Geomorphic indices for determining neotectonic activity in the Panyor River sub basins, India

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Abstract
In the present study, an attempt has been made to assess the neotectonic activity within the 20 sub-basins of the Panyor river using geomorphic indices. The geomorphic indices like asymmetry factor, transverse topographic symmetry factor, hypsometric integral, stream-length gradient index, drainage basin shape index, ratio of valley floor to valley height and mountain front sinuosity were estimated and the values range from 36.61 to 63.82, 0.12 to 0.54, 0.46 to 0.50, 0.68 to 3.89, -0.29 to 1.76, 75.27 to 1198.93 and 1.42 to 5.81, respectively.

Further, the index of relative active tectonics (IRAT) was derived from the geomorphic indices and it ranges from 1.17 to 2.29. Based on the IRAT values, the Panyor sub-basins were grouped into three classes based on the neotectonic activity viz. very high (1.0-1.5), high (1.5-2.0) and moderate (2.0-2.5). The IRAT classes determined indicate that the neotectonic activity has a strong control in subbasin 5 and it spatially increases from the southwestern part of the basin to the northeast.

Keywords: Geomorphic indices, Neotectonics, Panyor sub-basins, Index of Relative Active Tectonics.

Introduction

Neotectonic activity is defined as recent surface deformation by tectonic processes. Detailed investigations of earth movement and related seismicities are very important for the development and management of urban areas. Such studies need special attention when the earth disturbances impact the riverine geomorphological features. The implications of neotectonic activities over the drainage networks and basins reflect minor and major changes in terrain morphology and can be analysed to investigate the tectonic evolution and neotectonic activity of the river basin[2,4,18].

The response of landforms due to tectonic deformation processes can be evaluated effectively using geomorphic indices derived from the digital elevation model[11,27] and relative active tectonics (IRAT), which is the average index of all the classes of geomorphic indices[10]. The continuous deformation in active tectonic areas results in various geomorphological modifications including contrasted relief, changes in relative tectonic uplift, differential erosional rates, river incision variations and river profile gradient changes. Understanding of the tectonic processes and their consequences in tectonically disturbed areas can be improved by the detailed investigations of landscape and drainage networks by geomorphological analysis, which has been employed globally during the last few decades[5,15,21].

The drainage pattern in tectonically active regions is very sensitive to active processes such as folding and faulting which are responsible for accelerated river incision, basin asymmetries, drainage geometry and complexity and river deflections. The geomorphic indices are important indicators capable of decoding landform responses to active deformation processes and have been widely used as a reconnaissance tool to differentiate zones deformed by act. The geomorphic indices such as asymmetry factor, hypsometric integral[25], transverse topography symmetry[8], the ratio of basin elongation[5], the width of valley floor to valley height ratio[5] and index of stream length gradient[12], stream sinuosity[19] have been successfully used in active tectonic studies.

The drainage network and drainage basin evolution in the Indian Peninsular shield are reported to have been influenced by the deformation and shearing processes[9,26,28]. Towards the northern parts of the State, limited studies have been conducted on the neotectonic implications. However, sub-basin wise investigations towards the northern parts of the State have not been carried out so far and hence, an attempt is made in the present study to understand the neotectonic activities and to evaluate the evolution of drainage networks in the Panyor sub watershed, Arunachal Pradesh using geomorphic indices and IRAT.

Panyor sub watershed is part of the Subansiri watershed in Arunachal Pradesh. The study area is a part of northeastern India covering Arunachal Pradesh and Assam. Study area faslls in the toposheet numbers 46D-6, 7, 10, 11, 14, 15, 16 and 46E-3, 4 are used to prepare basemap and drainage. The profile of the Panyor river channel observed from the Lichi village (located within a zone of the Bomdila Thrust and MBT) onwards up to its confluence with the Subansiri River, shows structurally controlled nature of its channel flow on the Siwaliks. This river originates from the domain of the Lesser Himalayan region.

The MBT is associated with the passing of a N–S trending fault, a NW–SE trending transverse fault, Tipi thrust, a shutter ridge, Dikrang fault, a NW–SE trending transverse fault and Kimin anticline respectively across the channel. In our study area majorly covers the districts of Papum pari in Arunachal Pradesh and small part of north lakhimpur in Assam.

Geologically, the study area exposed Precambrian to recent rock types which include augen gneiss, biotite gneiss, granite gneiss, quartzite, sandstone with fossil woods, calcareous nodules, oxidized and unoxidized sand, silt and clay. The litho units are separated by major tectonic features and result in unique representative unit of the terrain. This gives advantages of interpretation over the rock units which are mingled through complex history of geological evolution of the terrain. The northernmost part of the basin is located on east-west trending older cover sequence affected by Himalayan fold-thrust movement. Immediate south of this sequence is the nearly east-west trending "crystalline complex overprinted by Himalayan fold-thrust movement" that occupies the upper Subansiri basin. Detailed geological information is given in the figure 4.

Material and Methods

Methodology of the study includes the acquisition of relevant data and the calculation of geomorphic indices. The data products have been grouped as primary and collateral data. The primary data includes satellite imagery such as Landsat 8/OLI and SRTM. Collateral data comprise of toposheets and district resource map which were used to prepare base map lithology map respectively. For the detailed and accurate neotectonic study.

Panyor subwatershed was divided into 20 fifth-order sub-basins. Thereafter, to assess the active neotectonic processes, the widely accepted geomorphic indices such as asymmetry factor, transverse topographic symmetry, factor, hypsometric integral, stream-length gradient index, drainage basin shape index, ratio of valley floor to valley height and mountain front sinuosity were generated. Finally, all the geomorphic indices were combined and divided into the number of indices to classify every sub-basin according to IRAT classification. The description and mathematical formula of each geomorphic index used in this study was discussed. The given flowchart explains the process carried out in this study (Figure 3).

Results and Discussion

Classification of sub basins: Drainage map was prepared from the survey of India toposheets on 1:50,000 scales. Majority of the drainage pattern shows dendritic nature and at places trellis pattern was also noticed. From the drainage map, stream orders were classified based on Strahler method[25].

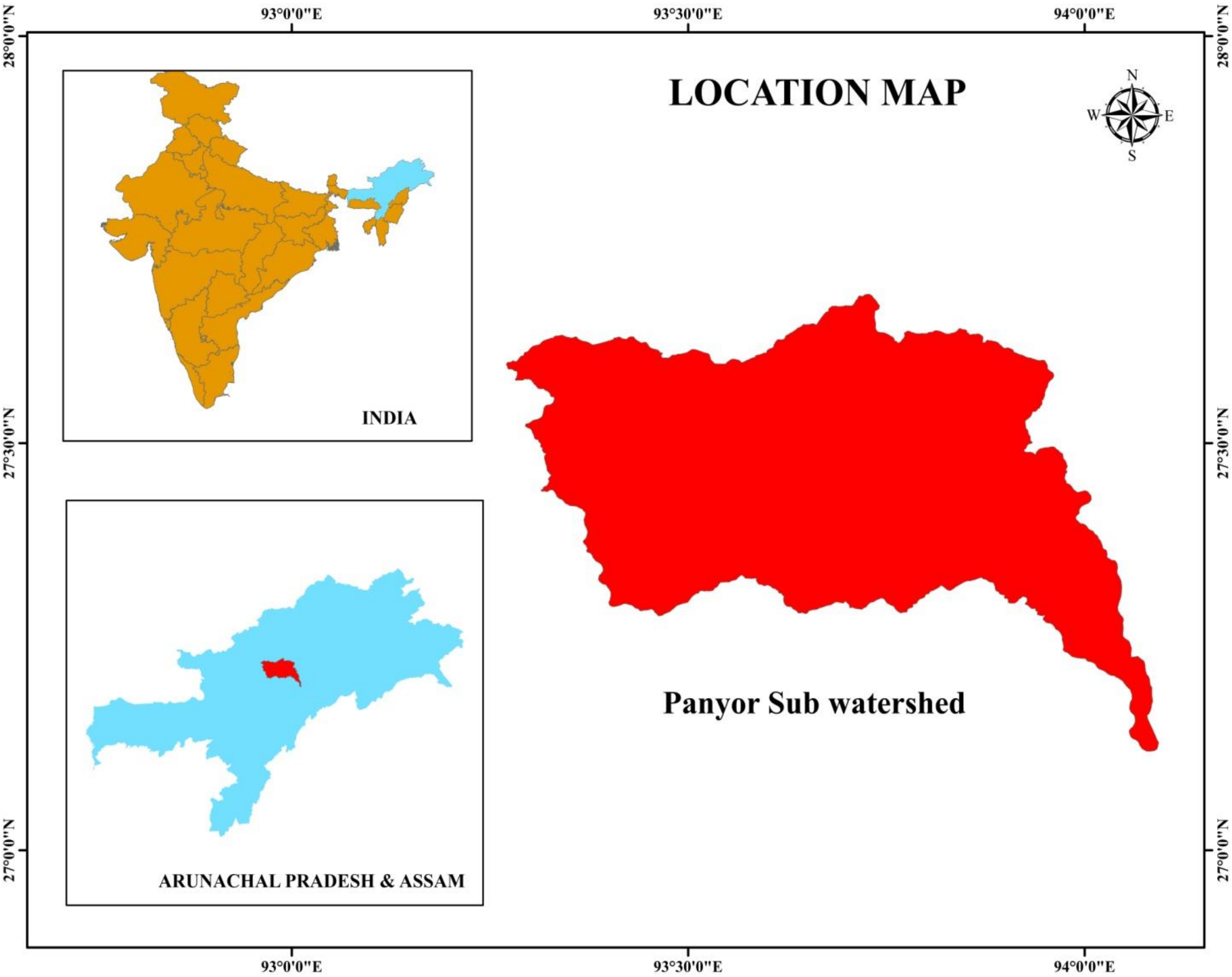

Fig. 1: Station distribution of INTERMAGNET geomagnetic monitoring network wherein different colors represent stations of different member institutions

