Natural Resource Management, GIS & Remote Sensing
Volume 3, Number 1, 1-13
April 2021
DOI: 10.22121/NGIS.2022.344798.1022

Investigation of active tectonic indices in Noorabad Fars catchment

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(Received: October 03, 2020/ Accepted: January 09, 2021)

Abstract

Parts of the earth's crust now have tectonic movements and will be prone to danger in the future. Therefore, geomorphological forms are very sensitive to tectonic activities and change as a result of these movements. Evaluation of tectonic activities using some quantitative indicators, plays an important role in recognizing these activities and helps to interpret the tectonic status of the areas. Passage of Kazerun fault from the middle part of Nurabad basin has an effective role in tectonic activity in this region. Undoubtedly, new construction activities in the region, along with other influential factors (uncontrolled abstraction of groundwater reserves, drought, etc.) can be one of the main causes of water loss in the region. For this purpose and with the aim of evaluating the tectonic activities of the region, some of the geomorphic indices such as basin shape index (BS), drainage basin asymmetry index (AF), inverse topographic symmetry index (T), mountain front sinusoidal index (J), hepatic integral (Hi), valley floor-to-height index (VF), river sinusoidality index (S), longitudinal river gradient index (SL), relative evaluation of tectonic activities (Iat) and hierarchical anomaly index (Δa) have been used. The results of geomorphological indices show that the whole basin is dynamic in terms of tectonic activities. The study of the tectonic status is in accordance with the active Kazerun fault.

Keywords: Tectonics, Noorabad plain, Geomophological indicators.

1.Introduction

In earth sciences, the word tectonics refers to deformed buildings and the architecture of the outermost part of the earth, the crust.Land and evaluation of these features and structures over time has geology (Soleimani 1387). Landforms in areas with active tectonics are the result of a complex combination of the effects of vertical and horizontal movements of crustal blocks and erosion or sedimentation by surface processes (Evans2006). In similar studies on several faults, Zovili et al. (2004) used indices such as flow length gradient (SL), mountain front sinusoidality (smf), and valley-to-height

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ratio (vf) to successfully study active tectonics. They knew. Tandon & Sing (2008) studied the neo-reconstruction activities of active mountain fronts in the northwestern Himalayas by analyzing faults and features and concluded that faults associated with mountain fronts and related structures are active. Also Hamdouni et al. (Hamdouni, 2008) used geomorphic indices and relative tectonic activity index (Lat) to classify the active tectonics of southern Spain and identified active tectonic zones. To study the geological status and operation of faults, first the tectonic status of the region in terms of activity must be determined.

The identification of active areas is of special tectonic importance. Almost no region in the world can be found that has not been affected by these movements over the last few thousand years. Kazemi et al. (2006) have investigated the role of structural factors in the abundance of water resources in the karst region of Lar using remote sensing and GIS. The results of his research show that there is a close relationship between the frequency of springs and the distance from tectonic elements. Maghsoudi et al. (2008) evaluated the role of active tectonics in regulating the Tajan River canal using geomorphic indices and concluded that there is active tectonic activity in the estuaries and considered the river gradient index as the best way to study river behavior. Technological activities along active fault lines have an important effect on the topographic features of natural environments. Salehi Esfandarani et al. (2010) investigated the subsidence of the southern Mahyar plain and the effect of resulting gaps on agricultural land Geological and hydrogeological studies have shown the increasing growth of this phenomenon in the southern Mahyar plain. The drop of about 40 cm of groundwater level per year, has provided a favorable environment for the occurrence of this unfortunate phenomenon in the southern Mahyar plain. In the following, the shape and status of the scattering of cracks in the plain and the effects of the cracks on residential, industrial and agricultural areas have been studied (Shayan et al., 2011). Maghsoudi and Emad al-Din (2011) analyzed the impact of active tectonic factor on the geomorphology of the Shalamzar basin and its downstream alluvial fans. In this study, they found that the tectonic factor has a significant effect on the study catchment and the basin is tectonically active. Pourkhosravani et al. (2012) studied duality in geomorphology. The results of this study showed that Ranjbarmanesh et al. (2013) studied the crisis caused by the decrease of groundwater level due to tectonic activity in Mahidasht plain and concluded that The rate of decline is consistent with tectonic activity, so adjacent tectonics can be one of the main causes of groundwater levels in the region. Aliabadi et al. (2014) investigated the role of active tectonics and tectonic lines in the formation of groundwater aquifers in Sabzevar plain using GIS and RS and concluded that there is a close relationship between fault lines and groundwater resources and tectonic lines. Despite the creation of some environmental bottlenecks, they can be considered as a potential in feeding the groundwater aquifers of the region. In this research, based on the available data and in a regional scale, the tectonic status of the region and the relationship between large-scale faults and fractures on the abundance status and quality of groundwater resources in Nurabad plain have been investigated.

