

A MORPHOTECTONIC SURVEY ON GOLPAYEGAN WATERSHED USING AHP METHOD IN GIS ENVIRONMENT

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Introduction

The term morphotectonics, generally, expresses the relationship between geomorphology and tectonics, and in many cases, morphotectonic, is considered to be tectonic geomorphology [1]. Morphometry is a quantitative measurement of the shape and geometry of landforms, which can be done in most simple variables such as size, height, area, gradient etc. [2]. These items enable geologists to describe quantitatively and compare the perspectives of different regions taking in hand the geomorphic characteristics [3]. Geomorphic indices are useful tools in morphotectonic studies for evaluation of tectonic activity level by providing quantitative insight on areas.

This article aims to further knowledge of the morphotectonic situation of Golpayegan water basin by surveying morphometric indices. This is accomplished by geomorphic approaches in the study of the mountain fronts and valley systems. The analysis endeavors to interpret the relative intensity of active tectonics through the compiling the results of this study which can be applied for the reduction of earthquake hazard [4].

Some researchers have already documented tectonic situation in this part of SSMZ [5; 6]. However, none of these studies has used a geomorphic analysis on morphometric indices to define patterns of the relative rates of tectonic activity in the region. The scope of this paper includes a brief outline of the morphotectonic zoning that are useful in defining relative rates of tectonic activity in the study area.

Tectonic Setting

The Golpayegan drainage basin is located in Sanandaj-Sirjan metamorphic zone of Iran and in the northeastern margin of the Zagros Mountains Ranges and southwest of Central Iranian volcanic belt. SSMZ, a 150–200 km metamorphic belt that is mainly composed of highly deformed rocks, extending for around 1500 km in NW–SE direction, was related to the destruction of the subducted Tethys Ocean followed by the collision of Arabian and Iranian continental plates [6–10]. SSMZ in Golpayegan region is divided into two parts [11–13]. The northern part, deformed in the Jurassic–Early Cretaceous and the Southern part consists of both Paleozoic units and a Carboniferous–Permian mafic and ultramafic complex. Polyphase deformation structures of SSMZ are attributed to dextral transpression that is related to the oblique convergence between the Arabian - Iranian continental plates [9; 14; 15]. On the other hand, subduction of the Oman oceanic crust besides Arabian collision, confined Iranian plate to have numerous active faults spread out over the large zones e.g. Zagros, Central Iranian plateau and Makran accretionary wedge [4; 16–18]. The non-occurrence of devastating earthquakes in this area could caused Golpayegan to be assumed as one of the passive areas of SSMZ, while the existence of some faults with NW-SE and NE-SW trends, parallel or perpendicular to the main Zagros thrust fault trend, made a question mark on this.

Morphometric approach

For this research, mountain fronts were selected considering geological and geomorphological characteristics, the orientation and continuity of topography, and cross-cutting of the front by a larger drainage [19–22].

Smf index, one of the geomorphic indices that is considered in this survey, has been defined as:

$$Smf = Lmf / Ls,$$

where *Lmf* is the length of the front along the mountain–piedmont junction and *Ls* is the straight-line length of the front. This index is used to know the balance between the tendency of the drainages to form an irregular mountain fronts and tectonic activity to form straight fronts [3; 23; 24].

YDK: 556.537
DOI: 10.21177/1998-4502-2019-11-3-305-314

*Spatial variation of tectonic activity along Golpayegan drainage basin in Iran are assessed using morphometric approaches by taking advantages of Geographical Information System, GIS. The Golpayegan region is located in the central part of Sanandaj-Sirjan metamorphic zone, SSMZ, of Iran, where is affected by Iranian – Arabian continental plate collision. The quantitative study of morphometric indices allows to compare geomorphic features and to zoning out and interpret the intensity of active tectonics. In this research, some morphometric indices such as Sinuosity of Mountain Fronts (*Smf*), Faceting of mountain fronts (*Facet*), Valley floor index (*Vf*) and valley ratio index (*V ratio*) is surveyed to be able to zone out the tectonic activity level in the water basin of Golpayegan taking advantages of fuzzy AHP method in the GIS environment.*

KEYWORDS:

Earth sciences, Geology, Morphometrics, Tectonics, Geomorphology, Iran

Article received 10.07.2019.

