GIS AND CARTOGRAPHY FOR MOUNTAIN ACTIVITIES AND NATURAL RESOURCES

M. Selcuk[1], M. Basaraner[1], N. Ulugtekin[2], T. Gokgoz[1], F. Gulgen[1], M.A. Yucel[1], A.O. Dogru[2], S. Bilgi[2], S. Cetinkaya[1], D. Ucar[2]

[1]Yildiz Tecnical University, Department of Geodesy and Photogrammetry Engineering, Division of Cartography, Istanbul {selcuk, mbasaran, gokgoz, fgulgen, aliyucel, sicetin@yildiz.edu.tr}
[2] Istanbul Tecnical University, Department of Geodesy and Photogrammetry Engineering, Division of Cartography, Istanbul {ulugtek, dogruahm, bilgis, ducar@itu.edu.tr}

Abstract

Mountains are complex ecological systems, with unique structures and functions, and have rich biodiversity, water and mineral resources, and opportunities for tourism. Their interesting and impressive nature is attractive as a place of escape for people in a stressful world. Mountains have become very important for tourism, which is the most rapidly growing industry in the world. Sports and leisure tourism in particular has increased in mountain areas over the past 30 years. Typical mountain activities include hiking, skiing, snowboarding, climbing, birdwatching and extreme sports. Mountains can also serve as a source of well-being and health. Better planning of activities and efficient management of natural resources in mountain areas are critical for the sustainable development. So, GIS and cartography can play a significant role in monitoring, protection and management of mountain areas through geospatial analysis and visualisation. Relevant studies are rare in Turkey. In this paper, we present a mountain GIS implementation of Mt. Aladaglar in Central Anatolia. Main part of the system is based on topographic data/maps and other related data/maps/materials. Remaining part of the system is based on thematic maps produced by General Directorate of Environmental Protection and National Parks. It enables different facilities such as querying, viewshed analysis, the extraction of cross-sections of mountain routes, animation and thematic mapping. Besides, a mountain map of Aladaglar is created mainly for sports and leisure activities based on geographic database.

1. INTRODUCTION

In the last years mountain cartography has become one of the most attractive fields of cartography. Living standard has been increasing, people are oriented to a more healthy way of life with closer connection to the nature and all these facts have caused that more and more people spend their time in mountain regions, walking paths and climbing peaks. A lot of people go to the mountains on their own, they also use the paths which were years ago accessible exclusively in the company of skilled mountain guides. The season of mountain visiting has been extended from a few summer months over the whole year, whenever weather and snow condition are suitable. Mountain maps representing various information in an accurate and understandable way are required for mountaineers to carry out their activities in safely. In this way, rescue, tourism, ecology and national park management can be managed using that kind of maps (Petrovic, 2001). The significance of mountain regions is increasingly being recognized by scientists, managers, and planners. From a scientific perspective, mountain research of high-magnitude processes, spatial and temporal scale dependencies, and internal and external forcings provides the opportunity to better understand complex systems and mountain geodynamics. From a human perspective, this understanding is very important for addressing natural hazard issues, and spatial information is required for inventory, planning, and mitigation. Similarly, the monitoring and assessment of mountain resources is critical for addressing issues of sustainability, population, economies, and geopolitics. Consequently, the demand for establishing an adequate cartographic base of spatial data that can be used to drive geographic information system (GIS) analysis is very much in demand (Buckley et al., 2004). A lot of people are encouraged to visit an unknown city without a city map or plan, it is also possible to drive and follow roads without using a road map. But, we can hardly imagine a mountaineer who is visiting an unknown mountain area without using a mountain map. This is the reason that more and more mountain maps and the other types of mountain area presentations have been requested on the market. Cartographers have answered such users' wishes by an increased mountain map production. Typical mountain maps are quite detailed large or medium scale topographic maps with accented mountain information, such as mountain tracks, mountain huts or ski mountaineering routes (Figure 1). Usually additional information as texts or pictures is added at the back side of the map or in a separate brochure (Petrovic, 2001). Especially the analysis and visualization of a large spectrum of new themes requires new cartographic methods and approaches which go beyond classic topographic and thematic cartography. In this domain, cartographic research stands only at its beginnings. The degree of automation of major production steps can still be increased significantly. Today's

Geographical Information Systems (GIS) still lack cartographically adequate and sophisticated visualization functions. Therefore the development of specialised tools (especially for difficult visualisation tasks of mountainous terrain) is a foremost task of cartographic application developers (Hurni et.al., 2006).

