Chapter - 7

MORPHOTECTONIC ANALYSIS

The channel configuration of all the drainage basins were quantitatively analyzed for stream order, drainage density and bifurcation ratio (Horton, 1945; Tucker and Bras, 1998). The morphotectonic parameters are useful for quantitative measurement of drainage basin topography to the regions undergoing tectonic deformation (Keller and Pinter, 2002; Dehbozorgi et al., 2010; Gao et al., 2013). In the present study, several morphotectonic parameters are calculated to distinguish the tectonically active regions by studying the major drainage basins. The detailed methodology regarding the geomorphic indices and morphotectonic parameters applied in the both the domains are explained below.

7.1 METHODOLOGY

7.1.1 Geomorphic indices

The geomorphic indices calculated are divisible into three aspects: linear, areal and relief as given in Table 7.1. The basin length, perimeter, area, stream number, stream order, channel slope, drainage density has been extracted from DEMs. Stream frequency (Fs), drainage texture (T), form factor (Ff), elongation ratio (Re), circularity ratio (Rc), relief ratio (Rr), ruggedness number (Rn) are calculated with the help of extracted data.

Linear aspect

For basin analysis, primarily ordering of stream is important to understand the variation in dimensions of the channel and drainage basin. Horton (1945) proposed the ordering of stream and Strahler (1964) then modifying the ordering pattern which has been adopted in this study. The size of river and basin varied greatly with the order of the basin. Ordering of streams is the first stage of basin analysis. The stream order (u) was first proposed by R.E Horton (1945), which led to the development of certain laws of drainage composition. Subsequently (Strahler, 1964) modified Horton's scheme of stream ordering by removing the problem of reclassification and renumbering of streams. The scheme of A.N Strahler is thus considered as the most simplest and easy for application and it has been extensively used by the geomorphologist for the morphometric analysis of network.

Table 7.1 Geomorphic indices of the drainage basin with units along with its mathematical expression and references.

Parameters	Definition	Source
Linear Aspects		
Perimeter (P) (km)		
Basin Length (Lb) (km)		
Stream Order (U)		Strahler (1957)
Stream number (Nu)		
Stream Length (Lu) (km)		Horton (1945)
Bifurcation ratio (Rb)	Rb = Nu/N(u+1)	Horton (1945)
Areal aspects		
Area (A) (km^2)		
Drainage density (Dd) (km km^{-1})	Dd = ΣLt/A	Horton (1945), Smith (1950)
Stream Frequency (Fs) (km^{-2})	Fs = Nt/A	Horton (1945)
Drainage Texture (T) (km km^{-4})	T = Dd x Fs	Smith (1950)
Form factor (Ff)	Ff = A/Lb^2	Horton (1945)
Circularity ratio (Rc)	Rc = 4πA/P^2	Miller (1953)
Elongation ratio (Re)	Re = 1.128√A/Lb	Schumm (1956)
Basin shape index (Bs)	Bs=Bl/Bw	Cannon (1976)
Relief Aspects		
Basin relief (r)	R = h-H	Schumm (1956)
Relief ratio (Rr)	Rr = R/Lb	Schumm (1956)
Ruggedness number (Rn)	Rn = R x Dd	Strahler (1958)

The foremost quantitative data required to calculate basic geomorphic indices are total stream number (Nu), total number of stream segments and total length of individual stream segments of each order. Stream length (Lu) measures the average (or mean) length of a stream in each orders, and is calculated by dividing the total length of all the streams in a particular order by the number of streams in that order. The stream length in each order increases exponentially with increasing stream order. These data helps further to calculate stream bifurcation ratio (Rb) and mean bifurcation ratio (Rbm). The bifurcation ratio is the ratio between the numbers of streams in one order and is calculated by dividing the number of streams in the lower by the number in the higher of the two orders. The Rb value of large basins is generally the average of the bifurcation ratios of the stream orders within it. It can be calculate by using the formula; Rb= Nu / (Nu+1), where, Nu = number of streams of a given order and (Nu+1) = number of streams of the next higher order. Presence of higher R_b values suggests the drainage complexity and structurally disturbed topography (Reddy et al., 2004). Mean Bifurcation Ratio (Rbm) is calculated as the arithmetic mean bifurcation ratio (Rb) and the result is tabulated corresponding to sub-order basins. The higher Rbm value indicates there may be some structural distortion in that basin area.

Areal aspect

The maximum basin length (L_b) value parallel to the main drainage line and perimeter (P) is extracted to characterize drainage basin shape by calculating elongation ratio (R_e), circularity ratio (R_c) and form factor (F_f). Elongation ratio (R_e), primarily used by Schumm (1956), ranges from 0 (highly elongated) with high relief and gradient steepness to 1 (circular) with low relief area (Strahler, 1964). Miller (1953) defined circularity ratio (R_c) used to distinguish the structural control on drainages by knowing the basin shape. Lower R_c value indicates strong structural control on drainage configuration. Horton (1932) suggested form factor (F_f) used to characterize different basin shape. The drainage density (Dd) defines the significant phase of the morphologic development of fluvial landscape (Horton, 1932; Horton 1945; Smith 1950; Tucker and Bras, 1998). Stream frequency (Fs) describes stream segment in a unit area by calculating the ratio of total number of streams to the basin area. The higher stream frequency referred to the enormity of the landmass and regional inclination of slope. The ratio of total number of streams of all orders in basin (Lt) to the perimeter (P) of the basin is drainage texture (T) defined by Horton, 1945 and classified by Smith (1950) in to coarse to very fine (<2 to >8). The highly undulating terrain shows fine to very fine texture that reveals high development of fluvial system in any basin. Horizontal projection of basin shape is described by the elongation ratio and drainage basin shape index (Bs) (Cannon, 1976; Ramírez-Herrera, 1998). Bs is expressed by the equation, Bs=Bl/Bw, where, Bl is the length of the basin measured from source to mouth and Bw is the width of the basin at the widest point. The shape and steepness verifies the rapid uplifting mountain fronts and basin widens from the mountain front during weak tectonic activity (Ramírez-Herrera, 1998). In the present study area, maximum basin shows elongate shape inferring to the ongoing tectonism that is sensitive to river and bedrock topography.

