Current Trends in Technology and Science
ISSN: 2279-0535. Volume: 3, Issue: 3 (April - May 2014)

Geomorphic Assessment of Active Tectonics in Tozlogol Basin, Sanandaj-Sirjan Zone, Iran

M.R. Saberi
PhD. Student, Faculty of Earth Science, Islamic Azad University, north Tehran branch,geotectonic2010@gmail.com

M. Pourkermani
Professor, Faculty of Earth Science, Islamic Azad University, north Tehran branch, pourkermani.mohsen@gmail.com

A. Nadimi
Assistant Professor, Department of Geology, Faculty of Science, University of Isfahan, Hezarjrib, Isfahan, Iran

M. Ghorashi
Associate Professor, Research institute for earth sciences, geological survey of Iran, ghoroshi_manoucher@yahoo.com

A. Asadi
Assistant Professor, Faculty of Earth Science, Islamic Azad University, Shiraz branch, asadi.abdolmajid@gmail.com

***Abstract* — The Tozlogol Basin is located in the central part of the Sanandaj-Sirjan zone, on the northeastern margin of the Zagros Orogeny. This basin is one of the Sanandaj-Sirjan zone basins that are filled by Pliocene–Holocene sediments. This basin has been investigated to examine the influence of tectonics activity through an analysis of the geomorphic indices that were computed using geographical information system (GIS). So that we analyzed geomorphic indices: such as: hypsometric integral (Hi), valley floor width-valley height ratio (VF), mountain front sinuosity (Smf). These indices were combined to yield the relative active tectonics index (Iat). Based on Iat values, the study area was divided into four parts: class1 (very high relative tectonic activity, 22.2% in area); class 2 (high, 33.3%); class3 (moderate) and class4 (low). In general, almost 77.7% of area has very high relative tectonic activity to moderate and 22.2% has low tectonic activity.**

***Keyword* — Tectonics, Morphotectonics, Active Tectonics, Sanandaj-Sirjan, Iran.**

1. Introduction

One of the earth science branches is tectonics. It discussed about forces interior crust and their Origen. Tectonics studies involves:”active tectonics and neotectonics “Active tectonics is defined formally as the “tectonics movement that are expected to occur within a future time span of concern to society”. Neotectonics is the study of phenomena over time span ranging from thousand to a few million years before present. Both fields are essential to the study of tectonic hazards because geologic events happen so infrequently (Cloetingh and Cornu, 2005).

Several methods use in neotectonics studies such as dating methods, paleoseismology and geodesy. One of these methods is morphotectonics and morphometry that include geomorphological quantitative studies.

Tectonics geomorphology deals with relations between tectonics and Geomorphologic processes shaping areas of active Cenozoic deformations (Burbank and Anderso, 2001). nowadays development of geomorphometric and geostatistic methods is connected especially with possibilities of fast derivation of parameters from a digital elevation model (DEM) which in GIS environment provides even exacting calculations practically unrealizable in analogue representation (Sung Chen, 2004).

In mountain ranges, recent and active tectonics can be viewed as the main factor contributing to rock uplift, being their present-day topography the result of the competition between tectonic and Erosional processes (e.g. England and Monlar, 1990; Bishop, 2007). in the same way geomorphic features can be used to evaluate recent and present-day tectonic activity (Keller et.al, 2000; Perez Pena, 2009) .In the other hand, Geomorphic indices are useful tools in the evaluation of active tectonics because they can provide rapid insight concerning specific areas within a region which is undergoing adjustment to relatively rapid, and even slow, rate of active tectonics (Keller, 1986).

In the field of tectonic geomorphology and landscape evaluation, the use of geographic information system (GIS) is relatively recent. In geomorphology, the traditional use of GIS capabilities can be found in multi-criterion analysis works that require the combination of different spatial data in conjunction with statical analysis (Perez Pena, 2009).

In this study, the morphometric indices of Tozlogol area in Sanandaj-Sirjan belt measured and then analyzed in ARC GIS 9.3. These parameters include: hypsometric integration, valley floor to valley height ratio or VF and mountain front sinuosity or SMF.

Current Trends in Technology and Science
ISSN: 2279-0535. Volume: 3, Issue: 3 (April - May 2014)

2. Regional Geology

Tozlogol basin is located 260 km far from southwest of Tehran at northeast of zagros mountain. It is between (286144, 3831232) and (500406, 3757647). This basin has a north-south trend and surround by mountains. Its vast is 2165494 hectare. Nine basins of studied area belong to Namak Lake the second order basin that it is belong to central Iran basins (Fig.1).

The studied area is in Markazi province in the view of politic deviation. Geographic limit of this area is: crest line of Saveh ,Qom , Kashan mountains in east, crest line of Nobaran, Hamedan and Razan mountains in north, crest line of Langroud , Astaneh, Shahre Miyan mountains in west and crest line of Muteh , Golpayegan mountains in south.

It is located at northwest of central Iran plateau, between two structural zone called central Iran and Sanandaj-Sirjan whereas the south and west region of it located in Sanandaj-Sirjan zone. This boundary is not abrupt, it is transitional zone. The strike of geology structures and main faults are northwest-southeast. Structural position of this area caused the sedimentation and lithostratigraphic sequence is variable. So that, the age and properties of formations and rock unites are different at different point of studied area.