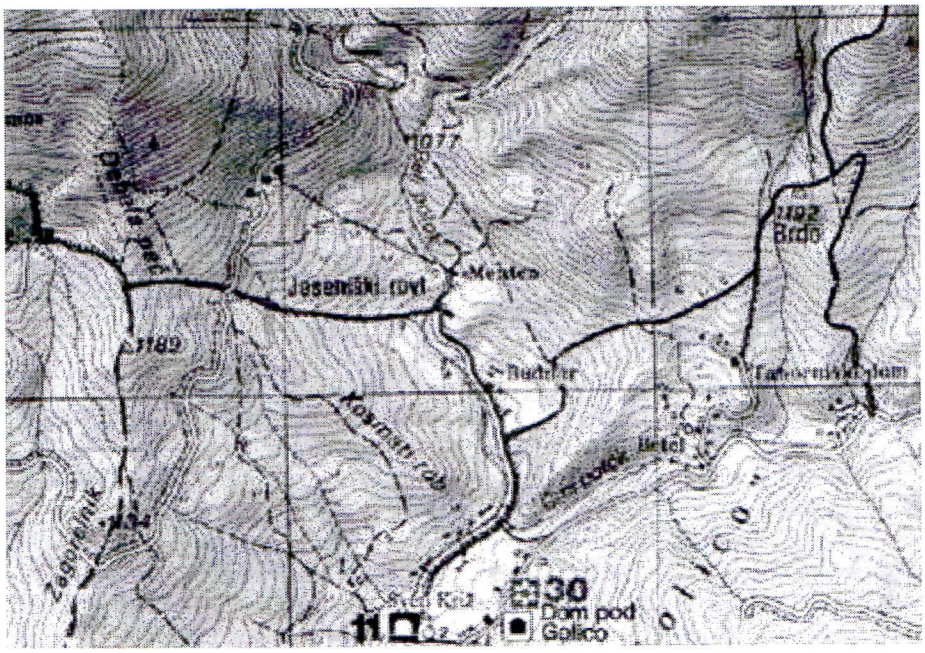

Figure 1. Insert from the mountain map (Petrovic, 2001)

Classic topographic maps are considered to be multipurpose maps by definition. First of all established for military purposes throughout the 19th and early 20th century, their scope of thematic applications has been widened since. Nevertheless, the maps were mainly used in 2-dimensional form as paper base-maps to be combined with thematic information. The digitization of those maps which began in the seventies and eighties of the 20th century led to a raster or vector-based, CAD-like representation of the same content or even to substantially thinned-out information (e. g. cliff areas), using rather unsophisticated data models like object-layers or Triangulated Irregular Networks (TIN). Especially for modeling, analysis and visualization of mountainous environments, those models are not sufficient (Hurni et al., 2003).

Most examples of topographic 3D-maps suffer from three typical problems in map design:

1. Ignorance of user needs: There is often an explicit target group, but the needs of the end users are not taken into account. The reason for this deficit seems very simple: We know very little about the specific needs of the different user groups of topographic 3D-maps. Often, we do not know what kind of information the users are really looking for. Why does somebody consult a 3D-map instead of a traditional topographic map? Furthermore, there are no empirical studies concerning how users read and analyse 3Dmaps.