Relief aspect

The relief parameter calculations is also applied to understand the channel gradient from source to mouth, channel slope changes and relief of the basin. The basin relief (r) is an important index to document the hydrological parameters by measuring the slope of the basin (Horton, 1945; Strahler, 1957). Basin relief (r) is the difference between highest and lowest elevation of the basin area from the drainage divide to the mouth (Costa, 1987). Greater relief is always observed on the drainage basin located at higher elevations linked with elevated and abrupt hillslopes and fast denudation rate (Keller and Pinter, 2002). The relief reduces up to 10% of its original value without any uplift in 11 years or may be more (Ahnert, 1970). Relief ratio (Rr) is the ratio of the basin relief of the particular drainage basin to its length (Schumm, 1956) signifying the relative relief irrespective of the topographic variation (Costa, 1987). Ruggedness number (Rn) is the product of drainage density and basin relief (Costa, 1987) representing the terrain complexity with that of its relief (Reddy et al., 2004; Altin and Altin, 2011). Low relief areas with higher drainage density will show highly rugged terrain than low drainage density with high relief areas (Costa, 1987).

7.1.2 Morphotectonic Parameters

The morphotectonic indices that were integrated along with the basic basin parameters are Basin shape index (Bs), Stream length-gradient index (SL index), Valley floor width to height ratio (Vf ratio), basin Asymmetric Factor (AF) and Hypsometric curve and hypsometric integral for estimating tectonic influences on landscape development of the basins.

Stream length-gradient index

Relating to stream power and being sensitive to minor channel slope changes (Hack, 1973; Font et al., 2010; Joshi et al, 2013), stream length-gradient index (S_L) proposed by Hack (1973) is an effective tool to calculate the rock strength by identifying the landscape changes to know possible tectonic activity, topography and rock resistance (Keller and Pinter, 2002; Troiani, 2008). SL index defined by Keller and Pinter (2002) as:

$$\mathbf{SL = (\Delta H/\Delta L)\ L}$$

Where, ΔH is the altitude variation of the segment, ΔL is the length of the segment, ΔH/ΔL is the channel slope or gradient of the segment and L is the length of the channel from the center of a segment from where SL is calculated to the highest point of the drainage divide. Lateral difference in SL index usually reflect variations in lithologic or tectonic controls (Burbank and Anderson, 2001). By classifying high and low SL index on a specific rock type indicate tectonic activity or present day tectonic activity is indicated respectively (Keller and Pinter, 2002).

Basin asymmetry factor (AF)

For understanding the occurrence of active tectonic deformation in any drainage basin, its shape and stream pattern has to be observed (Keller and Pinter, 2002). The basin asymmetry factor is thus calculated to identify the basin sloping relative to tectonic tilting at the basin scale (Keller and Pinter, 2002; Pérez-Peña et al., 2010; Dehbozorgi et a., 2010; Mahmood and Gloaguen, 2012; Joshi et al., 2013). AF is expressed as:

$$\mathbf{AF = 100\ (Ar/At)}$$

Where, Ar is the area to the right side of the basin (facing downstream) of the main trunk channel and At is the total area of the drainage basin. If the value is greater or smaller than 50, it shows the basin tilt (Keller and Pinter, 2002).

Valley floor width-to-height ratio (Vf ratio)

To understand the uplift rates, active or inactive river incision and to differentiate between U and V shaped valley floors (Keller and Pinter, 2002), the ratio of valley floor width to valley height (Vf) has been calculated and it is expressed as

$$\mathbf{Vf = 2Vfw\ /\ [(Eld\text{-}Esc) + (Erd\text{-}Esc)]}$$

Where Vf is the valley floor width to height ratio, Vfw is the valley floor width, Eld and Erd are the left and right side elevations of the valley divides, and Esc is the valley floor elevation. The high value (Vf >1) related with wide valley floor, low uplift rates and low value (Vf <1) indicates V shaped deep valleys with active uplifts and river incision (Keller and Pinter, 2002; Pérez-Peña, 2010).

Hypsometric Integral

For defining the development stages of drainage basin, the study of hypsometric curve and hypsometric integral (HI) are worthy (Strahler, 1952). The hypsometric integral (HI) describes the altitude-area relative distribution of a drainage basin topography while hypsometric curve represents the distribution of elevation with respect to area within it (Strahler, 1952). The HI is computed as

$$\mathbf{HI = (Mean\ Elevation - Minimum\ Elevation)\ /\ (Maximum\ Elevation\text{-}Minimum\ Elevation)}$$

Hypsometric curve

Relative young, mature and old drainage basins is illustrated by observing convex up, S-shaped and concave upward curves respectively (Strahler, 1957; Delcaillau et al., 1998; Keller and Pinter, 2002, Joshi et al., 2013). The hypsometric curve is directed by the stream network, basin geometry and also positively correlated with the rate of upiftment represented in a mathematical model by Willgoose and Hancock (1998).

