HYPSOMETRIC PROPERTIES OF THE HYDROLIC BASINS LOCATED ON WESTERN PART OF NAFZ

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Abstract - In this study morphometric properties of western part of the North Anatolian Fault zone (NAFZ) are investigated using hypsometric curve and hypsometric integral properties of hydraulic basins.
Fourteen hydraulic basins located on NAFZ are extracted from 1/100000 scale topographic maps of the area using D8 algorithm then for each basins hypsometric curve and hypsometric integral values are calculated in order to investigate erosional stage of the basins and the tectonic and lithological factors controlling it. The hypsometric integral is defined by assigning each Mean elevation, minimum elevation and maximum elevation values to each sub basin areas using zonal procedure.
According to generated results hypsometric integral values of hydraulic basins are ranges between 0,27 to 0,56. Low hypsometric values indicates old and more eroded areas on the other hand high hypsometric integral values indicated young and less eroded areas, S shaped and concave shape curves are observed in the area. Convex shaped hypsometric curve characterize basins in young stage, S shape curves indicate the basins in maturity stage and concave hypsometric curve characterize basins in old stage. According to result in the area erosional stage and level of tectonic activity of basins differs from each other.

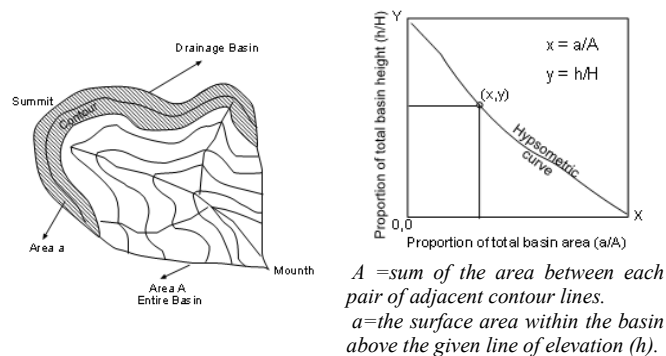**Keywords: GIS, Geomorphology, Geology, Basins, Turkey**

1. INTRODUCTION

Tectonic geomorphology is defined as the study of landforms produced by tectonic processes, or the application of geomorphic principles to the solution of tectonic problems (Keller, E.A. and Pinter N. 1996). The quantitative measurement of landscape is based on the calculation of geomorphic indices using topographic maps, aerial photographs and field work. The results of several indices can be combined in order to highlight tectonic activity and to provide an assessment of a relative degree of tectonic activity in an area (Keller, E.A. and Pinter N. 1996).

Morphometry is defined as quantitative measurement of landscape shape. At the simplest level, land forms can be characterized in terms of their size, elevation (maximum, minimum or average), and slope. Quantitative measurements allow geomorphologists to objectively compare different landforms and to calculate less straightforward parameters that may be useful for identifying a particular characteristic of an area such as level of tectonic activity (Keller E A and Pinter N. 1996).
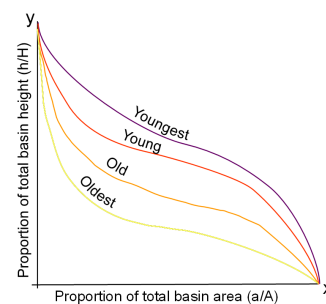
Geomorphic indices have been developed as basic reconnaissance tools to identify areas experiencing rapid tectonic deformation (Bull W. B. and McFadden L.D. 1977, Keller E A. and Pinter N 1996). These indices based on topography that are useful in studies of active tectonics.

The hypsometric curve of a catchment represents the relative area below (or above) a given altitude (Strahler, 1952). It describes the distributions of elevations across an area of land, from one drainage basin to entire planet. These curves have been used to infer the stage of development of the drainage network also it is a powerful tool to differentiate between tectonically active and inactive areas (Keller and Pinter 1996).

The curve is created by plotting the proportion of total basin height against the proportion of total basin area (figure 1). Convex hypsometric curves characterize young slightly eroded regions; S-shaped curves characterize moderately eroded regions; concave curves point to old, highly eroded regions, concave curves point to old, highly eroded regions (figure 2).

$x = a/A$
$y = h/H$

A = sum of the area between each pair of adjacent contour lines.
a = the surface area within the basin above the given line of elevation (h).

Figure 1. Hypsometric Curve and Integral

Figure 2. Interpretation of Hypsometric Curve

The shape of the hypsometric curves and the HI values provide valuable information not only on the erosional stage of the basin, but also on the tectonic, climatic, and lithological factors controlling it (e.g., Moglen and Bras, 1995; Willgoose and Hancock, 1998; Huang and Niemann, 2006).

The area below the hypsometric curve is known as the hypsometric integral (HI), varying from 0 to 1 (with values close to 0 in highly eroded regions and values close to 1 in slightly eroded regions). (Antonio Pedrera, et al. 2009).