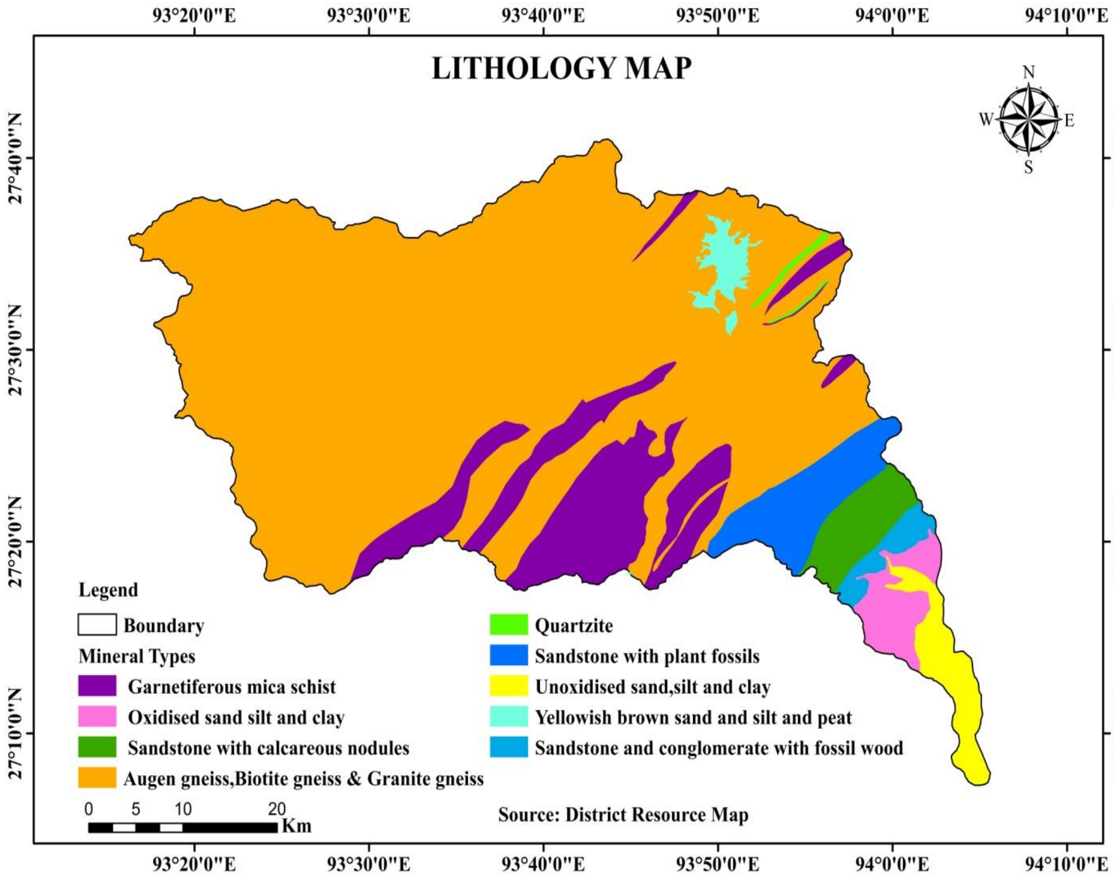

Figure 2: Lithology Map

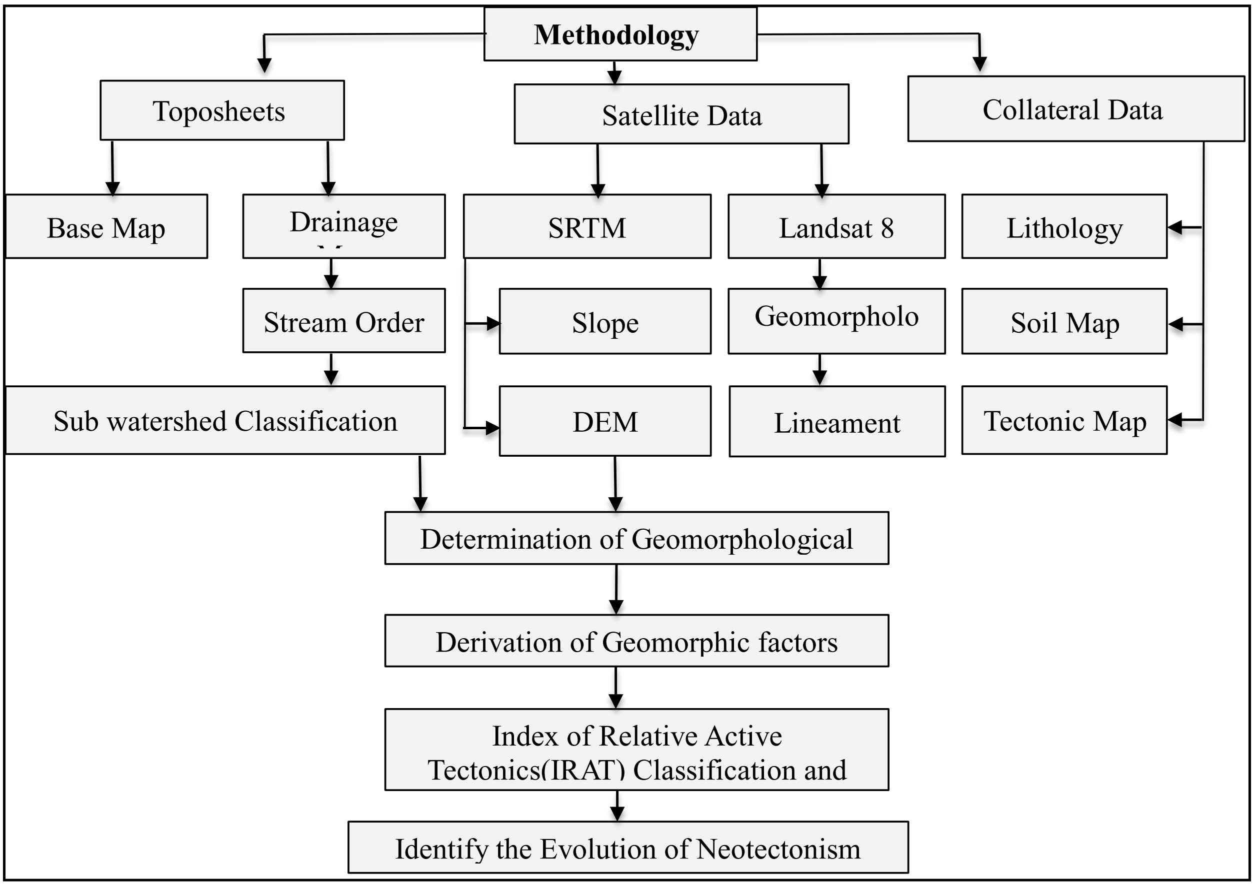

Figure 3: Flowchart of Methodology

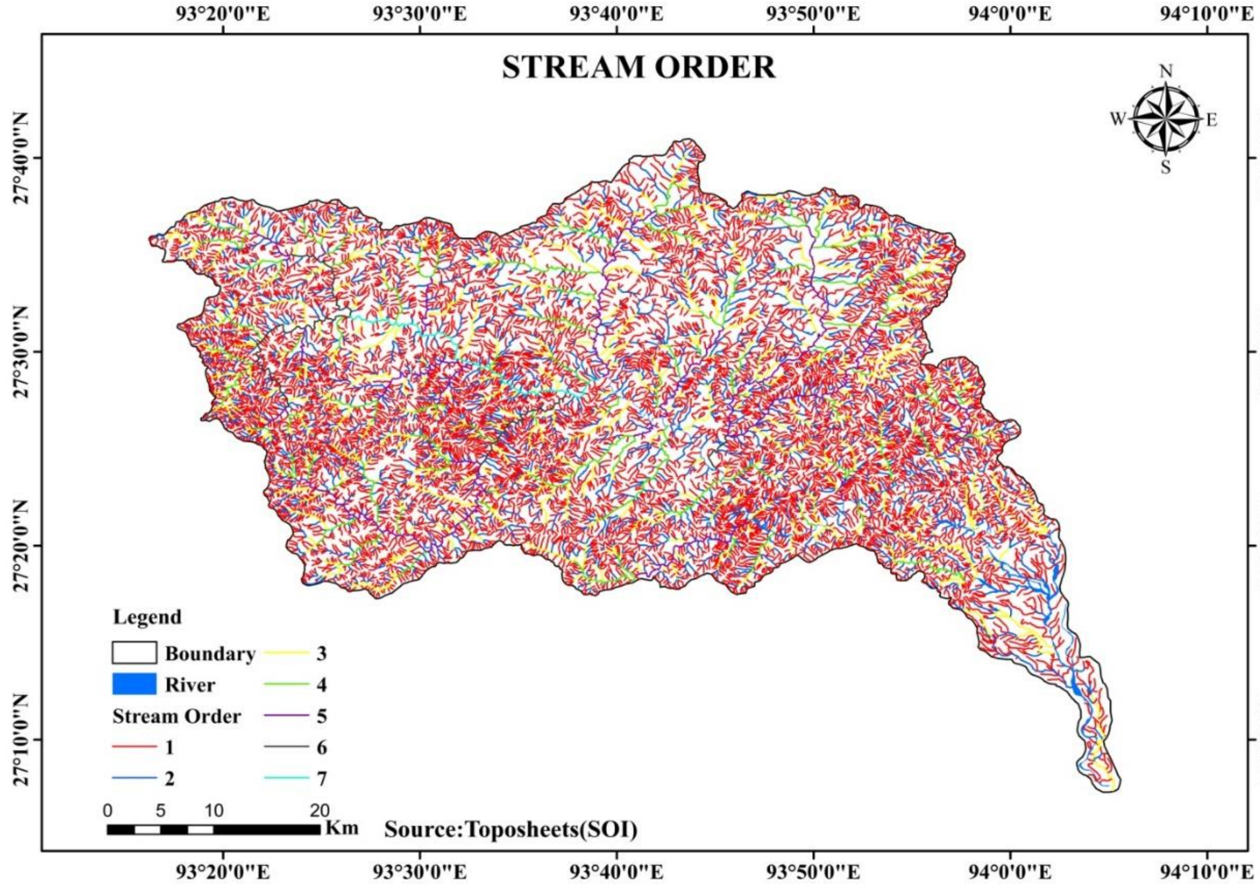

Figure 4: Map of Stream Order

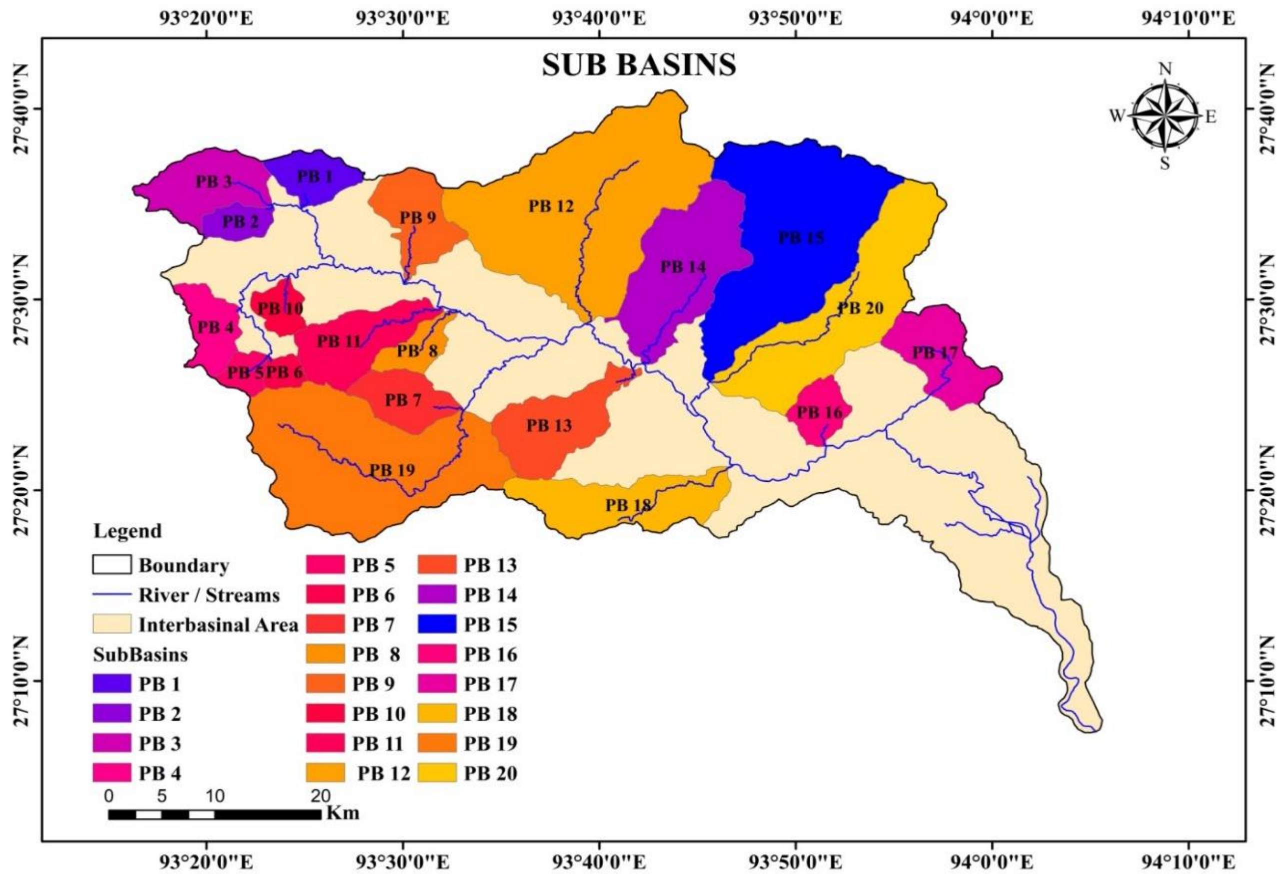

Figure 5: Basin elongation and tectonic activity

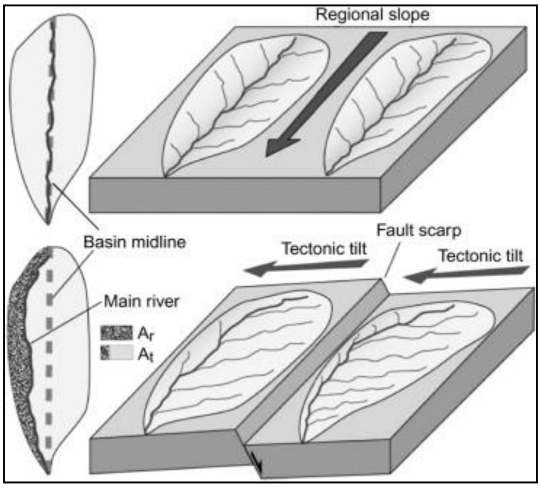

Figure 6.1: Regional Slope

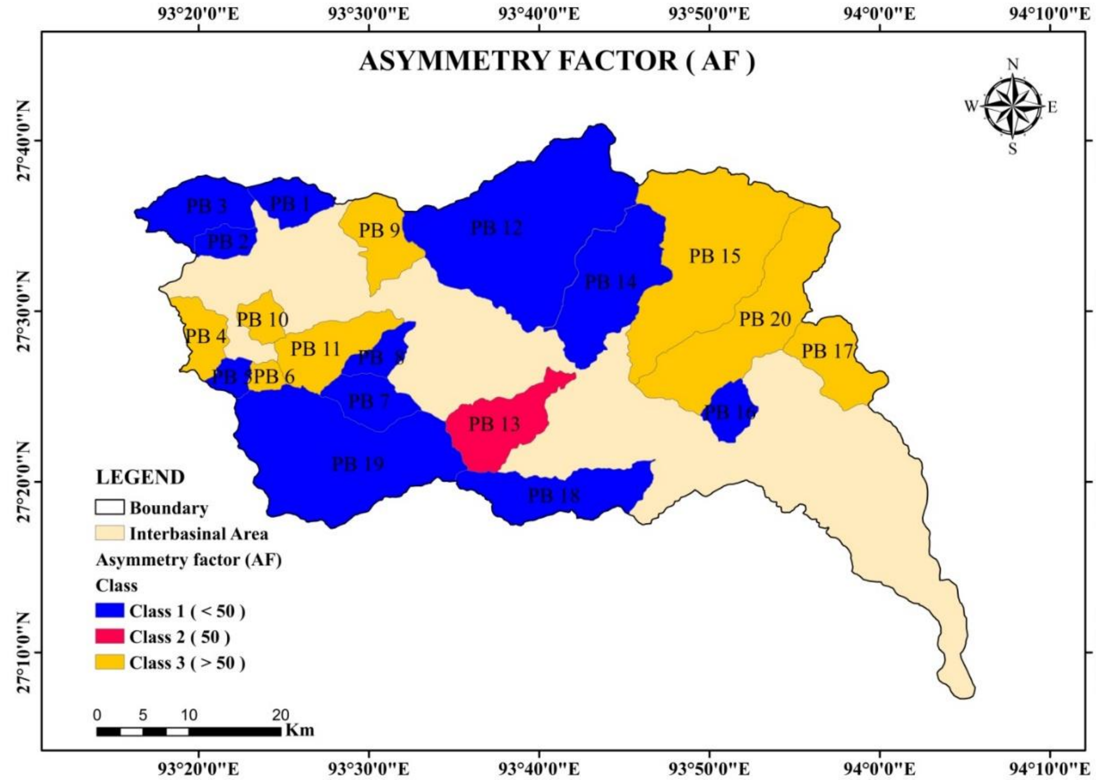

Figure 6.2: Flowchart and elongated basins

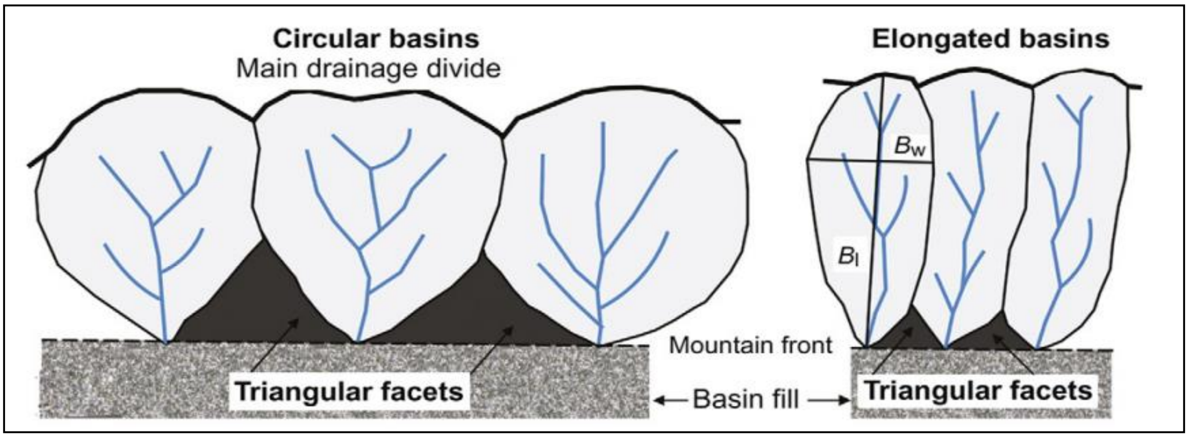

Figure 6.3: Circular and elongated basins

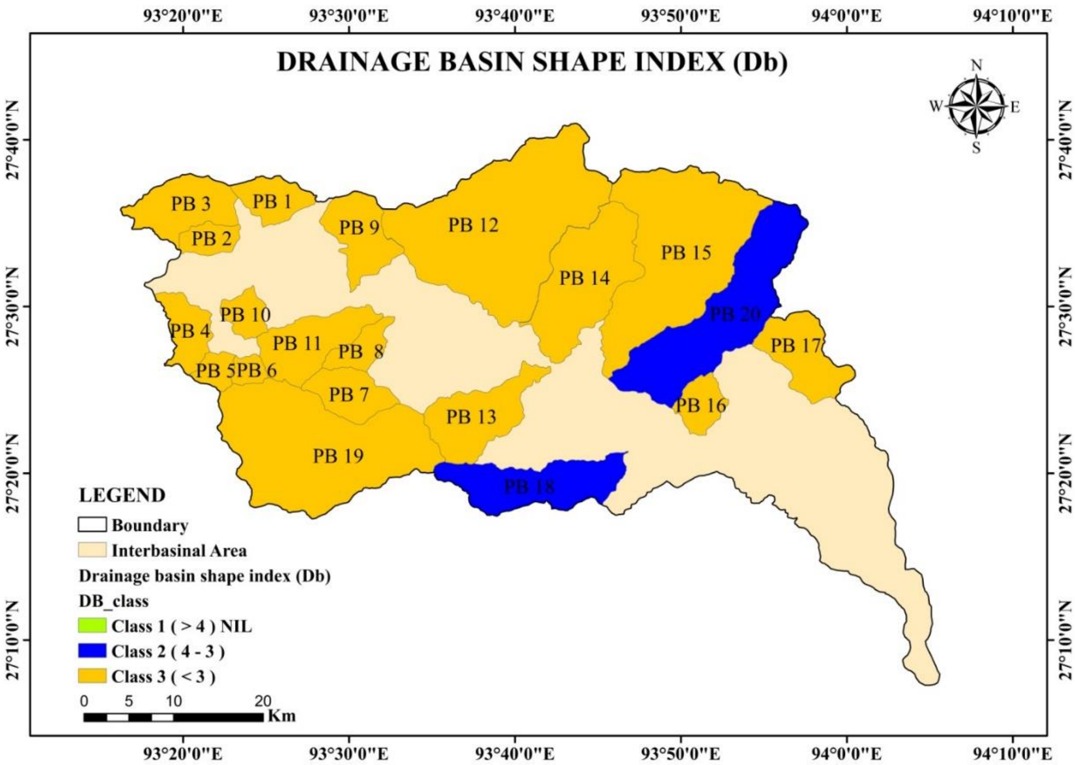

Figure 6.4: Drainage Basin Shape Index

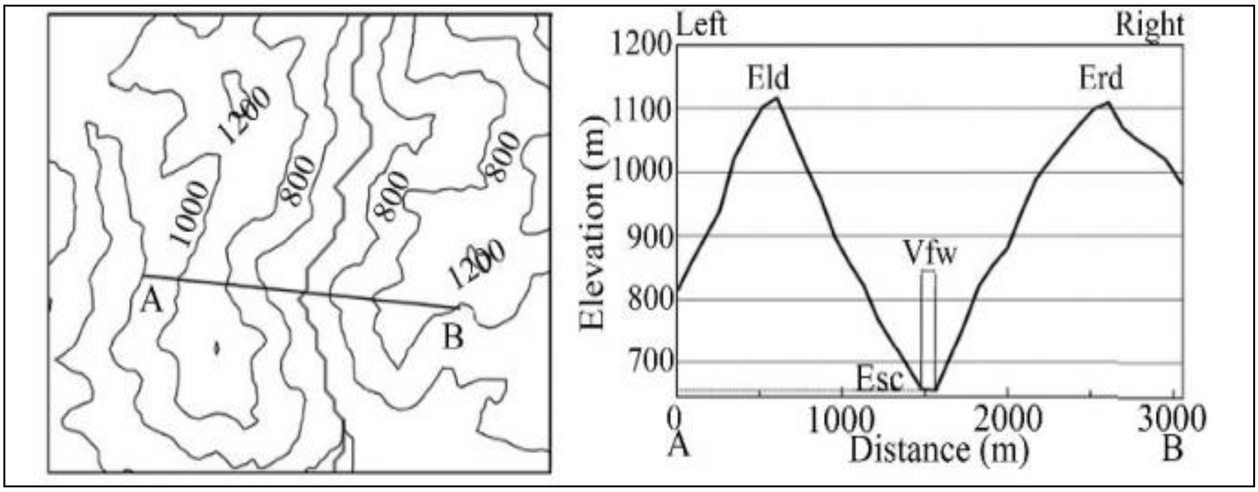

Figure 6.5: Graph between elongation and distance

Panyor sub watershed was classified into 20 sub basins based on the fifth order stream for the assessment of neotectonic activity. The sub basins were named PB1 to PB 20 and were assigned different colours for each basin under GIS environment. Unclassified basin was named as intrabasinal area which was not considered to the neotectonic study.

Determination and derivation of geomorphic indices

Asymmetry factor (AF): Asymmetry factor (AF) reflects the change in inclination of the basin area perpendicular to the stream flow direction. AF values higher or lower than 50 indicate active tectonics, differential erosion, or lithological control whereas AF values close to 50 indicate the absence of tilting or tectonic stability perpendicular to the direction of the main trunk channel. The effect of tectonic tilting on the trunk channel affects the length of the tributaries.

If the tectonic activity causes a dipping on the right side of the drainage basin, the tributaries to the right of the main stream will be shorter in length than those to the left side of the stream. The “AF” for the former will be greater than 50 and that for the latter will be less than 50. Steep and uneven sides also characterize the tectonically active landforms with flat floors which are created by the displacement of faults and the movement of the valley floor relative to the surrounding margins. This causes the river to migrate laterally.

AF index was analyzed for all the 20 sub-basins using the relation:

AF = (Ar/At)×100

where "Ar" is the area of the basin on the right side of the main trunk stream and "At" is the total area of the basin. AF calculated to the drainage response to uplift along a fault by migrating laterally in a down-tilt direction.