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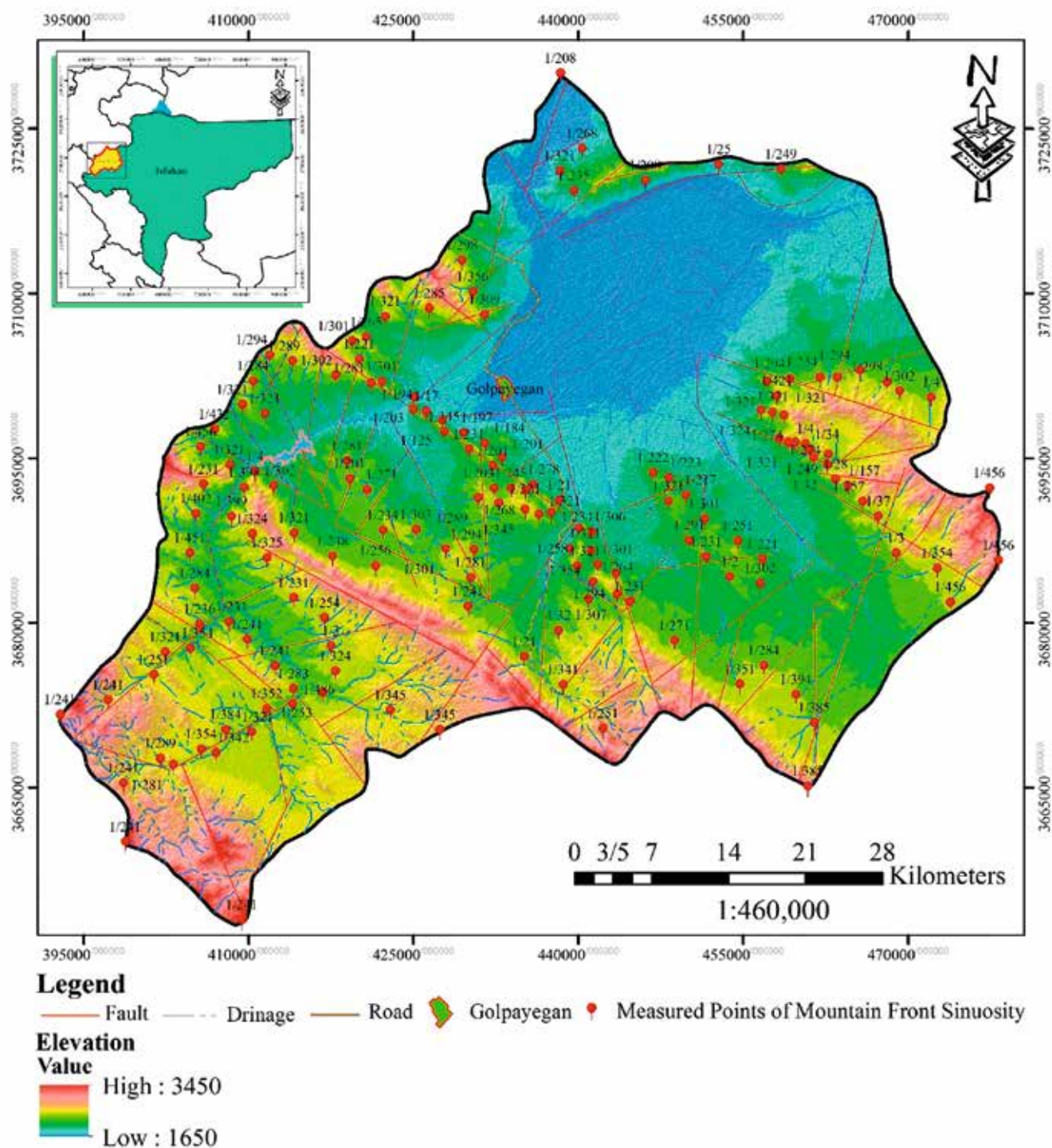


Fig. 1. Mountain fronts location which are used for calculation of mountain front sinuosity and faceting indices in Golpayegan region

Smf index is computed for 150 mountain fronts in Golpayegan region (Fig. 1). According to the fact that on the active fronts, values of this index approaches to 1.0 while in the areas by more prominent erosional processes, it reduced lower to indicate less tectonically active more irregular fronts; the relative activity map of the region based on *Smf* index is provided (Fig. 2)

Considering that active fronts tend to be less dissected, Facet is another morphometric index that has been defined on the 150 fronts of Golpayegan region by using following formula:

$$Facet = L_f / L_s,$$

where L_f is the cumulative lengths of facets of mountain front. Given the point that, high values of this index indicate tectonically active fronts due to recurrent faulting along the fronts, a map showing the relative tectonic activity based on *Facet* index is prepared (Fig. 3).

