Determining the temporal changes of land use by using orthophotos: The sample of Elmalı basin

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Water basins, which are used as the main drinking and domestic water resources in large cities, are polluted by excessive settlement, industry and agriculture. Thus it is important to take some protection precautions in catchment basins for both surface and underground water. In this study, the temporal changes of forests and cultivated lands as well as the settlements in water basins subjects were briefly explained and a sample application which uses real data were examined to demonstrate those explained contents. In order to extract temporal changes, orthophotos taken over years have been used as the base dataset. By this way, the temporal land use in the same region was determined. The study area involves Çavuşbaşı region of Beykoz district of Istanbul and Elmalı basin located in that region. The extracted information from temporal dataset may also be used for effective future planning purposes. This paper uses historical dataset between the years 1946 and 2013 to extract information to be used for the future projections. This dataset contains six different historic time intervals. Results from the analyses of the study show that there is a remarkable increase in urban areas especially since 1990s. This increment has caused a significant decrease in forest and cultivated areas. According to the juridical regulations, it is not allowed to construct buildings in absolute and short-range protection areas. However this study shows that an area of 4.0126 km2 (approximately 400 hectares) unauthorized structures was developed against to these regulations.

Key words: *Classification, land use, Elmalı basin, orthophoto, change detection, protection area*

1. Introduction

Water resources are scarce and their quality highly depends on time and their position in nature. That is why they are considered a very precious input directly affecting the life standards and the economic structure constantly increases the demand for the use of these sources. The use of these sources, which have been accepted as precious since the primitive tribes has caused conflicts and even wars among societies throughout history and majority of civilizations, failing to provide sufficient water resources have either migrated to better places or faced the danger of extinction. Even though the technology has advanced today, the conflicts about water resources still play important roles in international politics as complicated problems for societies in various countries. In this context, the studies on water resources management should lead us in both meeting today's needs and determining the position and amount of the most convenient types of use for resources (Meriç, 2004).

For environmental and basin protection and resource management, the sustainable development of coastal areas and basins should be planned: the reasons of shoreline changes should be investigated, coastal maps should be continuously updated and the changes should be monitored (Guariglia et al., 2006; Alesheikh et al., 2007; Van and Binh, 2009). The analysis of shoreline changes helps determining coastal zones and detecting short, medium and long-term uncontrolled changes in coastal areas (Ford, 2013).

Historical aerial images comprise the cadastral and topographic memory of a country. The aerial image archive of the General Command of Mapping keeps approximately 1.500.000 aerial photos of Turkey that have been taken for various purposes since 1939 to present. Today, it is required to produce the orthophotos of old-dated aerial photographs in order to satisfy the increasing need of geographical basemaps for existing geographical information systems. It is also necessary to display the temporal image data altogether on the screen (Yılmaz et al., 2013). In order to find temporal changes of a region, archieve data have significant importance. In Turkey, the aerial image archieves of the General Command of Mapping provide a huge amount of temporal image data for researchers.

According to the Organisation for Economic Cooperation and Development (OECD), the land use is grounded on the functional dimension of lands concerning various human reasons or economic activities. The categories of the land use could be classified as dwellings, industrial use, transportation, recreational use and nature protection zones. The increase in landuse destroys the ecosystem and water resources, which negatively affects the environmental plans (USA Environmental Protection Agency, 2001).

In Istanbul, the largest city of Turkey, the water is generally provided from the water basins within the borders of the city, except for Melen in Düzce province. The basins under investigation are under threat due

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to urbanization. The concept of basin is used and defined by a number of disciplines. The term basin signifies a plot of land that primarily shows a similarity and integrity in itself due to its biological and socio-economic characteristics and thus has greater differences from other plots of land (Geray and Küçükkaya, 2007).

According to the Water Pollution Control Regulations of Turkey, a basin is the entire region where both surface and underground water supplying a water resource, e.g., a stream, lake, dam reservoir or an underground water reservoir aggregate (Genç, 2004). Lake basins, on the other hand, comprise the area where water aggregate in dams. Lake basins are of vital importance with forests and in open lands they comprise, in terms of the continuity of the region's ecology. Lake basins have a great importance upon the formation of rain, the rain reaching the soil, water content and quality, surface flow, water retention amount of the land and the level of underground water (Şanlısoy and Demirsoy, 2002).

In recent years, photogrammetry and remote sensing technologies have been used in a widespread manner for the purpose of tracking changes in the coastal area management implementations. The changes may be found by processing the temporal aerial images of regions of interest (Sesli, 2010).

In previous studies, different applications such as detection of the changes on coastal line, determining the amounts of the coastal erosion, determining the shore border line and real estate structures violating the shore border line, determining the size and changes of deltas, lakes and basin etc., have been carried out by using the methods of remote sensing, digital photogrammetry and image processing (Ayad, 2005; Kuleli, 2005; Muttitanon and Tripathi, 2005; Vanderstraete et al. 2006; Ekercin, 2007; Wu, 2007; Zhang et al., 2007; Bayram et al., 2008; Ghanavati et al., 2008; Sesli et al., 2009; Kuleli, 2009; Şener et al., 2009; Aydinoglu and Gungor, 2010; Kuleli et al., 2011; Görmüş et al., 2014).