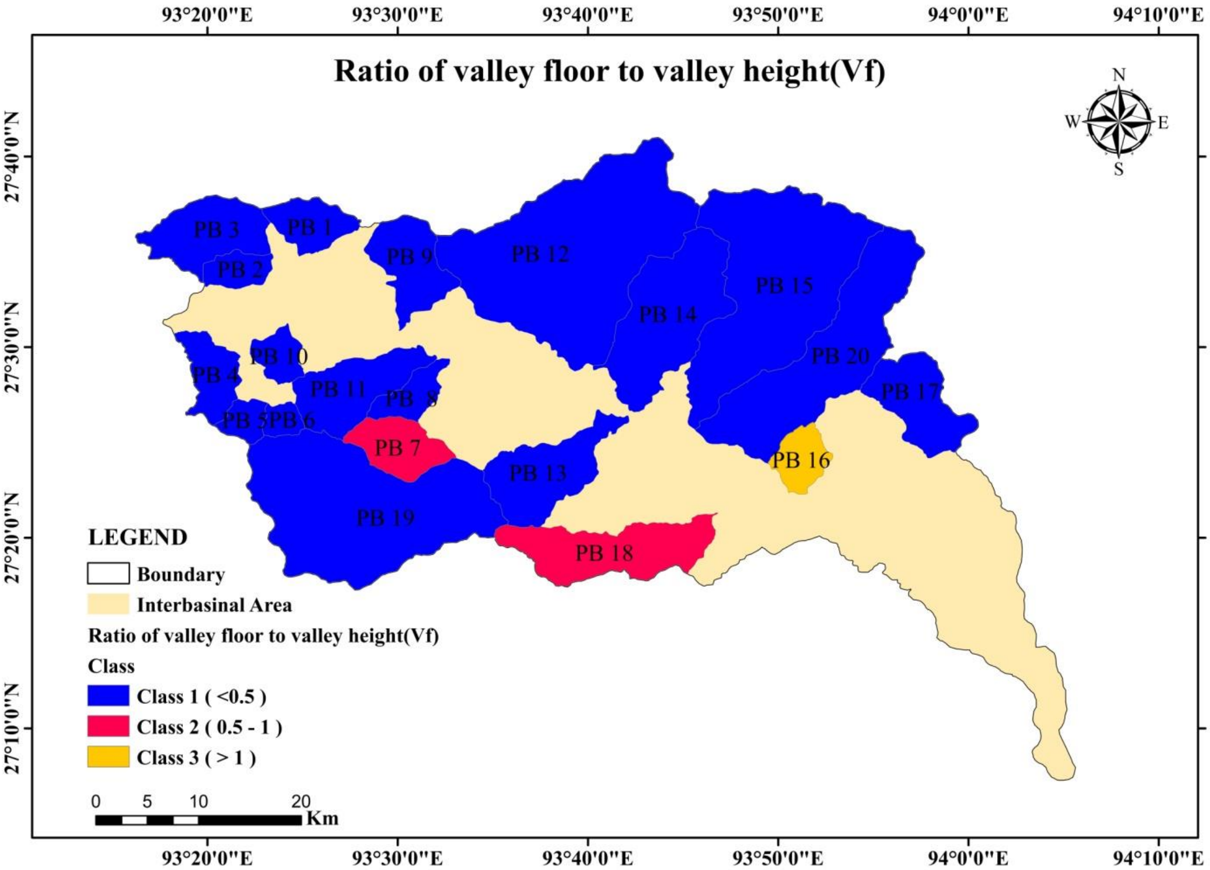

Figure 6.6: Valley floor to valley heights

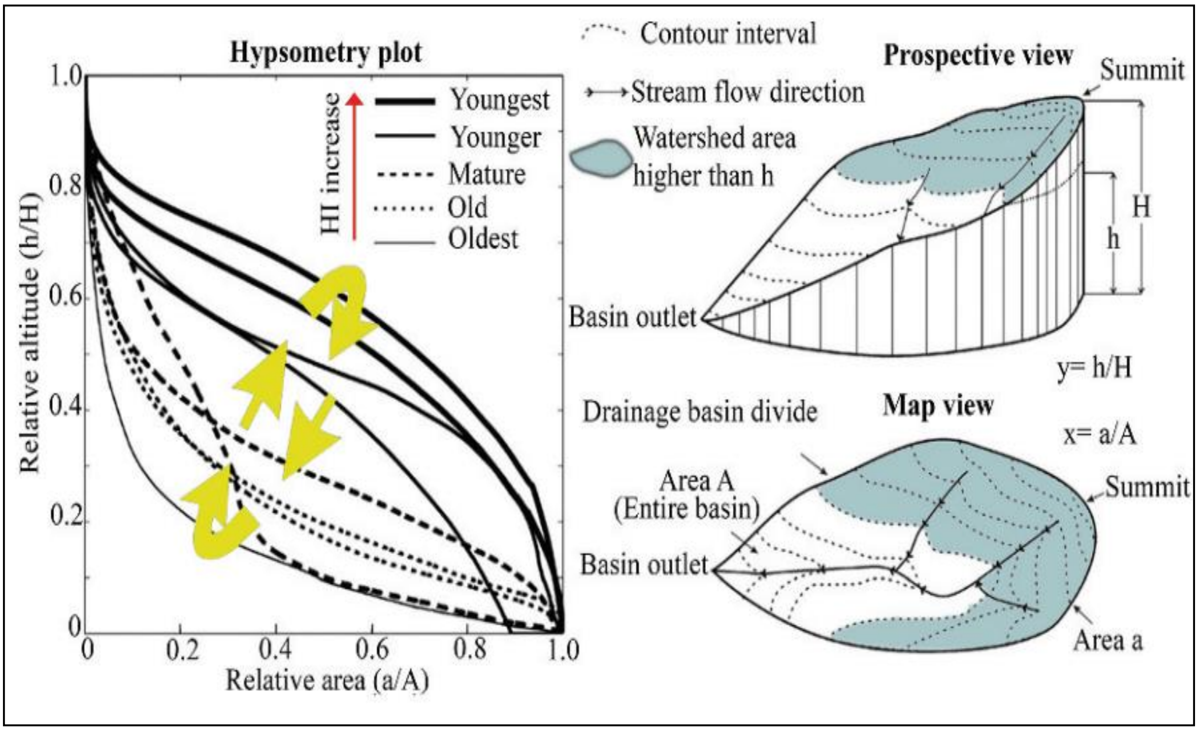

Figure 6.7: Hypsometry plot

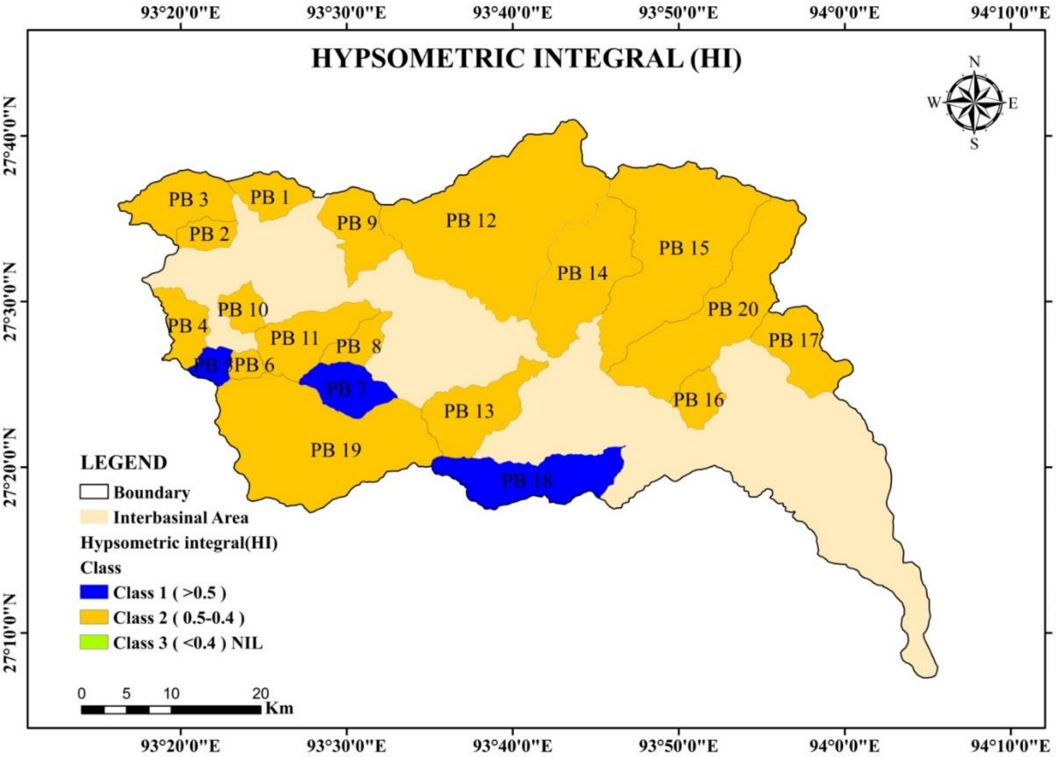

Figure 6.8: Flowchart of Hypsometric Integral

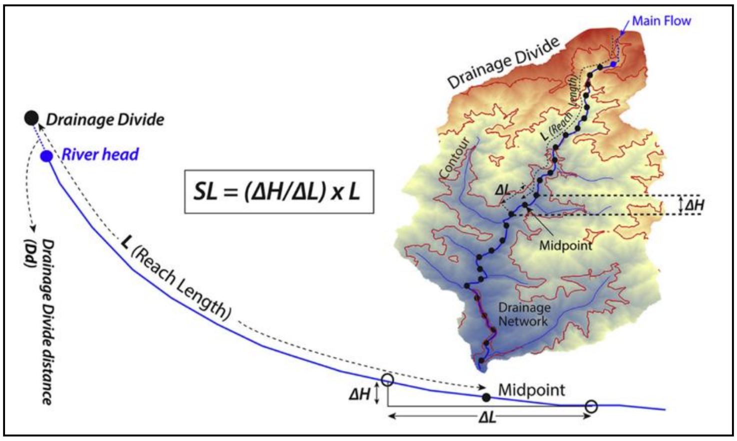

Figure 6.9: Chart of Drainage Divide

The absolute "AF" indices of the sub-basins have been calculated varying from 36.61 to 63.826. Based on these values, the sub-basins were classified into three categories viz. class 1 (AF<50), class 2 (AF-50) and class 3 (AF>50)[10]. Nearly 60% of sub basins belong to class 1, 5% of the sub-basins are under class 2 and the remaining 35% belong to class 3. The basin numbers PB4, PB6, PB9, PB10, PB11, PB15, PB20 and PB21 fell under the class 3 which indicates that these basins are tectonically disturbed.

Drainage basin shape index (Db): The drainage basin shape of an area is an indicator of the relative active tectonism. The "Db" is expressed by the relation:

Db = Bl/Bw

where "Bl" represents the basin length from the headwaters to the mouth and "Bw" represents the width at its widest point. A stretched river basin has a high "Db," whereas circular river basins have few tectonic activities. The model given in the figure 5 explains about the nature of basin elongation and its relation to tectonic activity.

Based on "Db" index values, sub-basins were categorized into class 1 (Db >4), class 2 (3< Db<4) and class 3(Db<3), which describes the elongated, semi elongated and circular basins[10] respectively. The "Db" values of sub-basins in Panyor sub watershed range from 0.68 to 3.89 (Table 1). In study area, there are no elongated sub-basins which are suggesting tectonic activity in the sub-basins. Only two sub-basins (PB 18 and PB 20) are of the semi-elongated type and the remaining sub basins are of circular type.

