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Designing and Developing a Province-Based Spatial Database for the Analysis of Potential Environmental Issues in Trabzon, Turkey

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Abstract

Environmental databases generated by automation of the decision-making process for resolving complex environmental problems can be used more efficiently than traditional environmental evaluation. Such databases allow access to and analysis of spatial information at either the local or regional level for purposes including the development and assessment of effect of environmental policies, land use planning, precautions for natural disasters, monitoring of the effects of such disasters, and planning of the responses to them. This requires gathering data about local and regional resources, including data on access to roads and rivers, settlements, soil, land cover, and population. The study reported here highlights some technical problems associated with the collection and integration of data from a data-poor environment, and describes the potential benefits of integrating spatial data in relation to environmental problems. The Black Sea region of Turkey, especially the Trabzon province, in which the study was conducted, is burdened with adverse environmental conditions in terms of climate, topography, and land cover. These adverse conditions often cause landslides and in some areas restrict settlement. The purpose of the study described here was to analyze the spatial change (1990–2000) in population distribution in the Trabzon province and to detect potential landslide areas within the province by using functions incorporated in Geographical Information Systems (GIS). The preliminary results of these analyses showed that 62.4% of the area of the Trabzon province is at risk for landslide and that 283 village settlements are within regions at high risk for landslide.

Key words: environmental database; GIS; spatial analysis; natural disaster; Trabzon

Introduction

Issues relating to environmental problems have become increasingly important in terms of protecting human life and safeguarding property. Use of classical methods for estimating the potential risk posed by environmental factors is relatively costly and time consuming, and is subject to a variety of errors of different types and sources. Environmental databases are widely recognized as powerful tools for multidisciplinary environmental research, and provide a basis for the analysis of environmental factors on the local and regional scale. Developments in the technology of Geographical Information Systems (GIS) have created promising opportunities for improving environmental databases and facilitating the application of spatial analyses.

GIS have been used throughout the world in global, regional, and local environmental studies, (Budic *et al.,* 2004; Coleman and McLaughlin, 1997; George, 2000). These systems allow the capture, storage, processing, and display of an unprecedented quantity of geographical and spatial information and wide variety of environmental and cultural phenomena (Aronoff, 1989; Huxhold and Allan, 1995; Longley *et al.,* 2001; Yomralioğlu, 2000). Current and accurate spatial data must be readily available for use in local, state, and national development, and for improving the quality and stability of the environment, as well as for flood and other disaster management, for urban and rural planning and development, and for infrastructure development (Cihlar *et al.,* 2000; Cowen, *et al.,* 1995; Klosterman, 1995; Mansourian *et al.,* 2006; Zhang and Beavis, 1999).

The applications of GIS can vary among countries, and are influenced by national legislative as well as by economic, social, and cultural factors. In Turkey, many public institutions have generated and used spatial data in many different for-

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mats, yet one of the most serious deficits in this work is the lack of reliable and accurate data about environmental problems generated before 2005. This problem had increased the difficulty of using spatial data in multidisciplinary studies. This was eased after 2005 by the Turkish Federal Regulation for Producing Large Scale Map and Map Data, issued to standardize the collection and sharing of GIS data among public institutions. However, there remains the need to collect spatial data about environmental issues and to use this to build an integrated database to prevent damage to the environment caused by human activity.

In order to design a useful spatial database for a specific geographic area, it is necessary to rapidly collect reliable and accurate geographic, social, and economic data from the regions within the area. The boundaries for a large study area for which a spatial database is to be developed should therefore be determined according to administrative districts. Turkey has four types of such administrative district: the province, township, subdistrict, and village. Of these, provincial administrators have the most senior position in terms of authority and responsibility. Provincial administrators are also responsible for preparing their own development schemes and supervising urban and rural areas within the division. When a planned improvement falls within the purview of more than one type of division, the provinces constitute the most important administrative units for planning and determining strategies at the local level. The provincial administrator must therefore make decisions by creating a Geographic Data Base (GDB) and providing base maps of the planned improvement (SPO, 1999).

In the Trabzon province, the creation of a Province Environmental Information System (PEIS) began in 2001 as a pilot study with the goal of solving environmental problems within the province. The project was funded by the State Planning Organization (SPO) of the Prime Ministry of Turkey and by the Karadeniz Technical University (KTU). The objective of the present study was to create a spatial database at the province level and to analyze the landslide potential of the region, which is one of the most important of its environmental issues. In the study, a spatial database infrastructure (SDI) for province-based environmental studies was developed and environmental problems were analyzed according to the Turkish administrative structure.