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1.1. Geographical location of the study area

The study area is located in the southern geographical area of the southwestern slopes of the Zagros Mountains and in its folded part. Nurabad area is connected with Masiri city from the north, Ghaemieh plain from the south, Mahour Milati plain from the west and Fahlian plain from the east. Nurabad plain is located in the geographical range of, 51º15′ to 51º 46′, east longitude and 29º 55′, to, 30º 17′ north latitude (Bagherinejad, 1390). The only city in this area is the city of Nurabad, which is located at an altitude of 935 meters above sea level and is located 150 kilometers northwest of Shiraz, the capital of Fars province. The maximum height is 2684 meters in Kuh khani in the southeast of the area and the minimum height is 698 meters in the estuary of Fahlian river near Baton village in the northwest of the plain.

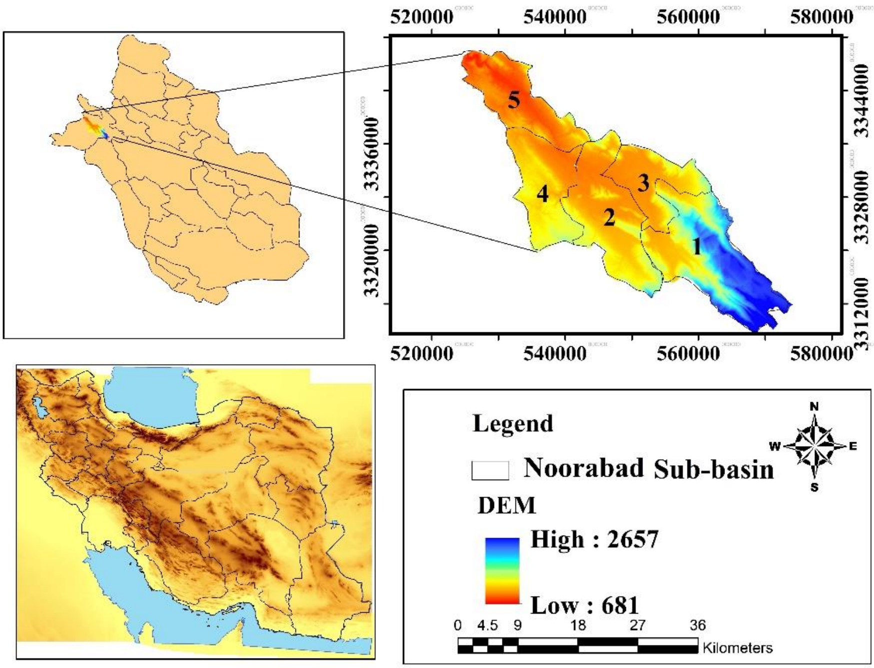

Figure 1- Location of Nurabad plain

2. Data and method

In order to study the activity status of the newest construction of the area, 1: 50000 topographic maps and 1: 10000 geological maps, Google Earth images and satellite images have been used. Topographic maps 1: 50,000 which includes 6 map sheets (Nurabad, Fahlian, Shirbim, Ghaemieh, and Baba Maidan) and 1: 100000 geological map which includes 4 map sheets (Fahlian, Sepidan, Kazerun and Kuh Dara). . In order to use these maps as a complete map, their mosaic operation was performed in the GES environment, Also, using topographic maps 1: 50000 and geological maps 1: 100000, raster data were converted into vectors and a map of the study area was drawn. To measure the desired parameters in the calculation of indices and drawing profiles, topographic maps and elevation model (Dem) 30 meters were used, then morphometric indices such as Bs, SL, AF, J, T, VF, S, HC, HI, Lat and tectonic parameters including Ha: number of hierarchical anomalies: aΔ hierarchical anomalies index was evaluated in the tectonic condition of the basin.

