Implementation of GIS for Landforms of Southern Marmara

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Key Words: Landform Classification, DEM, GIS, North Anatolian Fault Zone (NAFZ), Southern Marmara

SUMMARY

In this paper; it is aimed to generate a Geographical Information System (GIS) supported model that creates and classifies the landform features of the Southern Marmara, which is located between the central and southern segments of the North Anatolian Fault Zone (NAFZ). In the study, various methods and topographic algorithms were trained for the creation of the landforms such as different interpolation methods, slope, aspect, curvatures, textures, elevation groups and hillshade operations. In this respect, for the classification of landform features, an algorithm is used which is developed by Iwahashi and Pike in 2007. According to this algorithm, twelve different landform units are determined and their distribution is mapped by using Digital Elevation Model (DEM). As a consequence of classification map, it is found that the distribution of the landforms and morphological properties are likely to be connected to southern branch of NAFZ. The narrow and stretch inter mountain plains, linear ridges and main faults alongside the mountain fronts and linear valleys are the most important evidences supporting this inference.

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1. INTRODUCTION

The term “landform” as used by geoscientific modelers to denote a portion of the earth that unites the qualities of homogeneous and continuous relief due to the action of common geological and geomorphological processes (Bolongaro-Crevenna et al., 2005).

Landforms are natural features such as mountains, hills, lakes, plains, valleys, terraces, stream fans, etc. Mountain, hill and plain features are generally represented by points in GIS based topographic maps. However, other features such as valleys, terraces, fans haven’t been represented in GI systems. Hillside effects and the other perspective views are mostly being represented by the contour lines or TIN. Other data sources that can be used to imagine the landform impression on the screen is DEM.

According to Bolongaro-Crevenna et al. (2005):

- Geomorphometry, as a subdiscipline of geomorphology, has for its object the quantitative and qualitative description and measurement of landform and is based, principally, on the analysis of variations in elevation as a function of distance.
- A basic principal underlying geomorphometrics is that there exists a relationship between relief form and the numerical parameters used to describe it, as well as to the processes related to its genesis and evolution. This is to say that landforms are not chaotic, they are structured by geologic and geomorphic processes over time.
- One aim of geomorphologists working with landform models is to obtain better and better approximations of physical reality.
- Derivation of landform units can be carried using various approaches, including classification of morphometric parameters, filter techniques, cluster analysis, and multivariate statistics.
- A common focus of the study of landforms is to consider them as formed by small and simple elements topologically and structurally related.
- Morphometric studies usually begin with the extraction of basic components of relief, such as elevation, slope, and aspect; a more complete description of the landform may be achieved by using spatial derivatives of these initial descriptors, as well as useful indicators, e.g., the topographic wetness, stream power index, and aggradation and degradation index.
- Currently, geomorphology frequently relies on DEM as the information base from which both the basic components and indicators are extracted.

Currently, there are several researches available which are aimed at the determination and classification of the landforms by using automatic or semiautomatic algorithms (Weiss, 2001; Dehn et al., 2001; Shary et al., 2002; Burrough et al., 2000; Schmidt et al., 2004; Bolongaro-

Crevenna et al, 2005; Jordan et al., 2005; Drăguț et al., 2006; Prima et al., 2006; Iwahashi et al., 2007; Deng et al., 2007; Klingseisen et al., 2007; Arrella et al., 2007; Minár et al., 2008).

In this paper, it is aimed to examine and present the results of the model application, which was developed by Iwahashi and Pike (2007), for landforms located at Southern Marmara. This region is selected for this study, since Sothern Marmara is being threatening by disasters caused by tectonic reasons of NAF's southern branch. It is believed that the actual risk of the region is enough encouraging to carry out the study in order to examine the structural properties deeper. During the study, it is aimed to design and implement a database for the storage of the study area's landforms.

2. METHOD

An iterative procedure that implements the classification of continuous topography was developed by Iwahashi and Pike (2007). Three taxonomic criteria–slope gradient, local convexity and surface texture are derived from the DEM. According to Iwahashi and Pike (2007), the sequence of programmed operations (ArcInfo AML) combines twofold-partitioned maps of the three variables which are converted to the greyscale images, using the mean of each variable as the dividing threshold. To subdivide increasingly subtle topography, grid cells sloping at less than mean gradient of the input DEM are classified by designating mean values of successively lower-sloping subsets of the study area (nested means) as taxonomic thresholds, thereby increasing the number of output categories from the minimum 8 to 12 or 16 (Iwahashi and Pike, 2007).

The AML routine was converted to ArcGIS 9.2 Model Builder application for the study. Flow diagram of the interface was depicted in Figure 1.

