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Hypsometric Properties of Marvdasht Plain Basins in SW Iran (South of Zagros Fold-Thrust Belt)

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Abstract — hypsometric analysis of basin has generally been used to reveal the stages of geomorphic development. It is estimated by the graphical plot of the measured contour elevation and encompassed area by using empirical formulae. This study has been conducted to analyze the hypsometric properties of drainage basins in Marvdasht plain. In constructing the hypsometric integral curve, a Digital Elevation Model (DEM) with 30 m spatial resolution has been used. The result of hypsometric curve shows that 52 drainage basins are in Marvdasht plain. Three different approaches were used for estimation of hypsometric integrals. The hypsometric integral values (HI) ranges between 0.03 and 0.48 for all the basins of Marvdasht plain. In the study area, two stages of erosion cycle development, namely mature and old stages are distinguished. The obtained results of drowned hypsometric integral curves in 52 basins indicate the high value of HI is coincided to fault zones and folds and the northeast of Marvdasht plain is more active than other ones.

Keyword — Active Tectonics, Iran, Tectonics Geomorphology, Zagros Mountain

1. Introduction

Tectonics geomorphology deals with relations between tectonics and Geomorphologic processes shaping areas of active Cenozoic deformations (Burbank and Anderson, 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).
Morphometry has been a significant instrument of structural geomorphology (Strahler, 1952) since the 1950’s (Panek, 2004). Morphometric parameter can use for determining the deformation, which has been created by tectonics activity (Mardani et al., 2011). The advantage of morphotectonics parameters is in their fast derivation, mutual comparison and possibility of statistic evaluation for arbitrarily vast areas. The morphometric parameters have been used in various studies of geomorphology and surface water hydrology and evolution of basin morphology (Pisal et al., 2012). One of this parameter is hypsometric integral.
Land degradation and topology changes within watersheds are accomplished by weathering processes, stream erosion patterns and sediment transportation by surface runoff. In attempt to simulate the geologic stages of development and to study the influence of varying forcing factors (i.e. tectonics, climate, lithology) on watershed topology, the hypsometry of drainage basins (area-elevation analysis) (Strahler, 1952) has been evaluated by the researchers such as bishop et al.2002 and Ritter et al. 2002 (Singh et al., 2008).
Hypsometric analysis was first time introduced by Langbein (1974) to express the overall slope and the forms of drainage basin. Hurtrez et al. 1999a has been shown the hypsometric curve is related to the volume of the soil mass in the basin and the amount of erosion that had occurred in a basin against the remaining mass (Singh et al., 2008).

2. Study Area

The large alluvial Marvdasht plain bounded between latitude 29º27’ to 30º18’ N and longitude 52º25’ to 53º22’ E, which is located about 60 km north-east of the city of Shiraz in Fars province in southwest Iran and have area about 7.4 hectare (Fig. 1a). It is situated in the Zagros fold-and-thrust belt. The Zagros mountain range is divided into three tectonics zones from the NE to the SW: the High Zagros, the Zagros Simply Folded Belt, and the Zagros Foredeep Zone (Stöcklin, 1968; Falcon, 1974). The study area is located in the Simply Folded Belt (SFB) which has particularly been studied owing to the salt plugs and its structure at south and high Zagros at north.
The study area is covered by young alluvial of quaternary age that it has been covered the geological structure and fractures. In the Basin of Marvdasht, late Quaternary basin fills consist of loess, loess-like sediments and fine- or coarse-textured alluvium (Kehl et al., 2005). The

electrical conductivity (EC) values in µS cm-1 range from 500 to 8,140 for wells, 380 to 12,000 for Qantas and 460 to 1470 in whole plain of Marvdasht (Ghassemi et al., 1995). Salinity of the water resources increases downstream towards the salt lakes, whereas water table depth decreases to less than 2 m in the same direction. The shallow water table results from poor natural drainage of heavy textured alluvial deposits, excessive irrigation and seepage from irrigation canals. During the past, groundwater tables have risen as documented for the years 1971 to 1985 as published Nadji 1997 (Kehl , 2006). In the last two decades, they possibly decreased because of the construction of drains and lined canals in combination with excessive extraction of groundwater by wells (Kehl et al., 2005). Further details on the irrigation system and water quality of Marvdasht plain are given by Ghassemi et al. (1995) (Kehl, 2006). The climate of the area is inland climate. The average annual rainfall of the area is more than 300 mm (Tahghighat Madani khak Khoub Consulting Engineers, 2001).