Fig.1. Location of the study area in a map of Iran

The study area is covered by young alluvial of quaternary age that it has been covered the geological structure and fractures. The climate of the area is temperate mountain. The average annual rainfall of the area is more than 320 mm.

Hardness, mainly calcareous deposits and igneous unites and Erodible sediments form highlands and Lowlands of basin. There are many formation in this area such as Qom ,Tizkuh , upper red and lower red, Karaj, Shemshak, Nayband, Kazhdomi, Lalun, Mila, Darreh-Zanjir, Kahar formations (Fig. 2). It includes a wide range of rock from sedimentary to igneous rocks.

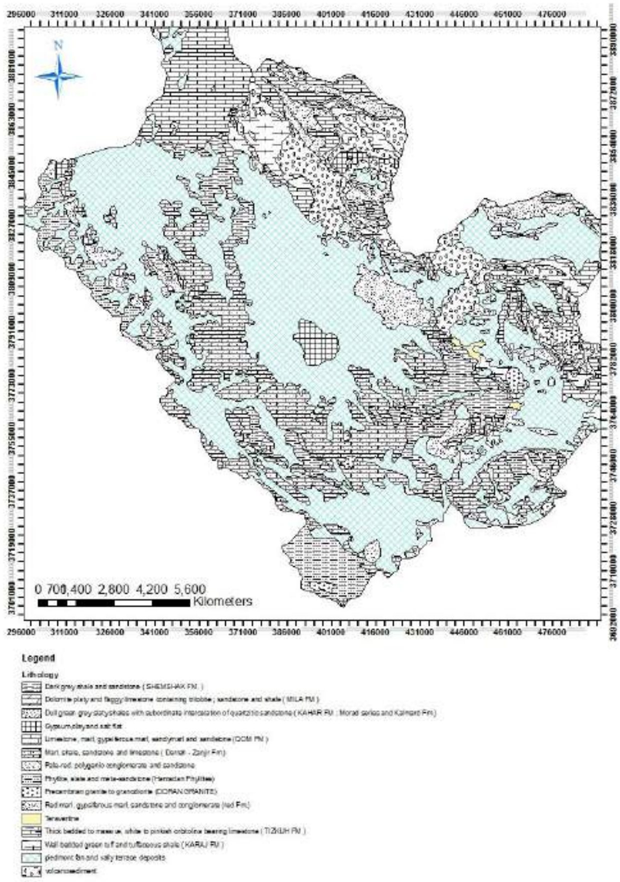

Fig.2. lithological map of the studied area, Markazi Province, Iran

3. Methods and Results

The theoretical basis for the morphometric analysis involves relative adjustments between local base-level processes such as tectonic uplift, stream down cutting and basin sedimentation and erosion controlled topographic mountain fronts (bull and McFadden,1977) Most of the morphometric variables used in this study were developed by bull and McFadden (1977).

In the tectonics geomorphology, the DEM (Fig.3) is used for better analysis of topographic parameters. It provides an opportunity to quantify land surface geometry in terms of elevation. The possibility of extracting river networks

Current Trends in Technology and Science
ISSN: 2279-0535. Volume: 3, Issue: 3 (April - May 2014)

with stream gradients and catchments areas is one of the most important its features (Perez Pena, 2009).

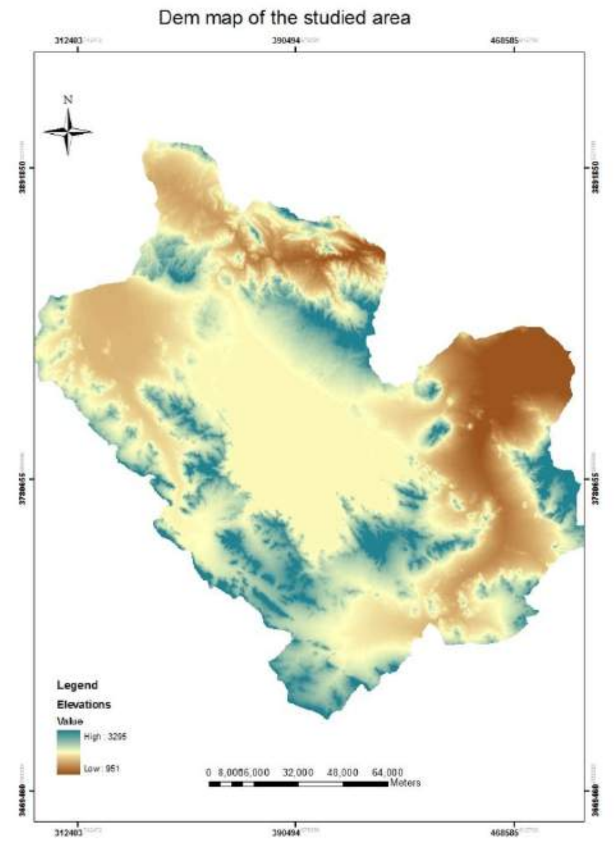

Fig.3. digital elevation model with 30 meter spatial resolution

ARCGIS 9.3 has been used for the present study. The digital elevation model (DEM) with 30 m spatial resolution has been used as a base map. The drainage basin's boundary has been identified through an extension called arc hydro tools 9 in ARCGIS software using DEM model as input. So that, 9 basins has been chosen for studying(Fig. 4).stream ordering method as suggested by Strahler has been employed (Strahler, 1957).