According to the Turkish Statistical Institute (TURKSTAT, 2006), the Trabzon province covers an area of 4664 km^2 and has a population of 979,295, giving it a population density of 210/km^2. The characteristics of the settled areas of the province are very diverse, but houses are scattered throughout rural areas. Unfavorable environmental conditions have resulted in some problems, such as areas of restricted settlement. The topography of the province is steep and the climate rainy (Reis, 2005). The most important reason for our having selected the Trabzon province as the region for development of an environmental spatial database is that it includes many of the public institutions of Turkey and has an economic preeminence over the neighboring provinces. Being on the historical Silk Road, it is also very important in terms of tourism and trade. In recent years, ecotourism has increased the popularity of the Trabzon province and contributed to the tourism potential of the region. Agriculture and fishing are the main occupations. The chief crop is the hazelnut, and hazelnut fields in the region are generally covered by forests.

Study area

The province of Trabzon is located between 39° 15′ and 40° 15′ east-longitude and 40° 30′ and 41° 7′ north-latitude

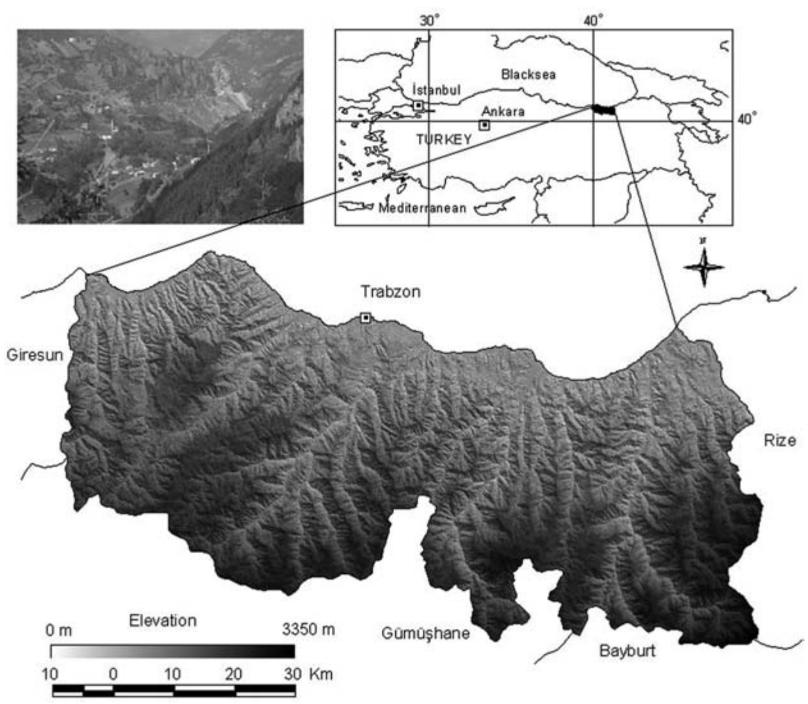

FIG. 1. The location of the Trabzon province in Turkey.

in the middle of the East-Black Sea region of Turkey (Fig. 1). In some areas of the province the elevation exceeds 3000 m above sea level. Generally, mountains, hills, and high plateaus are situated in the inner part of the region. Proximity to the sea results in a temperate climate with summers that are generally warm and winters that are mild. The overall annual average temperature of the Trabzon province is 14.5°C and the annual average precipitation is 838.4 mm (TSMS, 2001).

Methodology

Designing province-based environmental information system (PEIS)

In GIS-related studies, it is important to provide decision makers with high-quality and usable data within the shortest possible time (Baskent, 1997). This can be achieved through building a spatial database at the forefront. The present report summarizes the procedure for designing such a database. The data model is a conceptual index of defined types of data that represent real spatial features or objects such as buildings, rivers, and forests and their relationships established for the database. The data modeling used in constructing the database involves structuring, organizing, and displaying of the data for a specific environment where objects are held in thematic layers (Elmasri and Navathe, 2000). Three types of data models are commonly used in GIS: hierarchical, network, and relational data models. The latter is the most widely used of the three, and used in this study.