Table 7.2 Morphometric parameters with its mathematical formula utilized in the present study.

Morphometric Parameter	Mathematical Formula	Description	References
SL index, Stream-length gradient index	SL= (ΔH/ΔL)L	To calculate the rock strength by identifying the landscape changes to know possible tectonic activity, topography and rock resistance. Lateral difference usually reflect variations in lithologic or tectonic controls. By classifying high and low SL index on a specific rock type indicate tectonic activity or present day tectonic activity is indicated respectively.	Hack, 1973; Keller and Pinter, 2002; Troiani and Della Seta, 2008; Font et al., 2010
V_f, Valley floor width-to-height ratio	$V_f= 2V_{fw}/[(E_{ld}-E_{sc}) + (E_{rd}-E_{sc})]$	To understand the effect of tectonics in an uplifting terrain and to identify and distinguish between U-shaped valley and V-shaped valley. The Vf values are totally shape dependent. High uplift rate and deep incised channel shows low Vf value or Vf<1. Low uplift rate and broad channel due to base level erosion shows high Vf value or Vf>1.	Bull and McFadden, 1977; Keller and Pinter, 2002
AF, Asymmetry Factor	AF=100(Ar/At)	To calculate the shape of the drainage basin and for understanding the occurrence of active tectonic deformation. Also, to identify the basin sloping relative to tectonic tilting.	Hare and Gardner, 1985; Keller and Pinter, 2002; Pérez-Peña et al., 2010; Dehbozorgi et al., 2010
Hypsometric curve	x=a/A y=h/H	Curve is directed by stream network, basin geometry and positively correlated with uplift rate. Relative young, mature and old drainage basins is illustrated by observing convex up, S-shaped and concave curves respectively.	Strahler, 1952; Willgoose and Hancock, 1998; Delcaillau et al., 1998; Keller and Pinter, 2002
HI, Hypsometric Integral	$HI=(H_{mean}-H_{min})/(H_{max}-H_{min})$	For defining the development stages of drainage basin, HI value describes the altitude-area relative distribution of a drainage basin topography. The integral value depends on basin area and its geometry.	Strahler, 1952; Keller and Pinter, 2002

7.2 GEOMORPHIC INDICES – RESULTS

This domain is drained by the large Dhantarvadi river basin while Malan and Raidi River covers the other half region. The linear parameters calculated for Dhantarvadi river shows the watershed boundary is 174.5 km larger than Malan and Raidi river basin with perimeter 84.5 and 72.5 km respectively (Figure 7.1, Table 7.3).