2.1. Description and interpretation of results

Analysis of tectonic activities through geomorphological indicators

The various artifacts left on Earth indicate tectonic activity in different parts of the world. Faults, mountains, construction valleys, etc. are evidence of the dominance of tectonic morphology in past geological periods. Of course, it must be said that tectonic formation is very slow and it takes millions of years to create a tectonic phenomenon, but no doubt this phenomenon is still active today, causing the development of uplifts and subsidence on the surface of the earth in this Research to study nontectonic activity using tectonic indices

2.2. Geomorphological indicators

With the help of geomorphological indicators, it is possible to describe quantitatively and compare the shapes of roughness, and in the simplest form, the shapes of the earth's surface can be measured by calculating size, height and slope. Also, the use of quantitative methods along with qualitative explanations makes it possible to better understand how the complications (Emami, 1393: 40).

Basin shape index: (Bs)

The Bs index is used to assess tectonic activity in mountainous areas

Equation (1): $Bs = Bl / Bw$

Bs index: Basin form index; Bl: length of the farthest point to the exit of the basin; And Bw: is the length of the widest part of the basin. Based on the classification of high values of basin shape index ($Bs < 4$), longitudinal basin with active tectonics, ($4 < Bs < 3$) basins with medium tectonic activities and low values ($Bs < 3$) of circular basins with Shows low tectonic activity (Dehbozorgi 2010: 335). According to the lithological map of the basin, most of the faults are mainly formed with the north-south trend in resistant and very resistant formations of the mountainous part. Nurabad with the mountain front are also the product of this action. In addition to their independent role in the formation of the primary structures of the earth, faults are also involved in the transformation of the shape of many erosive features. According to Table (1), the shape index of Nurabad sub-basins is active and is due to the passage of Kazerun diameter fault, which has passed

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through this part with a north-south trend and has caused the activity of this index in the basin.

Table 1. the shape index of Nurabad sub-basins

Sub-basins	status	BS	BW	BL
1	Inactive	1.23	12	26
2	Relatively active	3	6	18
3	active	4.6	5	23
4	active	4	4	16
5	Relatively active	3.4	9	31

2.3. River gradient index: (SL)

This index was first presented by (Hock, 1973) in the study of the role of rock resistance on water flow in the Appalachian Mountains in the southeastern United States as numerical values of the river gradient index. The value of this index is high when the river bed rocks are resistant or in areas where active tectonic movements are effective in changing the vertical shape of the earth's crust. Accordingly, high values of SL in rocks with low strength or in rocks with the same strength, can indicate active and young tectonic movements (Hamdouni, 2008).

Relation (2): $Sl = (\Delta H / \Delta L)$

Sl River gradient index, ΔH: difference in height of the desired section, ΔL: desired branch length, Lsc: waterway length from the point where the index is calculated to the highest point of the waterway upstream. This index is a useful method to understand how the action and displacement caused by tectonic forces. (Chieh Chen, 2003: 114) Table (2) shows the river gradient index for each of the 5 sub-basins studied.

Table 2. River gradient index (SL)

Sub-basins	Status	Sl	Lsc	ΔL	ΔH
1	active	62	18090	10604	100
2	active	153	10277	6703	100
3	active	763	12465	1632	100
4	active	260	18807	7319	100
5	active	340	50648	24543	100

2.4. Asymmetry Index: (AF)

Asymmetry index is a method for assessing the presence of distortions caused by tectonic activities at the scale of the drainage basin. This method is used for relatively large areas.

Af = 100 * Ar / At = 336/417 * 100 = 80 relation (3):

AF: River asymmetry index, Ar: Basin area includes sub-drains on the right bank of the basin on the right side of the main waterway (downstream) and At is the total area of the drainage sub-basin (Hamdouni, 2008: 135).