In designing the database for the PEIS, all operations were conducted according to a province-based system. The thematic layers as digital coverage were grouped in two groups: the base thematic layers generated from scratch and reproduced layers from the existing pones. The base thematic layers consisted of spatial data initially generated by either digitizing or scanning. They may also be provided by public institutions in digital form, such as in the case of a land cover map based on field surveys and satellite images, or geological and soil maps obtained by digitizing of data on paper sheets. Base layers are divided into the eight geographic categories of hydrology, forestry, geology, and climate disciplines, making it possible to increase the number of layers according to the purpose of a study. The layers so produced are obtained by analysis of the base layers in accord with the end user's requirements. As with base layers, there is no restriction in generating produced layers, and they can be generated according to the user's needs. Figure 2 shows the general form of a province-based layer design.

The PEIS database was created with the ArcGIS software systems. Since most of the graphic data were in analog form, the mapped information had to be digitized, edited, and verified for accuracy. Paper records were entered into the GIS via the Excel and Arcview software systems. All data in the GIS were then transformed into a Universal Transverse Mercator (UTM) coordinate system. The digital elevation model of the Trabzon province was created by digitizing contour lines from standard topographic maps with a scale of 1:100,000.

Data collection

A wide range of spatial data were collected and entered into the GIS (Table 1). Base topographic data for the GIS consists of maps within the General Command of Mapping, at a scale of 1:100,000. Digital data that must be transformed into GIS format are generally produced in computer-assisted

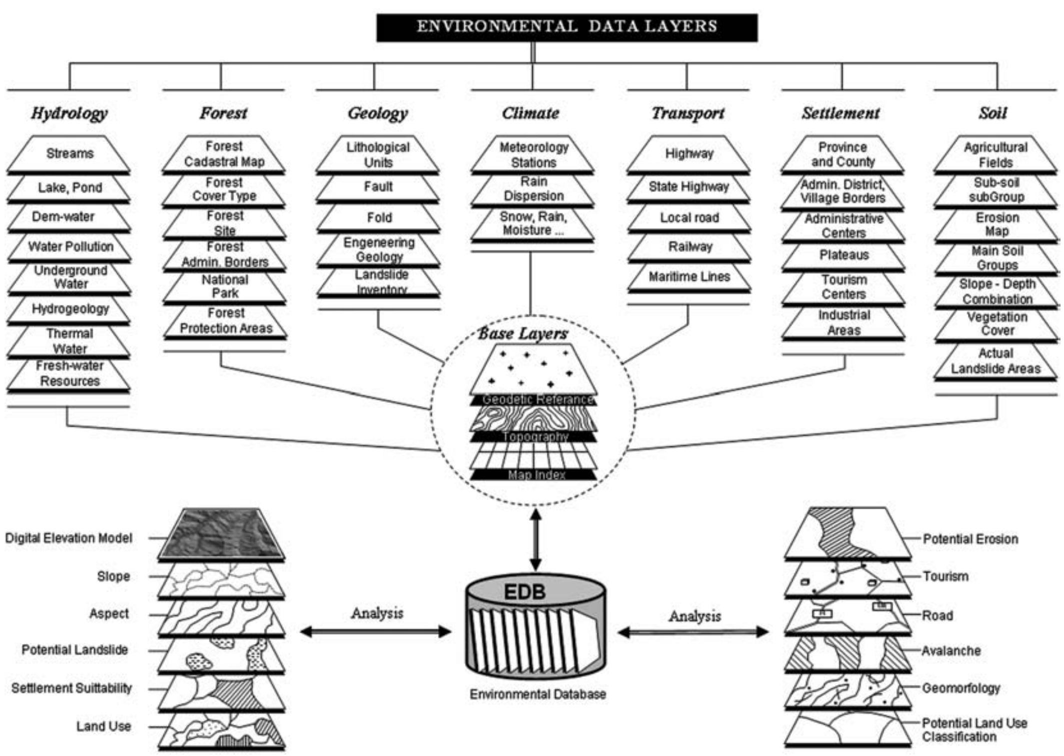

FIG. 2. Scheme of the Environmental Database.