Marvdasht plain has upland, broken anticlines and long synclines with northwest-southeast trend. Hardness and mainly calcareous deposits and Erodible sediments form highlands and Lowlands of basin. Folded Zagros located at south-southwest and high Zagros was at the eastern part of this basin. The strike of main geological structures are northwest-southeast which have been cut by faults with north-south or north northeast-south south west trend. Neyriz formation is the oldest formation belongs to lower Jurassic (Fig. 1a). It is a clastic formation with lithological composition of shale and quartzite. Khami formation is located on it that has upper Jurassic or early Cretaceous age. This formation is composed of Sormeh, Daryan, Fahliyan and the marly limestone of the Gadvan formations. The other formations are Kazhdomi formation and Bangestan group which is composed of Sarvak and Ilam formations belong to early Cretaceous to late Cretaceous (Afqah et al., 2011; Tahghighat Madani khak Khoub Consulting Engineers, 2001). In the present paper the authors had made an attempt to hypsometric analysis of Marvdasht plain basins.

We grouped the level of rock resistance based on rock types shown in Fig. 2 and field observations: low (alluvial deposits), moderate (gypseous marl, dolomitic limestone) and high (limestone, sandstone and dolomite) (El Hamdouni et al., 2007). Figure 1b shows the distribution of the resistant levels (Fig. 1b).

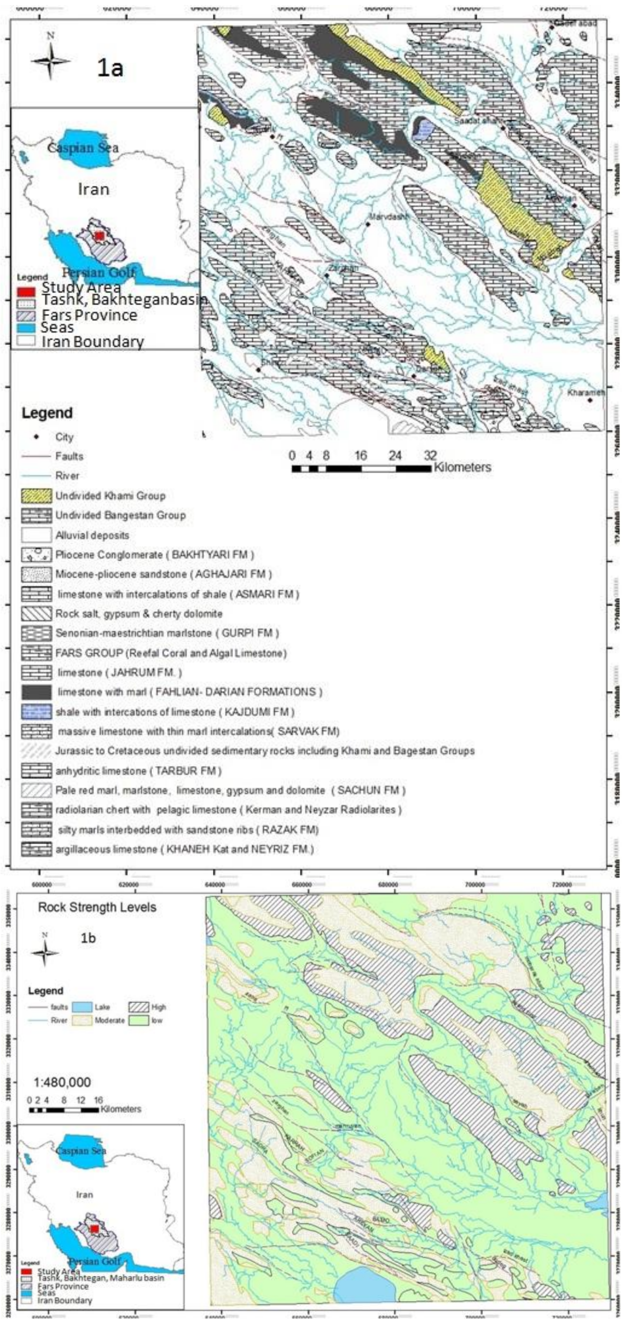

Fig.1. a. Geological map of the study area, western Shiraz, SE Fars, Iran (Derived from Shiraz, Sivand, Saadatshahr and Arsenjan 1:100,000 scale map) b. Distribution of rock strength levels