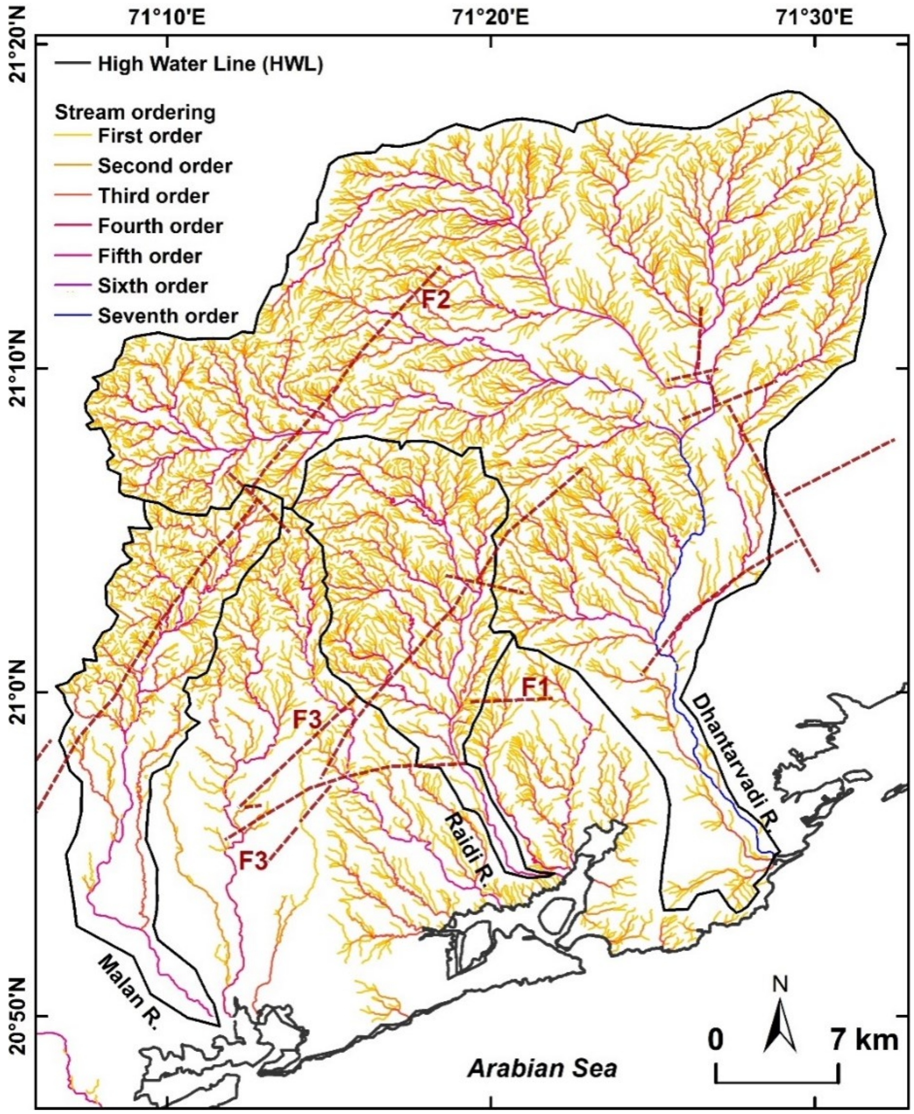

Figure 7.1 Stream ordering map of rivers flowing in morphotectonic domain-I. Note the enormity of Dhantarvadi drainage basin with 7th highest order while other rivers shows 5th highest order.

The basin length and length of main trunk stream of Dhantarvadi River is twice of Raidi River. The highest stream order is 7th order of Dhantarvadi River shows the massiveness with 3141 tributaries of ~2534 km total stream length (Figure 7.1, Table 7.3). However, Malan and Raidi river basin is of 5th order having 1292 drainages with ~937 total stream length of both the drainage basin which is less compare to Dhantarvadi

River (Figure 7.1, Table 7.3). The bifurcation ratio (Rb) calculated shows a special case of 4th and 5th order distortion in all three drainages with highest Rb values (Table 7.4). The cause of such diversion is the parallel drainages along the strike ridges and dyke ridges seen mostly in the middle reaches of the channel. The values indicates strong geological and structural control altering the drainage pattern. The structurally controlled terrain is dominantly at the central part of all basin which consists of southward tilted trappean lava flows and NE trending dyke swarms.

The total basin area covered by Dhantarvadi River is more than double the basin area occupied by Malan and Raidi River combined (Table 7.3). The drainage density (Dd) value is higher in Raidi basin which deduce the strong structural and tectonic control on drainages. The rectangular drainage pattern and anomalous right angle bends are mainly noticed in Raidi drainage system. The evolution of these drainage characteristics corresponds to high Rb and Dd value. However, Raidi basin also shows high Fs and T value (Table 7.3) indicative of higher degree of dissection and low rainfall intensity. The dry broad channel valley is thus observed in the Raidi river basin in the upland zone and over the pediment surface.

Table 7.3 Geomorphic indices results of Malan, Raidi and Dhantarvadi river flowing in morphotectonic domain-I.

Parameters	Malan R.	Raidi R.	Dhantarvadi R.
Linear Aspects			
Perimeter (P) (km)	84.50	72.49	174.51
Basin length (Lb) (km)	33.75	29.31	57.68
Length of the main trunk stream (km)	34	29	58
Highest stream order	V	V	VII
Total number of streams	557	735	3141
Total stream length (km)	384.55	552.35	2534.03
Mean Bifurcation Ratio (Rbm)	4.68	5.22	3.92
Areal aspects			
Basin area (A) (km^2)	153.73	162.35	866.67
Drainage density (Dd) ($km\ km^{-1}$)	2.50	3.40	2.92
Stream frequency (Fs) (km^{-2})	3.6	4.5	3.6
Drainage texture (T) ($km\ km^{-4}$)	9.1	15.4	10.6
Form factor (Ff)	0.13	0.19	0.26
Circularity ratio (Rc)	0.27	0.39	0.36
Elongation ratio (Re)	0.41	0.49	0.58
Basin shape index (Bs)	4.65	2.61	2.06
Relief Aspects			
Basin relief (R)	367	262	429
Relief ratio (Rr)	10.86	8.94	7.43
Ruggedness number (Rn)	917	891	1254

The correlation of several areal parameters calculated for inferring the shape of the basin shows Malan River as an elongated basin associated with relatively high tectonic activity (Table 7.5, Figure 7.2). The Ff value of these basins also infers that elongated basin shape suggesting deeply dissected terrain due to higher degree of dissection and structurally controlled terrain by the presence of faults, dyke ridges, tilted lava flows and trappean hills. The Malan River flows along the fault which divides undulated hilly topography in the west to dyke swarm region in the east. However, other faults mapped in this study are exposed around the Malan and Raidi river basin. This is indicative of fault controlled drainages, however, Dhantarvadi River is at moderate stage of erosion corresponds to less elongated basin shape.

Table 7.4 Bifurcation ratio (Rb) and Mean bifurcation ratio (Rbm) calculated for Malan, Raidi and Dhantarvadi drainages. Note 4th and 5th order streams with highest value indicating strong structural control.

River	Order	Number of streams	Bifurcation ratio (Rb)	Mean Bifurcation Ratio (Rbm)
Malan	1	418	3.98	4.68
	2	105	4.04	
	3	26	3.71	
	4	7	**7.00**	
	5	1	-	
Raidi	1	559	4.20	5.22
	2	133	4.03	
	3	33	3.67	
	4	9	**9.00**	
	5	1	-	
Dhantarvadi	1	2403	4.27	3.92
	2	563	4.14	
	3	136	4.39	
	4	31	**6.20**	
	5	5	2.50	
	6	2	2.00	
	7	1	-	

Table 7.5 Areal aspects parameters for calculating the shape of the drainage basin.

