Monitoring Coastal Land Use Changes on the Turkish Black Sea Coast with Remote Sensing: An Example from Trabzon, Turkey

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SUMMARY

Photogrammetry is a versatile field with many different applications. This paper introduces an efficient method to monitor environmental changes using a difference 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. Then, 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.

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1. INTRODUCTION

The advantages of sea and lake coasts and riversides have been effective in the development of many civilizations in areas since the early ages. The coasts, named as the natural sources, remaining untouched by human being for centuries brought up new ways of usage first by providing profile 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. 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). Successful implementation of digital photogrammetric workstation in mapping have been found in various disciplines (Chen et al., 1998; Skalet et al., 1992).

In this research, aerial photographs obtained were used to investigate the coastal land use status in the study area. The aerial photographs were converted to digital images using high-resolution scanning device. Using the digital images, the digital photogrammetric technique was applied to collect topographic features such as buildings, roads of the study area.

The objective of this research was to apply digital photogrammetry to monitor coastal land use change so as to provide valuable information for coastal line, coastal land use, and changing in density of buildings.

2. FUNDEMENTAL CONCEPTS ON COASTAL REGIONS IN TURKEY

2.1 Definitions

According to the Turkish Coastal Law numbered 3621/3830;
Coastal Line: It 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 touchs the earth on the positions other than flood.
Shore Border Line: It is a natural border of sandy, gravel, rocky, marsh, rushy, and other similar areas formed by the water mations against the earth after the coast line of sea, lakes and rivers. This border can't be changed eventhough sea is filled to obtain land.
Coast: This is an area between coast line and coast line cover.
Shore line (Buffer Zone): It is an area of at least 100 m with horizontally from the coast line cover of sea, lakes and rivers to earth.

On the coastal areas;

- The settlements targeting the prevention of the coast and usage of the coast for the public benefit: landing-place, harbour, hiding-place, pier, breakwater, bridge, .etc.
- The buildings and settlements that can only be constructed on the coasts because of their activity properties.
- In addition showers, shady sports, cabins, buffets not larger than 6 m^2 , and least 150 m between each one and mobile toilets and wooden piers that do not necessitate the building of canalization, can be constructed without any city planning.

On the first part of shore line; only green areas, children gardens, walking places, resting places and sightseeing areas, and pedestrian paths defined with the associated instructions can be constructed, On the second part of the shore line; touristic buildings and settlements, roads for the vehicles, open car parks and ..etc can be constructed.

2.2 The Laws about Coastal Region in Turkey

According to 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. According to the 2001 date 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 ownership. According to the Coastal Law numbered 3621/3830, the detection of the shore border line is obligatory to be able to make plans and plan's implementation on the coast and shore line.

But unfortunately, the usage out of public benefit is being seen because of the agitated in planning and the detection of coast line cover not in the way or at the time it must be done.

2.3 Problems on Coastal Region in Turkey

Turkey has very long coastal band and three sides of its area are surrounded by sea. 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 (Figure 1). In addition, Turkey has cultural and historical merits, especially natural attractiveness. Therefore, various investors prefer these areas. This situation causes many environmental problems on coastal areas.

On coastal areas in Turkey;

- Sea and water pollution,
- Prevented the public from accessing the coastline,
- Contradictions and insufficiencies in legal arrangements,
- Lack of authority,
- Coast erosions,
- Filling the coasts for aiming to getting property (aim)

- Unbalanced construction causes unplanned urban areas, scattered buildings, environmental buildings, and destroying water sources
- Coastal areas have insufficient social and technical infrastructure
- Uncontrolled urbanization and insufficient service appear
- Unbalanced developments on coastal areas result in land occupation
- The filling to obtain land parts violates the public benefit [Kuleli, 1998].