Ratio of valley floor to valley height (Vf): "Vf" which is measured near the mountain front, reflects the difference between incised V-shaped valleys (wineglass-shaped) and broader U-shaped valleys. It can be calculated using the formula:

Vf = 2Vfw/((Eld-Esc) + (Erd-Esc))

where Vf is the ratio of valley floor to valley height, Vfw is the width of the valley, Eld and Erd are elevations of the left and right valley dividing respectively and Esc is the elevation of the valley floor. The model clearly indicates the estimation of Vf ratio.

The index reflects the difference between incised V-shaped valleys (wineglass-shaped) and broader U-shaped valleys. Lower values of "Vf" are along the mountain front, where the rates of vertical tectonics are high. Also, "Vf" values are less than 1, in "V" shaped valleys with linear, active down cutting streams, which are subjected to active uplift. Similarly, "Vf" values are greater than 1 in U-shaped (flat-floored) valleys with a base level of erosion in response to relative tectonic inactivity.

The "Vf" of sub-basins ranges from -0.295 (PB 12) to 1.76 (PB 16). "Vf" of sub basins in the study area is classified into three categories viz. class 1 (<0.5) class 2 (0.5-1) class 1 (>1)[10]. About 85% of the sub-basins fall under category 1, in which the majority is distributed in the northern part of Panyor sub watershed. Nearly 10% of sub basins fall in class 2 and the remaining 5% belongs to the class 3 categories. The class 3 sub-basin is found in only one basin (PB 16) of Panyor sub watershed, suggesting tectonic inactivity.