The hypsometric curve of a catchment presents the distribution of area and altitudes within a basin (Strahler, 1952).the index is defined as the relative area below the hypsometric curve and thus expresses the volume of a basin that has not been eroded (Dehbozorgi et al. ,2010) . The hypsometric integral can be approximated by means of the following equation (Mayer, 1990; Keller and Pinter, 2002):

$$Hi = (\text{average elevation} - \text{min. elevation}) / (\text{max. elevation} - \text{min. elevation})$$

(1)

Fig.4. the basins of studied area

The elevation value of DEM has been used to find out the hypsometric integral for each basin in the Tozlogol basin. The hypsometric tool box (calhypso) downloaded from the ESRI website has been used to determine the hypsometric curve values (fig.5).

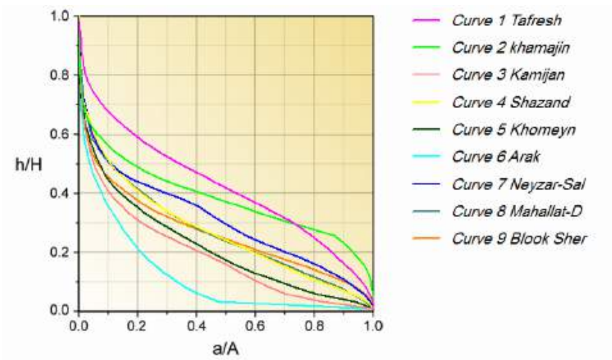

Fig.5. Hypsometric curves of nine basins, (A) is the total surface area within the basin above a given line of elevation (h), and (H) is the highest elevation of basin.

We used equation HI (eq.1) to compute Hi for each basin. It ranges from 0.19 at KAMIJAN basin to 0.41 at TAFRESH basin. Then we produced the Hi classification map according to El Hamdouni classification: class 1 ($hi \geq 0.5$), class2 ($hi < 0.4$) and class 3 ($0.4 \leq hi < 0.5$) (fig. 6and table1)

Current Trends in Technology and Science
ISSN: 2279-0535. Volume: 3, Issue: 3 (April - May 2014)

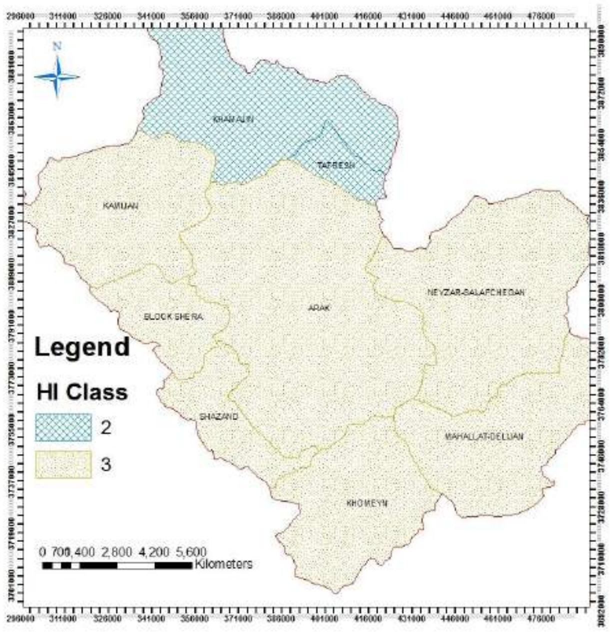

Fig.6. It shows the classification of hypsometric integral value

Table 1: hypsometric integral

Basin No.	Basin Name	At(Hectare)	Hi	Class of Hi
1	ARAK	556818	0.22	3
2	BLOCK SHERA	99819	0.26	3
3	KAMIJAN	254485	0.19	3
4	KHAMAJIN	293302	0.38	2
5	KHOMEYN	211695	0.26	3
6	MAHALLAT-DELIJAN	237693	0.26	3
7	NEYZAR-SALAFCHEGAN	372411	0.30	3
8	SHAZAND	96911	0.22	3
9	TAFRESH	42361	0.41	2

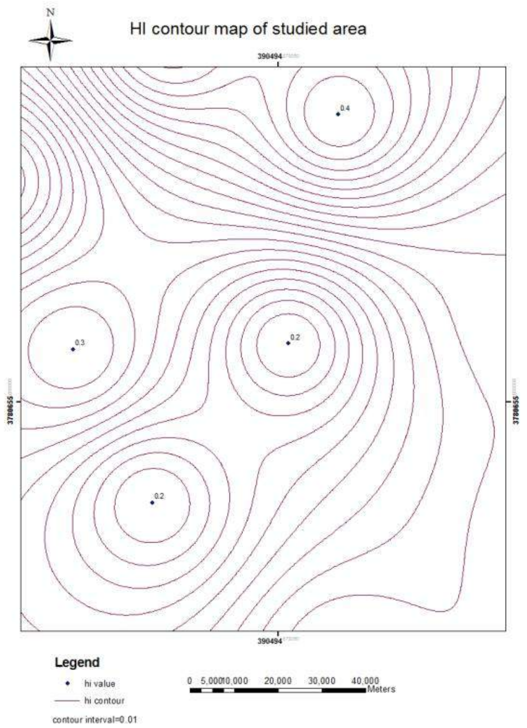

Fig.7. it shows the hypsometric integral value countered map of studied area.