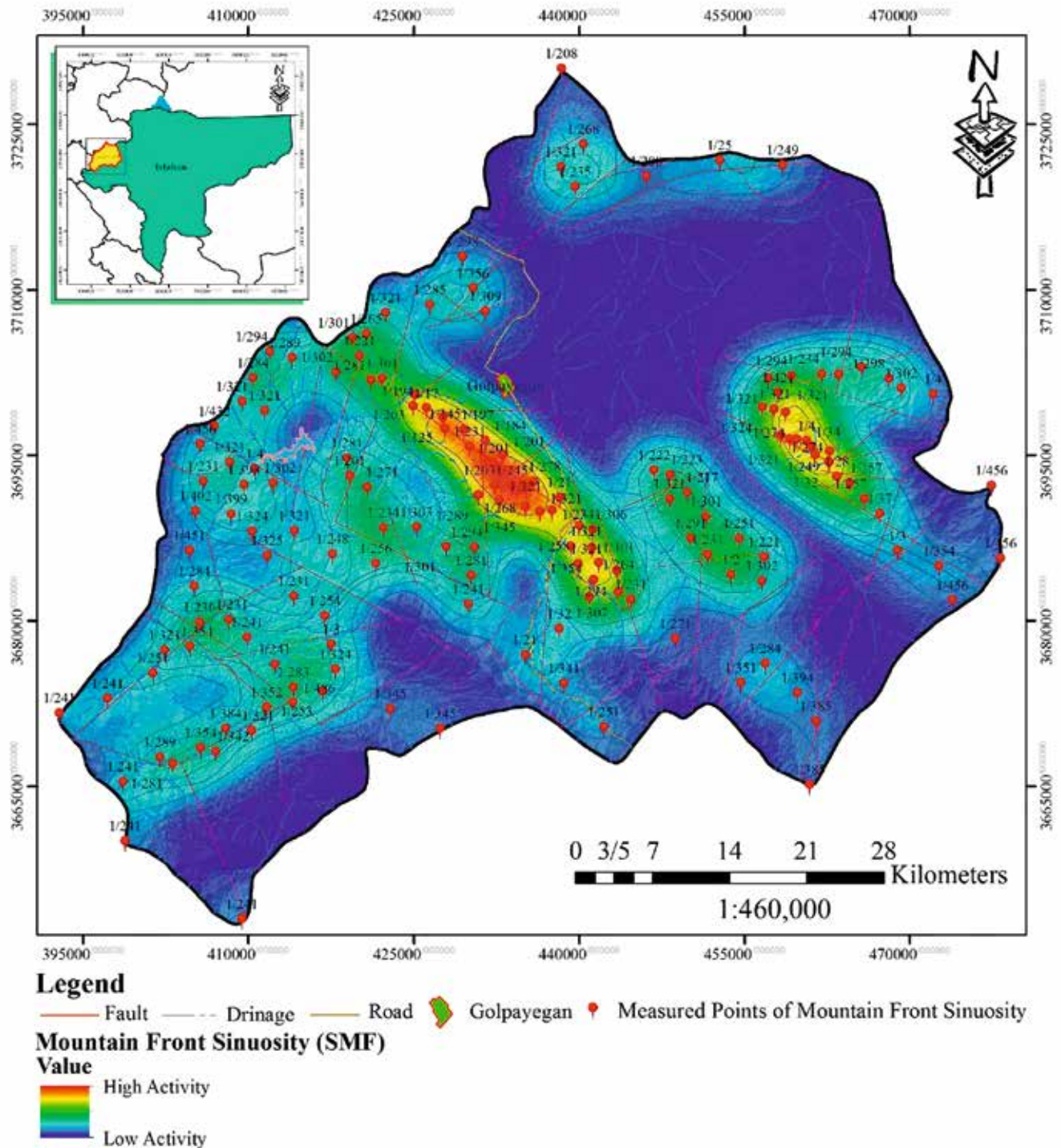


Fig. 2. Map of relative tectonic activity of the study area based on the values of mountain front sinuosity index in Golpayegan region

Valley floor, V_f , was another morphometric index that is measured in 124 stations at the study area to show the impact of local base-level changes in valley landform due to relative uplift (Fig 4). This index has been defined as:

$$V_f = 2V_{fw} / [(E_{ld} - E_{sc}) + (E_{rd} - E_{sc})],$$

where V_{fw} is the width of valley floor, E_{sc} is the elevation of the valley floor and E_{rd} and E_{ld} are the elevations of the right and left valley divides respectively [24]. Figure 5 shows the activity level of the study area based on the interpretation of V_f values considering that high values of this index display eroding laterally condition in broad-floored canyons while low values reflects influence of a base level fall at V-shaped valleys where stream is actively downcutting indicating more tectonic activity.