Basin	Nu	Bl	Bw	Bs	A	P	Rc	Ff	Re
Malan R.	557	33.75	7.26	4.65	153.7	84.5	0.27	0.13	0.41
Raidi R.	735	29.31	11.23	2.61	162.4	72.5	0.39	0.19	0.49
Dhantarvadi R.	3141	57.68	27.97	2.06	866.7	174.5	0.36	0.26	0.58

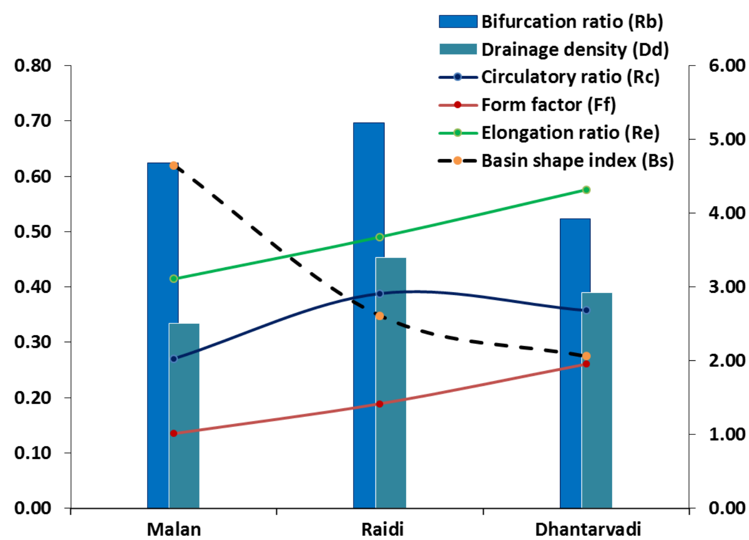

Figure 7.2 Graph showing correlation of calculated areal parameters for knowing the basin shape. Bs is inversely related to the Re and Rb is directly proportional to Dd. Malan River is highly elongated basin and Raidi River is an elongated basin with high Bifurcation ratio and drainage density.

7.3 MORPHOTECTONIC PARAMETERS - RESULTS

7.3.1 Stream length-gradient (SL) index

The SL index value ranges from 5 (Raidi basin) to 242 (Dhantarvadi basin) in this domain. We have divided the SL values and classified into four classes viz., class 1 (<40), class 2 (40-80), class 3 (80-120) and class 4 (>120). The SL values of Malan river basin ranges from 5 to 129 where the 100-80 m elevation shows relatively high SL value i.e. 123 and 129 (class 4). As the area consists of homogeneous lithology or trappean surface with dyke ridges trending ENE to NE, the role of tectonic activity plays an important role in this segment. The elevation 110m also shows comparatively high SL value of class 3 which is indicative of the tectonic control on the basin topography. Several abrupt SL peaks are observed in the Malan River which infers the slope break or sudden contrast of lithology. However, the SL values of Raidi river ranges from 8 to 133 where the higher SL value is at 170m, 140m, 110m and 40 m elevation. The peak between 50m to 40m elevation is due to the presence of Katar Fault (F1) with higher SL value of 133 of class 4. The SL graph of Raidi River shows wave-like pattern with sudden highs and lows inferring the gradient variation in bedrock surface throughout the stream. This river basin is surrounded by several major and local faults along with dyke ridges and tilted trappean lava flows. The basin is structurally controlled by these attributes while tectonically controlled due to fault zones.