The hypsometric curve of nine basins show studied area is in the mature and old state of Davis circles.

Two drainage basins are in maturely while seven basins show the old state .No drainage basin comes in youthful state in the study area. The value of Hi was found to be high along major faults and folds. . The results of the hypsometric integral shows that the highest value of Hi is correspond to north part of studied area.

Transverse valley profiles were defined using a valley floor- valley height ratio variable. Comparison of the width of the floor of a valley with its height provides an index that indicates whether the stream is actively down cutting or is primarily eroding laterally into the adjacent hill slopes (Ramirez-Herrera, 1998) .this index can be expressed by

$$vf = 2vf_w/(A_{ld} + A_{rd} - 2A_{sc})$$

(2)

Where vf_w is the width of the valley floor, A_{ld}, A_{rd} and A_{sc} are the altitudes of the left and right divides (looking downstream) and the stream channel , respectively (bull,2007). This index should be measured at the same distance from Front Mountain (Silva et al., 2003). So that we computed it at 1 km from front mountain .we used 3 D Analyst extension (interpolate line, create profile graph) to draw cross section from the DEM(fig.8).This index calculated for 272 valleys (fig.9).then the average of it obtained for each basin. Finally, VF was classified into three classes: class 1

Current Trends in Technology and Science
ISSN: 2279-0535. Volume: 3, Issue: 3 (April - May 2014)

($VF \leq 0.5$), class2 ($0.5 \leq VF < 1$) and class 3($VF \geq 1$) (El Hamdouni et al., 2007). The result of this index is shown in table (2) and figure (10).

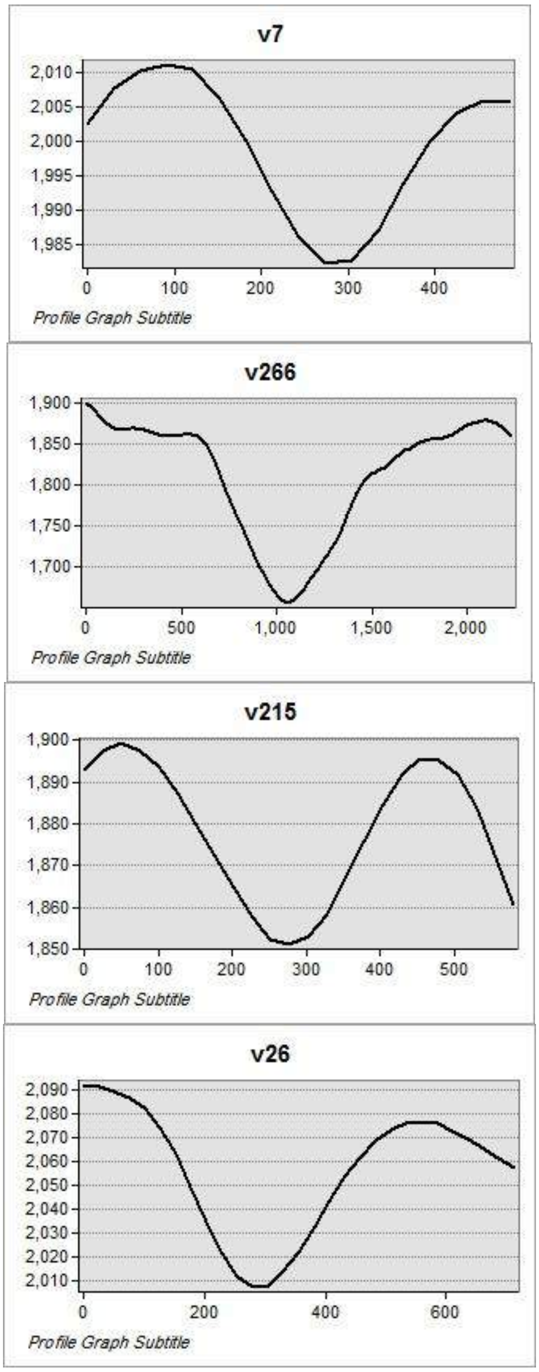

Fig.8. it shows some valleys profile in study area.

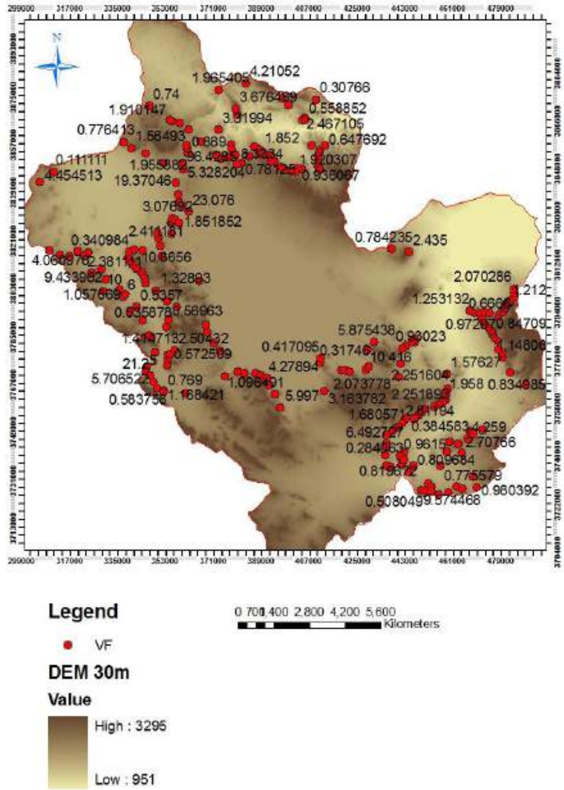

Fig.9. it shows the distribution of VF index and its measurement positions in study area.