2. Neglect of map symbolization and legend: We notice that symbolization and legends of topographic 3Dmaps are often neglected. Many map symbols are not fully designed according to objective. Some producers rely on their own subjective preferences of map symbols without examining whether they are appropriate for their purposes.

3. Missing cartographic principles for topographic 3D-maps: One reason for the neglect of map symbolization and of the legend is that there are no cartographic principles for designing map symbols for cartographic perspective views. Such principles would enhance consistency between design and meaning of map symbols. Cartographic principles are needed to define the shape of symbols (geometry, colour, outline), to master the complexity of perspective views (level of detail), and to position and label all map elements. Assisted by cartographic principles for topographic 3D-maps, we could adapt the symbolization of these innovative map products to the needs of specific cartographic customers (Haeberling, 1999).

Today, applications of mountain cartography are not only restricted to large mountainous areas like the Alps but one deals also with phenomena related to smaller areas, such as volcanic islands or coastal areas. Within this discipline, numerous thematic topics can be listed.

The following -incomplete- list gives an impression of the large extent of cartographic, mountain-related applications (Hurni et.al., 2003):

Topics	Phenomena (structures, processes)
Topographic relief representations	Heights: Represented by contour lines, spot heights, networks, hill-shading, (cliff representation)
Extent and surface	Geology, geomorphology, glaciology, permafrost, hydrology, climate
Dynamic processes	Glacier development, avalanches, "murgang", landscape change, vegetation development, weather
Anthropogenic influences	Settlement, economic structures, (mountain agriculture, tourism), leisure use (activities, infrastructure), traffic, environmental immissions (harmful substances, noise), culture (languages, customs)

A detailed review on the theory and practice of mountain cartography can be found in Hurni and Haeberling (2004).

2. CASE STUDY

2.1 Study Area

Mt. Aladaglar in the Central Anatolian Region of Turkey has been selected as study area since it is very important territory not only for domestic and foreign mountaineers and tourists but also for ecologists, geographers and geologists. This mountain range is in the provinces of Kayseri, Nigde and Adana, has a wide variety of plant and animal life and because of this a 54,524 hectare area was declared a national park in 1995. Forming part of the central Taurus mountain range, The Aladaglar massif boasts the region's highest peaks (Demirkazik summit, which stretches to 3756 m). In this range there are three peaks of about 3700m, many more over 3000m, with numerous lakes. Both the Mediterranean and Anatolian weather systems influence the climate of the Aladaglar Massif, bringing warm summers and cold winters to the area. In the spring, a large number of lakes are formed from the melting snow but the in dry summer season most of them evaporate. Only a few, fed by underground water sources, remain by the end of the summer. During summer time, entire families move up to the high meadows of Aladaglar massif where they pitch their tents for all the season. The geology of the area is responsible for the interesting rock formations and waterfalls. The erosion of limestone has created a fascinating karstic topography and hydrography, especially in the Yedigoller valley, where the karstic underground rivers and caverns collect the surface water. (URL 1; URL 2).

2.2 Data

In this study, raster topographic maps at 1:25:000 and vector contours belonging to these maps, obtained from General Command of Mapping, and thematic maps at 1:100 000, provided by General Directorate of Environmental Protection and National Parks, were used. Besides, the routes in mountaineering books as well as collected using mobile GPS by mountaineers were incorporated into the system.

2.3 Design

First, an object catalogue is created for mountain GIS, which comprises topographic and thematic object classes (Appendix). It is based on medium scale topographic map specifications, various mountain maps, thematic maps on natural resources and risks, and mountaineering documentations.