If the numerical value of this index is about 50; Indicates the existence of symmetry on both sides of the main waterway and as a result of tectonic inactivity. If the value of this index is greater than 50, it indicates erosion on the right side of the main waterway, and if the value of the index is less than 50, it indicates erosion on the left side of the main waterway. In this calculation, the numbers obtained from the sub-basins showed that the index value is greater than 50. Therefore, on the right side of the main waterway, we have tectonic activity and on the left side, we face the phenomenon of subsidence. Table (3) shows the asymmetry index for the 5 sub-basins.

Table 3. Basin asymmetry index

Sub-basins	**Status**	**Af**	**At**	**Ar**
1	active	75	145	110
2	active	58	31	18
3	active	100	62	62
4	active	177	94	167
5	active	165	23	38

Inverse topographic symmetry index: (T)

The presence of topographic asymmetry in the drainage network of basins with almost identical lithological features indicates the activity of active tectonics (Kellr & Pinter, 2002: 128).

Equation (4): T = Da / Dd

Where Da is the distance of the middle line of the drainage basin to the active belt of the meander of the basin (main river) and Dd is the distance of the middle line of the basin to its diffuse water. The numerical value of this index for perfectly symmetric basins is

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zero, while with increasing topographic asymmetry in a basin, the value of this index also increases and approaches one. (Randel, 1994: 150) Thus, the T-index is a vector whose numerical values are close to one indicating erosion in the region and consequently active tectonism. To calculate this index in Noorabad basin, a section was created in each sub-basin and its value was calculated. According to Table (4), the value of the index in each of the five sub-basins is less than 1 and is a sign of asymmetry and active tectonics in the whole basin. .

Table 4. Inverse topographic symmetry index

Sub-	**Status**	**T**	**Dd(km)**	**Da(km)**
1	active	0.9	4.93	4.48
2	active	0.85	7.67	6.58
3	active	0.78	4.85	3.81
4	active	0.84	7.97	6.73
5	active	0.80	6.61	8.29

Hypsometric curve and hypsometric integral

The hypsometric curve describes the distribution of heights perpendicular to an area of land, such as a drainage basin. This curve is plotted by applying the ratio of the total height of the basin (relative height) to the ratio of the total area of the basin (relative area). Hypsometric curves of a drainage basin are used as a tool to achieve the stages of geomorphic development resulting from simultaneous tectonization and stripping processes (Shobter & Wilson, 2007: 98).

In hypsometric integral, the results obtained from the morphology of a drainage basin are summarized and divided into three classes based on the shape and amount of convexity and concavity of the hypsometric curve. Larger numerical values (Hi </ 0.5) indicate young topography, medium numerical values (<4.4) indicate mature topography, and lower numerical values (Hi> 4.4) indicate older topography. The integral can be easily obtained from the following equation (Pike & Wilson, 1993: 1080)).

Equation (5): = H = (Hmean-Hmin) / (Hmax-Hmin)

H (1986-993) / (2484-698) = / 5

In this regard: Hmean average height of the basin; Hmax: maximum basin height; : Hmin is the lowest elevation of the basin. Based on the drawn hypsometric curves, a high percentage of the basin area has an old and mature topography.

Mountain Front Sinusity Index: (Smf)

Mountain Front Sinusity Index The balance between erosive processes that tend to cut and irregularize the mountain front through surface currents, as well as active and vertical new tectonics that are often consistent with faults and folds and tend to create a mountainous front. (Bull, 1977: 330) Mountain fronts that are associated with active erosion show an almost direct shape on topographic maps and aerial photographs, and if tectonic movements are low, erosive processes create fronts. Irregular and sinusoidal mountains are formed. The number of this index in mountainous fronts with high tectonic activity is very close to 1 and less than 1.4 indicates an active mountainous front (Rakul, 1986). Smf was calculated for 5 mountain front sub-basins and was divided into 3 classes with a value of less than 1.4 in each of the 5 sub-basins and indicating high tectonic activity in them.This index is defined as follows:

Equation (6): Smf = Lmf / Ls

: S Mountain front sinews or steep mountain slope maze, Lmf: The length of a steep mountain slope at the border between a mountain and a foothill, Ls: The length of the tangent line along a steep mountain slope. The mountain front sinusoidal index shows the balance between the erosive force that tries to cause erosion of mountain surfaces and the tectonic force that causes smooth fronts along the fault (Arfania, 2010). Table (5) shows the mountain front sinusoidal index in terms of tectonic activity for 5 sub-basins.