Table 1. Data Sources Used to Build PEIS

Data	*Feature of the data*	*Data type*	*Scale (1/x)*	*Resource*
Transportation	Line	Paper drawing/paper	100.000	Landsat ETM$^+$, general command of mapping
Forestry	Polygon	Paper	100.000	General directorate of forest
Landslide inventory	Polygon	Paper	100.000	General directorate of mineral research & exploration
Energy resource (pipe line, transformer)	Polygon, line, point	Paper/photocopied records	100.000	
Geology	Polygon	Paper/digital file	100.000	
Meteorological data	Point, text	Written descriptions		Turkish state of meteorological services
Culture and tourism areas	Point	Paper	100.000	General command of mapping, directorate of culture and tourism
Administrative boundaries and centers	Polygon, point	Photocopied records/paper drawing/digital file/written descriptions	100.000	General directorate of rural services, general directorate of land title and cadastre in Turkey, the ministry of public works and settlement
Land use/cover	Polygon	Paper	100.000	General directorate of rural services
Soil	Polygon	Paper/digital file	100.000	
Population	Text	Paper records		Turkish statistical institute (TURKSTAT)
Planning maps (regional and territorial plans)	Polygon	Paper map/paper records	100.000	The ministry of public works and settlement
Topography	Line	Paper	100.000	General command of mapping
Land cover	Raster	Image	100.000	Landsat ETM$^+$
Water resource (sea, lake, freshwater, coastal)	Polygon, line, point	Paper map/photocopied records	100.000	Landsat ETM$^+$

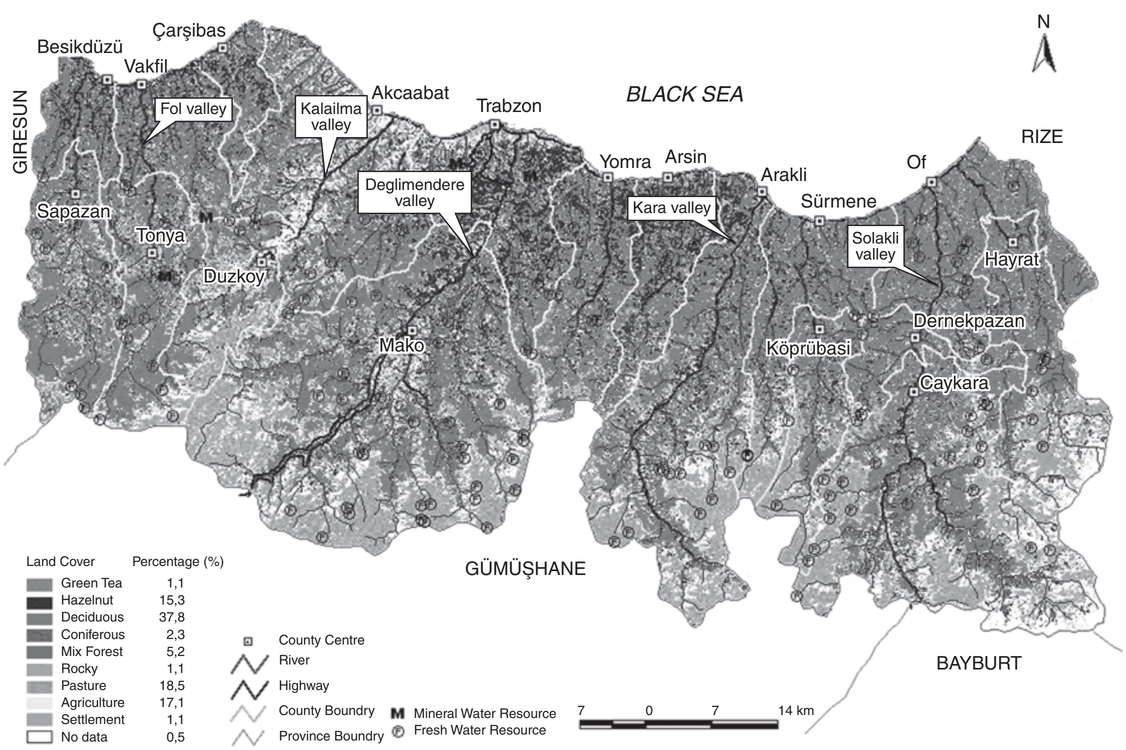

FIG. 3. Land cover map of the Trabzon province.

design (CAD) format. In the present study, the required data were collected from public institutions, and the resulting data set was originally cross-checked in terms of format, coordinate system, and accuracy before being stored in the GIS. Data that were not available from public institutions were collected from a Landsat satellite sensor image acquired on September 19, 2000.

Province-Level Geospatial Analyses for Environmental Management

Despite the wide range of data problems and various data types and formats involved in rendering an environmental analysis of the Trabzon province, there exists a consolidated database that holds most of the available data relating to the management of the province. This database plays a very important role in environmental monitoring, protection, and planning. In performing the analyses done in the present study, two key environmental analyses in the Trabzon region were taken into consideration, as follows: (1) demography and (2) landslide. The following sections explain how these environmental analyses were accomplished with the spatial analysis functions of GIS technology.