The values of Vf index in Arak, Kamijan and Shazand basins is considerably more than other basins. The high values of Vf index in Arak , Kamijan and Shazand basins is somewhat due to lithology because a lot of rocks in this region are marl, shale and other weak sedimentary rocks.

The values of Vf index in Tafresh basin is between 0.41 - 1.92 that imply v-shaped valleys and show an active tectonic region. The low values of Vf index in Tafresh basin is somewhat due to lithology because often rocks in this region are strength rocks such as dacitic to andesitic volcano sediment, andesite and tuff.

Current Trends in Technology and Science
ISSN: 2279-0535. Volume: 3, Issue: 3 (April - May 2014)

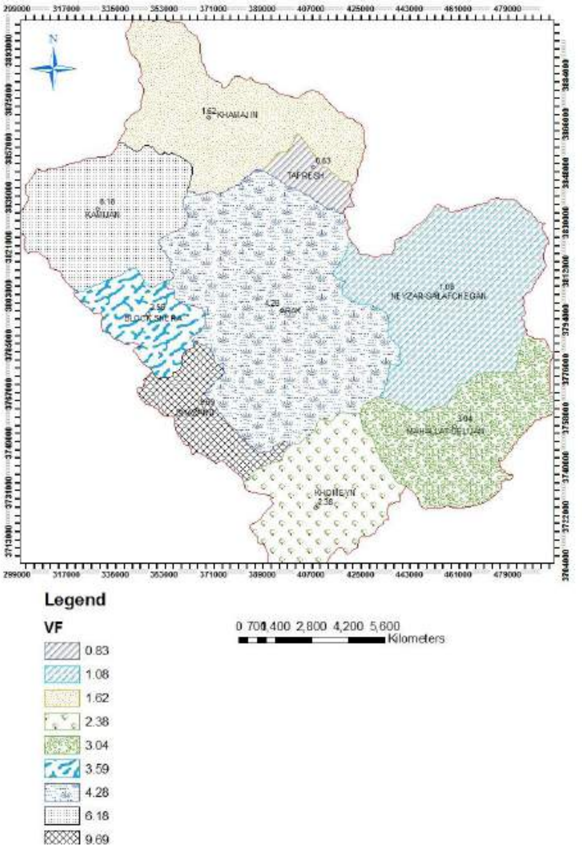

Fig.10. it shows the distribution of VF index in basins.

Table 2: valley floor- valley height ratio values- Arak basin

Valley name	Eld	Erd	Vfw	Esc	Vf
v237	1974	1970	347.826	1914	6.00
v239	2200	2170	312.5	1900	1.10
v233	2112	2275	928.57	1900	3.16
v240	2012	2112	200	1918.75	1.40
v242	1993	2129	566.66	1928.57	4.28
v241	2150	2287	100	1937.5	0.36
v247	2028	1976	1500	1880	12.30
v243	2255	1987	653.846	1912.5	3.14
v245	2287	2087	142.857	1912.5	0.52
v244	2287	2150	208.33	1937.5	0.74
v246	2037	2125	50	1937.5	0.35
v225	2115	2020	233.3	1955	2.07
v226	2036	2136	156.25	1914.285	0.91
v227	2160	2093	86.956	1986.67	0.62
v223	1896	1898	104.16	1887	10.42
v222	1892	1888	86.956	1883	12.42
v230	2250	2240	47.619	2095	0.32
v229	2185	2162	28.571	2105	0.42
v248	2170	2130	133.33	1890	0.51
v220	1970	2150	159.09	1908.34	1.05
v249	2301	2100	130.43	1937.5	0.50
v219	2190	1980	1086.956	1900	5.88
v50	2310	2140	833.33	1920	2.73
v251	2237	2162	138.09	1912.5	0.48
v253	2075	2075	3043.478	1900	17.39
v254	1992	2100	631.578	1866.67	3.52
v54	1883	1883	115.38	1878	23.08

Another index sensitive to tectonic uplift is the mountain-front sinuosity index that this index has been used to evaluate the tectonic activity along mountain fronts (Bull and McFadden, 1977; Keller and Pinter, 2002; Silva et. al., 2003).it was defined by Bull and McFadden (1977) and Bull (2007) as:

$$S_{mf} = L_{mf} / L_s \qquad (3)$$

Where L_{mf} is the length of the mountain front along the foot of the mountain, i.e. the topographic break in the slope, and L_S is the length of the mountain front measured along a straight line.