3. Methods

In the field of tectonics geomorphology and landscape evolution, the use of GIS is relatively recent. The availability of the DEM (Fig. 2) has produced a great revolution in this field. It has replaced old topographic maps, allowing for better and faster analysis of topographic parameters. One of the most important features of DEM is the possibility of extracting river networks with stream gradients and catchments areas (Perez Pena, 2009).

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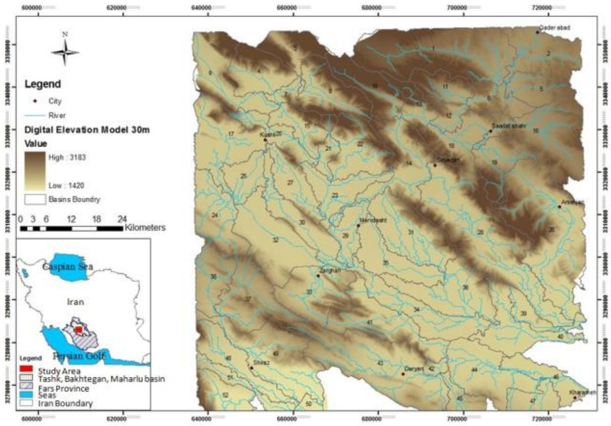


Fig.2. Digital elevation model with 30 m spatial resolution of study area showing 52 basin, Basins are indicated by numbers, for more details please refer to Table (1)

Geographical information system has been used for data preparation, data manipulation and analysis of data. 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 have been identified through an extension called arc hydro tools 9 (fill, flow direction, flow accumulation, stream definition, stream segmentation) in ARCGIS software using DEM model as input. We have been controlled drainages obtained by DEM with drainages of the survey of Iran topographical map in 1:25000 scales. So that, 52 basins has been chosen the study (Fig. 2).stream ordering method as suggested by Strahler has been employed (Strahler, 1957).

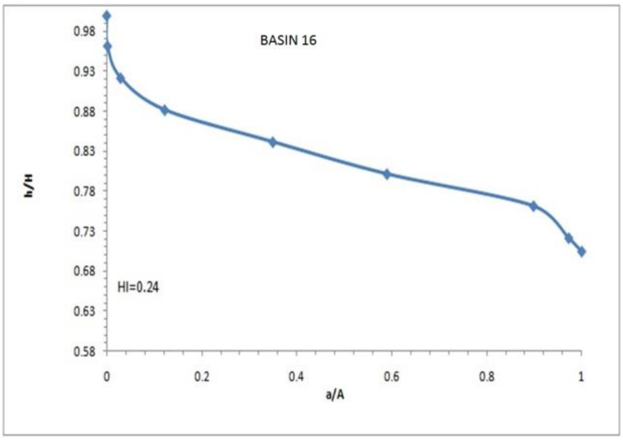
Hypsometric describes area distribution at different elevations (Strahler, 1952) and can be estimated using the hypsometric curve or the hypsometric integral (HI). The index is defined as the relative area below the hypsometric curve and thus expresses the volume of a basin that has not been eroded (Dehbozorgi et al., 2010). The hypsometric integral can be approximated by means of the following equation (Keller and Pinter, 2002):

