Monitoring Land Use Changes and Determining the Suitability of Land for Different Uses with Digital Photogrammetry

Mustafa ATASOY, Cemal BIYIK, Huseyin AYAZ, Fevzi KARSLI, Osman DEMIR and Emin Zeki BASKENT, Turkey

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SUMMARY

Up until now, detailed investigation has not been carried out to identify the current land use pattern in Turkey. Due to lack of control and misdirection of authority, land use traditions have become a serious problem. The malicious implementation resulted in loses of forest land to other uses. This implementation has still been ongoing. However, the process have been overwhelmingly criticized by scientific authorities, because the converted land that should be left for forestry activities with respect to scientific criteria, has damaged natural environment and encouraged other potential landowners to try to claim ownership in forested areas as such. Digital photogrammetric techniques with high accuracy could be used to monitor land use changes occurred as a result of implementing the article 2B of the 6831 Turkish Forest Law by comparing old and new aerial images. With this method, the land subject to article 2B implementation could be reforested or reclaimed as a forest area by taking into account land use suitability pattern determined by scientific criteria. The same is valid for forestland lost before 1982. To implement the method successfully and display the result, a case study area was selected and evaluated based on the historical changes and land use capabilities of converted forest areas. The 1/35,000 and 1/16,000 scale panchromatic and infrared aerial images, taken in 1955 and 2002 respectively, were scanned with 21 and 30-micron geometric resolution. These images were interpreted by using photogrammetric software SSK by Z/I Imaging Inc. and some areas were determined analytically. The historical status of the 2B subjected forest areas (legally converted forest areas) were easily determined in digital form. Such approach could effectively be used elsewhere when the ground truth is ascertained and the land classified according to appropriate land use categories.

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1. INTRODUCTION

Recent surveys indicate that changes in forest cover and land use have a direct and enormous effect on wildlife, water quality, climate and carbon cycling. The forest ecosystem is threatened constantly by both human impacts like forest fires, air pollution, clearing for agricultural uses, illegal cutting and also natural phenomena like storms and droughts. Monitoring as well as control of this dynamically structured forest ecosystem is a great challenge for the sustainable management of forest resources [İnan and Erdin, 2004].

Turkey can be considered a high elevation country with an average altitude of 1150 m, and 53 % of the total land area is not suitable for agriculture [Balci, 1996]. Moreover, Turkey is situated on ecological zones with a very sensitive and fragile natural balance [Gezer, 1996]. Thus, in the case of a widespread destruction of forest ecosystems, it will be highly unlikely that these ecosystems will recover.

Although there is an urgent need to maintain the already fragile natural balances in forest ecosystems, no efforts have been made concerning the site classification in the country. On the other hand, only in the 80% of the total land area has the cadastral work been completed. Cadastre defines the way in which the land is used and owned.

The State has been taking protective measures in forested areas since 1870. However, these measures have generally been insufficient. Due to a lack of land use principles and objectives, people continue to utilize land as has traditionally been practiced. Studies indicate that one third of the land area in the country has been inappropriately utilized [Cangir and Boyraz, 1996].

As a result of the inappropriate land use practices and land allocation for other uses, erosion has been active in about 73% of the total land area [Balci, 1996], resulting in a 500 million tons of soil annually being transported to lakes and seas [Balci and Öztan, 1987]. This process not only degrades the arable lands but also fills dams with sediments, pollutes water resources and causes floods.

Illegal and inappropriate forest utilization has been widely practiced due to a lack of effective preventive measures in land use. This has resulted in the clearance of forest cover and converted areas to agricultural, residential and/or range uses. In effective land management has left these areas to the mercy of the users. Since 1970, a total of about 500,000 ha of forested land has been degraded and thus allocated to other uses such as agricultural, residential and range. But legal incentives make these practices more appealing. Moreover,

the forest areas allocated for other uses are not evaluated as to how they should be used and for what land use they are appropriate. Thus, some areas that should scientifically be kept as forests have been allocated for other uses and vise versa [Ayaz, 1997; Ayanoğlu, 2003].

