

Natural Hazard Management in Regional Base using Geographical Information System

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Key words: GIS, Remote sensing, landslide, suitable settlement

SUMMARY

Today, one of the crucial issues in regional development is the management of the natural hazards for planning and controlling in a sustainable manner. Turkey is one of the countries that are under the high risk of natural hazards due to its tectonic activities, geological structure, topography and meteorological features. In the country, every year various types of natural hazards have been observed frequently. Among these earthquake, flood, landslide, avalanche and rock falls are the most common ones. The most important natural hazard in the Eastern Black sea Region of Turkey is the "landslides". In Trabzon province which is located at the NE of this region there are also unfavorable conditions on environment such as climate, topography and land cover. According to records kept since 1950 in Turkey, there have been observed 272 land slide occurrences in Trabzon, one of the leading areas where landslides occur mostly. Besides same environmental factors in the region cause settlement areas to be restricted. Therefore, to decrease the landslide risk and to plan suitable urban areas at regional level, firstly, potential landslide areas should be determined, then "suitable settlement areas" should be recommended accordingly considering these areas. The most common techniques realizing these studies are Geographic Information Systems (GIS) and Remote Sensing. In this study, GIS functions were used for analyzing the regions that are subject to natural hazard risk and suitable for settlement in high scale planning.

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1. INTRODUCTION

Information of environment is particularly important when analysing environmental problems. Estimation of potential risks due to the environmental problems through classical methods is costly, time consuming, and subject to a variety of errors in terms of types and sources. Developments in GIS have created promising opportunities for improving environmental databases and analysing them. All over the world in global, regional, and local environmental studies, such spatial systems as Geographical Information Systems (GIS) have been tended considerably (Budic et al., 2004). GIS allows people to capture, store, process, and display an unprecedented amount of geographical and spatial information about society and a wide variety of environmental and cultural phenomena (Aronoff, 1986; Yomralioglu, 2000, Longley et al., 2001).

Turkey is one of the countries that are under the high risk of natural hazards due to its tectonic formation, geological structure, topography and metrological features. In the country, various types of natural hazards have been observed frequently. Among these earthquake, flood, landslide, avalanche and rock falls are the most common natural hazards. Since the beginning of the 20th century 3591 people have been died, and 155.654 houses have already destroyed in natural hazards excluding quakes. Among these, landslides are the most widespread and damaging one. Due to landslides only 1.318 people have been lost their life and almost 63.000 houses have been destroyed since 1900. It has been reported that 95% population and 92% of area of Turkey are still under the risk of natural hazards (Reis and Yomralioglu, 2005).

According to records kept since 1950 in Turkey, province of Trabzon which is located at the north-east region has been one of the leading areas where landslides occur mostly. There have been 272 landslide occurrences in Trabzon since 1950 (İldır, 1995). The factors affecting the occurrence of landslides are the morphology of the region, geological structure, weathering of rocks, metrological characteristics, settlement type and excavation works for different purposes in the nature. Heavy precipitation and sloping topography increase the landslide risk in the province (Tahran, 1991). In this region, agricultural and urban areas are quite restricted from the unfavorable topographic structure and therefore, forests have been destroyed which further increase the landslide risk. To reduce the landslide risk, first of all potential landslide areas have to be assessed in the regional base. For this purpose a GIS analysis has been applied to determine potential landslide areas in Trabzon province. This study is conducted in the Trabzon province of East Blacksea Region of Turkey. Since Trabzon province covers a large area (4660 km²) and study is heavily dependent on raster/vector formatted spatial data.

In this region, characteristic of the settlement areas are scattered. Especially, in the rural areas houses are scattered the entire region. The most important reason of selecting this province is that it is a medium scale province, including many of the public institutions and having an economic preeminence than neighbour provinces. Besides, Trabzon is a historical city since it is located on the Silkroad. In this respect, it is one of the main turizm and culture cities of Turkey. In recent years, plateau turizm has increased its popularity and the turizm potential in this region. The people's meal of living is agriculture and fishing. The most harvested agrilculture product is the hazelnut and forestry areas are pretty much covered the whole region. There is a rougl topographic structure and a rainy climate (838.4 m2/mm) in this region (Reis, 2005). Unfavorable environmental conditions come with some environmental problems. Especially, the settlement areas are restricted in this respect. Another environmental problem is the landslides resulting from topographic structure and climate conditions. The objectives of this study are to constitute of a spatial database in province level and analyse the most important issues such as potential landslide and suitability settlement areas of the region.