2.4 Implementation

2.4.1 Spatial Data Processing

First, raster topographic maps were digitised in MapInfo Professional 8.5. Then these digital data were transformed to UTM Zone 36 (WGS84) from UTM Zone 36 (WGS84) coordinate system. After that, 10-metre DEM was created from 10-metre interval contours, regarding the characteristic structure of terrain in ArcInfo Workstation 9.1. This DEM was later

converted to Vertical Mapper 3.1. Designed object classes were structured in geographic database of MapInfo. Besides, mobile GPS data was converted to MapInfo Professional 8.5 through Global Mapper 8.0 software. Thematic data were originally in AutoCAD DWG format with a local coordinate system. It was transformed to UTM Zone 36 (WGS 84) coordinate system, using NetCAD 4.0 and converted to MapInfo. All these data were then processed to make them appropriate for GIS. Since one of the outputs of this system was a mountain map, a symbology study was made. Map symbols were determined by benefiting from the symbology used in the topographic maps and various mountain maps.

2.4.2 Spatial Analysis and Visualisation

Mountain GIS presented here enables to perform various spatial analyses and visualisations for the mountain area through the DEM. Cross-section creation of the mountain routes (Figure 2), point-to-point visibility analysis (Figure 3), viewshed analysis (Figure 4) can be performed and visually presented. Besides, slope and aspect grids can be created and related analyses can be made.

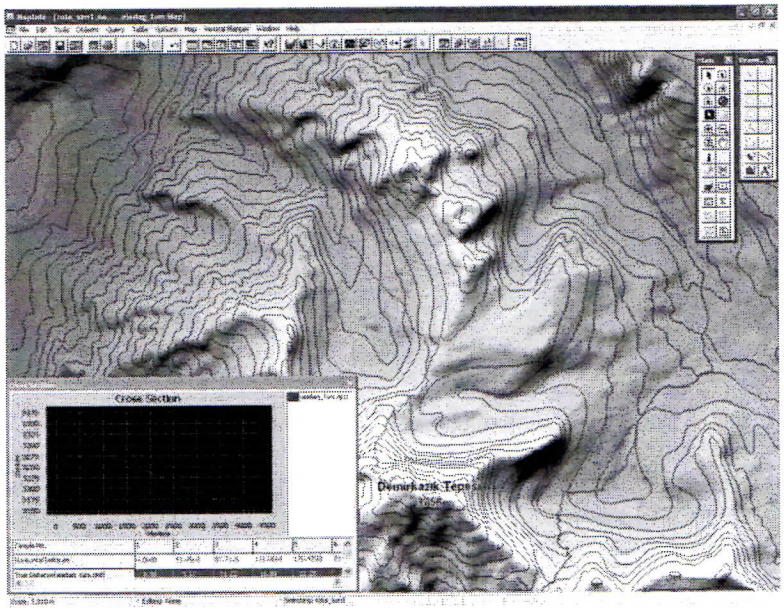

Figure 2. The cross-section of a mountain route

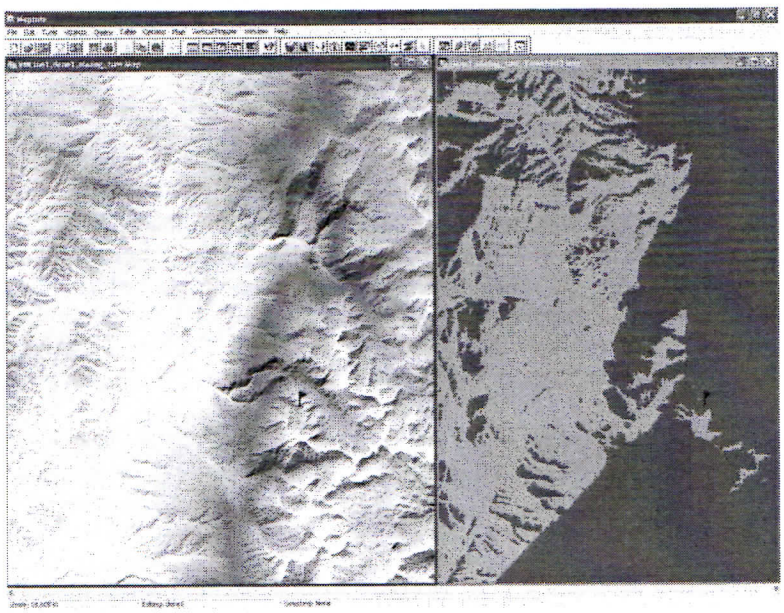

Figure 3. Point-to-point visibility analysis (green: visible, red: invisible)