Geospatial information on topography and demography

Topographic and demographic data are crucial for environmental management and planning. Spatial analysis shows the sloping nature of the topography of the Trabzon province. Only 16.4% of the province has terrain with a slope of less than 10%. Areas with slopes of 10–50% cover 43.1% of the Trabzon province, and land with a slope of 50% or more occupies 40.5% of the province.

There is also a complex land cover structure in the Trabzon region, which was determined by a classification of Landsat ETM+ images (Reis and Yomralioğlu, 2006). The type of land cover was categorized and allocated into one of nine classes after supervised classification and image enhancement of the ETM+ images (Fig. 3). These classes are (1) pasture, (2) deciduous forest, (3) coniferous forest, (4) mixed forest, (5) land used for cultivating green tea, (6) hazelnut growth, (7) rocky topography, (8) settlement area, and (9) agricultural area. The overall accuracy of this classification is 84.68%, with a Kappa coefficient of 0.829. The class of land cover having the largest proportion of area is deciduous forest, with 38% of the total area. This class includes some hardwood species, such as beech, hornbeam, and chestnut; conifers constitute 2.3% of the tree types in the Trabzon province. As a class, agricultural area is taken up mainly by the cultivation of corn, tobacco, beans, and other agricultural species cultivated in the region. Because of the scattered cultivated land in small parcels, owing to the topography of the region, some agricultural areas were listed in agricultural class Land devoted to agriculture constitutes 17.06% of the area of the Trabzon province, which is nearly equal to the area of pastoral land, which in turn covers 18.5% of the province. Cultivation of hazelnut, as the major agricultural product of the Trabzon province, covers 15.3% of the province land area, an area nearly as large as that covered by other land devoted to other agricultural plant species. The region contains only a few plantations growing green tea.

Table 2. The Population of the County Centers in 1990 and 2000

County centers	Population 1990	Population 2000	Change (%)
Trabzon	143,941	214,949	49.3
Akçaabat	25,285	39,102	54.6
Araklı	12,141	22,506	85.4
Arsin	6705	13,038	94.5
Beşikdüzü	14,047	29,766	111.9
Çarşıbaşı	7128	8532	19.7
Çaykara	2250	5829	159.1
Dernekpazari	2686	5108	90.2
Düzköy	4793	6863	43.2
Hayrat	4168	7665	83.9
Köprübaşı	4343	4998	15.1
Maçka	7673	11,060	44.1
Of	14,948	25,478	70.4
Şalpazarı	3665	7591	107.1
Sürmene	12,008	17,063	42.1
Tonya	11,058	12,666	14.5
Vakfıkebir	20,564	33,394	62.4
Yomra	7335	13,346	81.9

Table 3. Factor Scores and Weights Used in the Determination of the Landslide Potential Areas

Factors	*Scores*	*Weights*
Slope (%)		**100**
0–20	100	
21–30	70	
31–40	40	
41–50	20	
>51	10	
Lithology		**60**
Al, Pl	30	
Krü3, Krü4	60	
Ev, Jk, Jl,	70	
Krü2, Krü1	80	
γ	100	
Land Cover		**40**
Rocky	100	
Forest	80	
Settlement	50	
Agriculture, pasture	40	
Stream and Road		**20**
Stream*	10	
Road*	10	
Other areas	100	

*Stream and road are buffered at 100 m.

(Al: aluvium, Pl: pliocene, Ev: eosen, γ: upper cretaceous-paleocene, Krü1: basalt, andesite, and pyroclastics, Krü2: rhyodacite, dasitic lava, and pyroclastics, Krü3: mudstone, sandstone, and tuffite, Krü4: rhyolite, rhyodacitic lava, and pyroclastics, Jk: jurassic, Jl: liasic)