Fig. 1: The Example of land use violating the law in Trabzon

2.4 Fundamentals Basis on Photogrammetry

Photogrammetry, as its name implies, is a 3-dimensional coordinate measuring technique that uses photographs as the fundamental medium for measurement. The fundamental principle used by photogrammetry is triangulation. By taking photographs from at least two different locations, so-called "lines of sight" can be developed from each camera to points on the object. These lines of sight (sometimes called rays owing to their optical nature) are mathematically intersected to produce the 3-dimensional coordinates of the points of interest. This explanation is separated into two parts. Photography describes the photographic principles involved in photogrammetry, while measurement describes the techniques for producing 3-dimensional coordinates from two-dimensional photographs. Photography in its broadest sense is a process which converts the real 3-dimensional world into flat 2-dimensional images.

The camera is the device that makes this transformation or mapping from 3 dimensions to 2 dimensions. Unfortunately, we can not map the 3-dimensional world onto two dimensions completely so some information is lost (primarily the depth). Photogrammetry in its broadest sense reverses the photographic process described above. It converts or maps the flat 2-dimensional images back into the real 3-dimensional world. However, since information is

lost in the photographic process, we can not reconstruct the 3-dimensional world completely with just one photograph. As a minimum, we require two different photographs to reconstruct the 3-dimensional world. If this process was perfect, the two photographs are more than enough information to perfectly reconstruct the 3-dimensional world they represent. In photogrammetric evaluation, mathematical formulation (1), called collinearity equations, which is written according to Figure 2 is shown the following equations:

$$x - x_0 = -f \frac{m_{11}(X - X_0) + m_{12}(Y - Y_0) + m_{13}(Z - Z_0)}{m_{31}(X - X_0) + m_{32}(Y - Y_0) + m_{33}(Z - Z_0)}$$

$$y - y_0 = -f \frac{m_{21}(X - X_0) + m_{22}(Y - Y_0) + m_{23}(Z - Z_0)}{m_{31}(X - X_0) + m_{32}(Y - Y_0) + m_{33}(Z - Z_0)} \qquad (1)$$

where,

x, y are the image coordinates,
x_0, y_0 are the principle point coordinates,
f is focal lenght,
m_{ij} are the components of the rotational matrix,
X, Y, Z are the object space coordinates,
X_c, Y_c, Z_c are the coordinates of centre in object space.

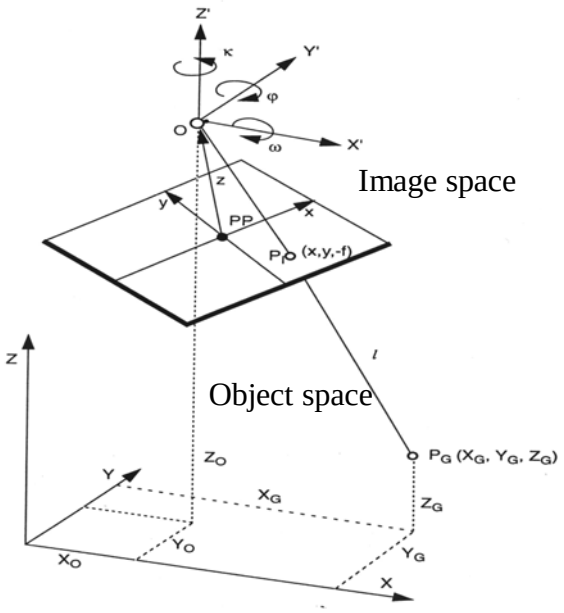

Fig. 2: The object and image space used in photogrammetry

3. THE STUDY AREA

As shown in Figure 3, the study area, Trabzon, is located in the north-east of Turkey and is about 3 km length of coastal zone. The city centre and its coastal zone were dealt with to examine coastal land use change.