In order to measure the mountain front sinuosity, first the main mountain fronts are isolated on the DEM and then for each front, SMF index is calculated by the use of equation (3) (fig. 11, 12). The mean values of SMF index in Arak, Block Shera, Kamijan, Khamajin, Khomayn ,Mahallat-Delijan, Neyzar-Salafchegan , Shazand and Tafresh basins are 1.5,1.4, 1.8,1.7,2.6,1.4,1.4,2.2 and4.9 respectively(table 3). Therefore, all mountain fronts in the Block Shera, Mahallat-Delijan and Neyzar-Salafchegan basins fall in the ‘intermediate active’ category.

The obtained data show that Block Shera, Neyzar-Salafchegan and Mahallat – Delijan are the most active basins. In fact, primary Front Mountain has regressed and has become pediment.

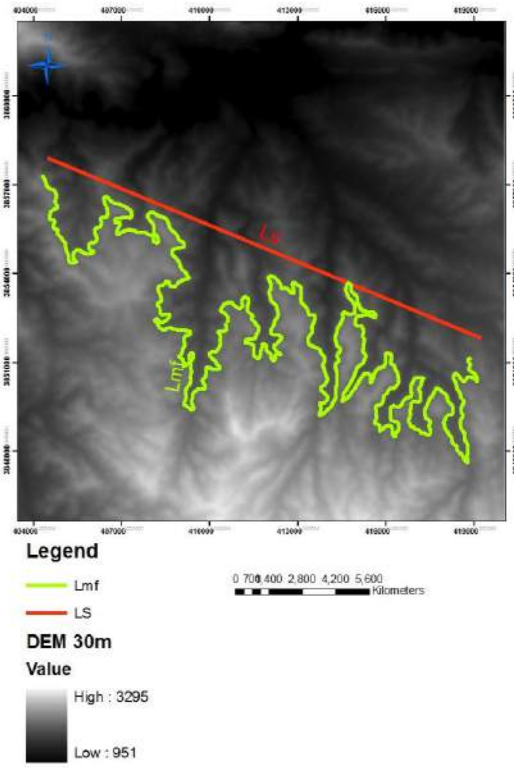

Fig.11. the measurement method of SMF index

Current Trends in Technology and Science
ISSN: 2279-0535. Volume: 3, Issue: 3 (April - May 2014)

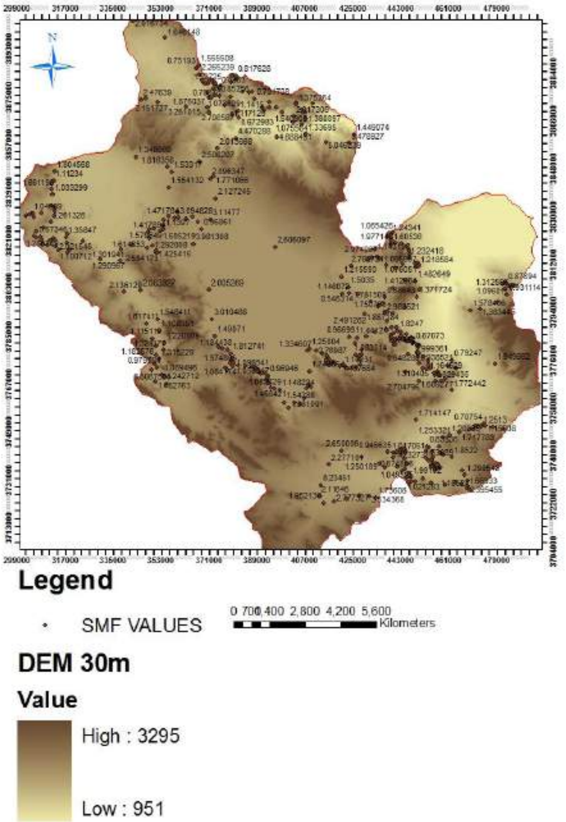

Fig.12. it shows the distribution of SMF index on DEM.

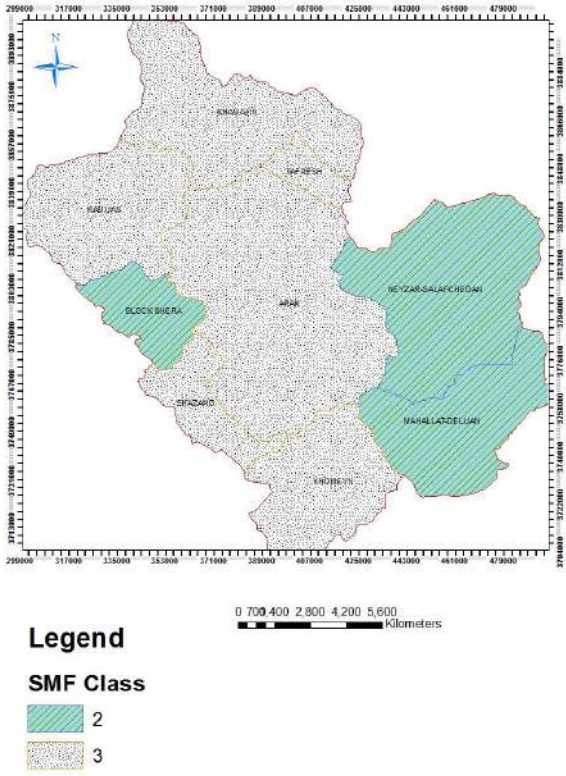

Fig.13. it shows the classification of SMF index in basins.