2. STUDY AREA

The Province of Trabzon is situated between 39° 15' - 40° 15' WE Longitudes and 41° 8' - 40° 30' NS Latitudes in the middle of East Black Sea Region of Turkey (Figure 1). In the province, increasing elevation beginning from the sea-level exceeds 3000 m in some areas. Generally, mountains, hills and high plateaus take part in inner land of the region. The province is the most important trade centre in the region with the features of having a rich historical and cultural wealth. (Reis and Yomralioglu, 2004)

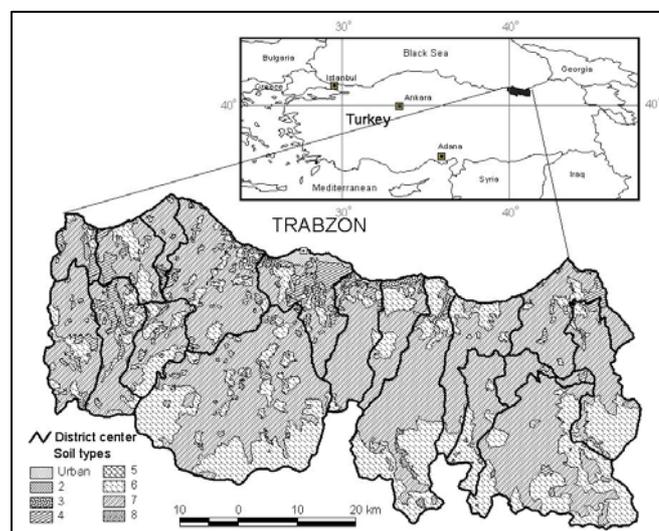


Figure 1. Study area:
(Trabzon Province with its administration sections)

3. ADMINISTRATIVE PARTS AND INFRASTRUCTURE OF THE DIGITAL MAPPING IN PROVINCE SCALE

Provinces form the basic administrative parts of the country and an important base for the public administration because, in accordance with the Turkish constitution, province system is accepted as a base in view of central management. In economical and social development, eliminating regional development differences and providing a nation wide balanced improvement, provinces should be accepted as main units. When considered that a planned improvement consist of local, regional and national stages, provinces forms the most important administrative step for planning and determination of strategies at local level [DPT, 1999].

In Turkey, there are three base local administration systems which are province, county and village. Among these, province administrations have the position being civil superior in respect of authority and responsibility. These administrations also prepare development schemes, through supervising urban and rural areas. Therefore, making decisions by province administrator will be possible only by forming Geographic Data-Base (GDB) and providing base maps aiming at the future planning.

In Turkey, the basic problem encountered in while constructing of spatial databases is the lack of required-quality and digital data. Some of the data exists on the paper sheets with different coordinate systems and A4 papers. These are copied from standard topographic maps at 1/25.000 and 1/100.000 scale maps that produced by General Command of Mapping. Digital data is generally produced in CAD format that must be transformed in GIS format. In this study, the necessary data collected from public institutions for Environmental analysis. This data was originally crosschecked in terms of digital format, coordinate system, and accuracy before it is corrected and stored in GIS. The data that was not found in public constitutions such as lan cover, highways and streams was collected from Landsat image dated 19 September 2000.

4. PLANNING STUDIES BEFORE NATURAL HAZARDS: A CASE STUDY OF TRABZON

In this study, initial environmental problems in the region were taken into consideration to make analyses. The first problem is the landslides and the second is the restricted settlement areas. The studies are given below, aim to solve the environmental problems using GIS spatial analysis fuctions. The analysis was created using both ArcGIS and Arcview.

4.1. Determining Potential Landslide Areas

There are a lot of parameters and methods to assess potential landslide areas. There is not any agreement on literature what factors should be included in the determination of the landslide risky areas (Gökçeoğlu ve Ercanoğlu, 2001). At least three factors that are topography, lithology and land use have been included in GIS analysis depending on the characteristics of the study area. In detailed studies, however, the number of factors can be increased

depending on the study area characteristics. In this study; topography, lithology, land use, stream, and road network are considered and matrix (grid) analysis method has been used to determine landslide hazardous areas. Therefore, all of the layers used in the analysis was converted into grid format at 100 m resolution.

Factor scores have been rated at 0-100 scale range. In the scale, high scores represent low land slide risk while low scores represent high landslide risk. Factor weights have been determined in a similar approach and each factor was scored relative to the other factors at 0-100 range scale. The spatial resolution of the Table 1 presents the factor scores and weights used in the determination of the potential landslide areas. Factor scores and weights were determined according to considerations of Yalçın et al. (2002)'s study. The slope is accepted as the most important factor because of its impact on the landslides. Therefore, slope factor has the highest weight.

Table 1. Factor scores and weights used in the determination of the potential landslide areas.