Slope gradient determined by using ArcGIS Spatial Analyst tools which uses Horn Algorithm. According to Iwahashi and Pike (2007), the surface curvature (local convexity) is measured by using the 3×3 Laplacian filter, an image processing operation that is used for edge enhancement and approximation of the second derivative of elevation, yielding positive values in convex-upward areas, negative values in concave areas, and zero on planar slopes. Local convexity at each grid cell was calculated as the percentage of the convex-upward cells within a constant radius of ten cells. Terrain texture (frequency of ridges and valleys or roughness), the measure is to emphasize its fine-versus coarse expression of topographic spacing, or grain. Texture is calculated by extracting grid cells that outlines the distribution of valleys and ridges in the DEM. These cells are identified from differences between the original DEM and a second DEM derived by passing the original through the median filter; the filter is a nonlinear image-processing operation that removes high-frequency spatial "noise" from a digital scene by replacing original values with a value of central tendency, here the median, computed for each 3×3 neighborhood. Terrain texture at each grid cell was calculated as the number of pits and peaks within a radius of ten cells. Iwahashi and Pike (2007).

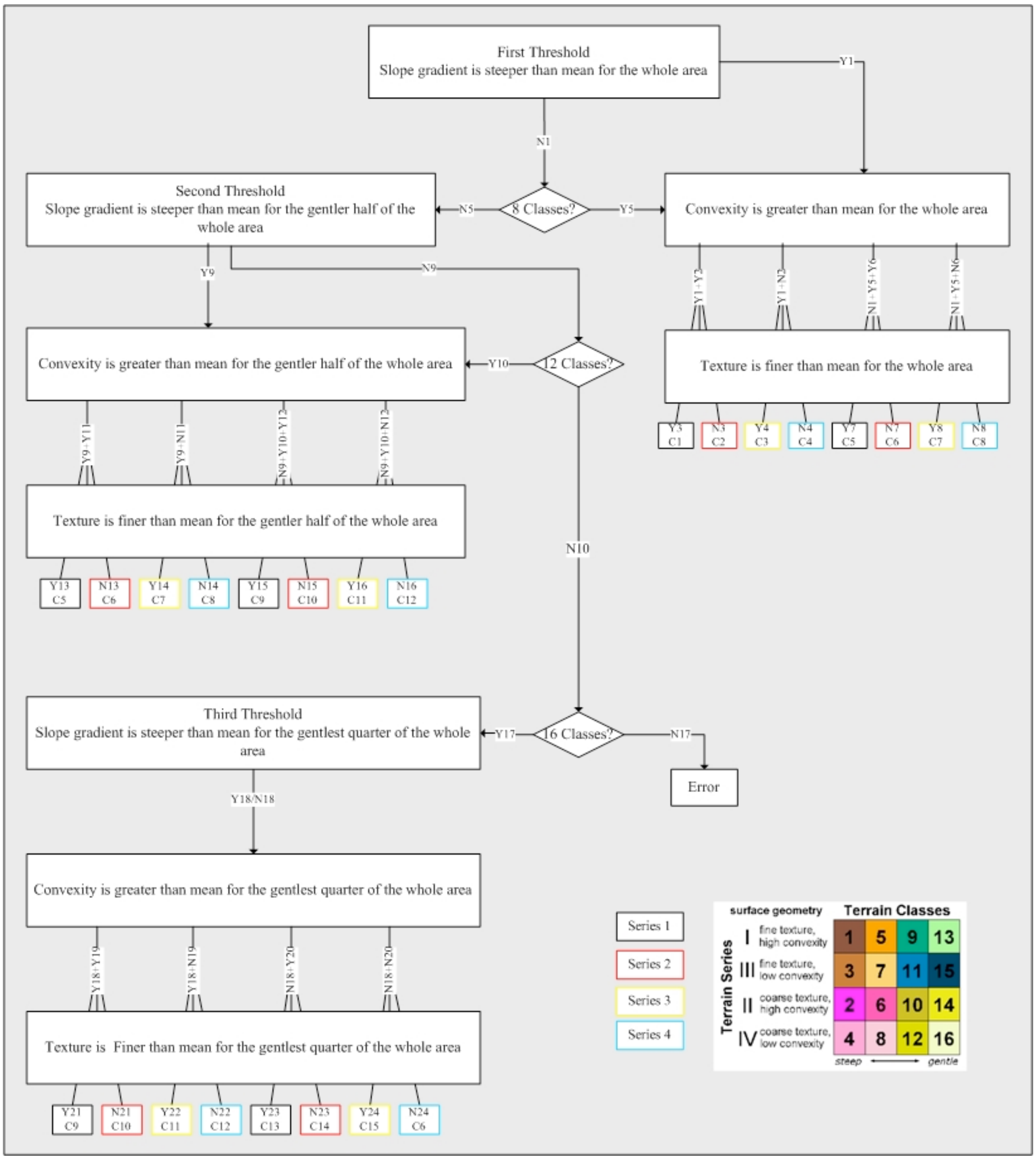

Figure 1: Program Flow diagram, adapted from Iwahashi and Pike (2007)