1.1. Problem Statement and the Related Legislations in Turkey

The protection and maintenance of water basins comprise the most important approach in the water resources management. The most general regulation regarding the protection of water resources is the regulation that was made with the 56th article of the Turkish Constitution Act, that suggests, "everyone has the right of living in a healthy and balanced environment. The government and the citizens are responsible for developing the environment, protecting the environmental health and preventing the environmental pollution". This underlines the necessity for cleaning and protecting the water that is one of the most important elements of the environment. Local governments have also made legal regulations regarding the protection of water resources. "ISKI (Istanbul Water and Sewerage Administration) Drinking Water Basins Regulation" is one of these regulations. As it is specified in the first article of the constitution, the objective of this regulation is to prevent the pollution of surface and underground water within and outside the borders of Istanbul Metropolitan Municipality, which provides and will provide the drinking and domestic water needed within the borders of Istanbul Metropolitan Municipality, in various ways (Olhan and Ataseven, 2009).

In Istanbul, the water demand of the Anatolian Side was met by a number of foundation distribution lines during the Ottoman period. The gradual disruption of those lines and the increase of population increased the need for constructing new water facilities towards the end of the 19th century and consequently a privilege of sixty-five years was given to a French company named Üsküdar-Kadıköy Water Company for the water supply of the region. The company constructed the Elmalı Dam above the Göksu stream 3 km. far from Bosphorus between the years 1891 and 1893. The region reached sufficient water right after the completion of the municipal water system with the distribution line (Esmer, 1983).

Some part of the Elmalı Dam was amplified by putting girders on filled penstocks in order to catch more water in 1948. However, the Elmalı Dam remained insufficient despite the amplification performed by the Istanbul Directorate of Water as the water demand of the city rapidly increased. There upon, the second Elmalı Dam was constructed 1,5 km far from the dam between the years 1952 and 1955, which brought 60.000 m^3 water per day (22.000.000 m^3 per year) to the region (Esmer, 1983). Being among the oldest water basins of Istanbul, Elmalı Dam and Elmalı Basin have survived until today. When the illegal housing in the region became a serious problem, both Beykoz and Çavuşbaşı were declared as archeological sites with the decision of the Ministry of Culture Istanbul Directorate of Cultural and Natural Heritage Preservation Board Numbered 3 on the 15th of November 1995 and numbered 7755 and despite all the precautions, this basin in Beykoz District fell under the influence of urbanization and both forest and cultivated lands were rapidly transformed into housing zones (Anonymous-1, 1995).

1.2. Aim of the Study

This study aims to investigate the changes in land use of the Elmalı Basin and Çavuşbaşı Region of the Beykoz District between the years 1946 and 2013 and to reveal important results. The obtained results are expected to give novel and effective insights to the local governments and planning authorities to protect the basins and inherit them to the next generations in a clean and healty manner.

2. Case study

The material of the study consists of orthophoto images taken in Istanbul in years 1946, 1954, 1972, 1993, 2003 and 2013. The accuracy of the used orthophoto images vary between ± 5 m and ± 8 m, and this accuracy ranges had been obtained by comparison of the ortho-images to the reference orthophotos (Yılmaz et al., 2013).

From the orthophoto images a pilot study region was selected and six temporal orthophoto images of this selected region were used for the analyses. The area of the selected region is approximately 55 km^2. The boundary of the study area involves Çavuşbaşı region of Beykoz district of Istanbul province and Elmalı Basin (Fig. 1). It is located between longitudes 29°05'17''E and 29°11'17''E and between latitudes 41°02'54''N and 41°06'23''N and at a distance of 15 km from the city center in the east part of İstanbul.

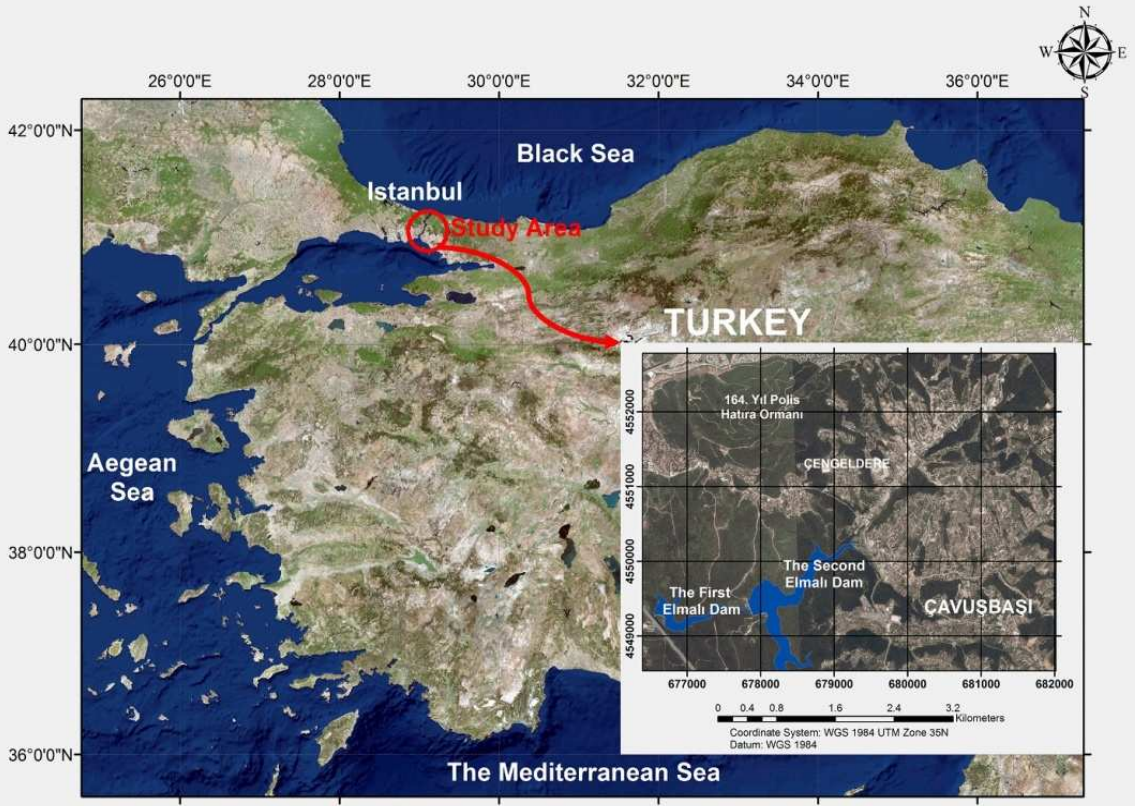

Fig. 1. Location of study area.