In this study hypsometric curve and hypsometric integral analysis are applied western part of the North Anatolian Fault Zone (NAFZ). According to generated results hypsometric integral values of western basins of NAFZ ranges between 0,27 to 0,56 indicating erosional stage and level of tectonic activity of basins differs from each other.

2. STUDY AREA

NAFZ is one of the most well known strike-slip faults of the world. Because of activity of NAFZ there has been much loss of life and property. In this study western part of the NAFZ zone is selected for analysis. The area is within Zone 36 of Universal Transverse Mercator projection system.The total area covers 18862.7 km^2

Morphologically the area is a mountainous region. The minimum and maximum elevation in the study area is 163 and 2583 m, respectively. The area is characterized by tectonically active NAFZ. Figure 3
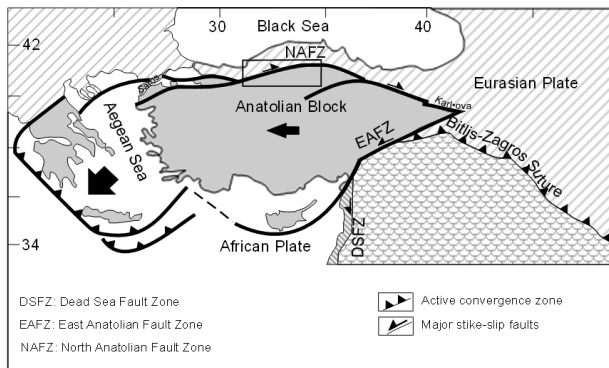

Figure 3. Study Area

METHOD OF THE STUDY

In this study DEM data is generated from 1/100000 scale topographic maps. There are many methods used to determine the flow directions from DEM data (Martz and Garbrecht, 1992; Moore et al.,1991). These methods differ from each other mainly by the number of possible flow directions that can be assigned to each grid cell, input data used to assign flow directions, and flow direction determination criteria. In this extraction procedure, Deterministic-8 (D8) algorithm is used. D8 algorithm is the the most convenient and widely used method to extract drainage network and its related basins (Hogg et al., 1997; Maidment, 1993). The result of the extracted hydrolic basins are given in below figure 4.
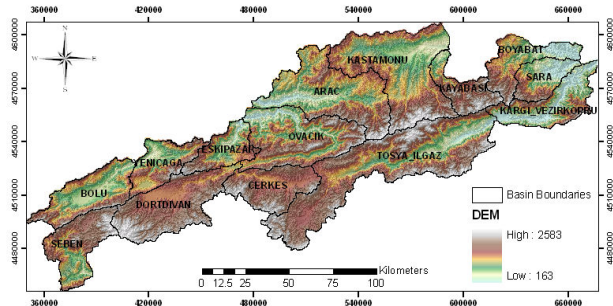

Figure 4. Hydrolic Basins

In order to generate hypsometric curve of basin areas DEM data of each basins are imported in MapInfo environment and areas between each 50 m contour environment area calculated. A contour interval of 50m is provided enough elevation ranges for the 1/100000 scale topographic maps and it gives smooth hypsometric curves The result of the hypsometric curves belonging to fourteen hydrolic basins are given in figure 5. According to generated results shape of hypsometric curves of hydrolic basins significantly differs from each other. Differences on hypsometric curve may provide information about tectonic effect of NAFZ on hydraulic basins. Yenicaga basin indicates convex shape curve characterizing this basin is the youngest stage and Kastamonu basin indicates concave shape curve characterizing this basin is in oldest stage in the area.
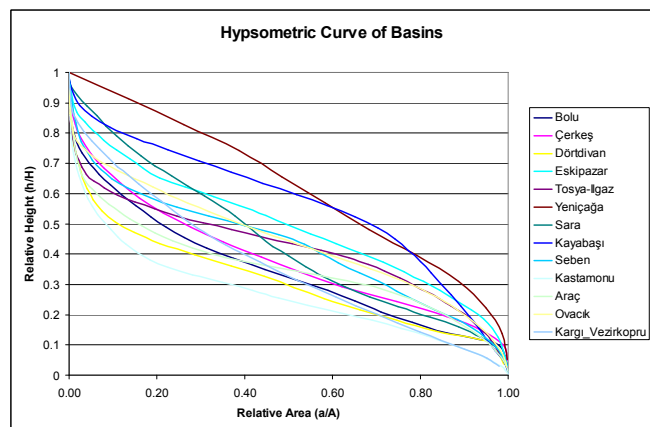

Figure 5. Hypsometric curve of fourteen basins

The simple way to characterize the shape of hypsometric curve for a given drainage basin is to calculate its hypsometric integral. The integral is defined as the area under the hypsometric curve.