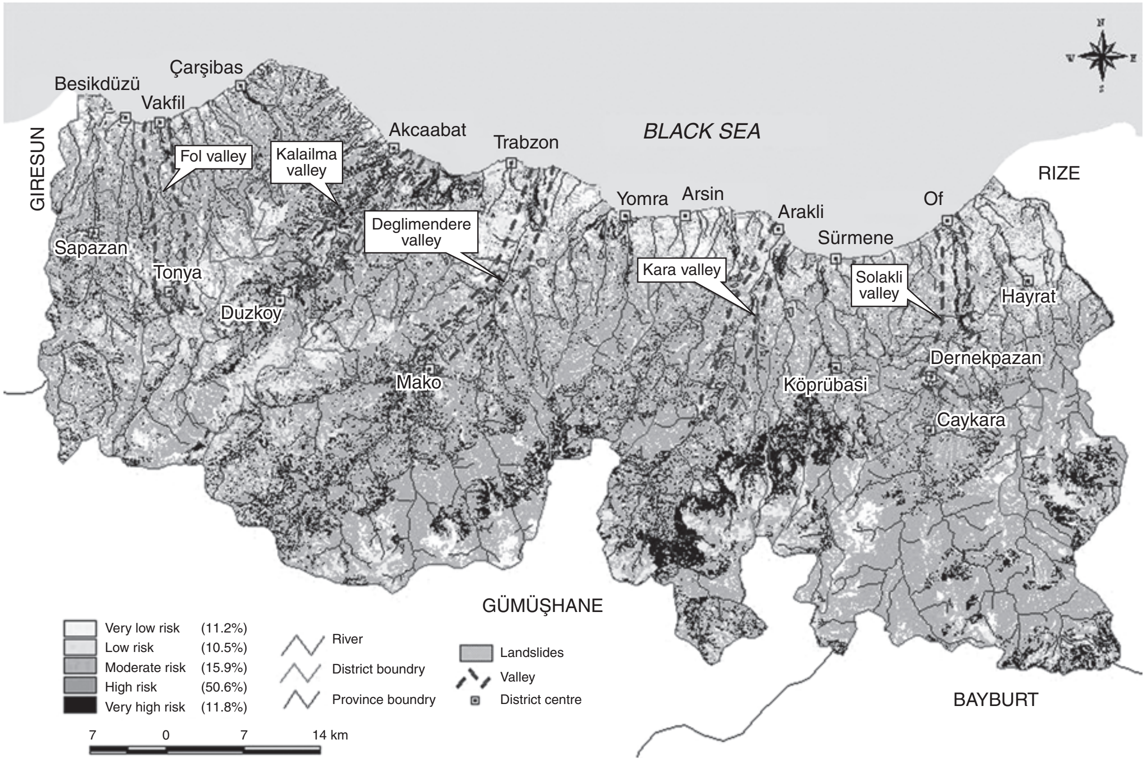

FIG. 4. Landslide potential map of the Trabzon province.

Topography and land cover influence the distribution of the population in the Trabzon province. Spatial analysis shows that population distribution becomes more dense in coastal areas, valleys, and riverside regions. Table 2 shows the growth of the population in the county centers of the Trabzon province between 1990 and 2000. In this period, total population growth in the province was 14% (from a population of 858,687 to a population of 979,295). The population growth was more pronounced in city centers, district centers, and coastal areas. In 2000, 51.5% of the population was living 1 km away from the coast. Moreover, the population density in valleys and riversides of the Trabzon province increased in 2000.

Demographic analysis shows that settlements in the Trabzon province are built along valleys (especially the five large valleys in the province) and rivers such as Fol River in the Vakfikebir district, Kalanima River in the Akçaabat district, Değirmendere River in the Trabzon district center, Kara River in the Araklı district, and Solaklı River in the Of district. Because of the rainy climate and steep topography of much of the province, the greater population in valleys and riversides intensified the potential damage from floods and landslides in such areas.

Landslide potential analysis

The Black Sea region of Turkey, including the Trabzon province, is at risk for natural hazards because of its climate and topographic structure (Akgun and Bulut, 2007). Landslides and floods are the main natural hazards in the region, and Trabzon is one of the leading provinces of landslide risk in Turkey, with 662 landslides having occurred and 245 people having died according to records kept since 1950 (Ergünay, 2003). Consequently, it is important to create a landslide potential map of the region in order to be able to protect human lives and prevent damage to property.

Many parameters and methods can be used to assess the landslide potential of an area. There is no agreement in the literature about the factors that should be included in determining landslide risk potential (Aleotti and Chowdhury, 1999; Gökçeoğlu and Ercanoğlu, 2001; Yalcın and Bulut, 2007). At least three factors, slope, lithology, and land use, are usually included in GIS analyses. However, the number of factors can be increased depending on the characteristics of the study area (Dai *et al.,* 2001; Yalcın, 2005). In the present study, slope, lithology, land use, stream networks, and road networks were included as factors, and a matrix (grid) analysis method was used to identify landslide hazard areas. For this purpose, all thematic layers

TABLE 4. RELATIONSHIP BETWEEN THE POTENTIAL LEVELS AND THE INVENTORY LANDSLIDE MAP

	Landslide inventory map	
Potential landslide class	*ha*	*%*
High risk	420	15.6
Risk	1301	48.4
Medium risk	463	17.2
Low risk	267	10.0
Very low risk	236	8.8
Total	**2687**	**100**

Table 5. Settlement Counts and Percentages According to the Landslide Potential Class

Potential landslide class	*Potential landslide areas (%)*	*Settlement counts*	*Settlement (%)*
High risk	11.8	56	10.1
Risk	50.6	227	40.9
Medium risk	15.9	108	19.5
Low risk	10.5	89	16.0
Very low risk	11.2	75	13.5
Total	**100**	**555**	**100**

used in the analysis were converted into grid format at a resolution of 100 m.