3. STUDY AREA AND USED DATA

The selected area of the project contains southern terrestrial zone of Sea of Marmara (Fig. 2). This zone is covered by shoreline between the Biga Peninsula and the Dardanelles coastal area. Northern boundary of the project area constitutes southern shore of Sea of Marmara, and southern boundary consolidates the line along Bilecik and Edremit Bay. Since the area, with approximately 29.500 km^2, is quite active from the seismic point of view, morphological units are mostly being constituted under control of tectonics. However, active tectonics of the zone is being controlled by NAFZ.

DEM with 100 meters grid size is derived from the contour lines with the conversion tools of ArcGIS 9.2. The contour data used in the project were obtained from General Command of Mapping, Turkey (GCM). Data was line type vector data and collected via photogrammetic methods. They were projected with ED50 datum and UTM coordinate system parameters; and GCM has determined the accuracy of the dataset as approximately 5 meters.

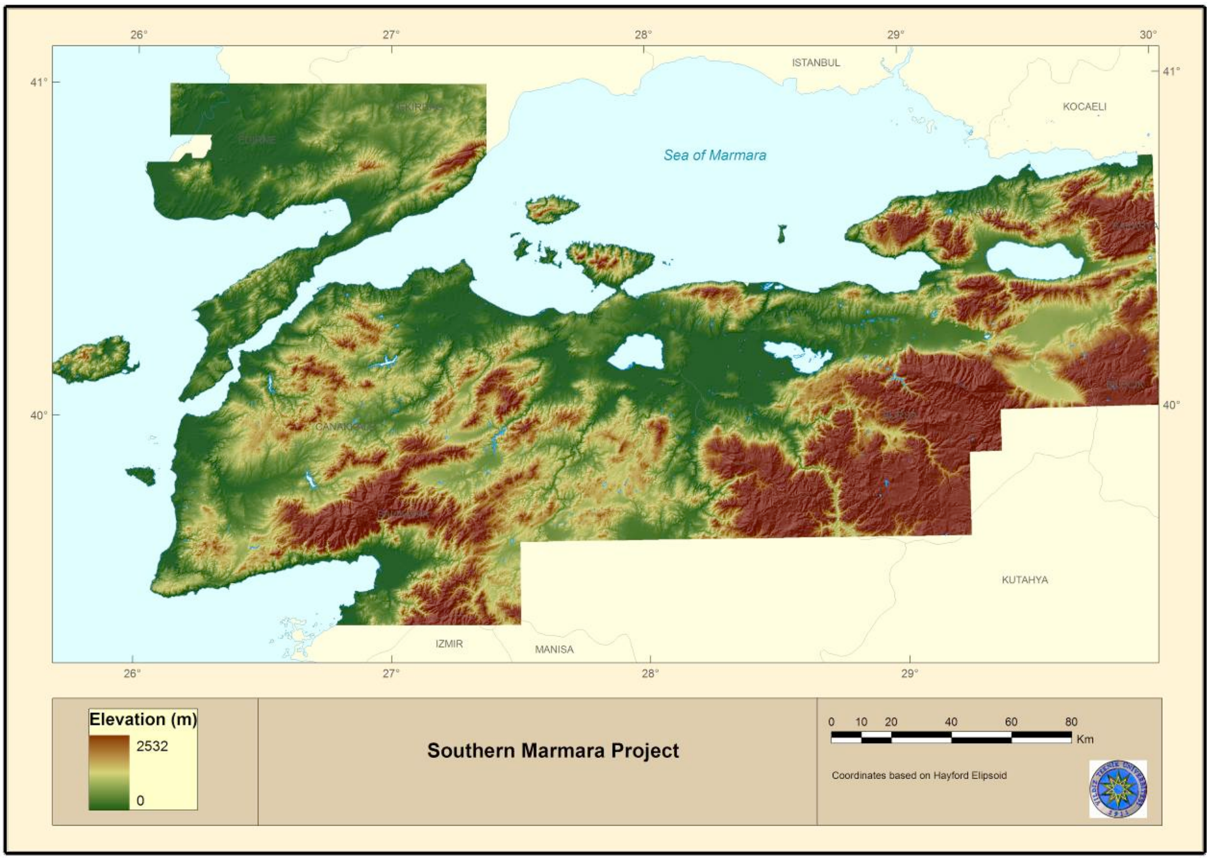

Figure 2: Study area and DEM-100m

4. RESULTS

The model which was developed by Iwahashi and Pike (2007), is implemented for the classification of landform in Southern Marmara instance by using DEM with 100m grid. For this purpose three different classification systems are applied, and the maps are prepared according to the classification systems. During the study, both of the results of 12 and 16 pair classifications are evaluated together, and morphological unit boundaries are described for 12 classes. Eventually, three macro morphological element, six distinctive hillside zones and alluvial fan and cone are automatically assigned to derived classes.