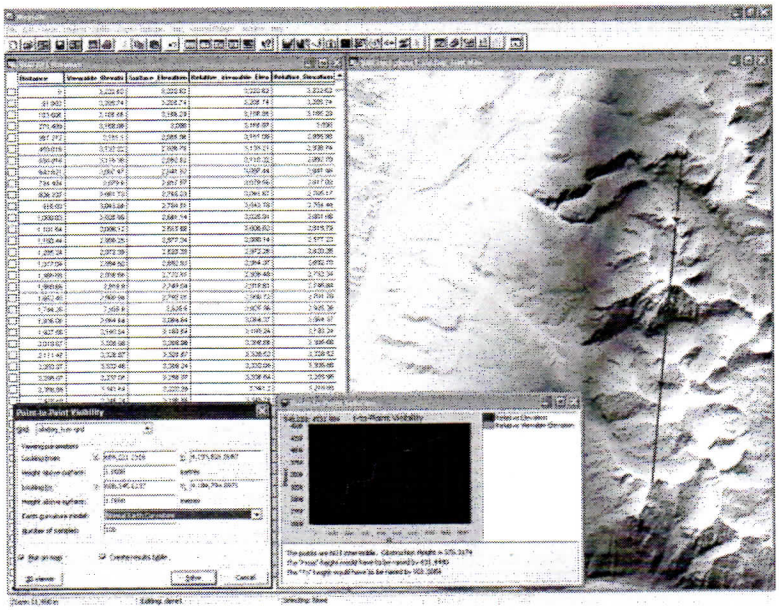

Figure 4. Viewshed analysis

2.4.3 Map Design and Production

Mountain maps are special types of thematic maps. In addition to base topographic objects, they contain mountain routes, campgrounds, risk regions etc. Figure 5 shows an extract of the mountain map produced in the mountain GIS.