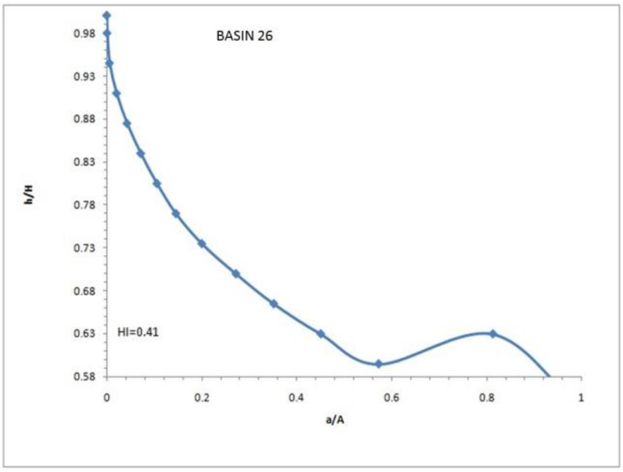
HI= (average elevation – min. elevation)/ (max. elevation - min. elevation) (1)

The elevation value of DEM has been used to find out the hypsometric integral for each basin in the Marvdasht plain. Programming in excel has been used to determine the hypsometric curve values. In order to generate the map of hi value, at the first, polygon shape file converted to point features by xtools pro and then the spatial analyst has been used. Finally, we classified Marvdasht plain based on three classifies called Strahler (1952), El Hamdouni et al. (2008) and Ramu and Mahalingam (2012).

4. RESULTS

The hypsometric integral value ranges from 0.03 (sub basin beiza-zarqan3) to 0.48 (sub basin Marvdasht Kharameh2). The hypsometric curve and the hypsometric integral are valuable tools in characterizing topography because they are correlated with the stages of geomorphic development of the landscape (Perez Pena et al., 2009). The values of elevation necessary for the calculation are obtained from a digital elevation model. The average elevation is from 50 points of elevation taken at random from the drainage basin. The hypsometric curve represents the relative proportion of area below (or above) a given height. Four drowned the hypsometric curve has been shown in figure 3 for example (Fig. 3).





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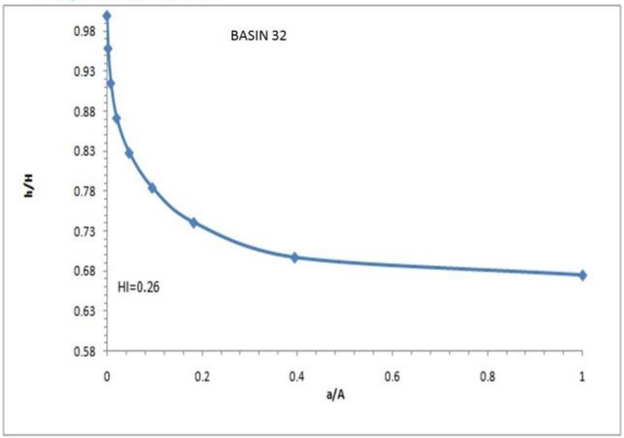

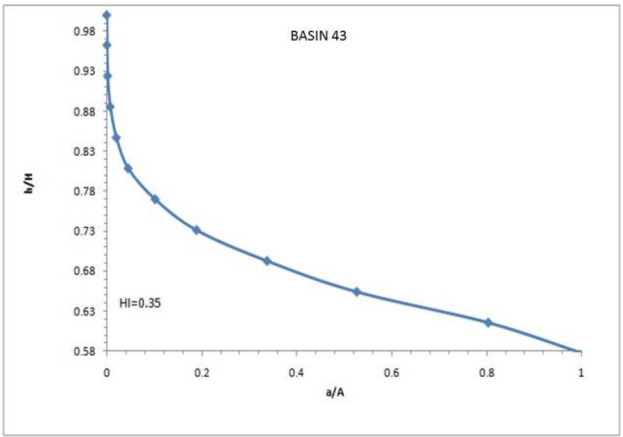

Fig.3. Hypsometric curves of four basins as sample work (A) is the total surface area within the basin above a given line of elevation (h), (H) is the highest elevation of basin.