One factor that helps reduce this trend is the movement of the population from rural areas to urban areas starting from 1980's. The share of the rural population in the country was 60 % in the 1970's, but it is now 35 % [DIE, 2004]. This situation, on the one hand, helped to decrease the social pressure on forest land in the rural areas, it gradually increased the illegal utilization and degradation of forest lands around the urban areas, on the other hand.

State has been severely criticized for passing laws that would legalize these actions and for not preventing the inappropriate land use allocations. However, these criticisms have no real scientific ground. There is not even a single literature that studies site properties, classifies sites for specific land uses and determine land use objectives in these areas. This paper proposes a method to identify this problem.

Recent advances in computer technology have allowed the development of software-based solutions to accurate topographic and planimetric mapping. The use of photogrammetry extends form the operation of analogue photogrammetric plotters through to the latest softcopy digital photogrammetry systems. While satellite imagery is an option for monitoring of the land use changes, its accuracy and availability in the past are major drawbacks for this study.

Photogrammetry is a technique whereby information about the position, size and shape can be attained. Photogrammetric products, however, refer almost exclusively to the object space (maps, surfaces (DEM's), orthophotos, points, profiles). Photogrammetry become still an important contribution to many disciplines. Forest and land use change detection can be effectively determined using aerial photographs with photogrammetric techniques (Kraus, 1993).

Since, remotely sensed data has become the major data source in the change detection of diverse applications including forest cover changes, because of the its advantages in fast, cost effective, synoptic, accurate, flexible and up to date properties and digital data acquisition characteristics, with the study, the land use change over the last 50 years was determined scientifically and the direction of the change was evaluated by using digital photogrammetric techniques [İnam and Erdin, 2004].

2. THE STUDY AREA AND DATA SET

The study area was selected in the Eastern Black Sea Region to determine the actual situation and change in land use over the last 50 years. Study area has a rugged topography with only about 10% of the area suitable for agriculture. The study area is situated in Çalköy district in the East Black Sea Region of Turkey (Figure 1). Çalköy, 30 km far from Black Sea, has 4318 of population. The total study area is about 600 hectares and average elevation of the area is

1200 m. The most important crops grown up in Çalköy are corn, bean, and potato. Most of the local residents live and work in Europe as industrial worker. The property cadastre works covering 501 hectares area is fulfilled by creating 2744 registered cadastral parcels. The cadastral works started in 1983 were finished at the end of 1991, taking about 8 years. In 1945, with the forest law No 4785, excluding some exceptions, the forests legally owned by people were nationalized over night. Therefore, in settlement areas related to forest, most of the lots covered by forest were registered as State forest in cadastral works. On the other hand, some areas that were originally used as agricultural fields in the former nationalization period, with current status of forest cover are registered as State forest during cadastral works. As a result, people in the region reacted seriously against cadastral works, and thus the cadastral works were sporadically halted and even most of them were delayed. The major cause for this delay is the forest property problems stated above in this region [Atasoy, 2004; Atasoy et al., 2004].

In order to accurately locate and determine the land use change over time available aerial photos were used in this study. Time series aerial photos of study area were obtained from General Command of Mapping (HGK) and General Directorate of Forestry (OGM) in digital format. These photos were produced for different purposes during 1955-2002 periods.