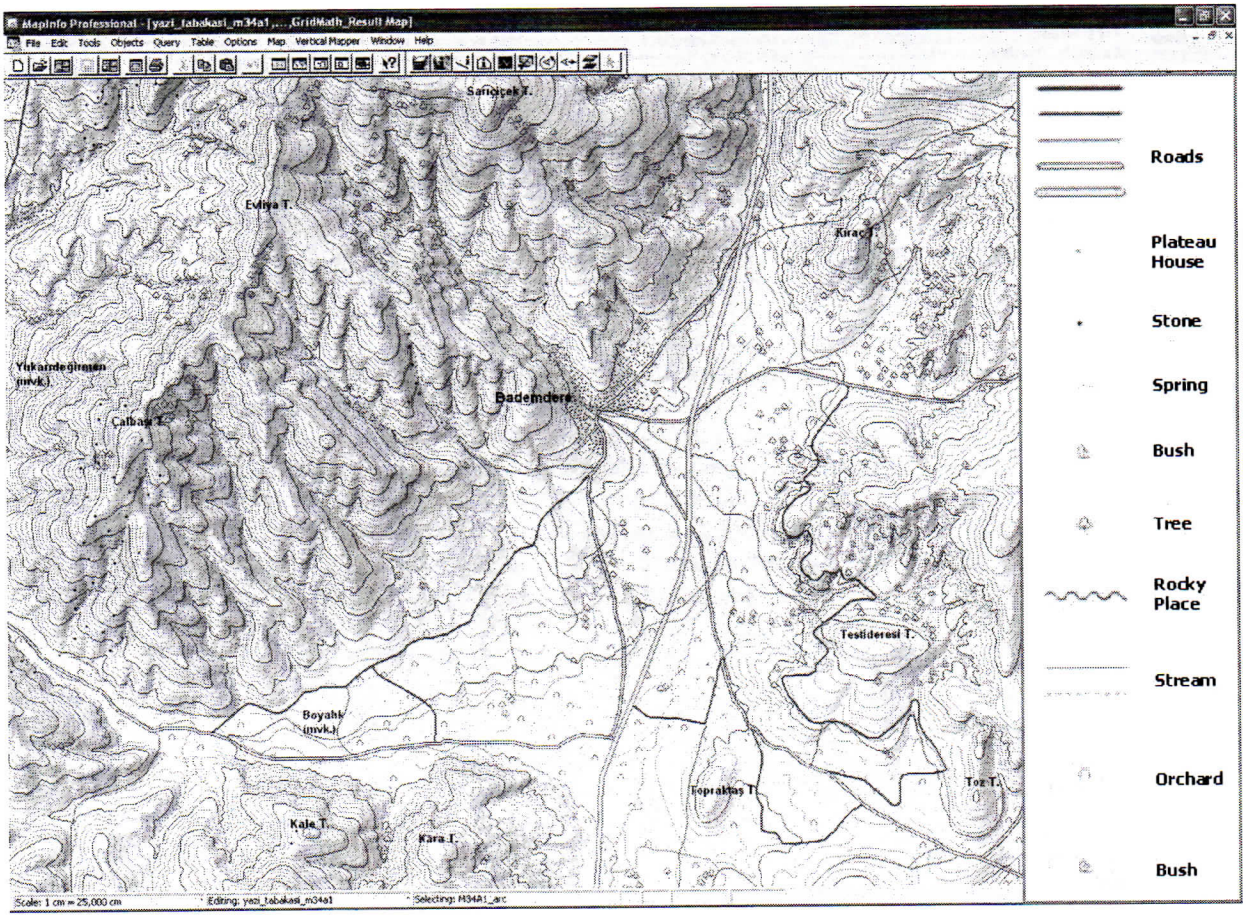

Figure 5. GIS screenshot of the mountain map

Existing thematic maps on environmental problems, geology, flora, fauna, soils for Aladaglar National Park were also edited and re-designed in mountain GIS environment (Figure 6).