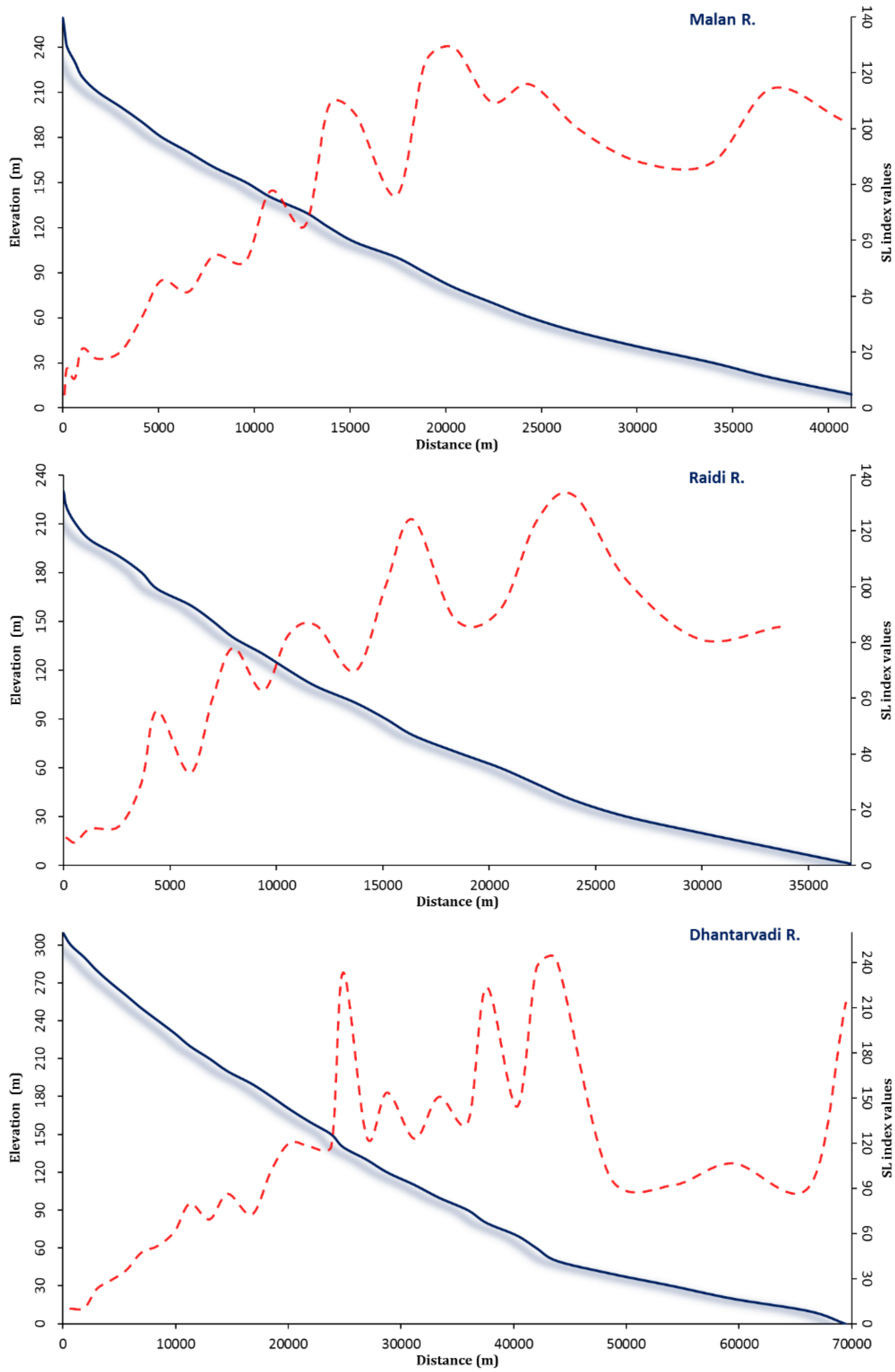

Figure 7.3 Stream length gradient index showing with longitudinal river profile showing sudden peaks at the sharp gradient change in channel bedrock. Note the SL peaks in Dhantarvadi river profile around dyke swarm area.

The SL values of Dhantarvadi River ranges from 10 to 242 with highest peaks noted in the middle reaches of the river at about 140m to 70m altitude. These abrupt peaks are observed around NE-SW trending dyke swarms where streams also shows anomalous bends towards south. The swinging of these dykes ridges from ENE to NE are observed at this terrain. This infers the structurally controlled terrain forming the present-day landscape and rivers are adjusting to the ground slope and hence eroding the extended dykes trending perpendicular to the channel flow. The cluster of peaks observed in the Dhantarvadi River is the zone of the change in the flow path of the main trunk stream from E-W to N-S. Therefore, the maximum SL values of this domain comes under class 3 and class 4 due to abrupt change in slope because of the structurally controlled landscape. Overall, the higher SL values in all the basin is due to the presence of faults, cuesta ridges with NW sloping escarpments, anomalous channel bends towards the regional slope and along the structural features, fault zones with multiple fault planes and slip direction due to reactivation.

7.3.2 Valley floor width-to-height ratio (Vf ratio)

The Vf ratio is measured on the DEM where cross sections were selected from the main trunk channel looking upstream only in the upland zone (Figure 7.4). This is due to the broad valleys over pediment surface shows observed up to coastal zone. For the present study, the ratio was measured to understand the tectonic and structural affect in the channel. The value of the Vf ratio is shown in table 7.6. The v-shaped valley in the upland terrain is the result of the sharp bedrock incision between ridges and trappean lava flows. The unpaired channel divides are observed at the anomalous sharp channel bends. For example, the middle reaches of Dhantarvadi River and upper reaches of Raidi River. The fault controlled drainages shows asymmetric V-shaped valleys inferring strong tectonic control on the domain. The U-shaped broad channel valleys are observed in the lower reaches with approximate width up to 150 m eroding Quaternary miliolite deposits.

7.3.3 Basin Asymmetry Factor (AF)

All three drainage basin are asymmetrical showing tectonic tilting. The asymmetrical factor of Malan and Dhantarvadi River is 42% and 31% respectively which states that some tectonic activity has taken place in the area which makes the stream basin tilted towards west. While Raidi River shows eastward ground tilting with asymmetric factor 0.69 resulting into the shifting of main stream towards right (looking upstream). This infers that the altitude variation is witnessed if we move from west to east.