Factor scores were assigned a range of 0–100, with high scores representing a low landslide risk and low scores a high landslide risk. Factor weights were determined similar to the factor scores and each factor was scored relative to the other factors on a scale of 0–100. Since the study area has a highly sloped topography, as previously noted, slope was given the greatest weight (100) among the factors causing landslides, since it is considered the most important risk factor for landslides. The factor scores and weights used in determining areas with landslide potential are shown in Table 3. These scores and weights were based on a study done by Yalcın *et al.* (2002).

Once they were determined, the factor scores were multiplied by the factor weights, after which pixel scores for the all factors were added to each item. The pixel scores were then evaluated and a map of landslide potential was generated, showing this potential (Fig. 4) according to the five categories of: (1) very low risk, (2) low risk, (3) moderate risk, (4) high risk, and (5) very high risk, respectively.

In order to verify the applicability of our landslide potential map, we used a landslide inventory map, which included landslides that are already occurred, produced by the General Directorate of Mineral Research & Exploration of the Government of Turkey. The inventory maps produced by the General Directorate before 2000 covered a total area of 2687 ha. To verify our results, we matched the landslide potential maps with the inventory used for the General Directorate map. Table 4 shows the area in hectars (ha) and percent (%) of relationship between the landslide potential levels in our map and the landslide inventory map. This showed that 64% of the landslide zones in the Trabzon province fall into the high and very high landslide-potential categories.

Figure 4 shows the areas at risk for landslide (except medium risk) cover 62.4% of the Trabzon province. By contrast, only 21.7% of the province's areas are not at risk. These areas are typically close to the coast, where a flat topography is frequent. In order to examine settled areas of the Trabzon province under possible landslide risk, we overlaid the landslide potential map and the map of currently settled areas in the Trabzon province. Table 5 shows the number of settlements in each of the landslide potential categories. According to these results, 56 villages are at high risk and 227 villages are at some risk of landslide. Thus, 51% of the villages in the Trabzon province are estimated to be at risk of a landslide.

Discussion and Conclusions

In this study, we successfully created a spatial database of environmental factors for landslide risk in the Trabzon province in Turkey. Difficulties were associated with data access, production time of the map, data incompatibility, and data accuracy. Essentially, these problems are not peculiar to Turkey; similar difficulties exist in most developing countries.

A GIS-based Environmental Information System is a versatile tool for the analysis of any type of environmental data. This kind of system provides digital information pertaining to a region of study in the form of maps, contours, reports, and graphs. This information permits successful analyses and the effective interpretation of environmental problems.

The present study indicates the importance of the PEIS for producing and analyzing spatial data for solving environmental problems encountered in the Trabzon province in Turkey. In permitting the generation of a map of landslide potential, the PEIS provides solutions for one of the most important such problems of this province. According to this map, about 64% of the study area is at risk for landslide. This is because most of the settlement areas within this 64% of the study area are in river basins and on sloping terrain. Dense forests and the topographic structure of this latter territory are forcing people in the region to find alternative settlement locations. However, the landslide risk to areas of potential settlement in a region should be determined before development, by using landslide potential maps like that produced in this study in order to protect people from the hazards of landslide.

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Author Disclaimer Statement

The authors declare no competing financial interests exist.

References

Akgun, A., and Bulut, F. (2007). GIS-based landslide susceptibility for Arsin-Yomra (Trabzon, North Turkey) region. *Environ. Geol.* 51, 1377–1387.

Aleotti, P., and Chowdhur, Y.R. (1999). Landslide hazard assessment: Summary review and new perspectives. *Bull. Eng. Geol. Environ*. 58, 21–44.

Aronoff, S. (1989). *Geographic Information System: A Management Perspective.* Ottowa: WDL Publication.

Baskent, E.Z. (1997). Türkiye ormancılığı için nasıl bir coğrafi bilgi sistemi (CBS) kurulmalidir? ön çalışma ve kavramsal yaklaşım. *J. Ag. and Forestry* 21, 493–505.

