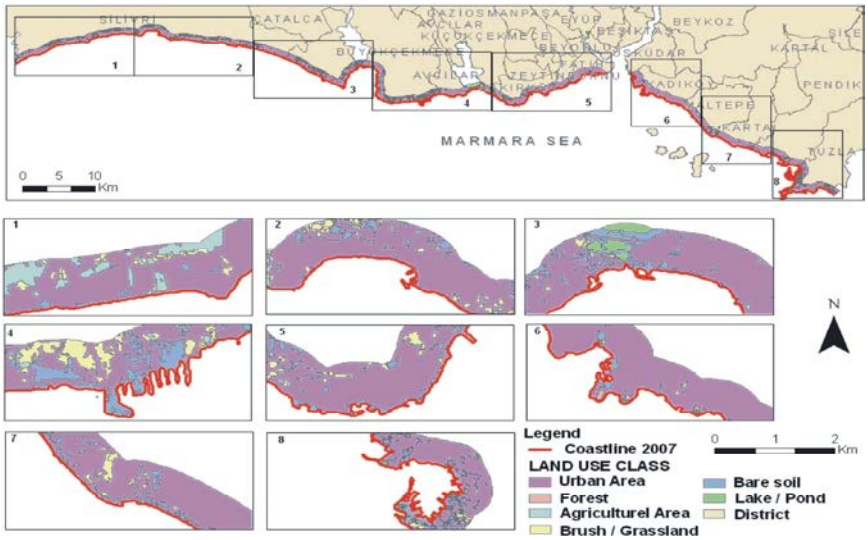

Fig. 3: Land Use of Marmara Sea Coasts of İstanbul in 2007 (Image: 11 May 2007)

second largest, following the residential areas, in 2007; it decreased due to the increase in residential areas during the 20 year period (Table 2).

The section shown as belonging to the lake/pond land use class of the study area forms parts of Büyükçekmece and Küçükçekmece Lake study area. The sections referred to as lake/pond covered a surface area of 243 ha, forming 1.5% of the study area in 2007 and increased by 60 ha in the period up to 2007 (Table 2).

CONCLUSION

Coastal areas belong to the government according to the 43rd Article of the Constitution (no. 2709, date 1982) and so it is necesssary to provide amenable coasts for people in İstanbul. Moreover, according to the 715th Article of Turkish Civil Law (no. 4721, date 2001), coasts are never a private property [31]. So, on the Marmara Sea coasts of İstanbul, especially at the coastline borders, it has been legally decided that it is necessary for there to be regulations for the prevention of construction. Still, according to the 5th Article of the law in force for the coast, planning and construction are never done at the border of coasts. Therefore municipalities must be careful about coasts and they must study them for social benefit and save them from the pressure of special possessions.

It is very important to revitalize the Marmara Sea coasts of İstanbul in order to solve problems concerning transportation, substructure and recreation and this is arranged by filling at coasts. These studies have been continuing. However, transportation and substructure works have caused great changes and destruction of the physical structure of the coasts of İstanbul. The natural coast area has been destroyed slowly by filling zones.

When we look at the study area and land use of filling zones on it, we see that recreation, transportation, accomodation and shopping areas are the main kinds of uses. Recreational places are pedestrian and bicycle roads, tea gardens, children's play areas and resting and picnic areas. Harbours and coast roads could be counted as transportation usage.

The recreational areas are quite important for a crowded city like İstanbul. So, multi-purpose criteria must be taken as a basis when arranging recreational areas and facilities. The coastal sites must be arranged for the development of social life. Qualified coastal sites in İstanbul must be present and it has many historical and natural environmental features. Wrong constructions and land use must be prevented by legal arrangements and applications must be checked for İstanbul coastal regions.

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