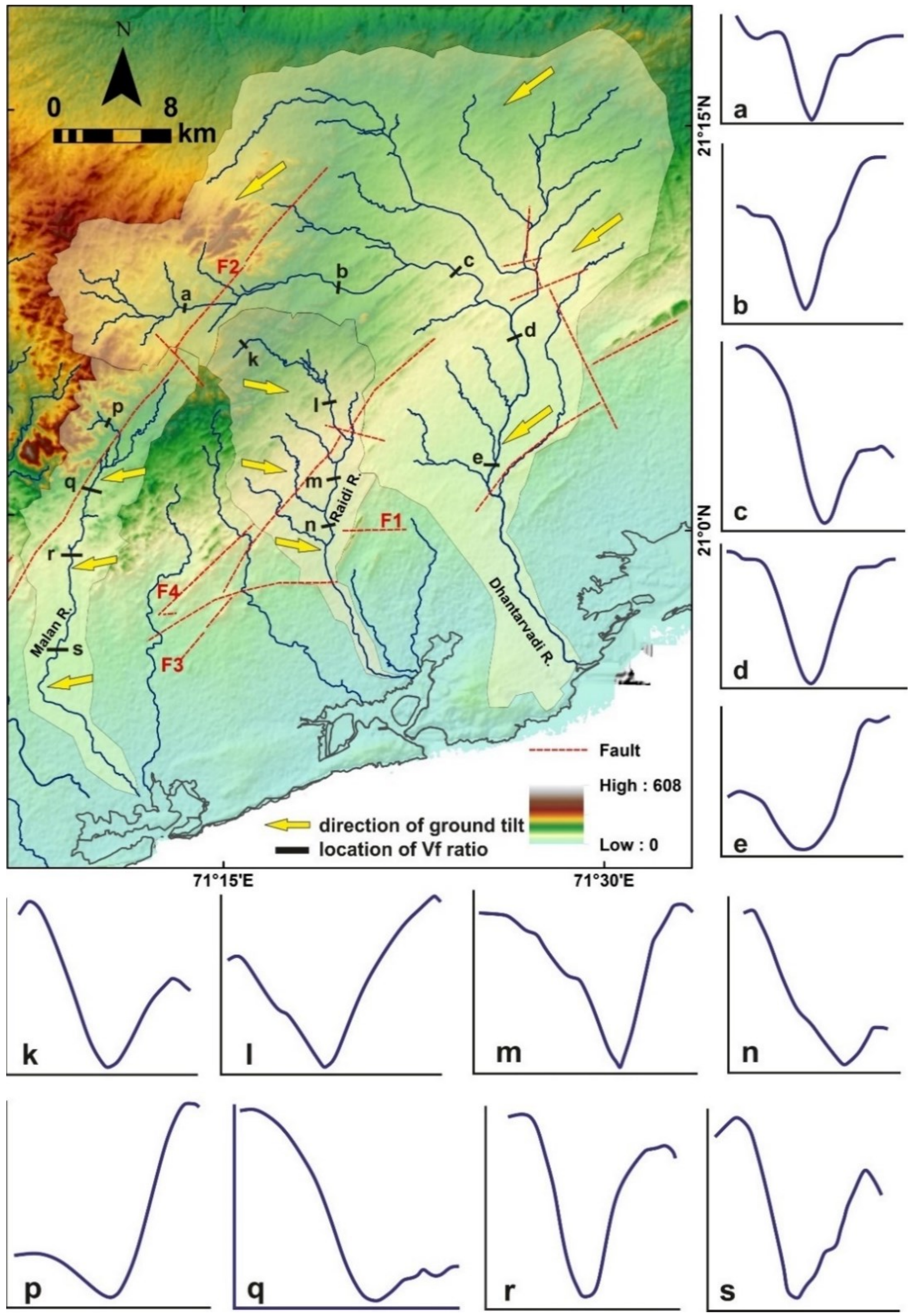

Figure 7.4 DEM showing drainage basin with south to southeast flowing channels. The black line is the cross-section locations of Vf ratio calculated showing channel valley shape. Cross-sections of Dhantarvadi River (a, b, c, d and e), Raidi River (k, l, m and n) and Malan river (p, q, r and s). Note the drainage divides unpaired near anomalous channel bends. Yellow arrow suggests the direction of the tectonic tilting of the basin. Note that W to SW tilting of Dhantarvadi and Malan River while Raidi River shows the opposite ground tilt.

The Malan river basin shows westward shifting of main stream away from Raidi river basin. There is presence of Malan River Fault passing between main trunk stream of

Malan and Raidi River. This may be the sole reason for the regional ground tilt of the main channel away from each other. Moreover, the dyke swarms also rotates from NE-SW to NNE-SSW around these region indicating some regional stress. While Dhantarvadi river basin, east to Raidi River, shows westward ground tilt and is highly asymmetrical. The asymmetry is about 30% where the main trunk stream is also shifting towards west. The Raidi and Dhantarvadi river basin results in the shifting of the main stream in opposite direction but towards the common drainage divide. This infers that all the basin of the present study area are highly asymmetrical and tilted which also shows shifting of the main trunk stream. The area is highly structurally controlled and it detects the presence of tectonics in larger scale.

Table 7.6 Valley floor width to height ratio, Asymmetric factor and Hypsometric integral calculated for river flowing in morphotectonic domain-I.