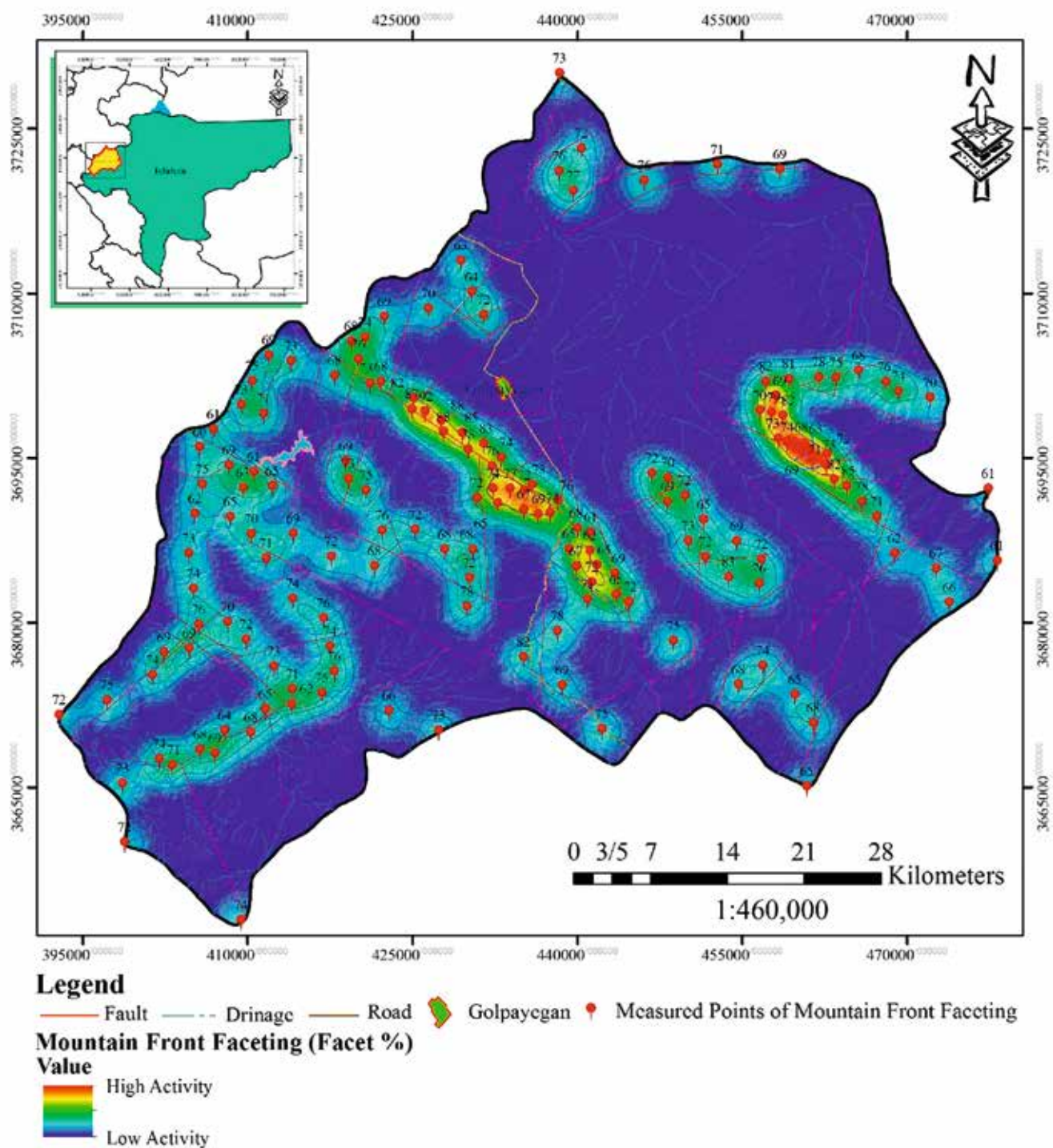


Fig. 3. Map of relative tectonic activity of Golpayegan region based on the values of mountain front faceting index