Afterwards, Figure 3 is prepared with the consideration of the current situation. It is shown that the consequences of the method were significant for the area. According to the inference of the evaluation of the zone, there are both large and small shore plains at the north and south; and there are hilly, plateau areas and mountainous areas are located behind the shore plains. It is also revealed that there are also inter mountain plains as well as the macro morphological units.

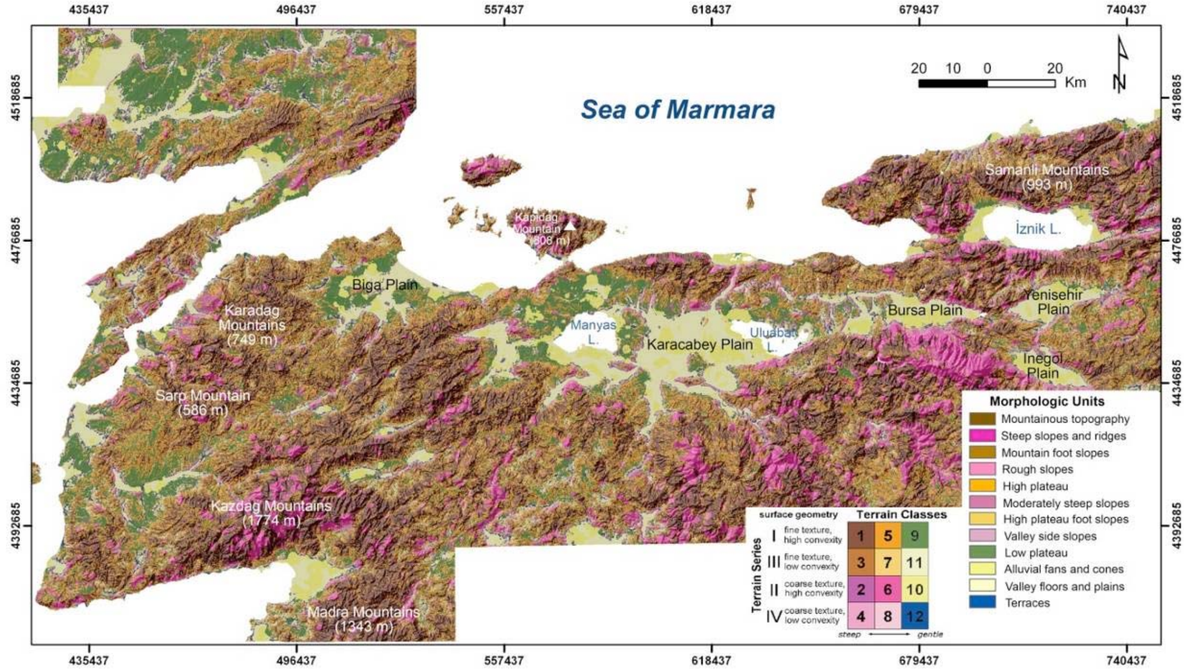

Figure 3. Classified landforms of Southern Marmara Region

5. CONCLUSIONS

Boundaries of landforms such as mountain, hill, valley and plain haven't been stored as polygonal or line type vector features in GIS based on topographic maps, in generally. Impressions for hillsides and the others are viewed by the contours or TIN. DEMs are also be used for giving landform impression on the screen. This study proves that the landforms can be described in raster formats; consequently, they can be also converted to vector data formats in geodatabases when necessary.

The model which was developed by Iwahashi and Pike (2007) is implemented for the classification of landform in Southern Marmara instance by using DEM with 100m grid. In this respect three different classification methods are applied, and result maps are prepared for the relevant classification system. The landforms are created in raster format via GIS tools, and results of this model are found very significant when compared to the reality.

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BIOGRAPHICAL NOTES

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