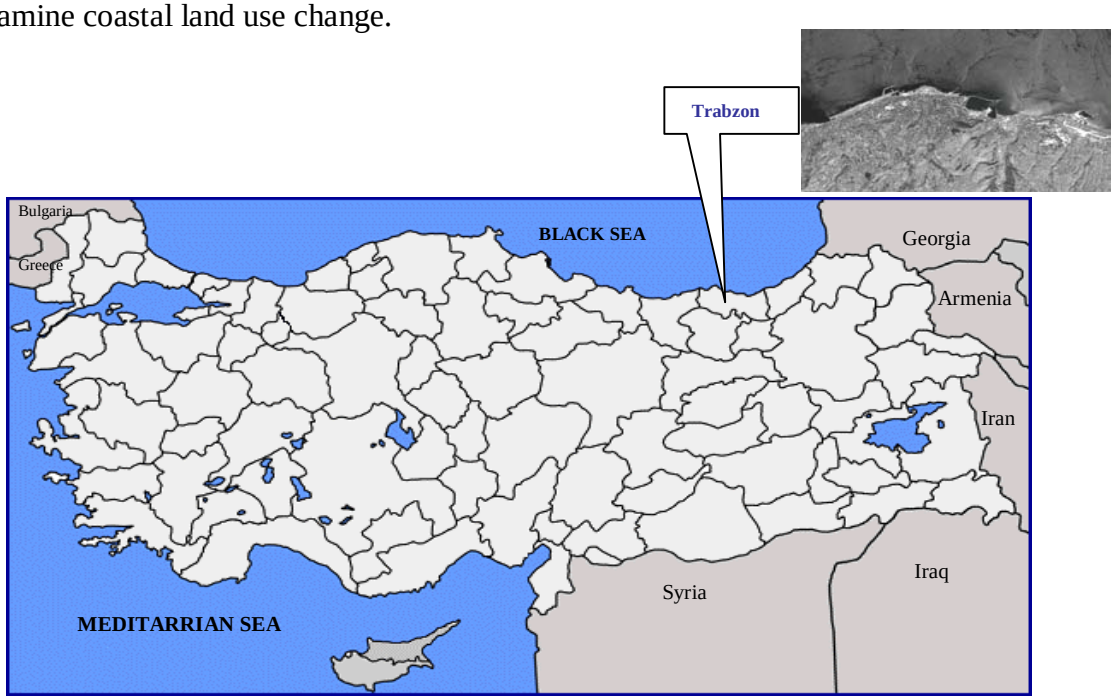

Fig. 3: Location map of the study area

4. CASE STUDY

Coastal land use change is becoming increasingly important to government authorities who are charged with monitoring changes to the coastline brought about by phenomena such as coastal line, density of buildings. Previously, monitoring techniques have often been crude and inefficient, due to the inherent problems associated with the wide areas and dynamic processes existing in the coastal zone. This research is developing a faster, more accurate and more efficient monitoring system.

In this study, coastal land use change in selected area was determined with digital stereo photogrammetric method using aerial photographs taken on 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 (Fig. 4 and 5). While panchromatic images were scanned with 1200 dpi geometric resolution, infrared images were scanned with 800 dpi geometric resolution.

Fig. 4: The old dated image covering coastal zone in the study area

The hardware and software used in the study included Z/I Imaging SSK digital photogrammetric system working on workstation and MicroStation V8 from Bentley. Imagery was 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 mapping and measured in one stereo pair. After the model oriented from the images in 1973 and 2002, respectively, the coastal line and other topographic features were measured.

Fig. 5: The new dated image covering coastal zone in the study area

For monitoring the coastal land use changes, topographic features such as coastal line, buildings, roads and green areas, which are belong to both dates were transferred and merged in Microstation software (Figure 6). Vector data created in different dates have been represented with various colors and coverage. This makes interpretation of changes done easily in study area.