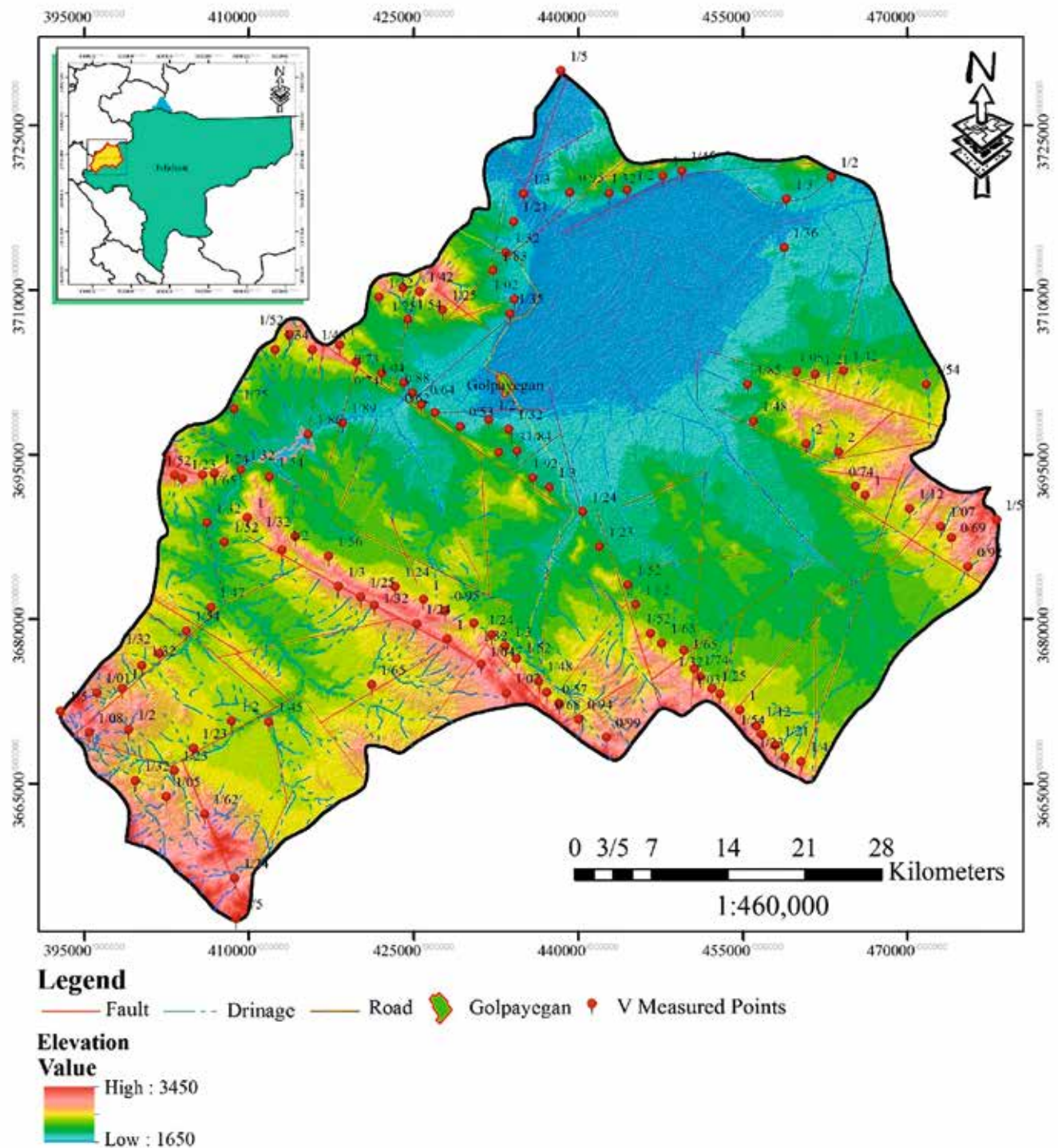


Fig. 4. location of the stations that are used for measurement of V and V_f related parameters