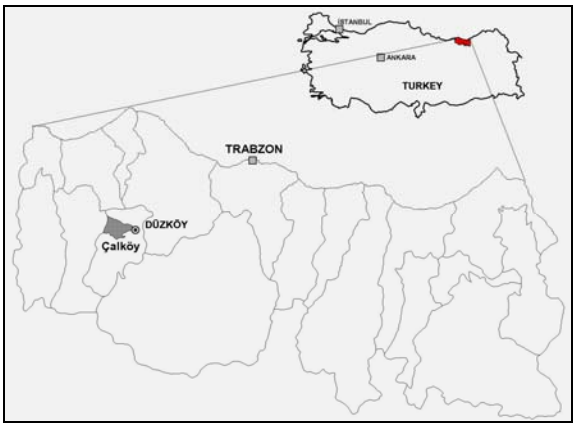

Figure 1. Location of study area

3. PHOTOGRAMMETRIC EVALUATION

3.1. The Used Photogrammetric System

In this study, Z/I Imaging Digital Photogrammetric designed by Zeiss and Intergraph initiative was used. Photogrammetric processes were conducted by Stereo Softcopy Kits (SSK) with ISPM, ISMS, IS, ISDM, ISSD, ISFC, ISBR, I/RAS C. Microstation V.8 by Bentley Inc. was used as a CAD tool in this study [Z/I Imaging, 2001].

3.2 Evaluation of the Aerial Images

Stereo photogrammetric evaluation was performed with Digital Photogrammetric Workstation Zeiss SSK, and aerial photographs of Çalköy district in Trabzon were used to digitize forest boundaries and other features. Pre-processing phases of the aerial images were conducted according to following instructions. First, image pyramids were made by using Many-Files-Converter module that enhance and ease image processing second the image was represented in three part overview, intermediate and detail. Finally, image orientation was carried out and the process continued. To get absolute orientation and superimposed to National Coordinate System pre-defined reference points such as schools, buildings and mosques corners were used to get the best result for references. These reference points were evaluated and fixed comparatively.

After pre-processing, the different dated images scanned with 21 micron precision and covered the selected area were transferred into the system. To establish the relationship between object space and image space, the ground control points were selected in model area to conduct all measurements in National Coordinate System. These points' coordinates were measured using GPS (Global Position System) technology. Then, inner, relative and absolute orientations were respectively performed. As a result of the absolute orientation, the accuracy was obtained as 45 cm in planimetry (x, y), 50 cm in height (z). The panchromatic and infrared aerial images taken between 1955 and 2002 in scale of 1/35000and 1/16000, respectively were used. The vector maps were produced from determining the images using the existing buildings, roads, forest boundaries, and the other important features. Available forested lands and cadastral units were compared according to related processes. The format transformation between .dgn and .dxf format products were made and finally the gained data was evaluated by using ArcInfo and ArcView GIS softwares.

4. CHANGE DETECTION OF FORESTED AREA IN ÇALKÖY

Change detection of forest area covering culture areas and high plateaus were assessed in Çalköy district. In the result of this assessment, it was seen that 334 hectare of forest areas were covered with the trees in 1955. There were 348.5 hectares forest areas in 2002. Since, most of the local residents had already left for Turkey to work in Europe, the change between 1955 and 2002 was occurred about 14.5 hectares. In this district examined change detection, between 1955 and 2002, the forest areas have been increased in 61.5 hectares as a result of the germination of the seeds naturally flying, declined 46.5 hectares because of clearing the forest cover and using it the aim of agriculture and pasture (Figure 2). Besides, it was determined that the forest area in which slope groups is increased or declined. While the forest is increasing about 46.2 hectares in land with %50 and more than higher slopes, in the other land with lower than %50 slopes the forest areas are declined. Increased areas were occurred not only higher slopes but also the effects of available forest areas. Declined areas were cleaned with the local residents to use settlement, raising livestock, and agricultural purpose. Increased and declined forest areas are depicted in figure 2 in Çalköy district. As

seen, 501 hectares agricultural areas have been in land with %0-50 slope groups. % 5.9 (29.6 hectares) of this areas have % 0-10 slope, % 12.4 (62.5 hectares) of this areas have % 11-20 slope, the rest of this areas (409.9 hectares) have higher than % 21 slope (Table 1).