Table 5. Mountain Front Sinusity Index (Smf)

Sub-basins	**Status**	**S**	**LS**	**LMF**
1	active	1.25	4.8	6
2	active	1.39	4.6	6.43
3	active	1.27	2.49	3.17
4	active	1.30	1.60	1.46
5	active	1.3	2.5	3.47

2.5. River sinusitis index :(S)

Sinus changes in a fluvial system are usually due to uplifts and subsidence that occur in the bed. This index is defined as follows Equation (7):

S = C / V

: C length of river path; S: sinusitis or river maze; And: V is the direct length of the valley in the above equation. High values of this index indicate that rivers with many mazes have reached equilibrium, while lower values of this index indicate rivers with straight paths that perform bed digging to achieve equilibrium. According to calculations, the maze index of the river is less than 1. Table (6) shows the main waterways related to each sub-basin 1 to 5, which shows the new construction activities in the area.

Table 6. River sine index

Sub-basins	Status	S	V	C
1	active	0.89	20.725	23.234
2	active	0.53	5.33	10.77
3	active	0.95	9.33	8.95
4	active	0.77	14.99	11.62
5	active	0.87	29.06	33.91

Valley width to height index (VF)

Among morphotectonic indices, VF index is the best index to evaluate the effects of tectonic activity in the form of valleys. This index was first used in 1977 by Bull & Macfadden. One of the important indicators in evaluating new construction activities is the valley floor width index or valley height ratio (VF).

This index is expressed by the following equation:

Equation (8):

$E_{id}=2Vfw / (E_{id}-E_{sc} + E_{rd}-E_{sc})$

Using this indicator, it is possible to understand the condition of the river. The river may be digging its bed, or engaging in lateral erosion, or attempting to expand its bed. Values less than 6 in this index indicate rising areas. In inactive areas, the average value of this index is usually higher than 7 (Arfania, 2010). In general, if the width of the valley floor is low and the height of the ridges is high, it indicates active tectonics. Table (7) shows the width of the valley floor to its height in 5 sub-basins studied.

Table 7. Index of valley floor width to its height (VF)

Sub-basins	Status	Vf	Vfw	Eld	Erd	Esc
1	active	0.14	89	1209	1664	1070
2	active	0.17	65	1305	1260	1100
3	active	0.22	37	1125	1200	1000
4	active	0.2	70	1280	1220	1000
5	active	0.05	72	2488	1436	1300

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2.6. Geomorphological evidence from active tectonics

By studying the landforms and drainage network systems and considering the tectonics and lithology, the performance of the newest active construction in each area can be evaluated. Landforms such as triangular surfaces, known as tandem triangles and older and younger, are closer to the mountain front. This index is one of the indicators determining the relative tectonic activity of the mountain ridge at the confluence of the foothills with the clay plain. Triangular mountain faults form between two watercourses that are triangular in shape and in some cases polygonal. Mountainous fronts with weaker tectonics, due to the greater erosion of waterways, have less triangular surfaces and smaller bases. V-shaped valleys are caused by tectonic activity or water erosion. The crust rises, resulting in plateaus and mountains, indicating the interference of tectonic movements and static changes, increasing the difference between the source and the base surface and increasing the average bed slope, thus increasing the initial strength of the water and beginning a new period. The movements of the tectonics and the formation of a new garrison in d Floods and vertical walls dominating the riverbed indicate the activity of new tectonic movements and the impact of the drainage system of the region from these movements. Figure (2) shows the geomorphological evidence of active tectonics in the study basin.