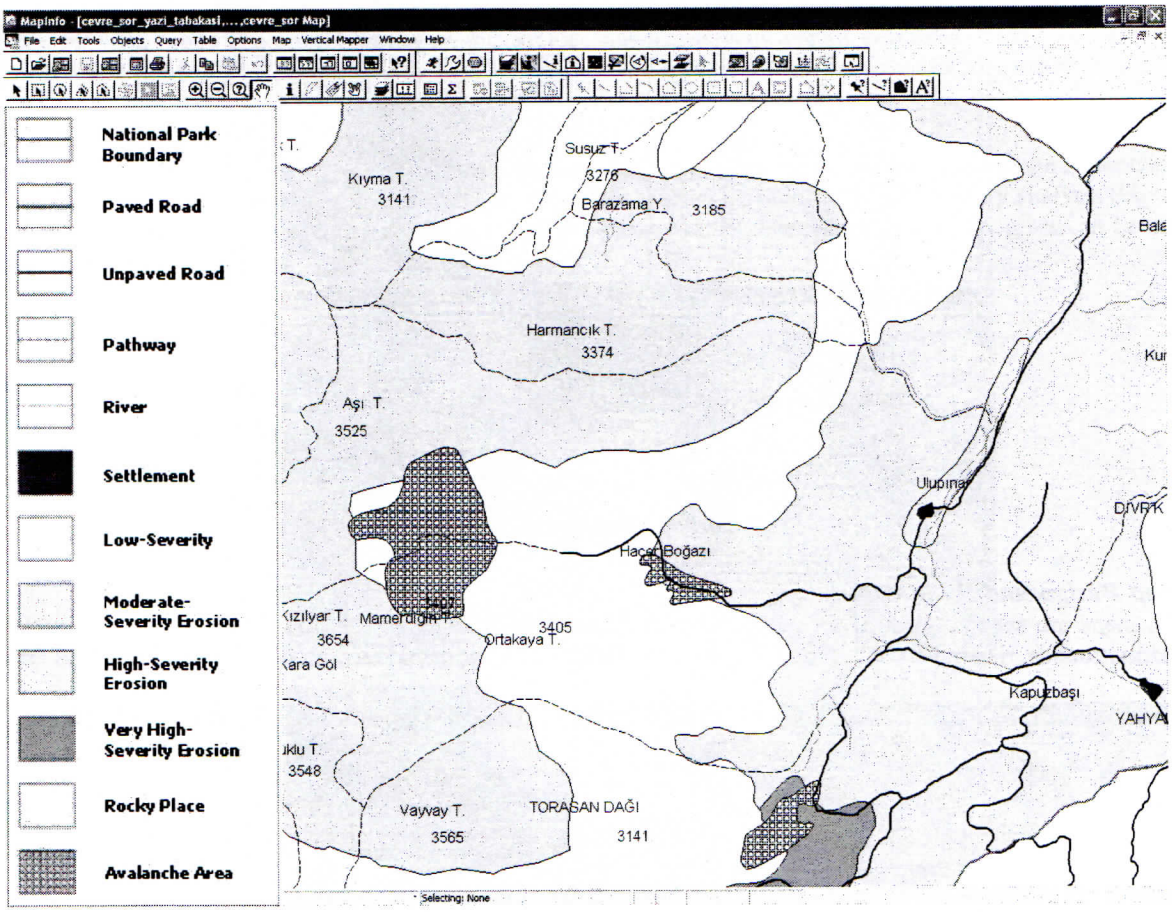

Figure 6. GIS screenshot of the thematic map on environmental problems

3. CONCLUSIONS

Since mountains are important areas in view of sports, tourism and ecology, various activities in these areas should appropriately be planned and managed. This can be feasible by means of accurate, up-to-date and complete geographic information. So, a mountain GIS that can be used in mountaineering, search and rescue, tourism, and natural resource management were created in this study. Effective communication of geographic information is another significant issue on efficient utilisation of this system. Hence, second step of the study has been the design and production of different thematic maps for Mt. Aladaglar. This is among the first studies in Turkey on mountain GIS and cartography, which will possibly light the way for more comprehensive studies. It is evident that effective management of mountain areas requires the contributions of different disciplines such as geomatics (geodesy and geoinformatics), geography, forestry, ecology, regional planning, meteorology and geology. New studies are being planned for the conservation, management and sustainable development of mountain areas within this perspective by the Ministry of Environment and Forestry.

ACKNOWLEDGEMENT

This research has been supported by Yildiz Technical University (YTU) Scientific Projects Coordination Department. Project Number: 25-05-03-01.

REFERENCES

Buckley, A., Hurni, L., Kriz, K., Patterson, T. and Olsenholler, J., 2004. "Cartography and visualization in mountain geomorphology". In: Bishop, M. and J. Shroder (Eds.): *Geographic Information Science and Mountain Geomorphology*, Chichester, UK: Springer-Praxis.

Haeberling, C., 1999. "Symbolization in topographic 3d-maps: conceptual aspects for user-oriented design". In: *Proceedings of 19th International Cartographic Conference*, Ottawa, Canada (CD).

Haeberling, C. and Hurni L., 2002. "Mountain cartography: revival of a classic domain". *ISPRS Journal of Photogrammetry and Remote Sensing*, Volume 57, Issues 1-2, pp. 134-158

Hurni, L., Haeberling, C. and Kriz, K., 2003. "Mountain cartography: state-of-the-art and current issues". In: *Proceedings of 21st International Cartographic Conference*, Durban, South Africa (CD).

Hurni, L., Iosifescu-Enescu, I., 2006. "What makes cartography interesting for mountain researchers?". *5th ICA Mountain Cartography Workshop*, Bohinj, Slovenia, 30 March - 1 April 2006.