Table 3: SMF values in studied area

Basin No.	Basin Name	Smf	Class of Smf
1	ARAK	1.5	3
2	BLOCK SHERA	1.4	2
3	KAMIJAN	1.8	3
4	KHAMAJIN	1.7	3
5	KHOMEYN	2.6	3
6	MAHALLAT-DELIJAN	1.4	2
7	NEYZAR-SALAFCHEGAN	1.4	2
8	SHAZAND	2.2	3
9	TAFRESH	4.9	3

Then we classified the basins to three groups based on SMF value: class1 ($SMF < 1.1$), class2 ($1.1 \leq SMF < 1.5$) and class3 ($SMF \geq 1.5$) (fig.13).

Finally, we obtained relative active tectonics index (Iat) value by averaging three calculated indexes and classified the area to four groups based on El Hamdouni et al. (2007) and evaluate the distributions of relative tectonic activity in the study area.(table4 , fig.14)the values of the index of active tectonics were divided into four classes to define the degree of active tectonics:1-very high($1 \leq Iat < 1.5$);2-high($1.5 \leq Iat < 2$);3-moderate($2 \leq Iat < 2.5$);and4-low($2.5 \leq Iat$)(El Hamdouni et.al, 2007)

Current Trends in Technology and Science
ISSN: 2279-0535. Volume: 3, Issue: 3 (April - May 2014)

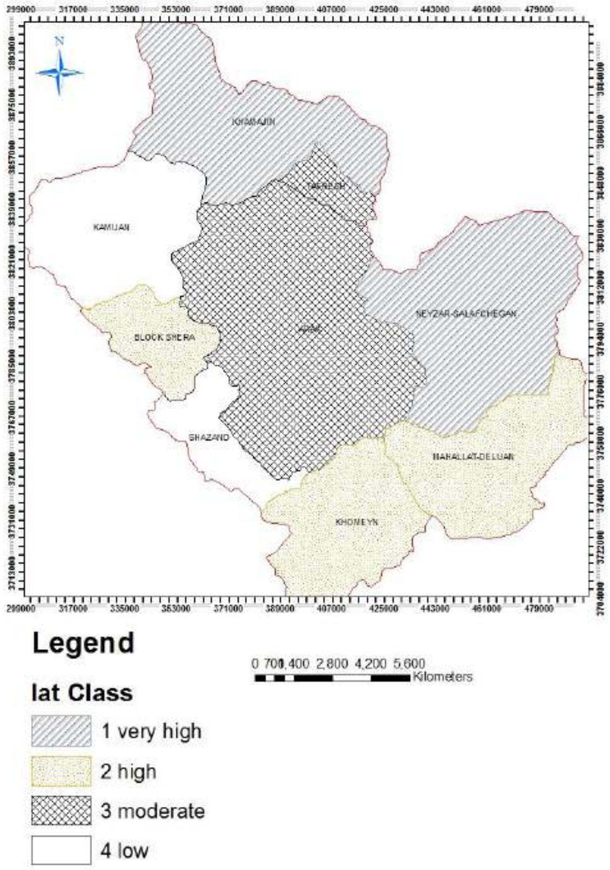

Fig.14. it shows the classification of active tectonic index in basins.

Table 4: Index of tectonic activity values in studied area

Basin No.	Basin Name	At(Hectare)	Class of HI	Class of VF	Class of SMF	Value of Iat	Class of Iat
1	ARAK	556818	3	3	3	2.01	3
2	BLOCK SHERA	99819	3	3	2	1.74	2
3	KAMIJAN	254485	3	3	3	2.72	4
4	KHAMAJIN	293302	2	3	3	1.22	1
5	KHOMEYN	211695	3	3	3	1.76	2
6	MAHALLA T-DELIJAN	237693	3	3	2	1.55	2
7	NEYZAR-SALAFCHE GAN	372411	3	3	2	0.92	1
8	SHAZAND	96911	3	3	3	4.03	4
9	TAFRESH	42361	2	2	3	2.04	3

The distribution of the four classes is shown in figure (14) and table (4) shows the results of the classification for each basins. About 22% of the studied area (about 665713 hectare) belongs to class 1; 33% (549206 hectare) to class2; 22% (599178 hectare) to class3; and 22% (351397 hectare) to class4.

9. Conclusion

Geomorphic indices computed using GIS was applied to this area to identify geomorphic anomalies and evaluate tectonic activity, because of the central Sanandaj-Sirjan lacks proper works on active tectonics. We used four geomorphic indices: hypsometric integral (Hi), valley floor width-valley height ratio (VF), mountain front sinuosity (Smf) and the combination of the above indices (Iat).

Morphometric indices studying indicate the low level of total activity in this area. The studied area is in class 2 in the view of active tectonic deviation according to SMF, VF values and evidence such as u-shaped valleys, high depression in mountain-plain boundary. In this area, the Erosional processes have been overcome to tectonic processes and the initial development of alluvial plain is seen.