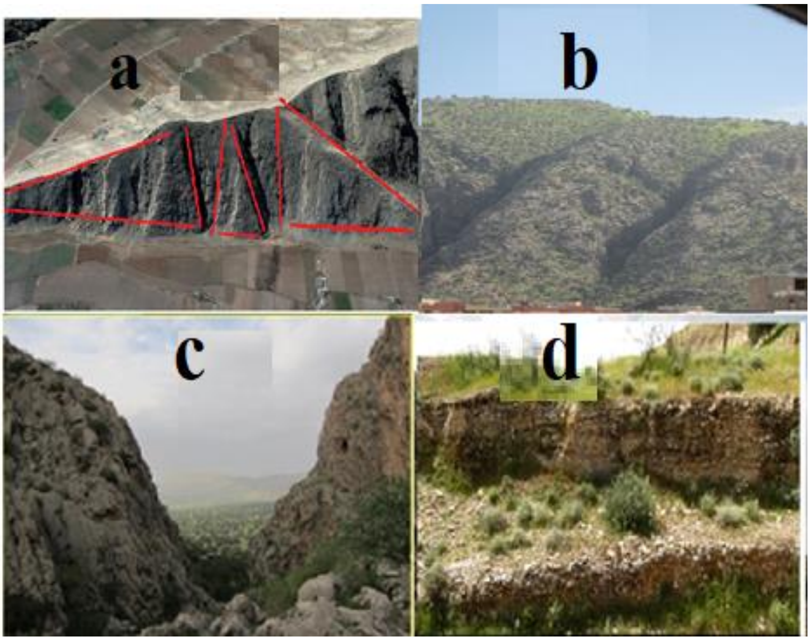

Figure 2- Geomorphological evidence from active tectonics

3. Conclusion

Geomorphic indices including basin shape, drainage basin asymmetry index, inverse topographic symmetry index, mountain front sinusoidal index, hypsometric integral,

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valley floor width to height index, river sinusoidal index, river longitudinal gradient index, active longitudinal gradient index Tectonics, number of hierarchical anomalies, hierarchical anomalies index, provide a relative classification of neoclassical activities in the region. By examining and calculating the tectonic indices in the area, we came to the conclusion that active tectonics is one of the factors in the study area, the amount of tectonic indices is also more active. Also, in parts of the region where tectonics is active (eastern and southern parts of the basin), the water level drop is more. Since tectonic activities cause complications such as faults and faults in karstic areas cause the transfer of groundwater and reduce the retention time of water in the region; The trend is to lower the water level and reduce the volume of the table. Therefore, in general, it can be inferred that the main factor in reducing the storage coefficient and water level decline in the region is tectonic activity and these studies confirm the development of geodetic theory at the basin level, which causes the expansion of subsidence and subsidence at the surface Basin has been considered. If the increasing need of groundwater for the population of the region is taken into account, the figures related to the level of water level indicate that the basin is critical in terms of the use of this water. It also indicates the risky trend of loss of this valuable resource in the basin and also the limitation in the development of groundwater use in the region; In the current situation, the need for proper management of these valuable resources is felt. Therefore, it is necessary to control and improve the amount of water pumping and optimal use of resources. Also, in order to strengthen the aquifer, artificial feeding schemes can be used in priority areas or practical measures can be taken to prevent water escape.

References

1. Ahmed, M. 1996. Lineament as ground water exploration guides in hard-rock trains of arid regions. Canadian Journal of Remote sensing, volume 22.1.

2. Arfa Nia, Ramin. 2010. Active tectonics in Eghlid region, application of digital terrestrial model (DTM) in morphotectonics. Journal of Applied Geology, 4: 256-245.

3. Aliabadi, Kazem; Mohammad Ali Zanganeh Asadi, Ali Akbar Shayan Yeganeh, Javad Jamalabadi and Alireza Hamidian. 2014. Investigation of the role of active tectonics and tectonic lines in the formation of groundwater aquifers in Sabzevar plain using GIS and RS. Bi-Quarterly Journal of Applied Geomorphology of Iran, Second Year, 4: 16-30.

4. Bagherinejad, Ismail. 2011. Groundwater flow simulation using a numerical model in GIS environment. Master Thesis in Remote Sensing. Shahid Beheshti University.

