Monitoring Coastal Land Use Changes Using Digital Photogrammetry: Case Study of Black Sea Coast of Trabzon, Turkey

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SUMMARY

The coasts, named as the natural sources, remaining untouched by human being for centuries brought up new ways of usage first by providing profil in terms of sea products and transportation, parallel to the development in social life forms and then by the increase in population and technological improvements. Photogrammetry has the advantages of acquiring information about a large area very efficiently and cost effectively. This paper introduces an efficient method to monitor environmental changes using a different approach for images taken from the same geographical location but at different times. If only available in an analog form, images need to be scanned before proceeding. After the completion of orientation process, the differences between consecutive data sets displayed in one picture immediately reveal environmental changes that happened in the time between, regarding e.g. urban development, roads, forests or coast lines. The described approach was verified by a test data set from Trabzon, in the east part of the Turkish Black Sea coast. Results gained so far are precise and clear enough to confirm the introduced method, and indicate that digital photogrammetry is an effective approach for monitoring coastal land use status of large area. In this study, the aerial photographs were obtained in two different times. By examining the photographs, it is apparent that coastal zone of the study area has been changed drastically in the course of time. The digital photogrammetric approach utilizes digital images to do all the measuring and digitising works. In this respect, high-quality digital images are required for use in digital photogrammetric processing. Besides, the processes of duplicating film and scanning positives should be done required geometric resolution with extra caution. This study shows that photogrammetry is very suitable for acquiring information about changes in a coastal area, particularly when cost, effectiveness, efficiency, and accuracy are all considered.

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1. INTRODUCTION

Coastline, defined as the line of contact between land and a water surface and, one of the most unique features on the earth's surface, have a dynamic nature. Coastline mapping and coastline change detection are critical for safe navigation, coastal resource management, coastal environmental protection, and sustainable coastal development and planning. Changes in the shape of coastline may fundamentally affect the environment of the coastal zone. These may be caused by natural processes and/or human activities.

Photogrammetry has the advantages of obtaining information about a large area very efficiently and cost effectively. Together with aerial photography, remotely sensed data forms the base for land use mapping and change detection (Pellikka et al., 2004). Especially for inaccessible areas, photogrammetry is far more superior than traditional ground survey. In recent years, inexpensive computers and advance of computer technologies contributed to the rapid development of digital photogrammetry (Dowman et al., 1992; Heipke, 1995). The information about the position, shape and geometric features of objects can be obtained from one or more photographs by the technique called Photogrammetry which is an option for monitoring of the land use changes. Digital photogrammetry applies the same principles and methods as traditional analog photogrammetry to obtain reliable information about physical object and the environment (Chandler, 1999; Schenk, 1999), and still contributes to many disciplines. Therefore, coastal area and land use change detection can be effectively determined using aerial photographs with digital photogrammetric techniques (Kraus, 1993). Successful implementation of digital photogrammetric workstation in mapping has been found in various disciplines (Chen et al., 1998; Skalet et al., 1992).

The aim of this study is to describe changes in coastal area, relate these changes to patterns of natural and human activities and make inferences about relationship between land cover change, succession and distribution. In this study, the aerial photographs were obtained 1973-2002 period, and used to investigate the coastal changes that took place over the last 30 years in the study area. The photographs were converted to digital images using high-resolution scanning device. Using the digital images, the digital photogrammetric technique was applied to monitoring coastal line and coastal land use changes of the study area.

2. COASTAL AREAS AND RELEVANT LAW IN TURKEY

Turkey has very long coastal line and three sides of its area are surrounded by the Mediterranean, Aegean and the Black Sea. The Sea of Marmara located between the Black Sea and Aegean is a water body connecting these two basins via the Turkish Strait Systems, Istanbul Strait and Canakkale Strait. Littoral of the land Turkey totals 8333 km with the islands (Burak et al., 2004). There are totally 28 cities and about 220 municipalities in only coastal zone of the Mediterranean, Aegean, the Black Sea and, Marmara regions. Generally, these are 38 % of the total cities and have 53 % population of the entire population in Turkey. Besides, the population of the cities in coastal areas has rapidly increased due to new policies and encouragements of the tourism after 1985 (Ongan, 1997).

Environmental conditions such as the climate, topography, and the characteristics of habitation vary in the coastal regions of Turkey. Therefore, several problems appear in the applications related to coastal planning. In addition, Turkey has cultural and historical merits, especially natural attractiveness. So, various investors prefer these areas. This situation causes many environmental problems in coastal areas. In coastal region of Turkey; sea and water pollution, prevented the public from accessing the coastline, contradictions and insufficiencies in legal arrangements, coastal erosions, filling the coasts for aiming to getting property, unbalanced construction causes unplanned urban areas, scattered buildings, environmental buildings, and destroying water sources, coastal region have insufficient social and technical infrastructure, uncontrolled urbanization and insufficient service appear, unbalanced developments in coastal areas result in land occupation, the filling to obtain land parts violates the public benefit (Kuleli, 1998).