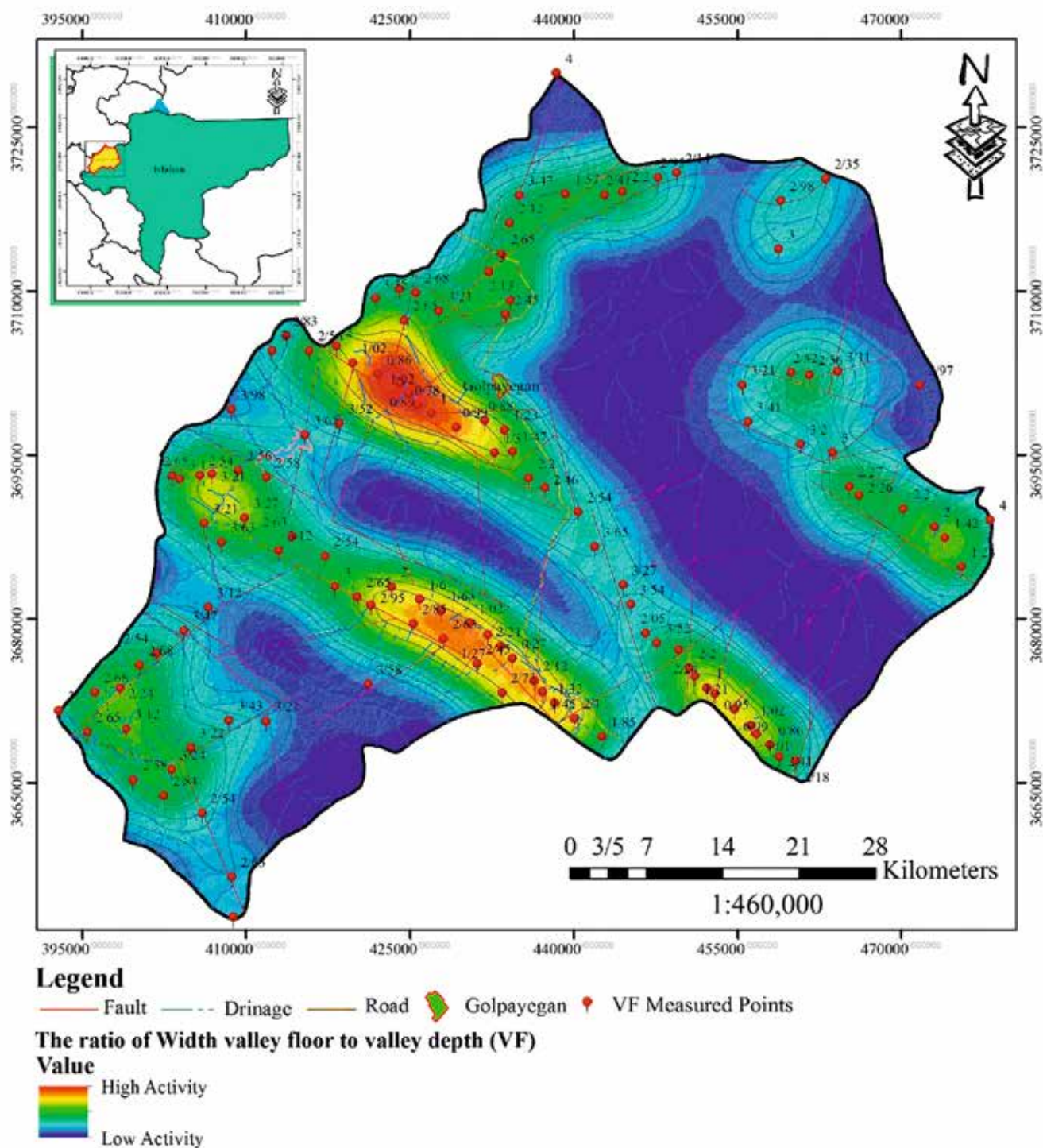


Fig. 5. Relative tectonic activity of Golpayegan region based on the values of Vf index

The V index is another indicator that is surveyed in the Golpayegan region at 124 stations (Fig. 4). This index is defined as:

$$V = A_v / A_c,$$

where A_v is the cross-sectional area of the valley and A_c is the semicircular surface of the radius h and h is the height of the division line of the valley. By computing this ratio, one can also obtain information about the region's uplift due to the active tectonics, so that the V ratio at 1 is indicative of the U -shaped valley showing the relatively passive zone and the continuous erosion of the valley walls. If the V ratio is too small, less than 1, the V -shaped valleys represent the active tectonic performance. Values larger than 1 also reflect that the width of the valley is much larger than the depth, and the area is tectonically inactive. Figure 6 shows the zoning of Golpayegan region according to the value of V index.