Strahler (1952) interpreted the shapes of the hypsometric curves by analyzing numerous drainage basins and classified the basins as youth (convex upward curves), mature (s-shaped hypsometric curves which is concave upwards at high elevations and convex downwards at low elevations) and peneplain or distorted (concave upward curves) (Singh et al., 2008). The studding plain was in mature in some portion and peneplain or distorted in often portions (table1).
HI values were grouped into three classes with respect to the convexity or concavity of the hypsometric curve by El Hamdouni et al. (2008): class 1 with convex hypsometric curves $(HI \geq 0.5)$; class2 with concave-convex hypsometric curves $(0.4 \leq HI < 0.5)$; and class3 with concave hypsometric curves $(0.4 < 0.4)$. On based it, Marvdasht plain was located into class2 and3 (table 1) where as Ramu and Mahalingam have been classified the HI values as following. if the result value was between 0.6 and 1; it indicates the youthful state of dissection; if the result value was between 0.3 and 0.60, it indicates a maturely dissected landform; and if the result was less than 0.35, then it indicates an equilibrium or old state of dissection. Our area indicates a maturely dissected landform and old state of dissection based this classification (table1).

Table (1) Hypsometric integral – Marvdasht plain basins [HI (hypsometric integral value), Basin No. (The dedicated number of each basin for using in maps), Classification of HI by (Strahler; 1952; El Hamdouni et al.; 2008 and Ramu, Mahalingam; 2012)]

Basin No.	Basin Name	HI	Classifications of HI		
			Strahler(1952)	El Hamdouni(2011)	Ramu, Mahalingam(2012)
1	QADERABAD-MADARSOLEYMAN1	0.32	2	3	3
2	QADERABAD-MADARSOLEYMAN2	0.16	3	3	3
3	MARVDASHT-KHARAMEH1	0.45	3	3	2
4	MARVDASHT-KHARAMEH2	0.48	2	3	2
5	QADERABAD-MADARSOLEYMAN3	0.19	3	3	3
6	SAADATABAD4	0.25	2	3	3
7	MARVDASHT-KHARAMEH5	0.3	2	2	2
8	MARVDASHT-KHARAMEH4	0.44	2	2	2
9	MARVDASHT-KHARAMEH3	0.43	2	3	2
10	SAADATABAD1	0.38	3	3	3
11	SAADATABAD3	0.32	3	3	3
12	SAADATABAD5	0.28	3	3	3
13	SAADATABAD2	0.39	2	2	2
14	MARVDASHT-KHARAMEH11	0.38	2	2	2
15	MARVDASHT-KHARAMEH7	0.34	3	3	3
16	SARPANIRAN	0.24	2	3	3
17	BEIZA-ZARQAN1	0.29	3	3	3
18	SAADAT ABAD6	0.36	3	3	3
19	SAADAT ABAD7	0.37	3	3	3
20	MARVDASHT-KHARAMEH6	0.3	3	3	3
21	MARVDASHT-KHARAMEH9	0.38	3	2	2
22	MARVDASHT-KHARAMEH8	0.41	3	3	3
23	MARVDASHT-KHARAMEH10	0.23	2	2	2
24	BEIZA-ZARQAN2	0.26	3	3	3
25	BEIZA-ZARQAN3	0.03	3	3	3
26	ARSENJAN	0.41	3	3	3
27	BEIZA-ZARQAN4	0.3	3	2	2
28	SEYEDAN-FAROUQ	0.42	3	3	2
29	MARV0.39DASHT-KHARAMEH14	0.15	3	3	3
30	BEIZA-ZARQAN5	0.22	3	3	3
31	MARVDASHT-KHARAMEH12	0.38	3	3	3
32	BEIZA-ZARQAN6	0.26	3	3	3
33	BEIZA-ZARQAN7	0.31	3	3	2
34	MARVDASHT-KHARAMEH16	0.1	3	3	3

35	MARVDASHT-KHARAMEH13	0.06	3	3	3
36	MARVDASHT-KHARAMEH17	0.28	2	3	3
37	SHIRAZ2	0.32	3	3	3
38	SHIRAZ1	0.24	3	3	2
39	MARVDASHT-KHARAMEH18	0.16	3	3	3
40	MARVDASHT-KHARAMEH19	0.25	3	3	3
41	MARVDASHT-KHARAMEH15	0.34	3	3	3
42	MARVDASHT-KHARAMEH21	0.23	3	3	3
43	DARYAN	0.35	3	3	3
44	MARVDASHT-KHARAMEH20	0.19	3	3	3
45	MARVDASHT-KHARAMEH22	0.19	3	3	3
46	MARVDASHT-KHARAMEH24	0.05	3	3	3
47	MARVDASHT-KHARAMEH23	0.18	3	3	3
48	SHIRAZ4	0.36	3	3	3
49	SHIRAZ3	0.41	3	2	2
50	SHIRAZ6	0.11	3	3	3
51	SHIRAZ5	0.26	3	3	3
52	QAREHBAGH	0.43	3	2	3