In Turkey, according to the Turkish Coastal Law; coastal line is a natural line changing due to some meteorological events on the sea, lakes and rivers. These are formed by the fusion of the points on which the water touches the earth on the positions other than flood. Coast is an area between coast line and shore border line. Shore line (shore buffer zone) is an area of at least 100 m with horizontally from the coast line cover of sea, lakes and rivers to earth. Detecting the shore border line is necessary to make plans and practice on the shore lines.

In accordance with the Constitution Law of Turkish Republic, the coasts are at the disposal of the government. In utilizing from the sea, lake and river shore lines one must take care of first of all the public benefit. In accordance with the Turkish Civil Law, the places with no property and the goods in the benefit of the public are in no ones ownership and can never be a subject of a private landownership. According to the Coastal Law, the detection of the shore border line is required to be able to make plans and plan's implementation on the coast and shore line.

3. CASE STUDY

3.1 Study Area

The study area, from Yildizli district to Trabzon Harbour, is located in the north coast of Trabzon and is about 8 km length of coastal zone. This area is shown in Figure 1. The city centre and its coastal line were dealt with to examine coastal line and land use change.

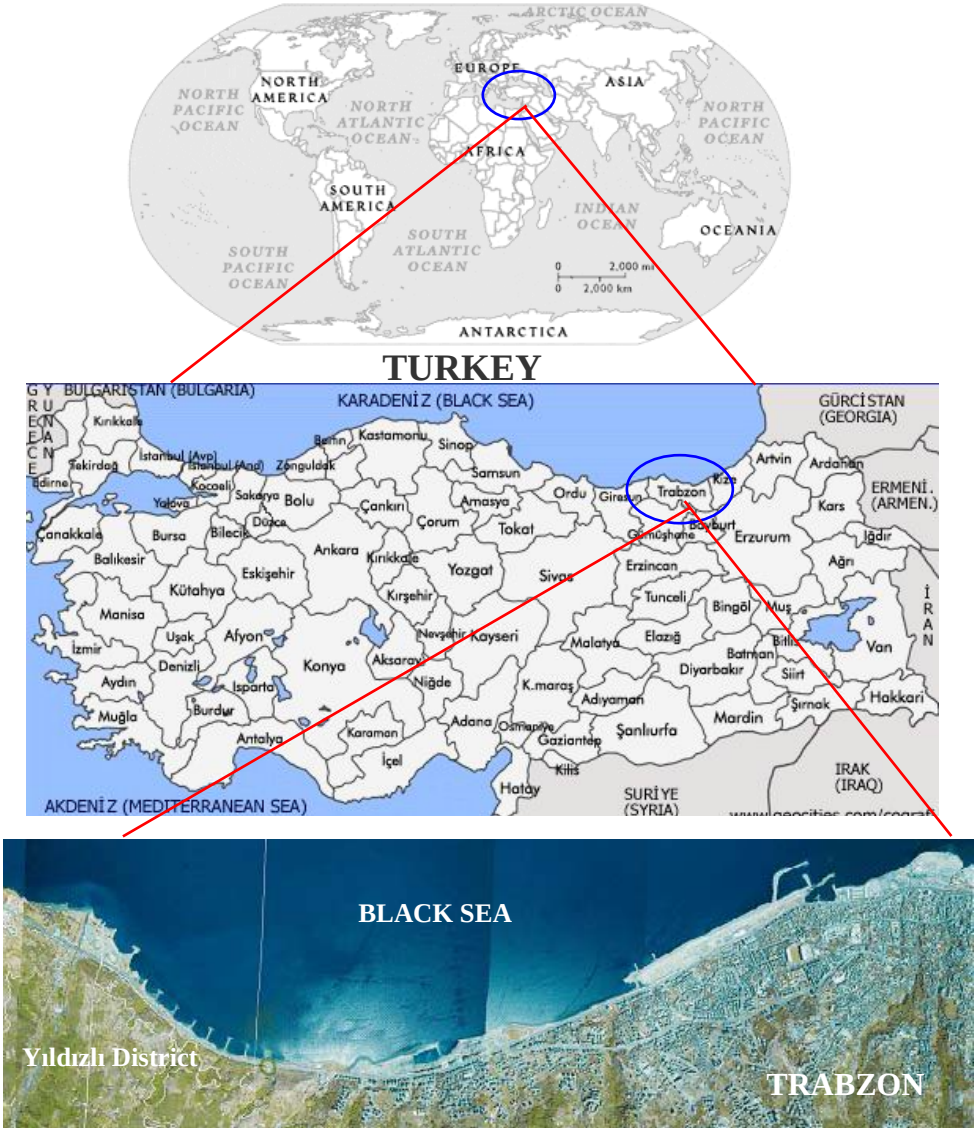

Figure 1. Location of study area

3.2. Data Sources

Time series aerial photos (1973 and 2002) of the study area in digital format were obtained from General Directorate of Forestry (Ankara) and District Directorate of Forestry (Trabzon). These photos were produced for different purposes during 1973-2002 periods. The images are of varying quality and scale (Table 1), and they provide a good indication of change detection of the study area. In addition to the aerial images, the topographical maps with 1:1000 scales were available for referencing the aerial images. Selected time independent objects such as building, road on this maps were used as control points. With these control points, it is established to relationship between object and image space.

Table 1. Details of aerial images

Date	Scale	Type	Purpose	# of Photos	Source
1973	1/23.000	Panchromatic	Revision of Topographical Maps	6986, 6987, 6988, 6989	District Directorate of Forestry (Trabzon)
2002	1/15.000	Color infrared	Forestry	4766, 4765, 4764 4763, 4762, 4761	General Directorate of Forestry (Ankara)

Figure 2. The different dated image covering the same coastal zone in the study area

3.3. Photogrammetric Evaluation and the Used Photogrammetric System