Factors	Scores	Weights
Slope (%)		100
0 – 20	100	
21 – 30	70	
31 – 40	40	
41 – 50	20	
> 51	10	
Lithology		60
A1, Pl	30	
Krū2, Krū1	60	
Ev, Jk, Jl,	70	
Krū2, Krū1	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

(A1: Aluvium, Pl: Pliocene, Ev: Eosen, γ: upper cretaceous-paleocene, Krū2: upper cretaceous, Krū1: upper cretaceous, Jk: jurassic, Jl: Liasic)

After determination of the factor scores and weights, they are multiplied with each other. Then, these pixel scores in the factors are added to each other. Finally, the pixel scores are evaluated and potential landslide map is produced in five classes (Figure 2). These classes are named as very low risk, low risk, medium risk, risk, and high risk respectively. Figure 6 shows that risky areas (except medium risk) which cover 62.4% of the province are dominant in Trabzon province of Turkey. On the contrary, only 21.7% of areas of the province are not under the landslide risk.

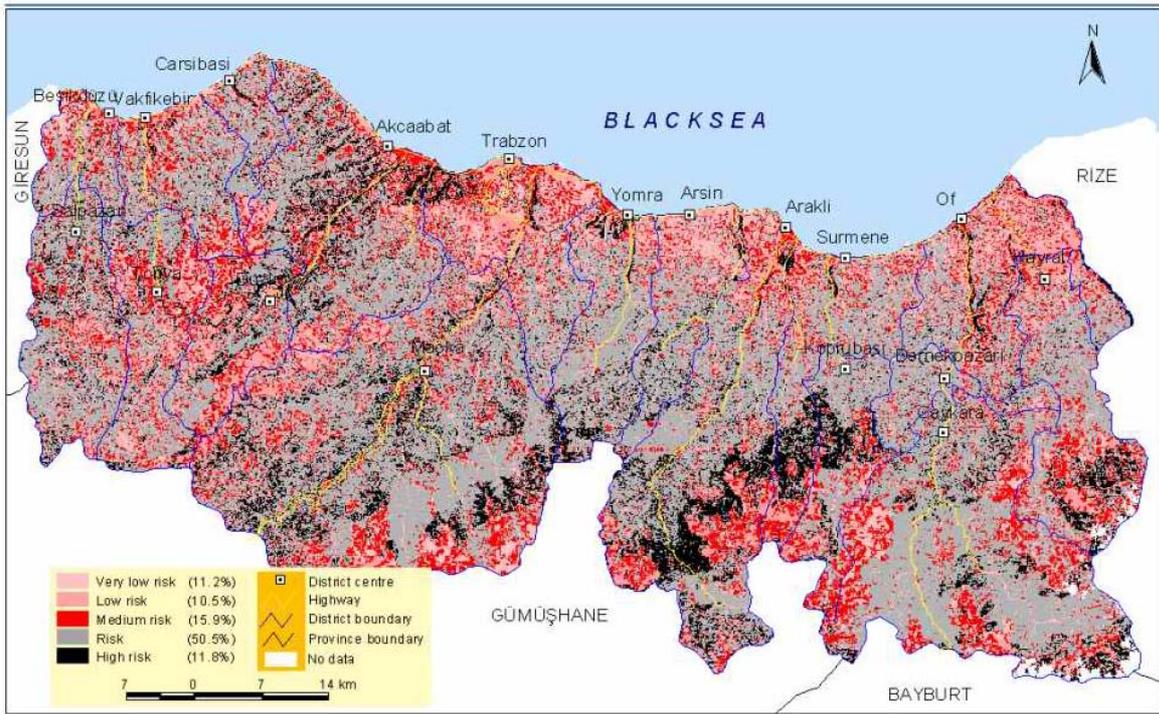


Figure 2. The landslide map of Trabzon

4.2. Determining of the Suitable Settlement Areas

It is necessary to determine potential settlement areas map and plan the settlement areas according to this map due to unsuitable topographic structure and climate conditions in Trabzon province. For this purpose, five factors have taken into consideration such as slope, lithology, land cover, streams, and landslides to determine potential Settlement areas. The matrix method has also been used in this analysis for determining factor points, weights, and class of the suitable settlements, according to Sancar's (2000) study for the city of Trabzon. Table 3 shows the factor points and weights used in this study.

Potential settlement areas are divided into five classes:

- 1- Areas having high priority to open for settlement (1st)
- 2- Areas having secondary priority to open for settlement (2nd)
- 3- Areas need special precautions to open for settlement (3rd)
- 4- Not suitable to open for settlement
- 5- Never suitable to open for settlement

After GIS analysis, potential settlement map has been produced (Figure 3.) This first analysis results show that 54% of Trabzon province is not suitable for settlement, 24% portion of the area can be opened for settlement with special precautions and only 21% of the area is suitable for settlement (Table 2).