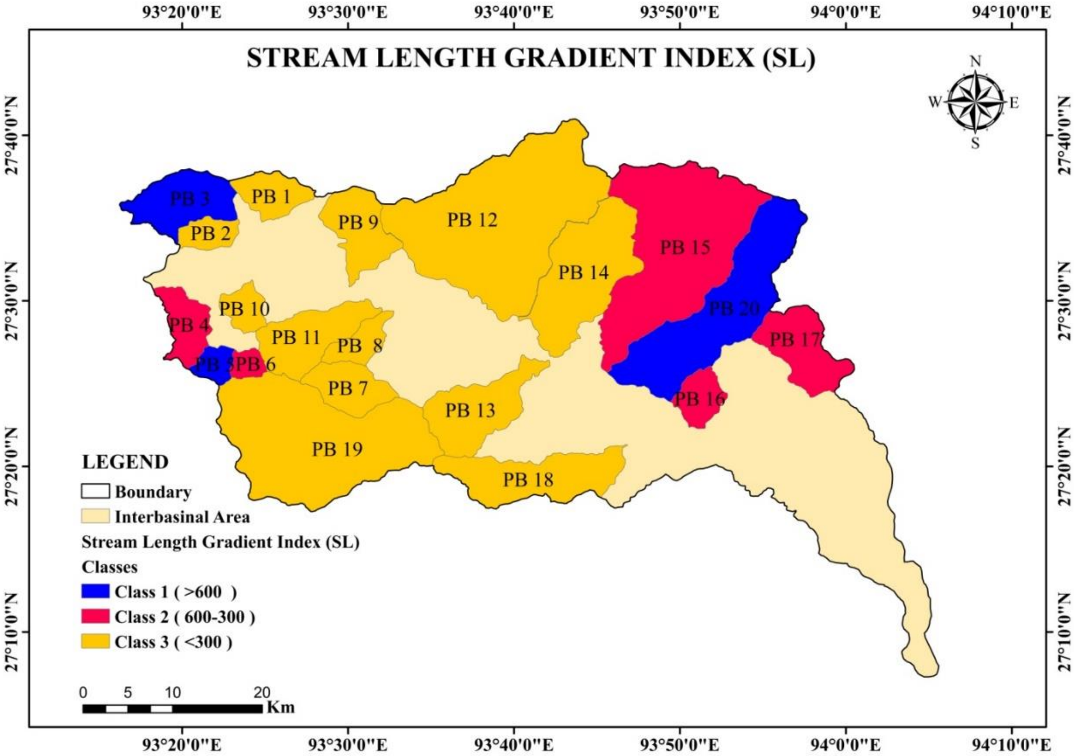

Figure 6.10: Flowchart of Stream Length Gradient Index

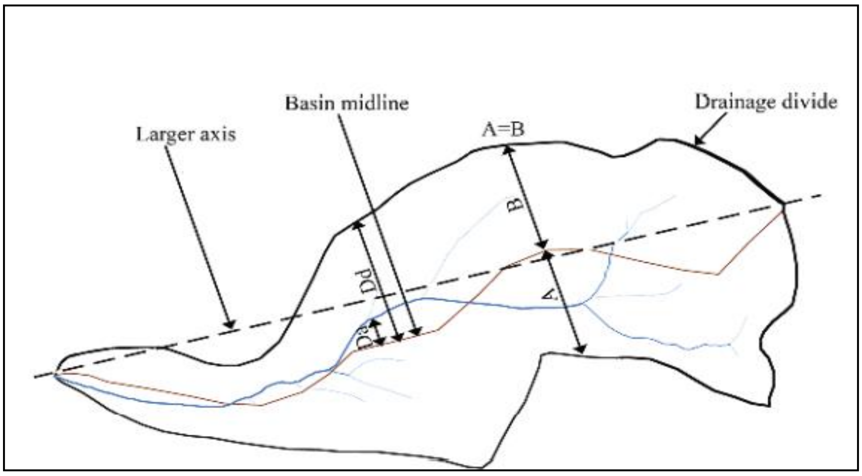

Figure 6.11: Flowchart of Basin Midline

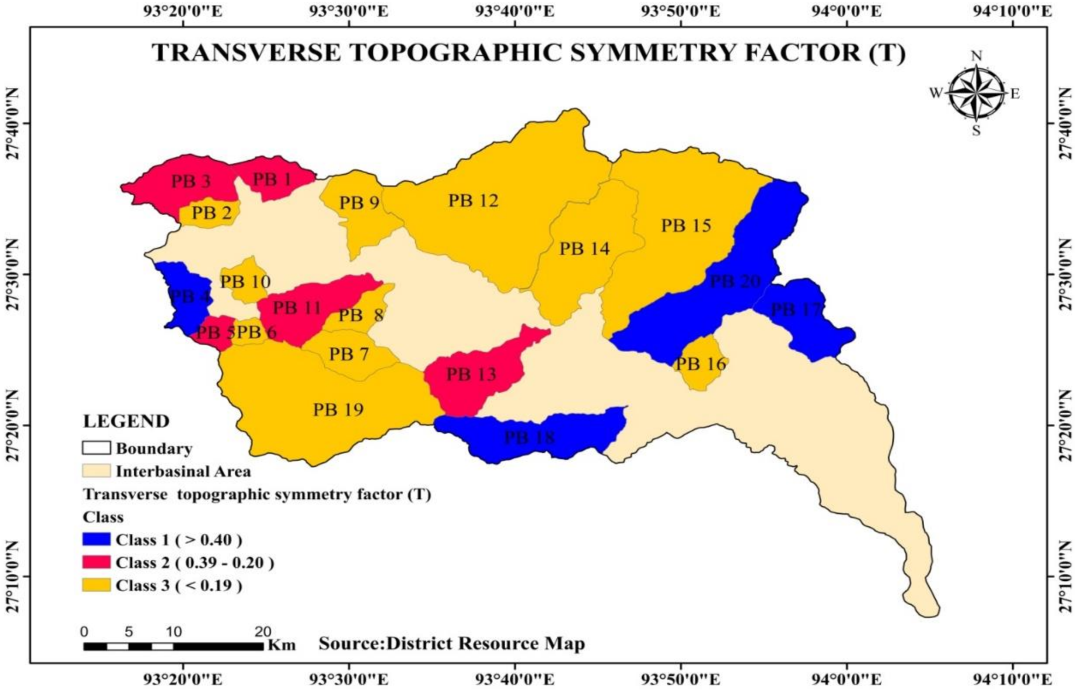

Figure 6.12: Flowchart of Transverse Topographic Symmetry Factor

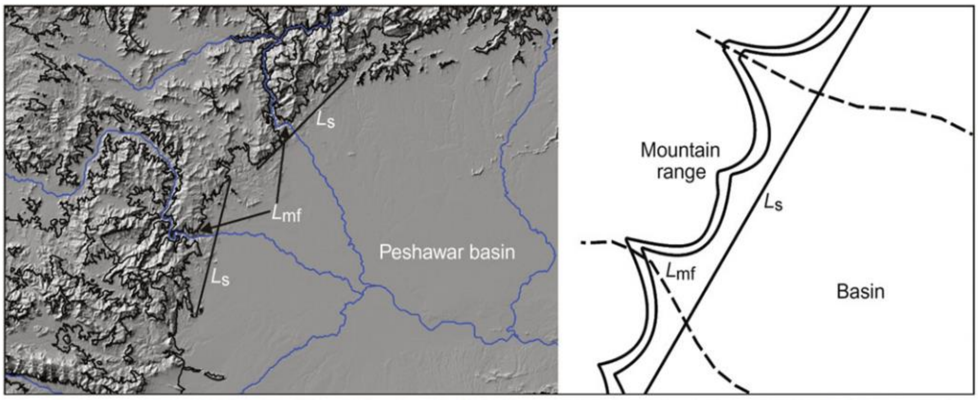

Figure 6.13: Mountain Range

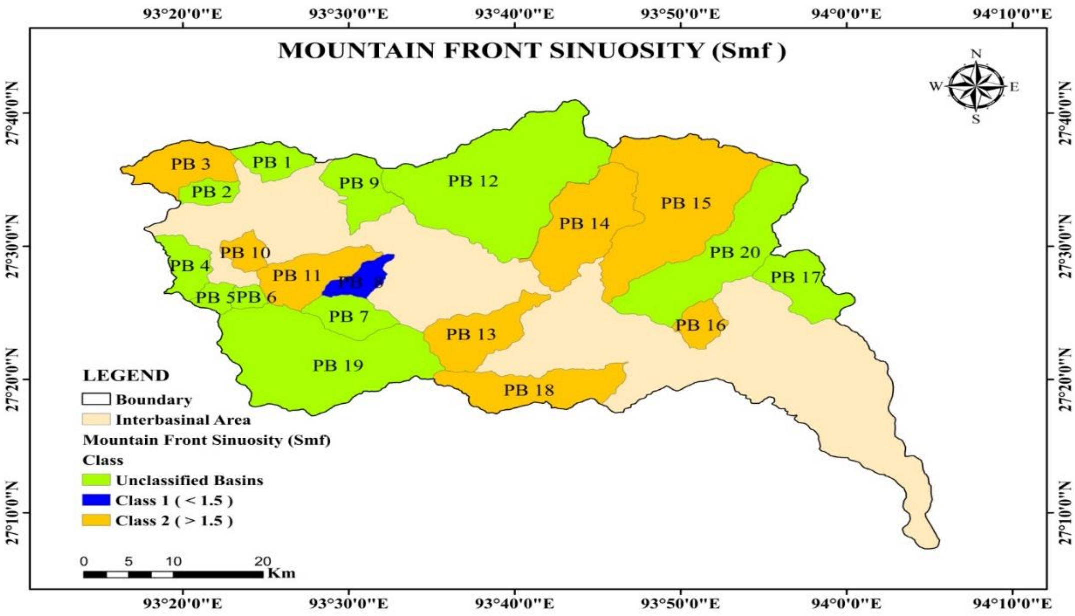

Figure 6.14: Flowchart of Mountain Front Sinuosity

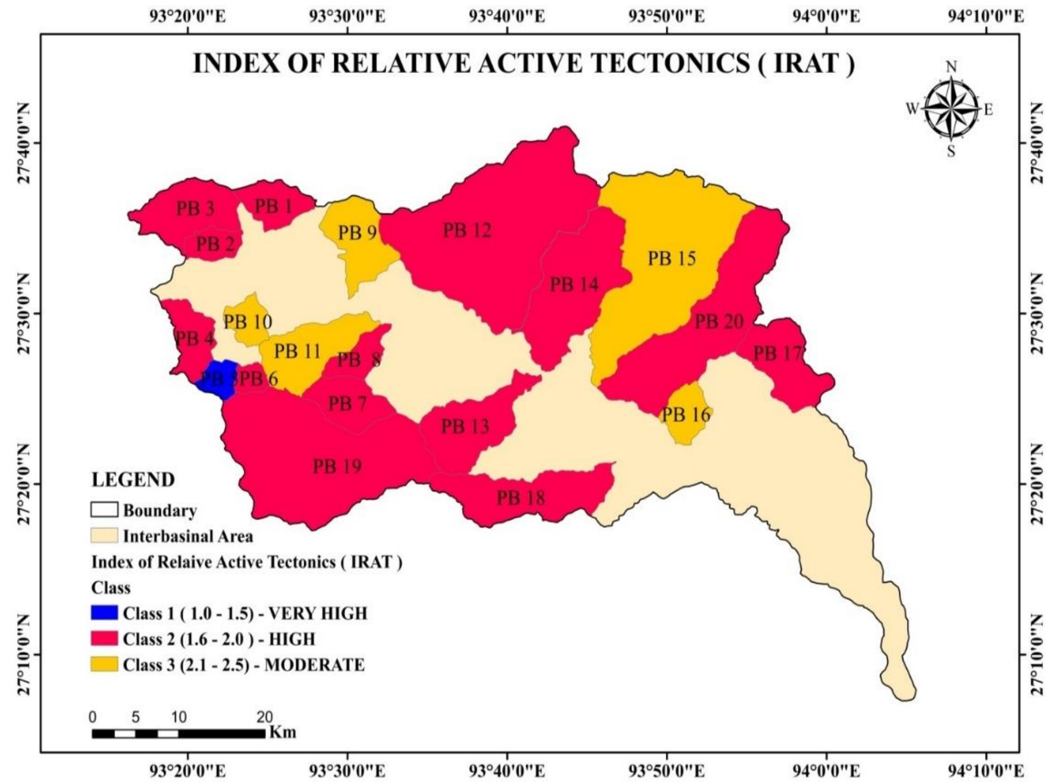

Figure 6.15: Flowchart of Index of Relation Active Tectonics

Table 1
Values of Geomorphic Indices

Basin name	AF	DB	Vf	HI	SL	T	Smf
PB 1	48.13	0.69	0.03	0.45	176.51	0.21	0.00
PB 2	44.21	1.68	0.03	0.50	30.43	0.11	0.00
PB 3	48.66	1.86	0.07	0.49	1198.93	0.20	3.10
PB 4	55.18	1.75	0.01	0.49	488.00	0.44	0.00
PB 5	40.56	1.16	0.00	0.51	607.22	0.27	0.00
PB 6	54.65	0.98	0.04	0.44	376.57	0.15	0.00
PB 7	48.89	1.82	0.53	0.51	117.95	0.11	0.00
PB 8	47.25	2.47	0.03	0.50	205.21	0.18	1.40
PB 9	54.98	1.80	0.24	0.49	245.49	0.11	0.00
PB 10	57.30	1.35	0.05	0.47	203.98	0.10	3.13
PB 11	54.01	1.87	0.05	0.48	205.21	0.19	2.55
PB 12	39.20	1.37	-0.30	0.47	75.26	0.09	0.00
PB 13	49.38	1.98	0.11	0.48	255.41	0.19	4.57
PB 14	36.09	1.96	-0.25	0.50	222.21	0.15	5.20
PB 15	52.05	1.55	0.08	0.46	495.93	0.18	4.62
PB 16	36.61	1.40	1.77	0.49	324.68	0.14	4.01
PB 17	52.58	1.27	0.43	0.49	561.32	0.42	0.00
PB 18	42.85	3.65	0.80	0.51	76.96	0.40	5.80
PB 19	40.12	1.53	-0.07	0.48	225.40	0.10	0.00
PB 20	63.83	3.88	0.34	0.50	645.65	0.36	0.00

Hypsometric integral (HI) factor: Hypsometric integral (area altitude analysis) indicates the cycle of erosion and compares different basins with erratic areas. Hypsometric analysis can be used to distinguish between erosional landforms at various stages of evolution due to hydrologic processes and land degradation factors. The hypsometric integral is defined as the area below the hypsometric curve and thus expresses the volume of a basin that has not been eroded. "HI" is represented by the distribution of the horizontal cross-sectional area of a landmass with respect to elevation. It describes the distribution of elevations in a drainage area and suggests the balance between internal as well as external processes in a basin. The internal processes tend to create relief and the external processes tend to lower the landscape. "HI" has an inverse relation with the total relief, slope steepness, drainage density and channel gradients. The given model explains hypsometry from oldest to youngest stage of the river. "HI" can be calculated using the relation:

HI = (Elev mean-Elev min)/(Elev max-Elev min)

The analysis of "HI" values as well as hypsometric curves provides vital information about the tectonic behavior of river basins along with the erosional stage of watersheds. The youthful stage of river basins is represented by convex curves with high "HI" values, the mature stage by concavo-convex or straight curves and the old stage by concave curves with low "HI" values). "HI" values range from 0 to 1[15,16]. High and intermediate to low "HI" values indicate drainage basins with youthful topography stage and mature stage with even dissection respectively. "HI" $\leq$0.3, 0.3 $\leq$ "HI" $\leq$0.6 and "HI" $\geq$0.6 represent the different erosional statuses of basins such as fully stabilised stage, erosion prone stage and high erosion disposed of the stage. Tectonically active basins are highly susceptible to erosion.

The degree of the extent of tectonic activity in Panyor sub watershed was analyzed based on the HI. Sub basins value of HI varied from 0.46 to 0.51 and classification was done based on the "HI" values, the sub-basins of Panyor sub watershed are categorized into three classes viz. class 1(HI > 0.5), class 2 (0.5 < HI > 0.4) and class 3 (HI < 0.40), which represent active basin moderately active basin and less active basin, respectively. Around 10% of sub basins fall in class 1, the remaining 90% in class 2 and class 3 is fully absent. The majority of the active sub-basins are distributed along the north western part of the Panyor sub watershed which is highly erosive due to the effect of active neotectonism. The hypsometric curves of three representative sub-basins from class 1and class 2 were plotted as shown in the map.

Stream length gradient index (SL): The "SL" index can be used to understand the relative tectonic activity in an area which describes the topographic evolution and river course deviation due to the variable strength of rocks and soils over which the river flows. Subsequently, the erosional processes approach a dynamic equilibrium, typically resulting in concave longitudinal river profiles. These deviations from stable river profiles are generally caused by tectonic, lithological, or climatic factors. "SL" index is given by the relation:

SL = (ΔH/ΔLr)×Lt

where "ΔH" is the change in altitude, "ΔLr" is the length of a reach and "ΔLt" is the horizontal length from the basin divide to the midpoint of the reach.