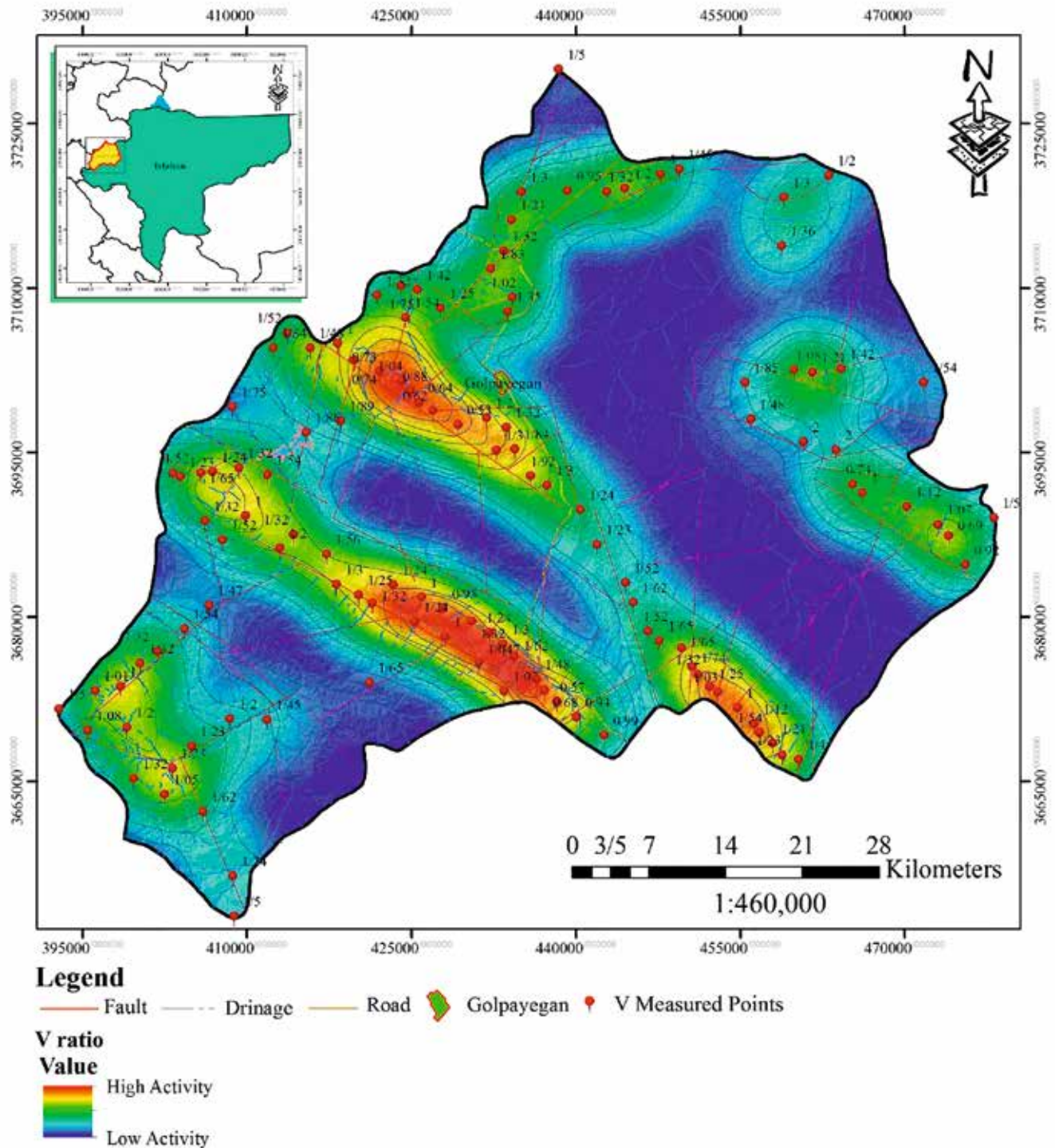


Fig. 6. Relative tectonic activity of Golpayegan region based on the values of V index

The study was finalized through integration of Smf , $Facet$, V_f and V indices in a GIS environment using an Analytic Hierarchy Process (AHP) procedure to achieve more appropriate ranking of regional tectonic activity. AHP as a decision-aiding method was introduced by [25] helped to quantify relative priorities for the selected set of morphometric indices on Golpayegan region, according to the preference matrix that compares all indices against each other in a pair-wise comparison matrix, to find the relative preference among them. For this purpose, by using expert selection software, after weighting, the coefficient of influence of each index is determined. However, the degree of importance of each index varies in this study and it can be graded. Special attention is paid to values of sinuosity and faceting of mountain fronts, which might more clearly reflect variations in the degree of uplift along each front. Because streams in the study area are relatively small, morphometric indices on drainage systems are of less relevance than others measured on the fronts. Implementing AHP, the relative tectonic activity map is finalized for Golpayegan area (Figure 7).