Hypsometric integral data were derived for each of the fifty-two drainage basins from 30 m DEM has been shown in table1. The result of the hypsometric integral shows all drainage basins come under the class 3 in all of classifications, except few basins which come in class 2. The result of hypsometric integral values have been mapped (Fig. 4) to see the visual interpretation of HI values between drainages basins.

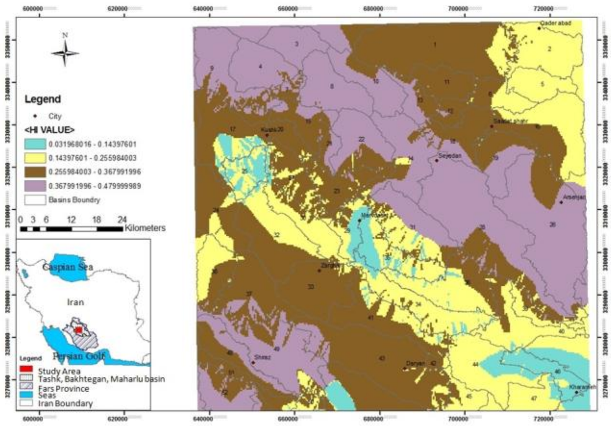

Fig.4. it shows the distribution of obtained hypsometric integral value at Marvdasht plain. The HI value interval is equal.

Then, HI value was contoured (Fig. 5) by spatial analyst extension and the hypsometric integral value of Marvdasht plain map has been used as a base map.

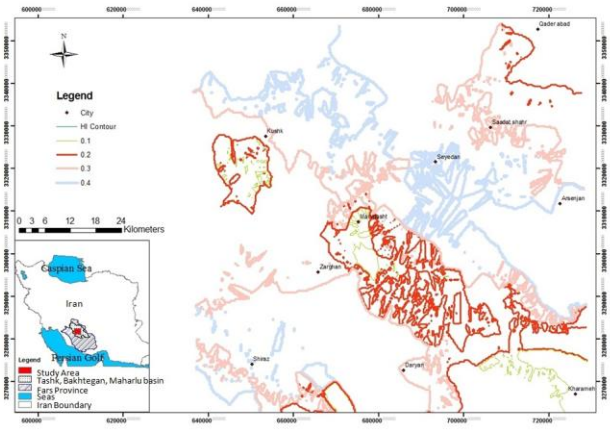

Fig.5. it shows the hypsometric integral value countered map of Marvdasht plain. Contour interval was selected 0.1 according to HI value. It shows Hi changes in the center of plain is more than other parts

We compare the results in three above Saied classification and provide HI distributions maps based on them (Figs. 6 to 8). In Stahler classification, 11 basins are in class 2 and other basins indicate peneplain stage (Fig. 6). As saw in figure 7, only nine basins locate in class 2 and indicate mature stage. Whereas, the HI map provided based on Ramu and Mahalingam (20012) shows more numbers of basins located in class 2 almost 17 basins (Fig. 8).

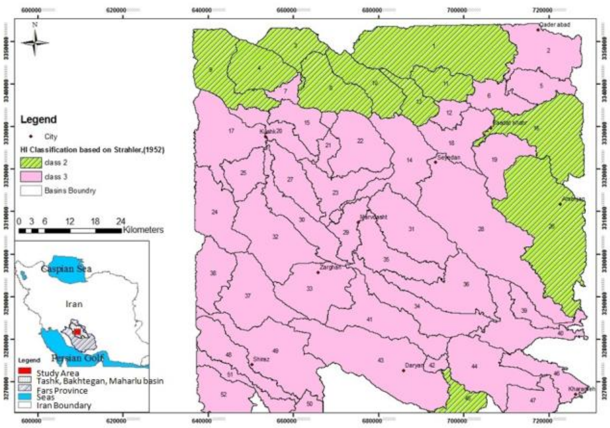

Fig.6. it shows the first HI classification map of study area, this classification is based on Strahler approach (1952). As was indicated11 basins are in class 2. They are on high and much less on moderate strength rocks.