The classified areas were obtained in vector data format by classification of orthophoto images. Vector data were represented with Personel Geodatabase (*.mdb) format. After preparing the study area by cutting it from orthophotos, it was formed the empty personal database in the Personel Geodatabase (*.mdb) format to keep the vector data that would be obtained as a result of the classification. This database respectively defined the details of "Dam", "Urban Area", "Wasteland", "Forest" and "Cultivated Area". Figure 2 shows the sample images of orthophotos according to years. All the data being prepared were structured in such a way to be in the UTM projection and WGS-84 Datum.

Similar to earlier studies in the literature (Marangoz et al., 2007) and (Yılmaz et al., 2013), orthophoto images have been used to find the land use information by manual classification of the land use areas. During the classification stage, the topological features of the candidate class partitions have also been considered to merge those partitions that form the classes. The reason for classifying the classes manually is that the manual classification is the most accurate method.

The purpose of this study is not to present a novel classification method, instead the land use areas are aimed to be found and the accuracy is the primary request for the results to be obtained from this research. Therefore the most accurate method that can be used for land use classification is still the manual classification that is free of possible errors, can arise from automatic operations. However, the manual classification is too time consuming and this is the cost of higher accuracy. Furthermore, some of the papers in the literature report that the accuracy and the success potential of manual segmentation are much higher and it is more accurate than the automatic classification methods (Marangoz et al., 2007).

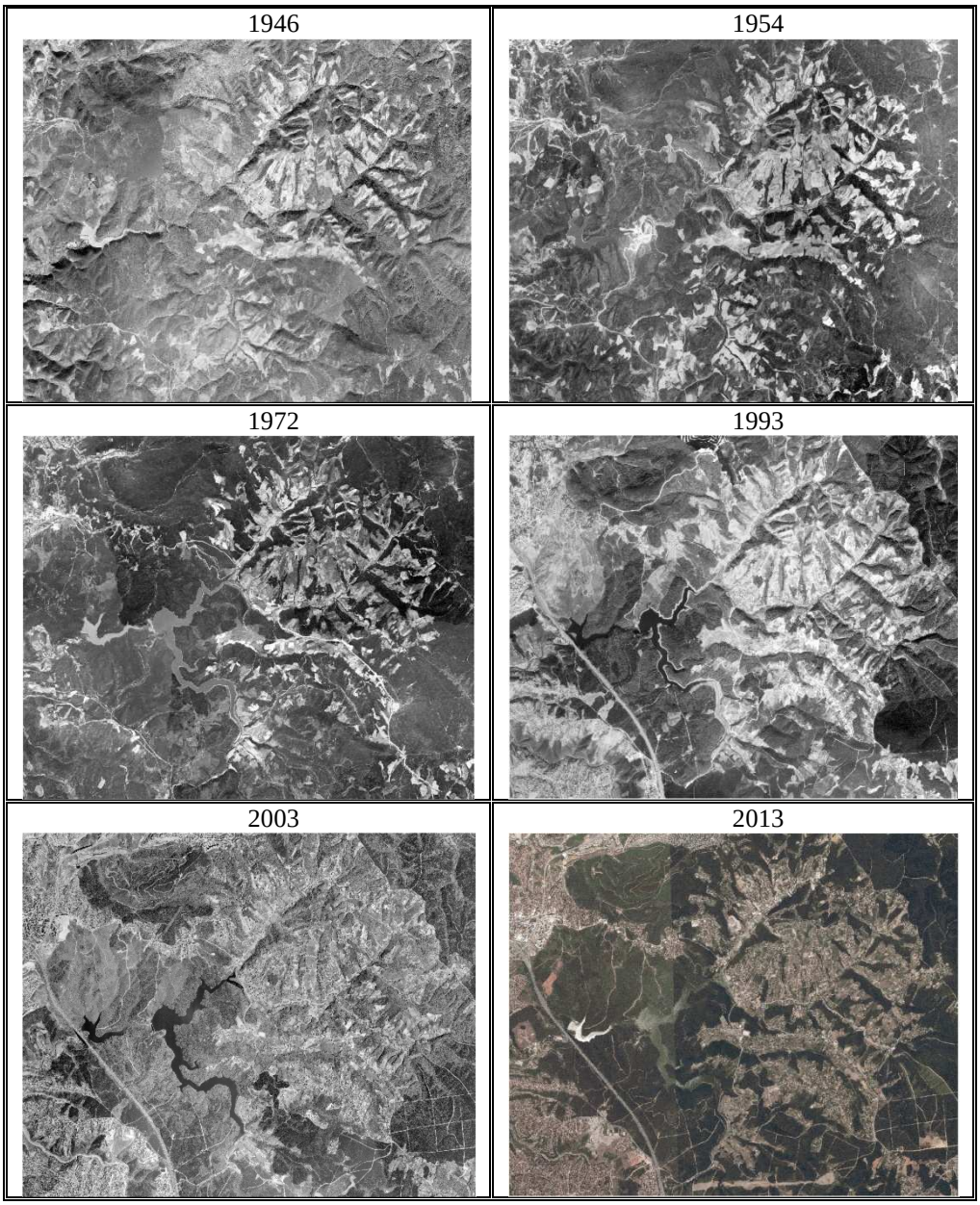

Fig. 2. Sample images of orthophotos.