Budic, Z.N, Feeney, M.E.F., Rajabifard, A., and Williamson, I. (2004). Are SDIs the needs of local planning? Case study of Victoria, Australia and Illinois, USA. *Computers, Environ. and Urban Systems* 28, 329–351.

Cihlar, J., Latifovic, R., Chen, J. M., and Beaubien, J. (2000). Selecting representative high resolution sample images for land cover studies part 1: Methodology. *Remote Sensing of Environ.* 71, 26–42.

Coleman, D.J., and McLaughlin, J. (1997). Defining global geospatial data infrastructure (ggdi): Components, stakeholders and interfaces. http://www.gsdi.org/docs.html (accessed 03-2004)

Cowen, D.J., Jensen, J.R., Bresnahan, P.J., et al., (1995). The design and implementation of an integrated geographic information system for environmental applications. *Photogrammetric Eng. & Remote Sensing* 61, 1393–1404.

Dai, F.C., Lee, C.F., Li, J., and Xu, Z.W. (2001). Assessment of landslide suspectibility on the natural terrain of Lantau Island, Hong Kong. *Environ. Geol.* 40, 381–391.

Elmasri, R., and Navathe, S.B. (2000). *Fundamentals of Database Systems.* Addison-Wesley.

Ergünay, O. (2003). Trabzon ilinin afet tehlikesi, afete hazırlık ve müdahele eğıtimi, Trabzon. www.kizilay.org.tr/images/pdf/Trabzon.pdf (accessed 11-2004)

George, H. (2000). Developing countries and remote sensing: How intergovernmental factors impede progress. *Space Policy* 16, 267–273.

Gökgeoğlu, C. and Ercanoğlu, M. (2001). Heyelan duyarlılık haritalarının hazırlanmasında kullanılan parametrelere ilişkin belirsizlikler. *Hacettepe Üniversitesi Yerbilimleri Uygulama ve Araştırma Merkezi Bülteni* 23, 189–206.

Huxhold, W.E., and Allan, A.G. (1995). *Managing Geographical Information System Projects.* New York: Oxford University Press.

Klosterman, R.E. (1995). The appropriateness of geographic information systems for regional planning in the developing world. *Comp. Environ. and Urban Systems* 19, 1–13.

Longley, P.A., Goodchild, M.F., Maguire, D.J., and Rhind, D.W. (2001). *Geographic Information Systems and Science.* London: Bath Press.

Mansourian, A., Rajabifard, A., Valadan Zoej, M.J., and Williamson, I. (2006). Using SDI and web-based system to facilitate disaster management. *Computers & Geoscience* 32, 303–315.

Reis, S. (2005). Coğrafi bilgi sistemleri ile il ölçeğinde afet yönetim amaçlı planlama, tmmob harita ve kadastro mühendisleri odası 10. *Türkiye Harita Bilimsel ve Teknik Kurultayı*, Ankara 242–251.

Reis, S., and Yomralıoğlu, T. (2006). Detection of current and potential hazelnut (corylus) plantation areas in Trabzon, North East Turkey using GIS & RS. *J. Environ. Biol*. 27(4), 653–659.

SPO. (1999). *Bölgesel gelişme özel ihtisas komisyonu raporu, VII. Beş yıllık kalkınma planı raporu.*

TSMS. (2001). Department of Statistic Directorate, Turkish State Meteorological Service, Ankara, Turkey.

TURKSTAT, (2006). Department of statistic directorate. http://www.die.gov.tr/nufus_sayimi/2000tablo3.xls

Yalcin, A., Reis, S., and Nişanci, R. (2002). Mass movement evaluation with geographical information systems: A case study from Gümüşhane region, International Symposium on Geographic Information Systems. 560–567, Istanbul, Turkey.

Yalcin, A. (2005). An investigation on Ardesen (Rize) region on the basis of landslide susceptibility. Ph.D. thesis, KTU, Fen Bilimleri Enstitüsü, Trabzon.

Yalcin, A., and Bulut, F. (2007). Landslide susceptibility mapping using GIS and digital photogrammetric techniques: A case study from Ardesen (NE-Turkey). *Natural Haz.* 41, 201–226.

Yomralioğlu, T. (2000). *Coğrafi Bilgi Sistemleri Temel Kavramlar ve Uygulamalar*. İstanbul: Seçil Offset.

Zhang, L., and Beavis, S.G. (1999). Development of a spatial database for large-scale catchment management: Geology, soils, and landuse in the Namoi Basin, Australia. *Environ. Int.* 25(6–7), 853–860.