Table 2. Factor scores and weights used in the determination of the potential settlement areas

Factors	Scores	Weights
Soil class		4
1 st , 2 nd and 3 rd class	10	
4. and 5. class	40	
6. class	70	
7. and 8. class	100	
Slope groupe (%)		6
0 – 5	100	
6 – 20	76	
21 – 30	54	
31 – 40	32	
> 41	10	
Lithology		4
Al ₁ , Pl	10	
Ev, Jk, jl, Krü2, Krü 1	55	
Krü2, Krü1,γ	100	
Land cover		2
Forest (Deciduous, coniferous, mixwood)	10	
Others land classes (hazelnut, greentea, rocky, pature, agriculture, settlement)	100	
Landslide areas		6
Very low risk	100	
Low risk	76	
Medium risk	54	
Risk	32	
High risk	10	
stream		1
streams *	10	
Other areas	100	

* Streams buffered 100m

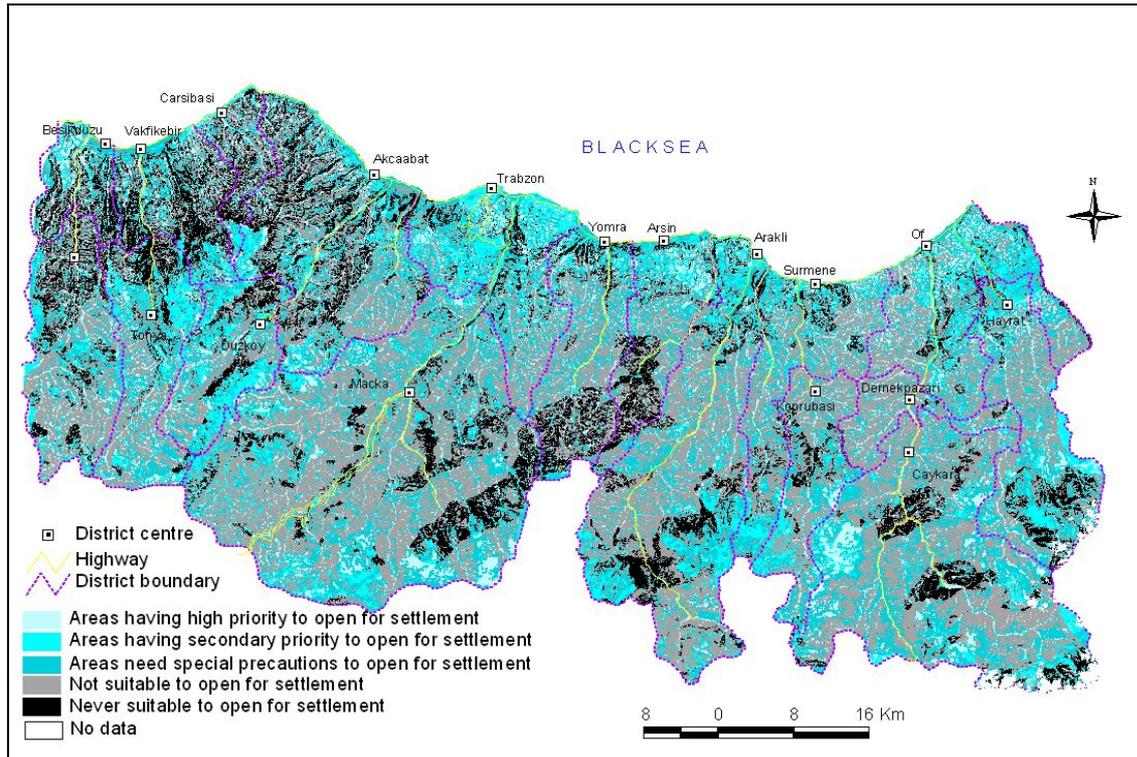


Figure 3. Potential settlement areas of Trabzon

5. CONCLUSION

This study shows the importance of the natural hazard management for producing and analyzing spatial data to solve the environmental problems encountered in the Trabzon Province. This study allows solving the most important problems such as producing potential landslide maps and potential settlement maps in the region. According to the potential landslide map, 50% and above area of the province is under landslide risk. Furthermore, 51% of the settlement areas are located in the risky landslide areas because the most of the settlement areas are built on the river basins sloppy hills. Especially, dense forest and topographic structure are forcing the people in the region to find suitable areas. To protect people from unfavourable settlement areas which cause the loss of lives and property, suitable settlement areas were searched. For this purpose, few alternative settlement areas were detected.

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BIOGRAPHICAL NOTES

Selçuk Reis works at the Department of Geodesy and Photogrammetry Engineering at Aksaray University, Turkey. He completed his MScE thesis in 1996. He received his PhD degree in July 2003. He has GIS and Remote Sensing skills including experience of packages such as Arc Info, Arc View, Er Mapper, AutoCAD.

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