Table 1 shows the explanations of details that are classified as “Dam”, “Urban Area”, “Wasteland”, “Forest” and “Cultivated Area”.

Tab. 1. *Detail explanations*

Detail Number	Detail Name	Explanation
1	Dam (Blue)	The large water area behind the dam that is constructed to provide irrigation and drinking water or produce electrical energy.
2	Urban Area (Pink)	Areas that are allocated for the city life and involve details like buildings, roads, parks, facilities, etc.
3	Wasteland (Fawn)	Uncultivated lands outside of the urban areas that have no quality as a forest or cultivated area.
4	Forest (Green)	Areas like forests, bushes and lands that may gain the quality of a forest in a short time even if the trees are destroyed.
5	Cultivated area (Purple)	Lands where various agricultural activities are conducted.

As a result of the classification that was performed based on the detail explanations in Table 1, the vector data that would serve for the examination part of the study were obtained (Fig. 3-8).

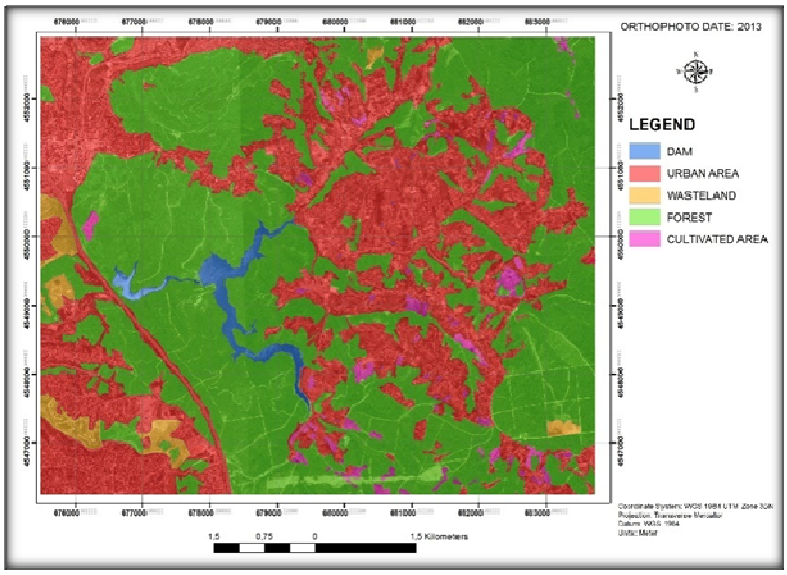

Fig. 3. Classification results obtained from the orthophoto image dated 2013.

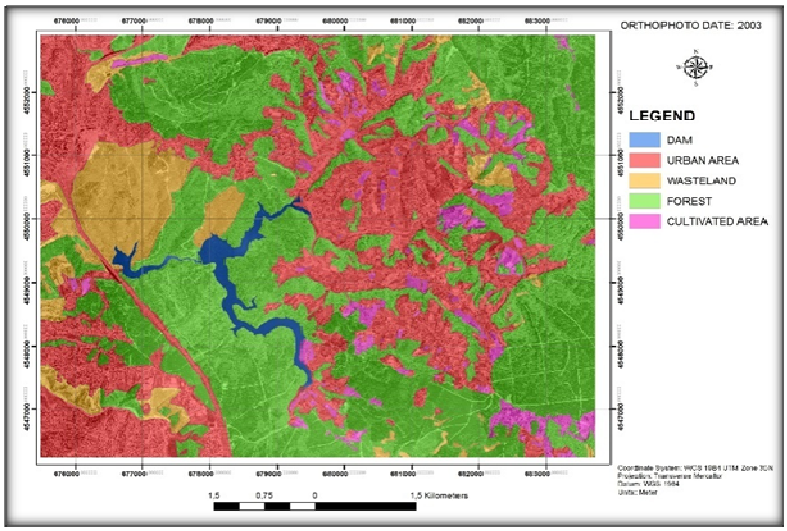

Fig. 4. Classification results obtained from the orthophoto image dated 2003.

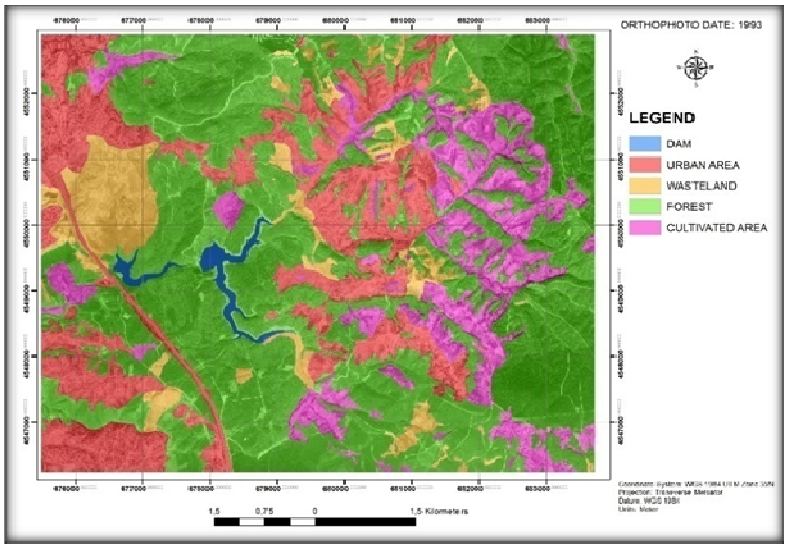

Fig. 5. Classification results obtained from the orthophoto image dated 1993.