Table 1. The slope groups of the land used as agricultural areas

Slope Group (%)	0-10	11-20	21>	Total
Parcel Area (ha.)	29.6	62.5	409.9	501.9
Percentage (%)	5.9	12.4	81.7	100

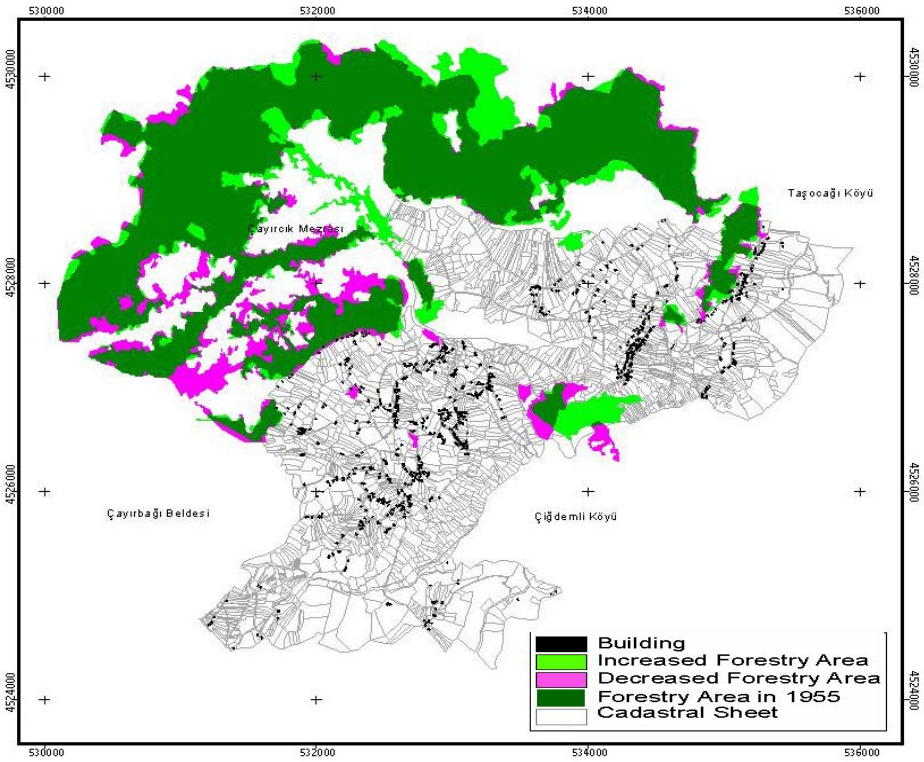

Figure 2. Increased and declined forest areas

These areas mentioned above are not scientifically appropriate for the agriculture life and they have incorrectly been allocated to current uses. In addition, the local residents have allowed some other areas to forested area. Available forest areas have been in land with higher slopes. In time, small cluster forest areas in the cultural areas were vanished by the human impacts.