HI values— provide valuable information not only on the erosional stage of the basin, but also on the tectonic, climatic and lithological factors controlling it. In order to determine the Hypsometric Integral values of a drainage basin the hypsometric integral is defined by assigning each Mean elevation, minimum elevation and maximum elevation values to each sub basin areas using zonal procedure using formula as;.

$$\frac{MeanElevation - MinimumElevation}{MaximumElevation - MinimumElevation} \quad (1)$$

In theory hypsometric integral values are ranges between 0 and 1. In this study hypsometric values ranges between 0,27 and 0,56. Low hypsometric integral values indicate old and more eroded areas and evenly dissected drainage basins. High values of the hypsometric integral indicate that most of the topography is high relative to the mean, such as a smooth upland surface cut by deeply incised streams indicating young and less eroded areas. Thematic map of HI values and descriptive statistics of hydrolic basins are shown in figure 6 and table 1 respectively.
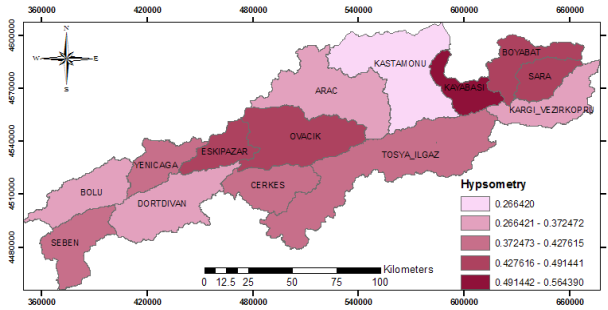

Figure 6: HI values Hydrolic Basins Along NAFZ

Table1: Descriptive statistics and HI values of Hydrolic Basins

BasinName	Area(km^2)	Elevation (m)			HI
		Min	Max	Mean	
Bolu	1110.6	520	1979	1042	0.36
Seben	1039.98	600	2217	1288	0.43
Yenicaga	763.32	520	1908	1093	0.41
Dortdivan	1627.75	975	2378	1426	0.32
Eskipazar	660.19	300	1910	1091	0.49
Cerkes	1007.59	975	2019	1393	0.40
Ovacik	1787.78	301	2149	1120	0.44
Arac	2029.97	330	2399	1065	0.36
TosyaIlgaz	3356.59	345	2583	1312	0.43
Kastamonu	2357.52	590	2583	1121	0.27
Kayabasi	633.05	590	1945	1355	0.56
Boyabat	839.49	210	1947	976	0.44
Sara	605.31	210	1715	869	0.44
KargiVezirkopru	1045.04	163	1945	831	0.37

Statistical test is applied to data to test and quantify relationship between features. In order to detect departures from spatial randomness weighted correlation coefficient Morans I is used (Moran 1950). Moran's I is calculated based on the following formula:

$$I = \frac{n}{\sum_i \sum_j W_1} \frac{\sum_i \sum_j \left(X1 - \bar{X} \right)\left(X_j - \bar{X} \right)}{\sum_i \left(X1 - \bar{X} \right)^2} \qquad (2)$$

x = observed value at location
n = the number of locations
w = weights to every pair of locations in the study

Result of Morans I ranges from -1 to+1. Positive values indicate positive spatial autocorrelation while negative values indicate negative spatial autocorrelation. A zero values indicate no spatial autocorrelation exist. When no statistically significant autocorrelation exist the pattern of spatial distribution is considered as random. The results of the analysis are interpreted with the null hypothesis for global Morans I statistics the null hypothesis is constructed as "Attributes being analyzed is randomly distributed among features in the study area" the results are analyzed at 99% confidence level.

In order to analyze the distribution HI values in the area the Morans I statistics are applied. Summary statistics of global Morans I is given in table 2.

Table 2:Global Moran's I Summary

Moran's Index	-0.161168
Expected Index	-0.076923
Variance	0.045507
Z Score	-0.394915
p-value	0.692905

According to generated results in the in the study area Morans I value is -0.16 indicating negative spatial autocorrelation and at 99% confidence level due to large significance values (>.01) null hypothesis is accepted indicating that the distribution of HI values is random in the area.

RESULTS

In this study hypsometric curve and hypsometric integral analysis are applied hydrolic basins of western part of the NAFZ. According to generated results convex, S shaped and concave hypsometric curve are observed in the area hypsometric indicating erosional stage of basins differs in the area. According to result of Morans I at 99% confidence level HI values indicates random distribution in the area. In the study area Yenicaga basin belons the youngest stage and Kastamonu basin is the oldest stage comparing to other basins. HI values of basins ranges from 0,27 to 0,56 indicating erosional stage and level of tectonic activity of basins differs from each other. Low hypsometric integral values indicate old and more eroded areas and evenly dissected drainage basins. High values of the hypsometric integral indicate that most of the topography is high relative to the mean, such as a smooth upland surface cut by deeply incised streams indicating young and less eroded areas.

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