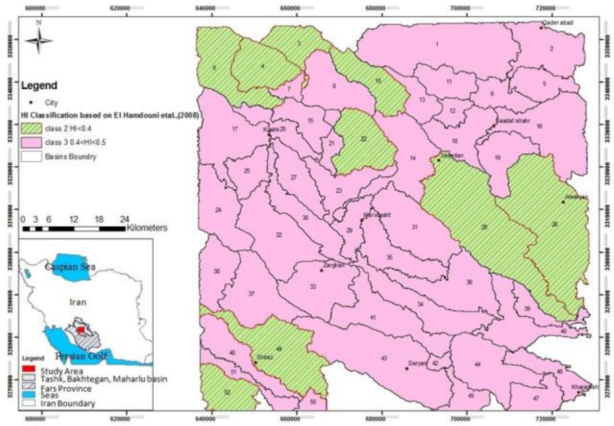

Fig.7. it shows the second HI classification map of study area, this classification is based on El-Hamdouni approach (2008).

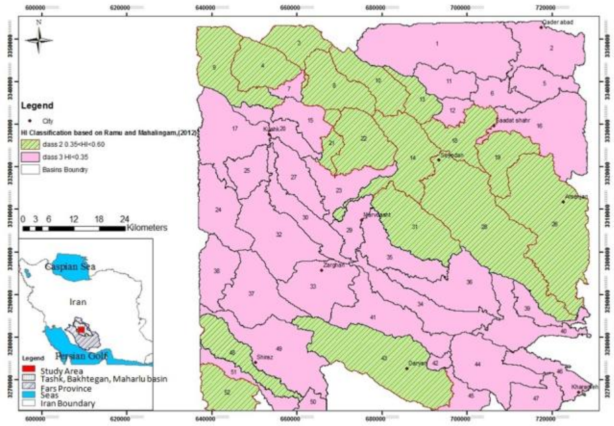

Fig.8. It shows the third HI classification map. This classification is extracted Ramu and Mahalingam paper (2012).

Finally, the results of these three classifications have been mapped (Fig. 9) totally to see the visual situation of basin according them. 32 % basins are non-overlapped, 9.4% are in class 2 and 58.5% are in class 3 in three classification comparing.

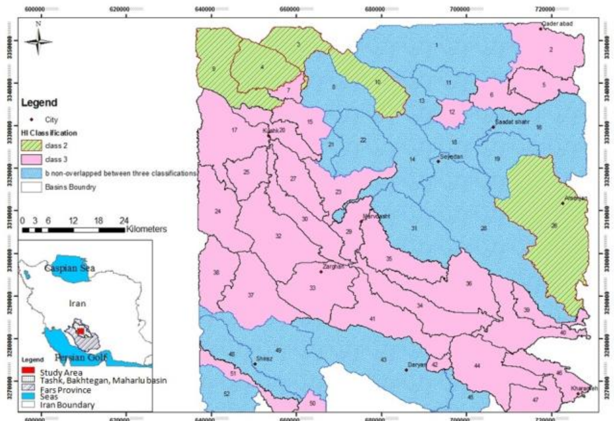

Fig.9. it shows HI combined classification map. This map is the combination of previous three maps.

5. Discussion

Hypsometric is affected principally by tectonics, lithology, and climatic factors (Perez Pena et al., 2009) so that these factors considered in interpretation. The hypsometric curves not only have been used to infer the stage of development of the drainage network but also it is a powerful tool to differentiate between tectonically active and inactive areas (Keller and Pinter, 2002).