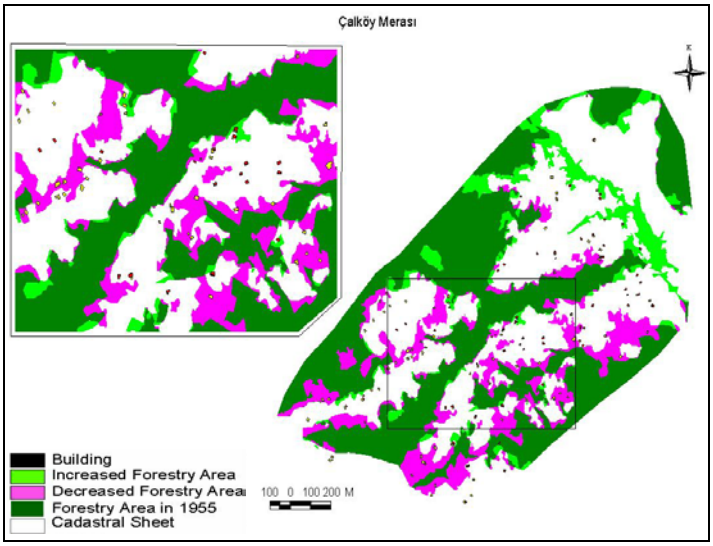

Figure 3. Changes in pasture areas

From Figure 3, it was experienced that there were a great deal of declined forest areas in Çalköy pasture. According to assessment for the pasture areas, about in 200 hectares areas, there were 106 and 95 hectares forest in 1955 and 2002, respectively. Between 1955 and 2002, while 27 hectares of areas were declined, 16 ha of areas were increased in forest area. In the study area, the use by the local residents for cultivation and raising livestock has affected on declining of the forest areas. As result of this, the houses available in 1955 were constantly added to new ones. Most of the houses were built in forested areas. Then, the forest areas surrounding the houses have been cleared and cut for farmland or converted it to agricultural areas. Whilst there were 48 houses in outside of the forest area in 1955, there were 107 houses in the same area by 2002. 22 houses available in 1955 remained in the same place, but 43 houses were built in different places in the forest area (Figures 4,5). It is seen that increased forest area have been located in outside of settlement and higher slope lands.

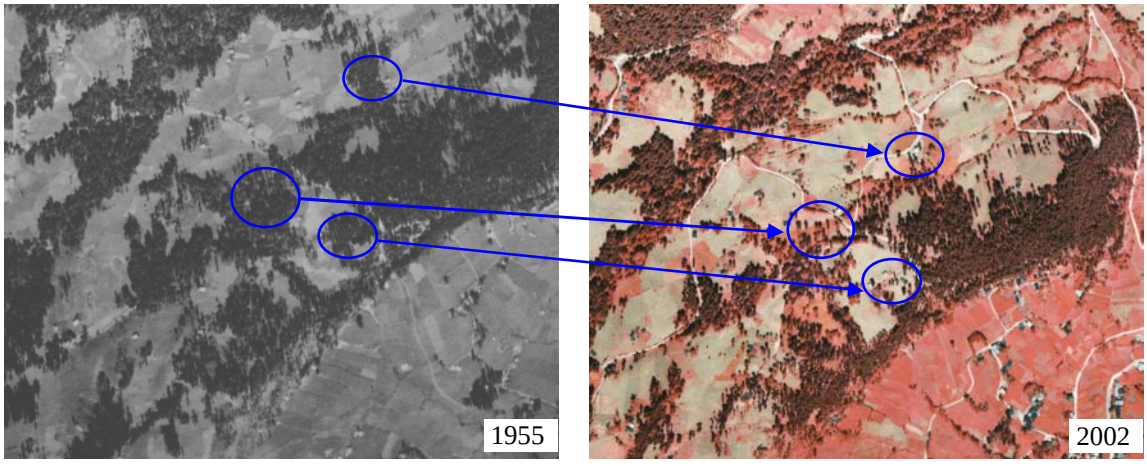

Figure 4. Changes in forest areas in Çalköy between 1955 and 2002

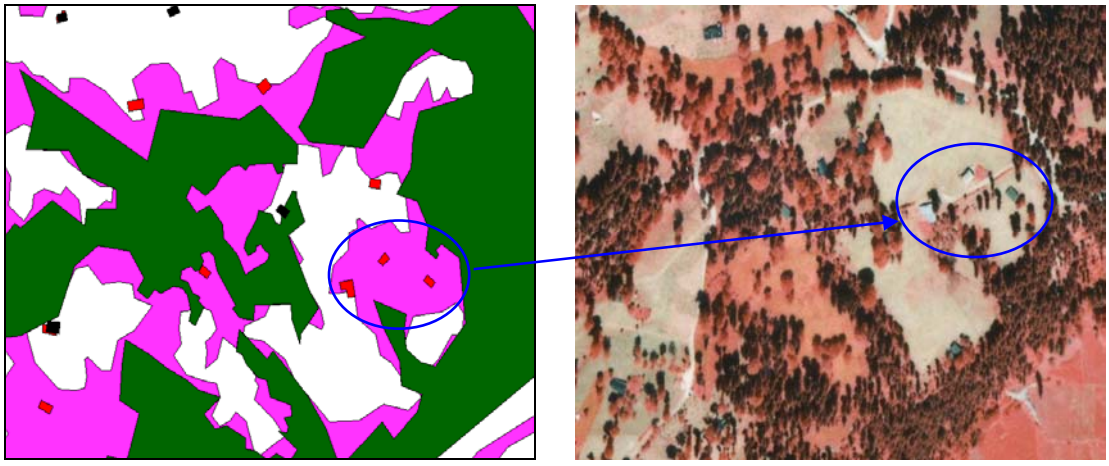

Figure 5. The houses built in forest areas (The same legend in Figure 3)