Photogrammetry is the technique of measuring objects (2D or 3D) from photographs. It is the goal of photogrammetry to derive geometrical parameters of remote objects from photographs. The imaging process is mathematically formulated by a perspective transformation which gives the relation between the position of a point in the photograph (described by image co-ordinates) and its objects co-ordinates (X, Y, Z). The results of a photogrammetric process can be coordinates of the required object-points, topographical and thematical maps, and rectified photographs (orthophoto) (Kraus, 1993). In this study, Z/I Imaging Digital Photogrammetric system for photogrammetric evaluation and Microstation

V.8 by Bentley Inc. were used as a CAD tool. Photogrammetric processes were conducted by Stereo Softcopy Kits (SSK) provided by Z/I Imaging (2001) (Atasoy et al., 2006).

In this study, coastal land use change in selected area was determined with digital stereo photogrammetric method using aerial photographs taken in different dates. A set of aerial photographs of the study area was acquired in 1973 and 2002. The photographs taken in 1973 and in 2002 are panchromatic and color infrared in scale of 1:23000 and 1:15000, respectively. The different dated image covering the same coastal zone in the study area can be seen Figure 2. While panchromatic images were scanned with 1200 dpi geometric resolution, infrared images were scanned with 800 dpi geometric resolution. The hardware and software used in the study included Z/I Imaging SSK digital photogrammetric system working on workstation and MicroStation V8 from Bentley. Images were processed in SSK performing model orientation and extracting topographic features. Because of the nature of the triangulation algorithms in SSK, some ground control points are required to give initial approximations of the model, as both the relative and absolute orientation stages are performed simultaneously. Four ground control points were scaled from existing topographical maps and measured in one stereo pair. After the model oriented from the images in 1973 and 2002, respectively, coastal line and other topographic features were measured. For monitoring coastal land use changes, topographic features such as coastal line, which are belong to both dates were transferred and merged in Net CAD software. Vector data created in different dates have been represented with various colors and coverage.

4. CHANGE DETECTION OF COASTAL LINE IN SELECTED AREA

Change detection of coastal line was evaluated for study area. As a result, it was found that during 1973-2002 period, 71,8 hectares of filling areas and 7,5 hectares of coastal erosion were covered with coastal line (Figure 3). As it can be seen from figure 3, while some areas were affected by human-induced impacts, some were changed with the natural effects. These affects can be formed in either negative or positive way.