Petrovic, D., 2001. "Three-dimensional mountain map". In: *Proceedings of 20th International Cartographic Conference*, Beijing, China.

URL 1: http://www.kultur.gov.tr/EN/BelgeGoster.aspx?17A16AE30572D313FFB2CB2AD591CE26991E4DDB4479F88 (Accessed: 02.11.2007)

URL 2: http://www.infohub.com/TRAVEL/SIT/sit_pages/21077.html (Accessed: 02.11.2007)

Appendix. Mountain GIS object classes

OBJECT CLASS	**GEOMETRY**	**ATTRIBUTES**
CONTOURS	Line	Height, Type
HEIGHT POINT	Point	Height
DEPRESSION	Point	-
WATERFALL	Line	Name, Height
STREAM	Area/Line	Type
LAKE	Area	Name, Type, Depth, WaterCharacteristic
SPRING	Point	Name
WATER WELL	Point	Type
WATER BRIDGE	Line/Point	Condition
TOWER	Point	Type, Height
WATER TOWER	Point	Height
GLACIER	Area	-
GRAVEL	Area	-
AVALANCHE PATH	Line	-
COLLAPSED LAND	Area	-
MOUNTAIN PASS	Point	Name
SNOWY AREA	Area	-
ROCK	Point	-
ROCKY PLACE	Line	Type
SLIDING LAND	Area	-
SANDHILL	Area	-
SAND AREA	Area	-
LAVA FIELD	Area	-
WOODED MARSH	Area	-
CAVE	Point	-
STONE	Point	-
STONY PLACE	Area	-
TERRACE	Line	-
SOIL ERASION	Line/Area	-
SOIL SET	Line	Type
SOIL CLIFF	Line	Depth
PLATEAU HOUSE	Point/Area	Condition
CAMPGROUND	Point	-

ROAD	Line	Name, Condition, NumberOfLane, PavementType, PlatformWidth, PavementSurfaceWidth, PurposeOfUsage, SuitableWeatherCondition
BRIDGE	Point/Line	Name, Type
TREE	Point	Type
AFFORESTATION AREA	Area	-
VINEYARD	Area	-
MARSH	Area	-
MARSH FIELD / MEADOWLAND	Area	-
MARSH/REEDY/SEDGE FIELD	Area	-
BUSH	Point	-
BUSHY FIELD	Area	-
MEADOWLAND	Area	-
PLANTATION	Area	-
ORCHARD	Area	-
FOREST	Area	Type
SEDGE /REEDY FIELD	Area	Type
FAUNA	Area	Type, SpecialName
WILD LIFE HABITAT	Area	Type
FLORA	Point	EndemicTypes
PLANT FORMATION	Area	Type
AVALANCHE AREA	Area	AreaID, Risk
AVALANCHE RECORDS	-	AreaID , Date, NumberOfDeaths, NumberOfInjuries
LANDSLIDE AREA	Area	AreaID , Risk
LANDSLIDE RECORDS	-	AreaID, Date
ROCK ROLLING AREA	Area	AreaID, Risk
ROCK ROLLING RECORDS	-	AreaID, Date
SOIL	Area	CapabilityClass
WATERSHEDS	Area	Name
GEOLOGY	Area	GroundType, GroundRockType
LARGE SOIL GROUPS	Area	Type
EROSION FIELD	Area	RiskRank
FOREST SERIES	Area	Type
LANDUSE	Area	Type
PROPERTY	Area	Owner, Usage
PROPERTY BOUNDARY	Line	Type

Contact person:

Dr. Melih Basaraner
Yildiz Technical University
Faculty of Civil Engineering
Department of Geodesy and Photogrammetry Engineering
Division of Cartography
TR-34349 Besiktas-Istanbul
Tel: +90(212)2597070 ext: 2515
Fax: +90(212)2596762
E-mail: mbasaran@yildiz.edu.tr