5. CONLUSIONS

In the study area, the local residents have traditionally selected their land use form. In generally, the local residents don't leave the forested land yet, they use these areas as cultivation area. Even, in the land near some settlements, they have cleaned small cluster forest area and have converted it to farmland and residential areas, while they were located in the higher slope areas. The amount of the land with higher slope and this misusage is 46.5 hectares. But, it is seen that the land used as agricultural before far from settlement, has been forested in time with the effect of near the forest of them. These forested areas are intensively located in the land with higher slopes and should be really forest areas. Farmland is situated in the land with lower slopes.

The main area of the declined forest areas is the state forest not registered to ownership in the pasture areas. The most forest declined is in the surrounding of pastures. Livelihood of the local residents is raising livestock. For this reason, the forest areas have been converted to pasture by cleaning.

In one hand, the local residents preserve the forest areas in the culture areas; on the other hand, they built house, cleaned the trees, and converted it to farmland in the forest area surrounding the state forestry's. However, the important contradiction is that the local residents maintain the forest areas in the culture areas and permit the forested areas up to finalize cadastral works of these areas and destroy the state forest with the idea of their without owners. The buildings have been built in the forest areas near the higher plateaus. With time, the trees around these buildings have been cut, and the areas have been converted to pasture.

In the result of the study, it can be said that remotely sensed data like aerial images can be used as very handy and appropriate tools for monitoring and change detection. Land cover

change or change detection can be analyzed using these data for different dates integrated Geographic Information System (GIS).

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BIOGRAPHICAL NOTES

Mustafa ATASOY is a research assistant at the Karadeniz Technical University (KTU), Turkey. He graduated from the Department of Geodesy and Photogrammetry Engineering at KTU in 1993. He received his MSc degree with thesis "Investigating the problems of applications modifying post-cadastre parcel ownership" in February 1997. He began PhD in September 1997. He has studied on "Solving Forest Property Problems by Digital Photogrammetric Method in Cadastral Works (Eastern Black Sea Region Case Study)" as his PhD thesis. His research interests are cadastral systems and forest cadastre, Digital Photogrammetry.

CONTACTS

Mustafa ATASOY
Karadeniz Technical University
Department of Geodesy and Photogrammetry Engineering
Trabzon / TURKEY
Tel: +90 (462) 3772774
Fax: +90 (462) 3280918
e-mail: amustafa@ktu.edu.tr

Cemal BIYIK
Karadeniz Technical University
Department of Geodesy and Photogrammetry Engineering
Trabzon / TURKEY
Tel: +90 (462) 3772767
Fax: +90 (462) 3280918
e-mail: biyik@ktu.edu.tr

Hüseyin AYAZ
Karadeniz Technical University
Faculty of Forestry
Trabzon / TURKEY
Tel: +90 (462)3772814
e-mail: hayaz@ktu.edu.tr

Fevzi KARSLI
Karadeniz Technical University
Department of Geodesy and Photogrammetry Engineering
Trabzon / TURKEY
Tel: +90 (462) 3772769
Fax: +90 (462) 3280918
e-mail: fkarsli@ktu.edu.tr

Osman DEMİR
Karadeniz Technical University
Department of Geodesy and Photogrammetry Engineering
Trabzon / TURKEY
Tel: +90 (462) 3773124
Fax: +90 (462) 3280918
e-mail: osmand@ktu.edu.tr

Emin Zeki BAŞKENT
Karadeniz Technical University
Faculty of Forestry
Trabzon / TURKEY
Tel: +90 (462)3772863
e-mail: baskent@ktu.edu.tr