In this study, spatial variations of tectonic activity at Marvdasht plain were investigated by hypsometric integral analysis. The changes of hypsometric integral point to a general trend of increasing tectonics activity towards the northeast but it is gradually decreasing towards the southwest.

We matched hypsometric integral value, tectonics map, lithology and climatic data (Figs. 10 and 11) for distinguishing their effects. The results show that basins located at northeast of Marvdasht plain have high values of HI. This portion of plain has been covered by limestone and other high strength rocks so that it has low erosion rather than other portions. So that, in this part the role of tectonics is more than other factors because Marvdasht plain has a same climate in all of itself why lithology less vast.

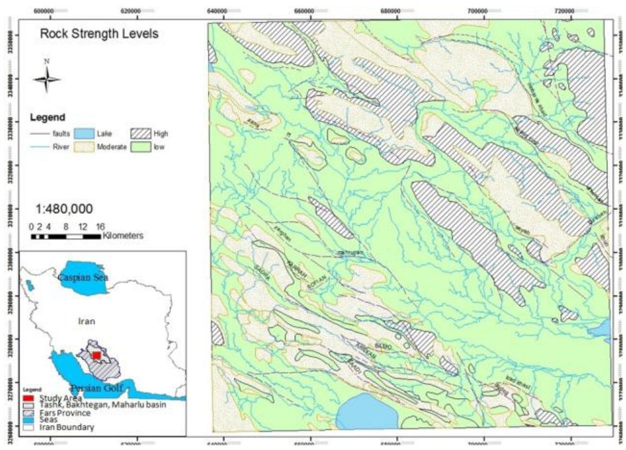

Fig.10. It shows HI value on rock strength map. There are HI anomalies in some basins such as basin 4, 3, 8, 28, 26 and 27.

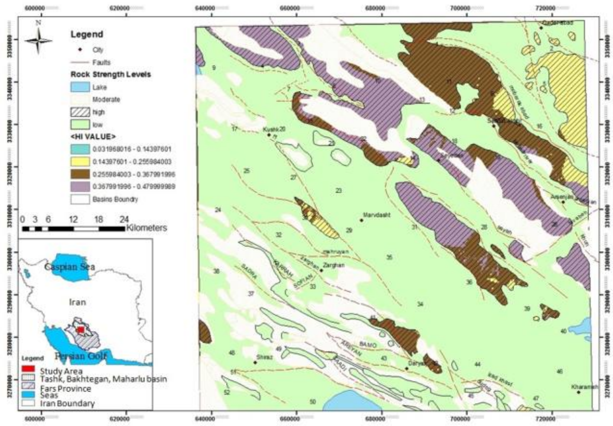

Fig.11. it shows HI changes map for the study area on rock strength map. It indicates high values of HI are consistent with fault trends and high strength rocks.

HI value Distribution in Lithology data is same and it doesn't differ significantly from one lithology to other one but in the strike of tectonics structures such as faults and folds variation of HI value has been happened. In fact, high hypsometric integral values indicated more tectonics activity and less eroded areas.

9. CONCLUSION

Hypsometric integrals for the all 52 basins have been computed using GIS following Strahler (1952), El Hamdouni et al. (2008) and Ramu and Mahalingam (2012) and plotted. It is considered to be suitable for evaluating these basins. The following conclusions have emerged from this study:

The study of hypsometric integral and curve has been retrieved in that the integral values vary from 0.03 to 0.48.

The maximum hypsometric integral belongs to Marvdasht-kharameh2 sub basin.

among the fifty-two drainage basins , five drainage basins are in maturely while thirty-one basins show the old state and other basins indicate each of these stages depend on chosen classification. No drainage basin comes in youthful state in the study area.

The resultant hypsometric curve graphs drowned by excel and calhypso has shown that s-shaped less rather than concave curve.

The value of HI was found to be high along major faults and folds.

The emphasis of the hypsometric integral on the active tectonic region in the northeast of plain is completely in agreement with structures in this part. So that this part of Marvdasht plain is more active than other parts.

A conclusion section is not required. Although a conclusion may review the main points of the paper, do not replicate the abstract as the conclusion. A conclusion might elaborate on the importance of the work or suggest applications and extensions.

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AUTHOR’S PROFILE

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