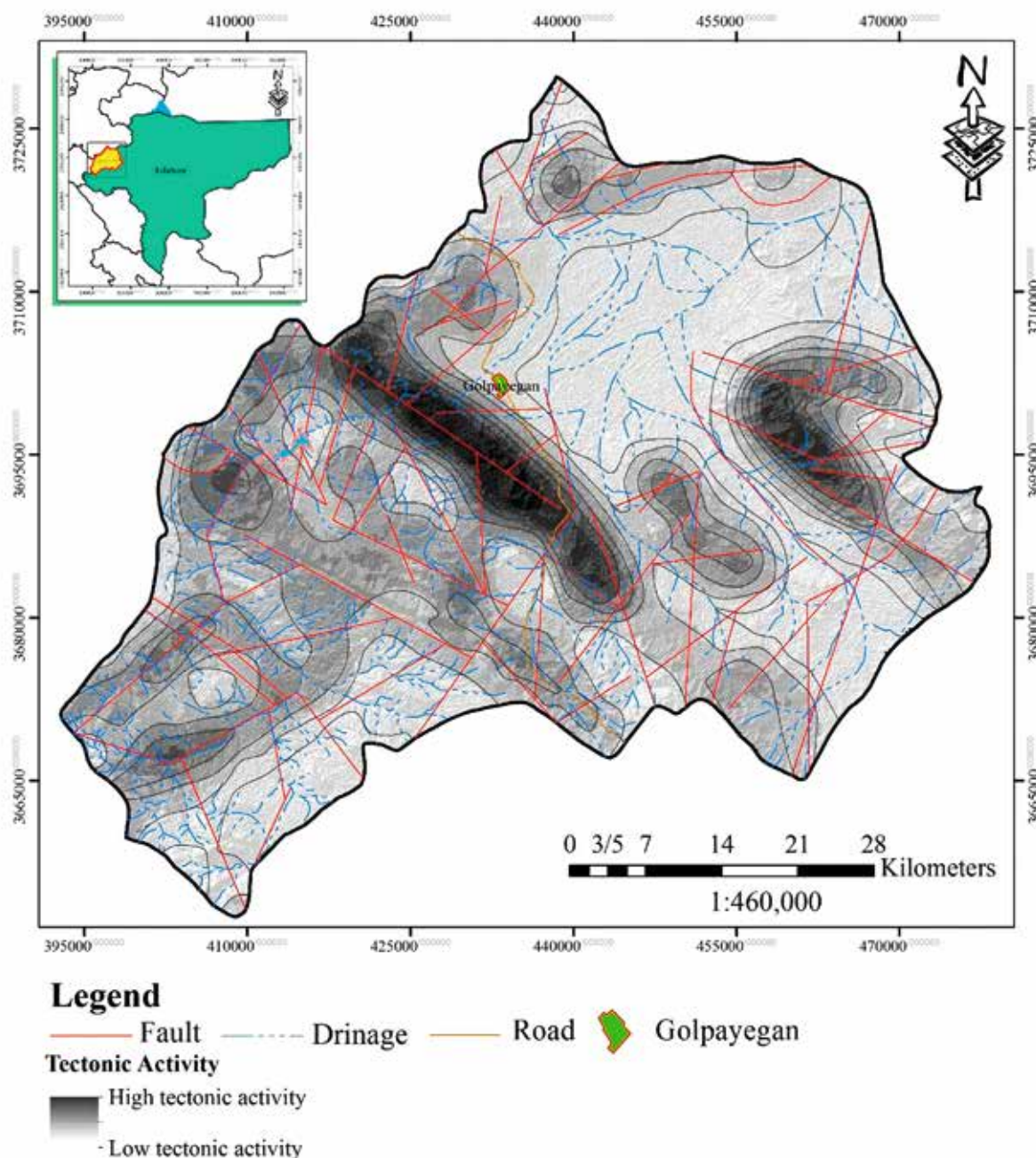


Fig. 7. Map of relative tectonic activity of Golpayegan region based on the values of geomorphic indices

Conclusion

The morphometric data provided evidence for relative variations in tectonic activity among the Golpayegan basin. In the attributed morphometric approach on 150 mountain fronts and 124 valley stations, geomorphic indices suggest a relatively high degree of tectonic activity along the western part of the Golpayegan city, in a zone parallel to the main thrust of Zagros. The computation of morphometric indices in Golpayegan basin means that tectonic activity is remarkable from Morphometric point of view. Tectonic activity is not been the same throughout the region, and according to the final map, it is higher in the western part of the Golpayegan city, in a zone parallel to the main thrust of Zagros. Although no major earthquakes have been reported in the Golpayegan area, but the morphometric evidence indicates the overall activity of tectonic setting of the region; so, it's good to keep in mind it, considering presence of faults in this area, and the age of the seismic recorders respect to geomorphic features. Geomorphic evaluation of the Golpayegan region suggests that some NW-SE trending faults, and specifically the tips of some faults at the west the Golpayegan city, should be considered as areas of potentially earthquake risk.

ACKNOWLEDGEMENTS:

The authors gratefully acknowledge Prof. Hojjatollah Ranjbar for his helpful discussions and comments. Thanks also to the unknown reviewers for their constructive suggestions for improvement of the earlier versions of the manuscript.

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