5. Bahrami, Shahram; Mehran Maghsoudi and Kazem Bahrami. Investigation of the role of tectonics in morphometric anomalies of drainage network in four watersheds in Zagros. Natural Geography Research, 76: 70-51.

6. Bull, W.B. 1984. Tectonic Geomorphology. Journal of Geological Education,v (32) .pp: 310-342.

7. Bull, W. B, and L.D. MacFadden. 1977. Tectonic geomorphology north and south of the Garlock Fault, California. In: Doehring, D. O. (ed.). Geomorphology in Arid Regions, Proceedings of the Eighth Annual Geomorphology Symposium, State University of New York, Binghamton: 115–138.

8. Emami, Fahima. 2014. Investigation of the role of tectonics in the formation and evolution of alluvial fan cones in Kermanshah province. Master Thesis. University of Sistan and Baluchestan.

9. Hashemi, Seyed Nasser. 2010. Investigation of the role of main faults in controlling the frequency and quality of groundwater resources. Research project 86003 SW, Semnan province.

10. Guarnieri.P, and C. Pirrotta. 2008. The Response of Drainage Basins to the Late Quaternary Tectonics in the Sicilian Side of the Messina Strait (NE Sicily), Geomorphology, 95, pp. 260–273

11. Hamdouni. R.El.; C. Iriggaray, T. Fernandez, J. Chacon, and E.A. Keller. 2008. Assessment of relative active tectonics, southwest border of the Sierra Nevada(Southern Spain). Geomorphology. 96. pp: 150-173.

12. Keller, E. A, and N. Pinter. 2002. Active Tectonics–Earthquakes, Uplift, and Landscape (2nd edition). Prentice Hall. London. 362 pp.

13. Pike,R.J.;Wilson, S.E.,1971.Elevation-relief ratio,hypsometric integral and geomorphic area- altitude analysis. Geological Society of America Bulletin82.1079-1084

14. Randel, T .1994. Analysis of drainage- basin symmetry as arpin techniques to areas of possible Qaternery tilt-block tectonice: An examble from the Mississippi Embayment.
Geological society. Vol.106. Pp571-581.

15. Rockwell.T.K.; E.A. Keller, and D.L. Johnson. 1985.Tectonic geomorphology of alluvial fans and mountion fronts near Ventura. California. In: Morisawa, M.(Ed)

16. Shtober Zisu. N.; N. Greenbaum, M. Inbar. A. Flexer. 2007. Morphometricandgeomorphicapproaches for assessment of tectonic activity. DeadSeaRift(Israel). Geomorphology 102.93-104.

17. Pourkhosravani MohsenRamesht m.h; Al-Madrasi Seyed Ali (2012), Duality in Geomorphology

18. Ranjbarmanesh, Nasrin; Mojgan Entezari and Mohammad Hossein Ramesht. Crisis caused by falling groundwater level due to tectonic activity in Mahidasht plain. Iranian Journal of Applied Geomorphology, p.10.

19. Soleimani, Shahriar. Guidelines in identifying active and young tectonic movements »with a view to ancient foundations

20. Seismology «Journal of the International Institute of Seismology and Earthquake Engineering.Number: .78-99-11p.

21. Shayan, Siavash; Mohammad Sharifi Kia, Gholamreza Zare and Shahram Amiri. 2011. Evaluation of tectonic activities of catchments with geomorphological indicators (Case study of Response catchment, Fars province). Quarterly Journal of Geography and Land Management, 1: 52-37.

22. Salehi Esfandarani Reza, Ghafouri Mohammad, Lashkaripour Gholamreza, Maryam Dehghani (2010), Investigation of subsidence of the southern Mahyar plain and the impact of the resulting gaps on agricultural land, 7th Iranian Conference on Engineering Geology and Environment, 2011-09- 04

23. Zovoili. E.;E. Konstantinidi, and I.K. Koukouvelas. 2004. TECTONIC GEOMORPHOLOGY OF ESCARPMENTS: THE CASES OF KOMOTADES AND ANCHIALOS FAULTS, Bulletin of the Geological society of Greece vol. XXXVI. Proceedings of the 10th International congress. Thessaloniki. April 2004.