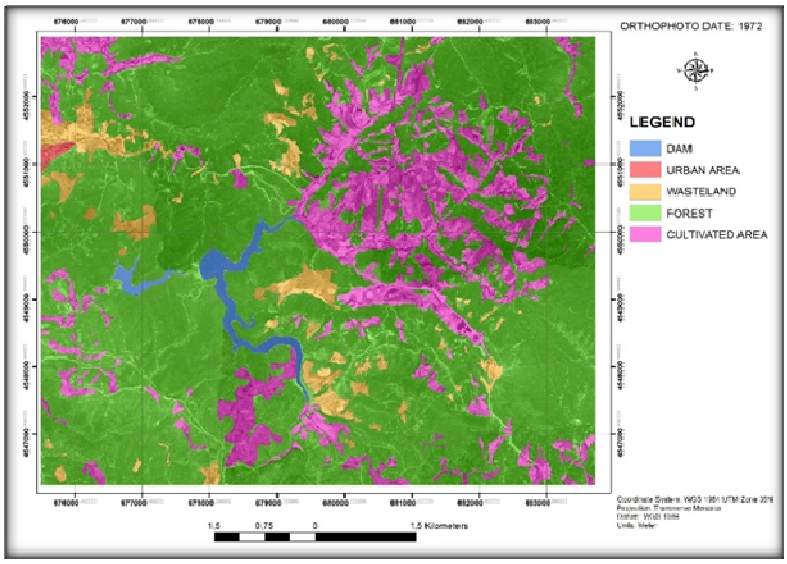

Fig. 6. Classification results obtained from the orthophoto image dated 1972.

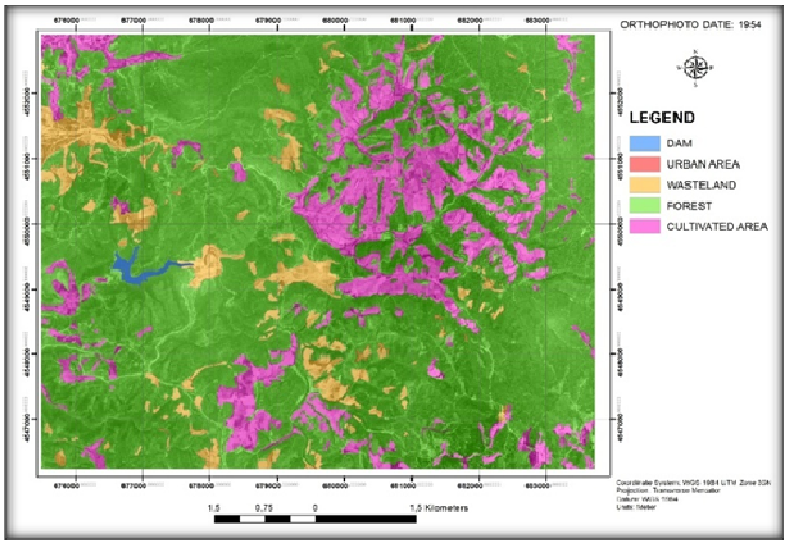

Fig. 7. Classification results obtained from the orthophoto image dated 1954.

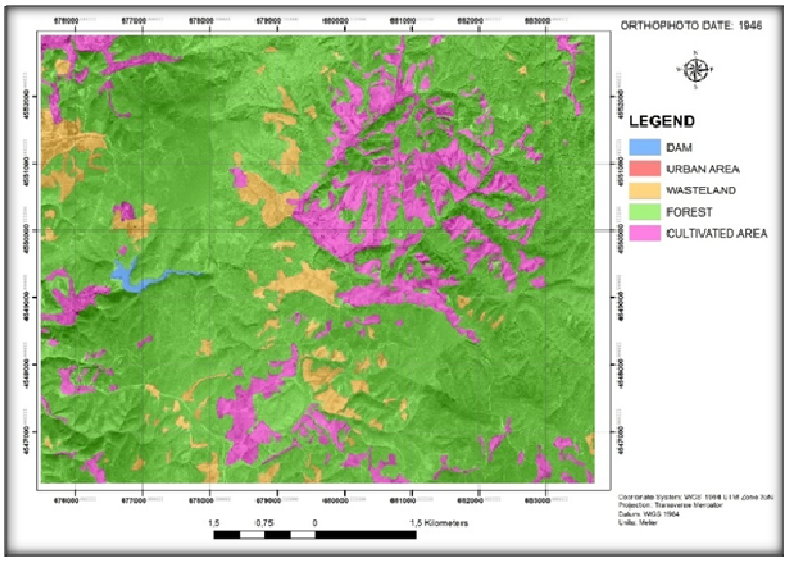

Fig. 8. Classification results obtained from the orthophoto image dated 1946.

3. Result and discussion

From the data that were classified according to years, the area information regarding the details of "Dam", Urban Area", "Wasteland", "Forest" and "Cultivated Area" were calculated. The results obtained are presented in Tables 2 and 3.

Tab. 2. Land use for the study area according to years [km^2]

YEAR	DAM	URBAN AREA	FOREST	CULTIVATED AREA	WASTELAND
2013	0.86250	21.50818	30.29947	1.12000	1.11951
2003	0.86174	18.86145	27.97733	2.31457	4.89457
1993	0.90879	11.37405	31.37006	7.27295	3.98381
1972	0.89954	0.09847	41.51365	9.86454	2.53346
1954	0.16951	0.00000	42.00587	9.16911	3.56517
1946	0.15803	0.00000	43.29277	8.14015	3.31871

Tab. 3. Land use for the study area according to years [%].