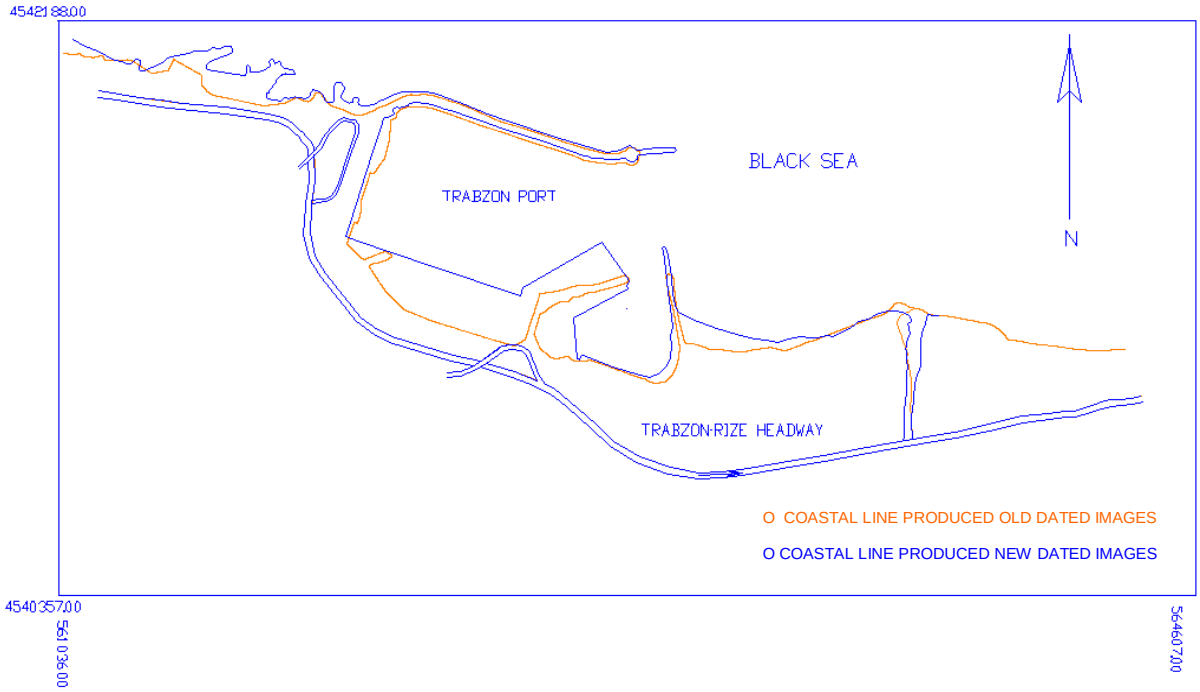

Fig. 6: Vector mapping of study area created from images

5. DISCUSSION

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.

The results of aerotriangulation provide the basis for model adjustment and further measuring task, therefore the aerotriangulation 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.

6. CONCLUSIONS

According to 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 ownership. According to the Coastal Law numbered 3621/3830, the detection of the shore border line is obligatory to be able to make plans and plan's implementation on the coast and shore line. Shore border line must urgently be detected, land ownership boundary and their legal states must immediately be defined clearly. 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.

REFERENCES

Chen, Y.K., J.F. Jan, and H.Y. Lai, 1998. Mapping and establishing topographic layers for GIS in mountainous forest area by digital photogrammetric technique. Quart. Journ. Exp. For. National Taiwan University, 12 (3), pp. 139-156. [in Chinese with English summary]

Dowman, I.J., H. Ebner, and C. Heipke, 1992. Overview of European developments in digital photogrammetric workstations. Photogrammetric Engineering and Remote Sensing, 58 (1), pp. 51-56.

Heipke, C., 1995. State-of-the-Art of digital photogrammetric workstations for topographic applications. Photogrammetric Engineering and Remote Sensing, 61 (1), pp. 49-56.

Kuleli, T., "Adana –Hatay İl Sınırından Yumurtalık'a Kadar Olan Kıyı Şeridi İçin CBS İle Kıyı Yönetim Planı Oluşturulması", Doktora Tezi, Çukurova Üniversitesi Fen Bilimleri Enstitüsü Su Ürünleri Anabilim Dalı, 1998.

Skalet, C.D., Y.G. Lee, and L.J. Ladner, 1992. Implementation of softcopy photogrammetric workstations at the U.S. Geological Survey. Photogrammetric Engineering and Remote Sensing, 58 (1), pp. 57-64.

BIOGRAPHICAL NOTES

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