Rocks of consistent resistance showing a high value of stream length gradient index or fluctuation of "SL" values indicate the active tectonism in the area. Based on SL values, the sub-basins are classified into class-1 (SL >600), class 2(300≤SL<600) and class 3(SL<300). The "SL" values of sub basins in Panyor sub watershed range from 75.27 (PB12) to 1198.93(PB3). About 10% of sub-basins belong to class 1 (SL >600), 25% belong to class 2 (SL between 300 and 600) and the remaining 65% belong to class 3 (SLL <300). The majority of the class-1 and class-2 sub-basins are located in the eastern parts of the study area, which lie adjacent to Panyor river, indicating moderate to high tectonic activity.

Transverse topographic symmetry factor (T): The transverse topographic symmetry factor assesses the degree of tilting of a drainage basin resulting from active tectonics and detects the zones of lateral shifting. "T" can be determined by the relation:

T = Da/Dd

where "Da" is the distance from the midline of the basin to the main river axis and "Dd" represents the distance from the basin midline to the boundary of the basin divide. "T" factor is a vector quantity with values ranging from 0 to 1. Basins with "T" values near to "0" are symmetric and those with values close to "1" are tilted[8,15].

The dominant direction of drainage in a basin can be represented by the direction of a mean resultant vector calculated from a set of vectors. The ratio of the length of the resultant vector to the number of the calculated vectors, which is a measure of dispersion, is represented by the mean resultant length with values ranging from "0" to "1." The values of mean resultant length close to "1" indicate small dispersion from the main direction and those close to "0" indicate wide dispersion. A possible tectonic signature in a drainage basin can be understood by a set of values in broad areas.

The "T" factor values of the sub-basins vary from 0.12 (SB6 and SB 12) to 0.54 (SB 36) and are categorized into 3 viz. class 1(T > 0.40), class 2 (0.20 < T > .39) and class 3(T<0.19) based on the degree of tilting. About 20% of the sub-basins in Panyor watershed fall in class 1, 25% in class 2 and 55% in class 3. Sub basins PB4, PB17, PB18 and PB20 are characterized by a relatively higher "T" factor, which indicates the migration of river channels from the mid-line of the sub-basins. Such migrations usually occur as a result of ground tilting or differential erosion. The migration directions of the river channels are usually the same as that of tilting. However, a lower "T" factor was also identified in 11sub basins indicating lesser migration of river channels.

Mount front sinuosity (Smf): Mountain front sinuosity is defined as the ratio of the length of the mountain front along the foot of the mountain to the straight-line length of that front. Smf can be calculated using the formula:

Smf = Lmf/Ls, where "Smf" is mountain front sinuosity, "Lmf" is the length of the mountain front along with the topographic break in slope at the foot of the mountain and Ls is the straight-line length of the mountain front.

“Smf” represents the balance between erosion that tends to produce asymmetrical or sinuous fronts and tectonic forces that tend to create a straight mountain front coinciding with an active range-bounding fault. Values of “Smf” approach 1.0 on the most tectonically active fronts whereas “Smf” increases if the rate of uplift is reduced and erosional processes begin to form a front that becomes more irregular with time. “Smf” values less than 1.4 indicate tectonically active fronts[15].

The “Smf” values of the sub-basins were classified into three classes viz. class 1 (< 1.5) and class 2 (>1.5). The “Smf” values of subbasins vary from 1.42 (PB 8) to 5.81 (PB 18), as shown in table 2. The “Smf” values were not calculated in 11 sub-basins due to their abrupt change in slope and lack of a prominent mountain front. Out of the remaining sub-basins, class 1 and class 2 represent 5% and 40% of sub basins respectively. The above said geomorphic indices were used to calculate the relative active tectonic index to understand the tectonic activities in Panyor sub watershed.

The tectonic activities in the area were analysed with the geomorphic indices and the values of different indices are shown in table 1. The calculated values of each parameter are detailed as follows:

Evaluation of index of relative active tectonics (IRAT): IRAT describes the spatial distribution of relative active tectonics in an area by combining the mean of the class values of seven computed geomorphic indices. Numerous approaches used a combination of two or more indices to provide semi quantitative information regarding the relative tectonic activity in active mountain ranges. “IRAT” index is calculated by the formula:

IRAT = S/N

where “S” is the sum of the class values of geomorphic indices used and “N” is the number of selected geomorphic indices. The “IRAT” indices can be grouped into four classes based on the degree of relative tectonic activity[10] which are class 1 (1.0 to 1.5), class 2 (1.5 to 2) and class 3 (2.0 to 2.5) with very high, high and moderate relative tectonic activity respectively.

The classes of all geomorphic indices including “IRAT” are given in table 2. The “IRAT” values vary from 1.17 to 2.29 (Figure 7). Only one basin (PB 4) sub basins come under the class 1 category, which represents very high relative tectonic activity. About 70% of sub-basins fall in the “IRAT” class 2, which represents high relative tectonic activity and 25% of the area comes in class 3 which signifies moderate relative tectonic activity.

There is no class 4, representing low relative tectonic activity. The spatial distribution of different “IRAT” classes among sub-basins shows a gradational pattern from South west to North east indicating the tectonic activity in the Panyor sub watershed. The majority of the sub-basins in the western parts of the basin is characterised by moderate “IRAT” values and this may be related to the erosion prone conditions in the relatively plain areas.

Table 2
“IRAT” value and classes of sub-basins in Panyor sub watershed

Basin name	AF	DB	vf	HI	SL	T	Smf	IRAT value	IRAT class
PB 1	1	1	1	2	3	2	0	1.83	2.00
PB 2	1	1	1	2	3	3	0	1.57	2.00
PB 3	1	1	1	2	1	2	3	1.67	2.00
PB 4	3	1	1	2	2	1	0	1.17	1.00
PB 5	1	1	1	1	1	2	0	2.00	2.00
PB 6	3	1	1	2	2	3	0	1.83	2.00
PB 7	1	1	2	1	3	3	0	1.86	2.00
PB 8	1	1	1	2	3	3	2	2.17	3.00
PB 9	3	1	1	2	3	3	0	2.29	3.00
PB 10	3	1	1	2	3	3	3	2.14	3.00
PB 11	3	1	1	2	3	2	3	1.83	2.00
PB 12	1	1	1	2	3	3	0	2.00	2.00
PB 13	2	1	1	2	3	2	3	2.00	2.00
PB 14	1	1	1	2	3	3	3	2.14	3.00
PB 15	3	1	1	2	2	3	3	2.14	3.00
PB 16	1	1	3	2	2	3	3	1.67	2.00
PB 17	3	1	1	2	2	1	0	1.86	2.00
PB 18	1	2	2	1	3	1	3	1.83	2.00
PB 19	1	1	1	2	3	3	0	1.67	2.00
PB 20	3	2	1	2	1	1	0	1.67	2.00

However, PB 9, PB 10 and PB 11 in the central western part of Panyor sub watershed exhibit variations in “IRAT” classes as compared to the surrounding sub-basins. The moderate “IRAT” class of these three sub-basins suggests tectonic disturbances. The sub-basins with high relative tectonic activity are mainly distributed in the south western part of Panyor sub watershed.

Discussion

The results of the analysis of “IRAT” show that the panyor sub watershed is tectonically active and the intensity of tectonism is comparably more in the sub basins in the western part of panyor sub watershed. Earthquakes can often be related to tectonic activities. Several studies have been carried out so far on the occurrence of moderate earth quakes in Peninsular India, which are generally caused by the northward movement of these compressional tectonic regimes. The longitudinal profile of the Panyor River channel, observed from the Lichi village (located within a zone of the Bomdila Thrust and MBT) onwards up to its confluence with the Subansiri River, also shows structurally controlled nature of its channel on its short stretch of 25.25 km flow on the Siwaliks.

This river originates from the domain of the Lesser Himalayan region, the MBT associated with the passing of a N–S trending fault, a NW–SE trending transverse fault, Tipi thrust, a shutter ridge, Dikrang fault, a NW–SE trending transverse fault and Kimin anticline respectively, across the channel. The activeness of the basin is evidenced by the recent earthquakes reported in the neighbouring area, which might have been caused by the impact of the main boundary thrust and shear zones. This study concludes that neotectonic disturbances in the area, especially in the western parts of Panyor sub water shed, have a control on the drainage network evolution of the basin.

Conclusion

The response of the landforms to tectonic deformative processes can be effectively understood through geomorphic indices. The extend of neotectonism was analyzed using geomorphic indices such as asymmetry factor, transverse topographic symmetry factor, hypsometric integral, stream-length gradient index, drainage basin shape index, ratio of valley floor to valley height and mountain front sinuosity with the values varying respectively. Based on the individual geomorphic indices, it is observed that almost all the basins are tectonic active except basin number. Further, the relative active tectonics index (IRAT) was derived from the geomorphic indices using GIS and values varying from 1.17 to 2.29.

Based on the degree of relative tectonic activity, Panyor sub watershed was classified into class 1,2 and 3 corresponding to very high (1.0-1.5), high (1.5-2) and moderate (2.0-2.5) tectonically active basins. The basin 5 indicates very high relative active tectonic in the Panyor subwatershed based on the IRAD calculations. The spatial distribution of different “IRAT” classes shows a gradational pattern from south west to north east suggesting a gradual increase in the neotectonic activity in the basin.

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