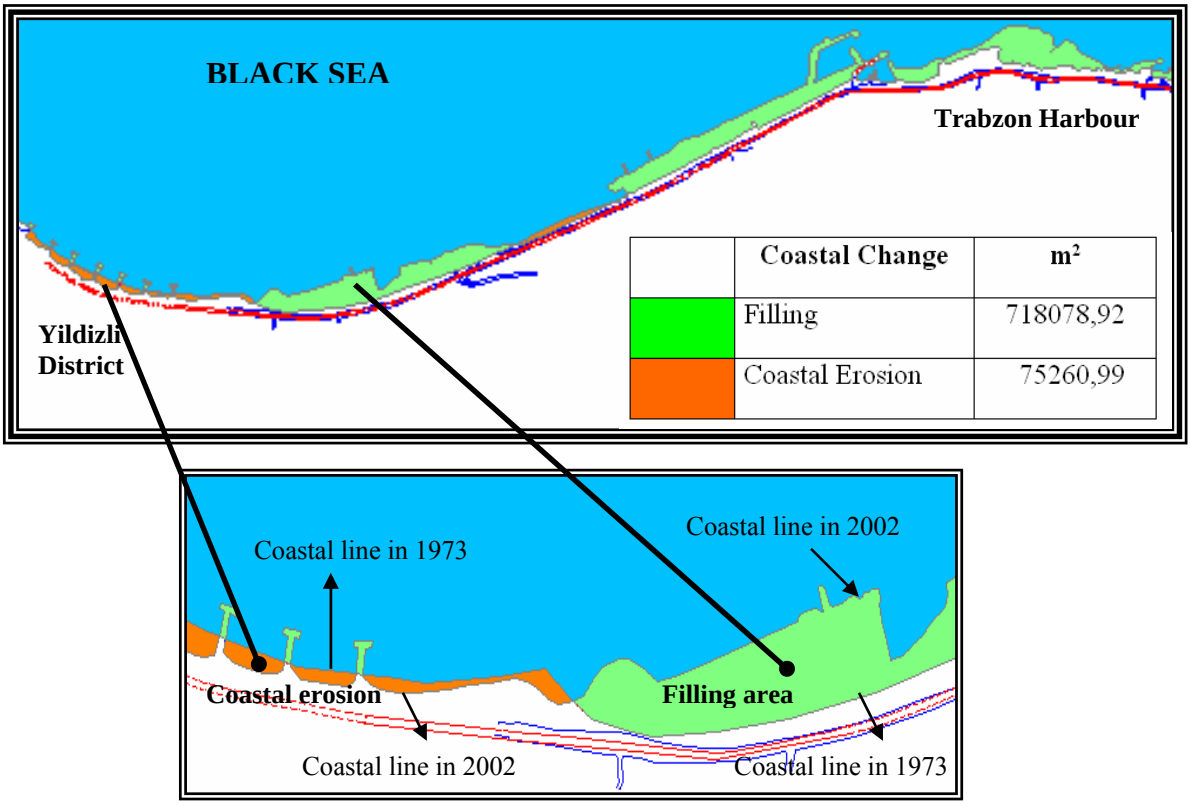

Figure 3. Coastal line changes in the study area

5. DISCUSSION AND CONCLUSIONS

In this study, the aerial photographs were obtained in two different times. By examining the photographs, it is apparent that coastal zone of the study area has been changed drastically in the course of time. The digital photogrammetric approach utilizes digital images to do all the measuring and digitizing works. In this respect, high-quality digital images are required for use in digital photogrammetric processing. Besides, the processes of duplicating film and scanning positives should be done required geometric resolution with extra caution.

The results of aero triangulation provide the basis for model adjustment and further measuring task, therefore the aero triangulation process has to be done carefully. Especially, ground survey should be done to acquire data about the control points for providing good results. The accuracy of the photogrammetric mapping process highly depend on the accuracy of control points, equipment used for measurement, and most importantly, well-trained people that execute the tasks. To insure satisfactory results, ground survey is necessary to obtain data for control points.

This study shows that photogrammetry is very suitable for acquiring information about changes in a coastal area, particularly when cost, effectiveness, efficiency, and accuracy are all considered.

In monitoring the coastal region that have a rapid changing characteristic, that analyzing land use changes with aerial photos is far more easy and fast than the classical surveying methods, especially for administrators.

Using the technique of digital photogrammetry seems promising for detecting changes in the coastal zone. But the scale of the images used has to be chosen based on the magnitude of the area. The scale of aerial images must be 1:4000 to 1:5000 for monitoring coastal line change. Aerial photogrammetry is an effective approach for acquiring information about a coastal area, particularly when cost, effectiveness, efficiency, and accuracy are all considered. Integrated with GIS, digital photogrammetric approach can provide timely and accurate information about an area, which can be valuable for various disciplines.

Further study is suggested to monitor the coastal changes of the study area. It is recommended to acquire aerial photographs old and new dated in order to monitor temporal changes in this area. Considering the cost and time constraint, as well as the desirable accuracy of the data generated from the mapping process, digital photogrammetric approach may be most suitable to meet the objective.

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BIOGRAPHICAL NOTES

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