About two-thirds of the studied area has Iat values of class 1, 2 and 3 indicating moderately to very highly active tectonics. These classes correspond well to the areas with prominent scarps of tectonic origin, triangular facets, deformed alluvial fans and deep narrow gorges.

Reference

[1] Bishop, P., "Long-term landscape evolution: linking tectonics and surface processes", Earth Surface Processes and Landforms, 32, 329-365, 2007, ISSN 0197-9337 (doi:10.1002/esp.1493) .

[2] Bull, W.B., McFadden, L.D., "Tectonic geomorphology north and south of the Garlock fault, California", proceeding of the 8th Annual geomorphology symposium, New York, 1977.

[3] Bull, W.B., "Tectonic geomorphology of mountains: a new approach to paleoseismology", Blackwell, Malden, 2007.

[4] Burbank, D.W., Anderson, R.S., "Tectonics geomorphology", Blackwell, Oxford, 2001.

[5] Cloetingh, S., Cornu, T., "Surveys on environmental tectonics", Quaternary science reviews, 24, 235-240, 2005.

[6] Dehbozorgi, M., Pourkermani, M., Arian, M., Matkan, A.A., Motamedi, H., Hosseiniasl, A., "Quantitative analysis of relative tectonics activity in the Sarvestan area, central zagros, Iran", geomorphology, 1-13, 2010.

[7] England, PH., Monlar, P., "surface uplift, uplift of rocks, and exhumation of rocks", Geology, v.18, 1173-1177, 1990.

[8] Hamdouni, R. El., Irigaray, C., Fernandez, T., Chacon, J., Keller, E.A., "Assessment of relative active tectonics, southwest border of the Sierra Nevada (southern Spain)", Journal of geomorphology, 96, 150-173, 2008.

[9] Keller, E. A., " Investigation of active tectonics: use of surficial Earth processes", in Wallace, R. E. (Ed.), Active Tectonics, Studies in Geophysics, National Academy Press, Washington, DC, 136–147, 1986.

[10] Keller, E. A., Pinter, N., "Active Tectonics: Earthquakes, Uplift, and Landscape", second ed. Prentice Hall, New Jersey, 2002.

[11] Mayer, L., "Introduction to Quantitative Geomorphology", Prentice Hall, Englewood, Cliffs, NJ, 1990.
[12] Perez Pena, J. V., "Gis-based tools and methods for landscape analysis and active tectonics evaluation", tesis doctoral, Universidad de Granada, departamento de geodinamica, 2009.
[13] Ramirez-Herrera, M.T., "Geomorphic assessment of active tectonics in the Acambay graben, Mexican volcanic belt", earth surface processes and landforms, 23,317-332, 1998.
[14] Silva, P.G., Goy, J.L., Zazo, C., Bardajm, T., "Fault generated mountain fronts in southeast Spain: geomorphologic assessment of tectonic and earthquake activity", geomorphology, 250, 203-226, 2003.
[15] Strahler, A., "Hypsometric (area-altitude) analysis of Erosional topography", geology society of America, 63,117-1142, 1952.
[16] Sung, Q.CH., Chen, Y-CH., "self-affinity dimension of topography and its implications in morphotectonics: An example from Taiwan", Geomorphology, 110-118, 2004.

AUTHOR'S PROFILE

Mohammad Reza Saberi is graduated in B.S and M.Sc in tectonics from Golpayegan University, Isfahan, Iran and Islamic Azad University, North Tehran branch, Tehran, Iran respectively. He is PhD Student at IAU (Islamic Azad University North Tehran branch, Iran). His interested research fields are: Study structural geology (structural field Studies and statistical data analysis, and analogue modeling); Study geophysics data by (using field work and statistical data analysis); Study application of tectonics in the Development and Exploration of Water Resources.

Mohsen Pourkermani was born in 1946, in Tehran, Iran. He is graduated in B.S, M.Sc and PhD in structural geology from the University of Tarbiat Moallem Tehran, University of Montpellier and university of Paris, respectively. He was full professor at Shahid Beheshti University and now is at Islamic Azad University, north Tehran branch, Iran. His interested research fields are the study structural geology, seismotectonics and morphotectonics.

Alireza Nadimi was born in 1967. He is structural geologist; Assistant Professor at Department of Geology, University of Isfahan, Iran. He earned his Ph.D. degree at University of Warsaw, Poland in 2010. His research includes strike-slip faulting and its associated structures, active faults, active tectonics of Iran, especially is Sanandaj-Sirjan Zone, Urumieh-Dokhtar Magmatic Arc and Central Iran structural zones of Iran.

Manoucher Ghorashi was born in 1941, in Iran. He is graduated in B.S, M.Sc and PhD in structural geology from Tehran University and London University, respectively. He was Associate Professor at Research institute for earth sciences, geological survey of Iran. His interested research fields are neotectonics and seismotectonics.

Abdoolmajid Asadi is graduated in PhD degree in tectonics from the earth science department of the Tehran science and research university, Iran in 2005. He is currently associate professor of structural geology and tectonics at the earth sciences department of the Islamic Azad university Shiraz branch, Iran. his research interests include: (I) the study structural geology (using geometric-kinematic modeling and analogue modeling) ;(II)study geophysics data by (using field work and statistical data analysis and interpretation of reflection seismic profiles) ;(III)seismic earthquake rejection (using fractal methods).