YEAR	DAM	URBAN AREA	FOREST	CULTIVATED AREA	WASTELAND	TOTAL
2013	1.57%	39.17%	55.18%	2.04%	2.04%	100
2003	1.57%	34.35%	50.95%	4.22%	8.91%	100
1993	1.66%	20.71%	57.13%	13.25%	7.25%	100
1972	1.64%	0.18%	75.60%	17.97%	4.61%	100
1954	0.31%	0.00%	76.50%	16.70%	6.49%	100
1946	0.29%	0.00%	78.84%	14.82%	6.05%	100

Examining the land use given in tables in terms of area and percentage, there has been a remarkable increase in urban areas since the 1990s. In addition, there has been an observable decrease in forest and cultivated areas as well. Examining the classified data given in Figures 3-8, there has been a rapid urban transformation in the Çavuşbaşı region in the middle of the study area and the nearby cultivated areas since the 1990s. The land use diagram in Figure 9 also displays this change.

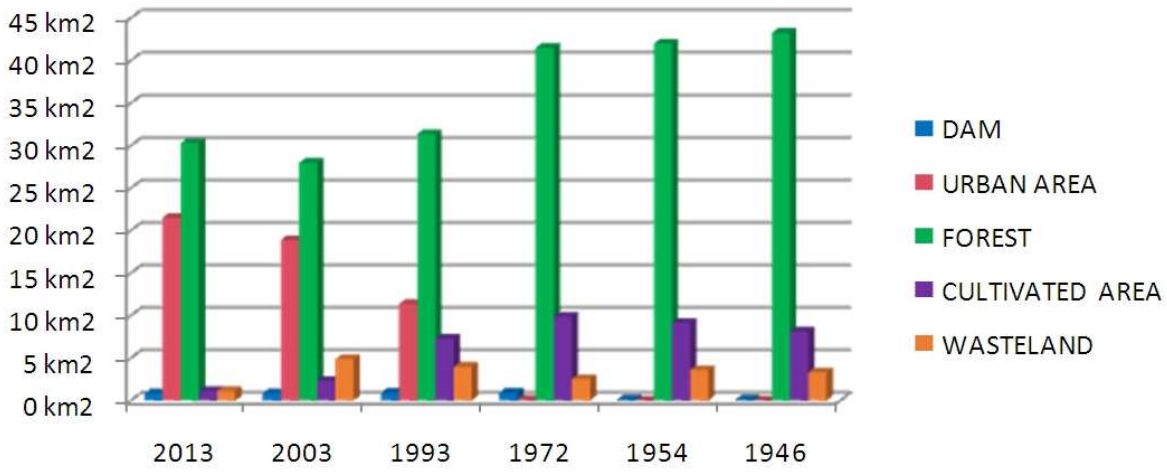

Fig. 9. Land use according to years.

The space occupied by Elmalı-1 Dam and Elmalı-2 Dam which were completed in 1955, has not displayed a great change over years. According to the data given in Table 4, it is possible to conclude that the water resources in the basin have not been damaged in terms of water efficiency despite the effects of urbanization.

Tab. 4. *Dam areas in the study region [km^2].*

YEAR	ELMALI-1 DAM	ELMALI-2 DAM
2013	0.15105	0.71145
2003	0.15029	0.71145
1993	0.15029	0.75850
1972	0.14105	0.75850
1954	0.16951	-
1946	0.15803	-

The intense migration into region has caused rapid increase in urban areas since the 1980s. Examining the data of the Turkish Statistical Institute (TSI), it is clearly possible to see a **rapid increase in the population of the Çavuşbaşı region between the years 1990 and 2000** (Tab. 5).

Tab. 5. *Population data of Istanbul, Beykoz and Çavuşbaşı (Anonymous-4, 2014).*

YEAR	Population of ISTANBUL	Increase Ratio [%]	Population of BEYKOZ	Increase Ratio [%]	Population of ÇAVUŞBAŞI	Increase Ratio [%]
1965	2293823	-	51689	-	1445	-
1970	3019032	31.62%	61206	18.41%	1501	3.88%
1975	3904588	29.33%	76804	25.48%	1891	25.98%
1985	5842985	49.64%	118697	54.55%	2841	50.24%
1990	7309190	25.09%	142075	19.70%	4693	65.19%
2000	10018735	37.07%	172291	21.27%	15753	235.67%
2007*	11174257	11.53%	200572	16.41%	19539	24.03%

*Çavuşbaşı Municipality has joined the Beykoz Municipality as from 2008.

Figure 10 shows the distribution of the land use over years in percents. While almost the entire study region consisted of forest and cultivated areas in 1946, the forest and cultivated areas are observed to have rapid decrease due to the current change. Eventhough the forest areas were transformed into urban areas, the presence of forests in the region has displayed an increase since 2013, compared to 2003, which is associated with the large-scale forest fires that occurred in the region between 3rd and 4th of September 1998 (Anonymous-2, 1998). The forest areas that were ruined in these fires explain the decrease in forest areas in 2003. An increase was observed in the forest areas in 2013 compared to 2003, which was a result of planting some of the areas that had been ruined thus far.