Basin	Vf ratio	Basin area (A) km^2	Area of a part of a basin on the right of the main stream (looking downstream) km^2	AF %	Maximum elevation (m)	Mean elevation (m)	Minimum elevation (m)	Hypsometric Integral
Malan R.	0.52 1.62 2.17 6.25	154	64.92	42	375	129.8	8.3	0.33
Raidi R.	0.92 0.96 0.70 3.06	162	112.51	69	268	113.8	6	0.41
Dhantarvadi R.	1.63 0.94 1.24 1.03 7.72	867	269.10	31	430	148.7	1.1	0.34

7.3.4 Hypsometric integral (HI)

To characterize the shape of the drainage basin, the hypsometric integral (HI) is to be calculated. The high integral values of Raidi river basin indicates that the topography of the area is high relative to its mean elevation. This is indicative of strong denudation in the upland zone by deeply incised streams. The intermediate Hi value of the Malan and

Dhantarvadi river basin indicates that the more evenly dissected drainage basin. The low Hi value of Malan River is indicative of highly dissected topography due to tectonically active region. This is due to the river flowing along the fault (F1) eroding the trappean lava flows and dyke ridges in the upland zone while Tertiary deposits over pediment surface. The Malan River also deposits thin layer of alluvium in the lower reaches of its channel. The enormous drainage basin of Dhantarvadi and its large tributaries highly eroded the trappean covered upland hilly terrain. Due to strong denudation, the relief observed in this basin is less compared to Raidi river basin. The development of the river basin and the fluvial erosion stage is calculated by plotting the hypsometric curve.

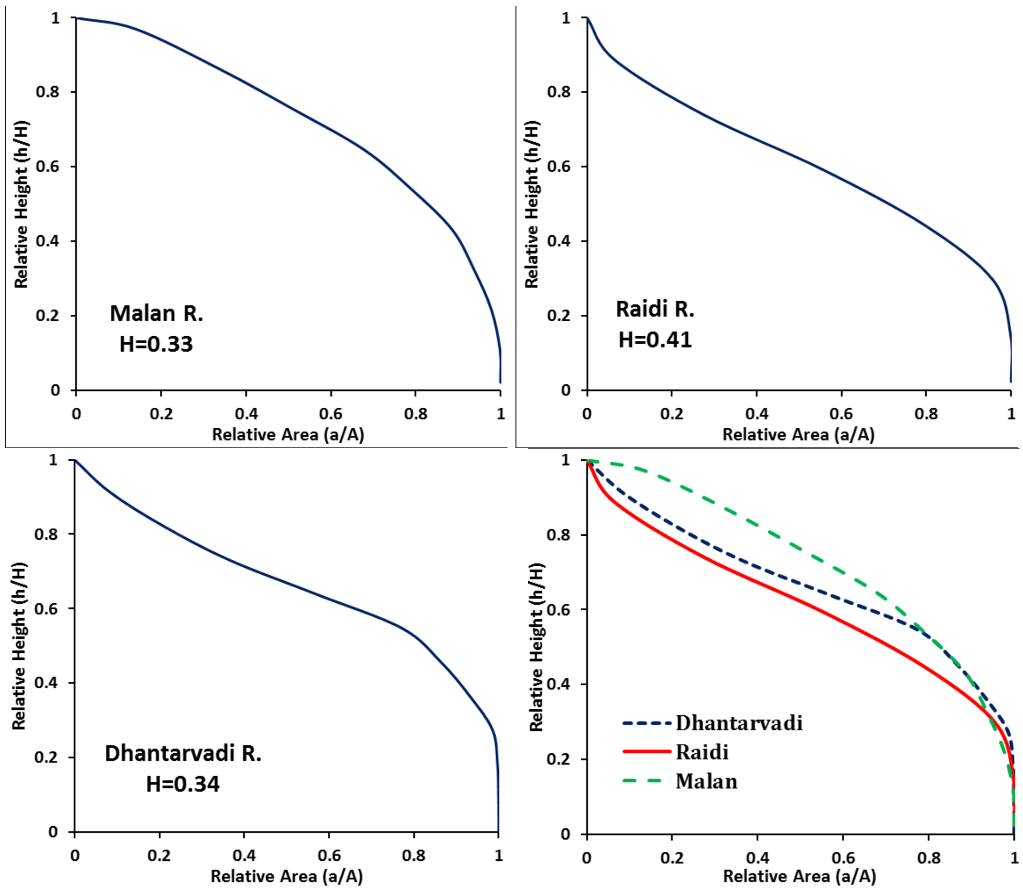

Figure 7.5 Hypsometric curve plotted for Malan, Raidi and Dhantarvadi river basin. H is the Hypsometric integral value. Comparison of all three drainage basins shows Malan river basin is at youthful stage while Raidi and Dhantarvadi basin shows mature basin development stage.

7.3.5 Hypsometric curve

The Malan River is showing convex up curve relating to the youthful stage of drainage basin with deep incised valleys and narrow gorges. This is because maximum basin area is covered by trappean hills and dyke ridges. The river incising through these trappean dykes while flowing along the NNE to NE trending fault (F2). The geomorphic variation of both the drainage divides of Malan River mainly corresponds to the structural features observed along the channel. The river has evenly dissected the basin by south flowing streams. The HI value is, therefore, low compared to other two drainage basins in this domain (Figure 7.5). The Raidi and Dhantarvadi river basin shows s-shaped hypsometric curves related to mature stage of erosion with maximum area eroded and denudation is still enduring. The Raidi River flows over the dyke swarm zone that controls the fluvial system. However, the HI value is higher inferring that the maximum area of the basin are occupied by dyke ridges that show higher relief relative to the mean elevation (Figure 7.5). The Dhantarvadi River also exhibits mature topography as seen by the sigmoidal shape hypsometric curve (Figure 7.5). However, HI value is close to Malan river basin suggesting evenly dissected terrain (Figure 7.5). This infers that drainage basins are at youthful to mature stage of basin development consisting of deep incised streams, bedrock erosion and evenly dissected topography.