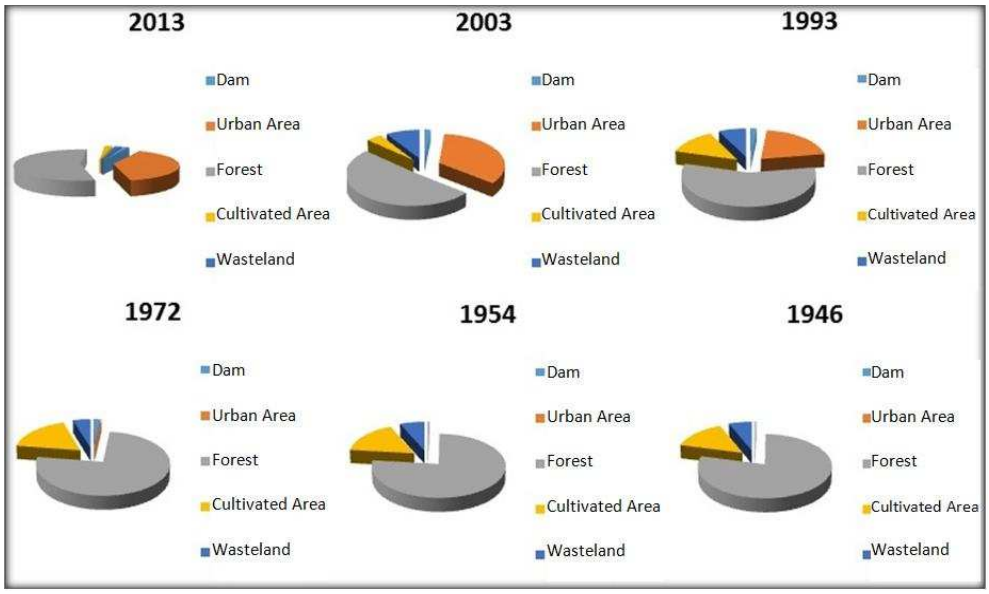

Fig. 10. Distribution of the land use over years [%].

"ISKI Drinking Water Basins Regulation" aimed to prevent the pollution of surface and underground water within and outside the borders of Istanbul Metropolitan Municipality, which provides and will continue to provide the drinking and domestic water needed in the borders of Istanbul Metropolitan Municipality, in various ways. The fourth article of this regulation defined the protection areas. Table 6 shows the explanations about the protection areas.

Tab. 6. Protection areas according to the Drinking Water Basins Regulation

PROTECTION AREA	EXPLANATION
Absolute Protection Area	A horizontal land area of 300 m. as from the line formed by the water and the land at the highest water level around the artificial and natural lakes that provide and will provide drinking and domestic water. In case that the area in question exceeds the basin border, the absolute protection area ends on that border.
Short-Range Protection Area	A horizontal land area of 700 m. as from the upper border of the absolute protection area. In case that the border of the area in question exceeds the border of the catchment basin, the short-range protection area ends on the basin border.
Mid-Range Protection Area	A horizontal land area of 1000 m. as from the upper border of the short-range protection area. In case that the border of the area in question exceeds the border of the catchment basin, the mid-range protection area ends on the basin border.
Long-Range Protection Area	The entire land area starting from the upper border of the mid-range protection area until the end of the catchment basin.

Results marked the protection areas that were determined on the orthophotos of 2013 by the regulation in an attempt to determine the settlements included in the protection areas (see Figures 11 and 12).

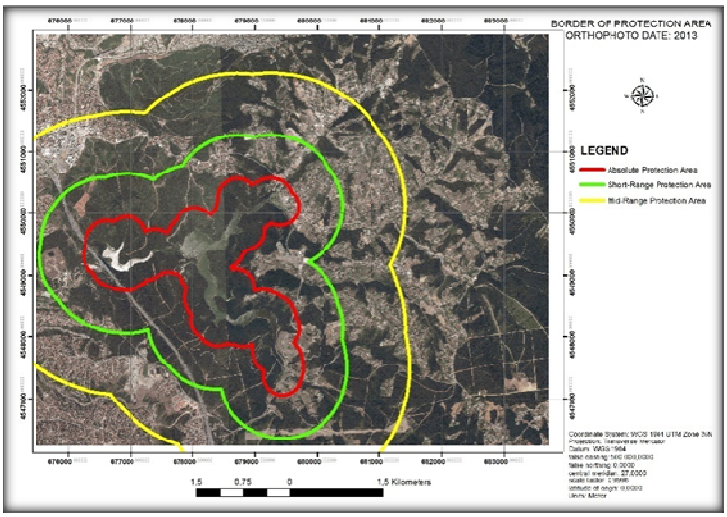

Fig. 11. Borders of the protection area.

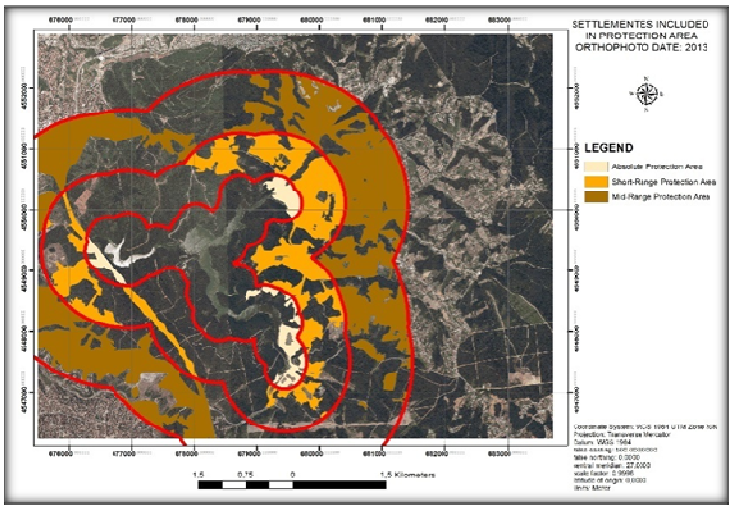

Fig. 12. Settlements included in protection areas.

The rules to be applied in the protection areas are explained in the 6th article of the Drinking Water Basins Regulation. In case that the department fails to make a decision, the ISKI (İstanbul Water and Sewerage Administration) Board of Management is authorized to make decisions about whether the matters that are not included in these articles are contaminating in respect to their activities or not, within the scope of applicable legislation and regulation.

In Lake and Stream Absolute Protection Areas (0-300 m); It is not allowed to construct buildings by any means except for purification plants to be constructed by the administration. It is not allowed to establish cemeteries, throw away or store liquid and solid wastes. However, it is allowed to plant trees and constitute trip, observation and fishing areas without doing activities like concretion that may obstruct the soil permeability and destroying the natural structure, in accordance with the landscape plans to be prepared by receiving the opinions of ISKI. These areas are not allowed to be 300 m. closer to the catchment structure. In compulsory cases, the roads may be enabled to have only the transportational functions regarding these parts. It is not allowed to construct facilities like stopovers, gas stations, parking lots.

In Short-Range Protection Areas (300-1000 m); It is not allowed to construct buildings by any means except for purification plants to be constructed by the administration. It is not allowed to establish cemeteries, throw away or store liquid and solid wastes. However, it is allowed to plant trees and constitute trip, observation and open sports areas without doing activities like concretion that may obstruct the soil permeability and destroying the natural structure, in accordance with landscape plans to be prepared by receiving the opinions of ISKI. It is not allowed to restore or destroy and then reconstruct the available buildings in the short-range protection areas. In compulsory cases, the roads may be enabled to have only the transportational functions regarding these parts. It is not allowed to construct facilities like stopovers, gas stations.

In Mid-Range Protection Areas (1000–2000 m); It is not allowed to construct industrial buildings, free zones, medical faculties, educational institutions processing chemical substances in laboratories and workshops, hospitals, gas stations, stockbreeding facilities, slaughterhouses, stores of chemical substances, fuels, toxic, harmful and hazardous substances, solid waste storage facilities, garbage collection and disposal centers and cemeteries. In case that the department fails to make a decision, the ISKI Board of Management is authorized to make decisions about whether the matters that are not included in these articles are contaminating in respect to their activities or not, within the scope of applicable legislation and regulation.

In Long-Range Protection Areas (between a basin border of 2000 m); It is not allowed to construct stores for metal hardening (with salt), metal coating, surface cleaning (with acids), textile coloring and printing, scrap plastic washing, lifted washing-greasing, chemical substance stores (combustible, inflammable, explosive), chemical substance production facilities causing industrial and waste water, scrap paper processing, raw hide processing, acid production and storage sites, agricultural contention production and storage sites, battery-accumulator production sites, grease oil plants (petroleum-derived), pig and dog breeding farms, integrated stockbreeding facilities, medicine synthesis plants, heavy metal salt production, window washing, wool washing, waste separation, storage and demolition centers, open coal storages, printing houses, chemical substance and fuel tanks (Anonymous-3, 2006).

4. Conclusions

Büyükçekmece, Küçükçekmece, Terkos, Elmalı, Ömerli, Darlık, Alibeyköy and Melen basins witness the land uses like settlements, industrialization, highways and agricultural areas, which are not allowed according to the regulation of ISKI since 2006. Büyükçekmece, Elmalı, Ömerli and Alibeyköy basins have the heaviest population and industrialization (Baykal et al., 2000). Thus, both the water quality and the sustainability of the basin's ecosystem are jeopardized. It is primarily required to remove all the settlements in the absolute and short-range protection areas within the scope of the regulation and plant these areas again. As a matter of fact, the "Green Belt Foresting Action Plan for Dam Basins" by the Ministry of Forestry and Water Affairs has clearly revealed the importance of this matter. One of the most important functions of forests is to regulate the water regime, supply the water resources in case of water scarcity, clean the water and increase its quality. Relevant studies have suggested that basins covered by forests receive a higher amount of rain and produce more usable water. Elmalı Basin was put under protection by the ISKI Drinking Water Basins Regulation, which became effective in 2006. However, the settlements in protection areas were intervened in a distance of 100 m around the lakes or streams until the preparation of the "Environmental Plans". Thus, local governments are required to prepare and enact the Environmental Plans for the protection of basins. The primary goal of forestations to be performed in drinking water basins is to form an ecosystem, which will prevent the erosions, have natural tree species requiring a lower level of water consumption and prioritize the hydrological function in order to produce abundant, quality, healthy and fresh water. On the other hand, the secondary goal is to prevent the settlement pressure that is causing water pollutions. The use of these areas as cultivated areas embellish the environment and provide the community health, which comprise the collective services. Thus, it is required to pay a great attention to planting the basins.

The literature review and the results of the temporal change performed with orthophotos in this study revealed that the urban land use of the Çavuşbaşı Region and Elmalı Basin threatens the water resources. As indicated by the temporal changes, this threat will increasingly continue unless the necessary precautions are taken. Table 7 clearly displays this result.

Tab. 7. Settlements included in the borders of the protection area.

AREA OF SETTLEMENTS	ABSOLUTE PROTECTION AREA	SHORT-RANGE PROTECTION AREA	MID-RANGE PROTECTION AREA
	0.69415 km^2	3.31845 km^2	7.68279 km^2

According to the juridical regulation, **it is not allowed to construct any buildings in absolute and short-range protection areas.** However, in this study, examining Figure 12 and Table 7; it is observed that an area of **4.0126 km^2 (approximately 400 hectares)** is structured against the regulation. Local governments and the administration are responsible for determining the reasons of this settlement and taking the necessary precautions.

Acknowledgement: *The authors wish to thank Turkish General Command of Mapping, Dr. Sedat Dogan and Dr. Ozgur Merih Araz for their technical support.*

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