

Morphotectonic and Morphometric analysis for Neotectonic activity of Kehmil basin, Kashmir Himalayas: Using Geospatial techniques

Mohd Aadil Bhat^{1*}, Tanveer A. Dar², Bilal Ahmad Kaboo³

^{1,2,3}Department of Earth Sciences, University of Kashmir,
Hazratbal, Srinagar-190006, J&K, (India)

ABSTRACT

The study has been carried out in Kehmil River which is left bank tributary of river Pohru, lies to the northeast of the Kashmir valley. Geomorphic indices and various morphometric parameters were used to investigate the tectonic behavior of study area. ASTER DEM OF 30m resolution was used to calculate various geomorphic indices and morphometric parameters. Morphometric parameters and eight geomorphic indices calculated in the present work along with the extensive field data suggests the area to be tectonically active. The results in the present study indicate predominance of tectonic activity over erosional processes in shaping the landforms of basin. In the present study, integrated GIS and remote sensing proves to be reliable and helpful in analyzing land form changes and understanding tectonic nature of Basin.

Keywords: *Geomorphic Indices, Neotectonics, ASTER DEM, Kehmil Basin.*

I. INTRODUCTION

The Morphotectonic examination in view of the geomorphic indices helps in understanding the endogenic and exogenesis processes of basin (Baioni, D. 2007; Raju, G.S. and Babu, K.R. 2012). Geomorphic indices provide relative evaluation of tectonic activities in a basin (Keller, E.A. and Pinter, N. 1996). The geomorphic indices have been used as a fundamental observation tool for tectonic deformation of basin (Keller, E.A. and Pinter, N. 1996; Bull, W.B. and McFadden, L.D. 1977). The Himalayan region being tectonically active changes morphology of river basins (Garde, R.J. 2006). Investigating Geomorphic indices with Geospatial techniques has been used successfully to evaluate the tectonic behavior of basin with easier and better accuracy (Das, A.K. and Mukherjee, S. 2005). The main objectives of the present study is to examine the Neotectonic activity based on morphometric and Geomorphic indices using Geospatial techniques.

II. STUDY AREA

The Kehmil Basin located in the great northwest complex of Himalaya region extends between 33°25'N-73°35' N latitude and from 73°35'-75°35' E longitude (Fig.1). The total catchment area of the watershed is about 350 sq. km. The Kehmil River is the left bank tributary of river Pohru and fall in the administrative boundary of district Kupwara. The Kehmil River flows in an easterly direction and joins the Pohru River one kilometer to the south

of Kupwara. The gradient of river is quite steep in higher reaches. Kehmil basin reveals a variegated topography due to combined action of glaciers and rivers showing the presence of both V and U shaped valleys. The study area is characterized by temperate cum Mediterranean type of climate (Meher 1971).

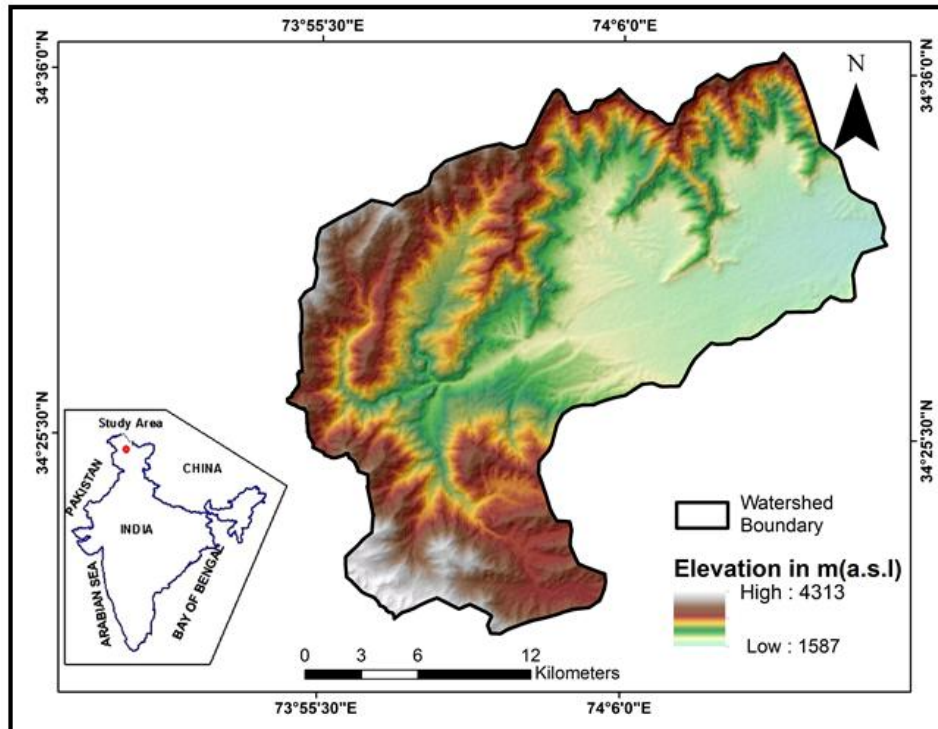


Fig.1 Showing study area location map.

2.1 GEOMORPHOLOGY AND GEOLOGY OF KEHMIL BASIN.

The Kehmil river a perennial river, flows over the heterogeneous rock types and rocky mountains from source to mouth with the development of some anomalous features like V shaped-valley (Fig 2.a), deep and narrow fluvial valleys, steep longitudinal profiles with Knick points (Fig 2.b), development of Triangular facets (Fig 2.c), rough terrain, entrenched meanders, deeply incised gorges (Fig 2.d) and general youthful topography. The river shows number of braided bars at Chowikbal, Trehgam, and Kralpora. The Kehmil Basin shows unpaired river terraces, three river terraces on the left bank and two terraces on the right bank (Fig 2.e). After Marser, the Kehmil River shows intense meandering (Fig 2.f).

Kehmil Basin flows through a diverse lithology i.e. from Panjal volcanic in the youthful stage to series of rocks (Salkhala's) in the middle and after covering a longitudinal distance of 39 km it is flowing through Quaternary deposits of alluvium in the old stage. The rock formation underlying the Kehmil basin ranges in age from Pre-Cambrian to Quaternary. The pioneer work on the geology of study area was contributed by Geological Survey of India 1971-72 and Wadia institute of Himalayan Geology 2005, Thakur and Rawat, (1992). The lithological map of study area is shown in (Fig.3). In the study area the oldest formation

comprises the Salkhalas series showing high grade metamorphism. Salkhalas group are followed by Panjal volcanics of Upper Carboniferous age which in turn are overlaid by Muth quartzite. Lower reaches of the study area consists of Plio-Pleistocene deposits and recent alluvium. The Plio-Pleistocene of Kashmir comprises the Karewa Formation that contains lacustrine and fluvial sediments intercalated with glacial tills. Lithologically, the alluvium consists of blue grey sand, silts and varved clays. The size of grains ranges from fine, medium to coarse.



Fig. (2.a) V-shaped valley, (2.b) (Knick point), (2.c) Triangular facets, (2.d) (deeply incised river, (2.e) river terraces, (2.f) river meandering.

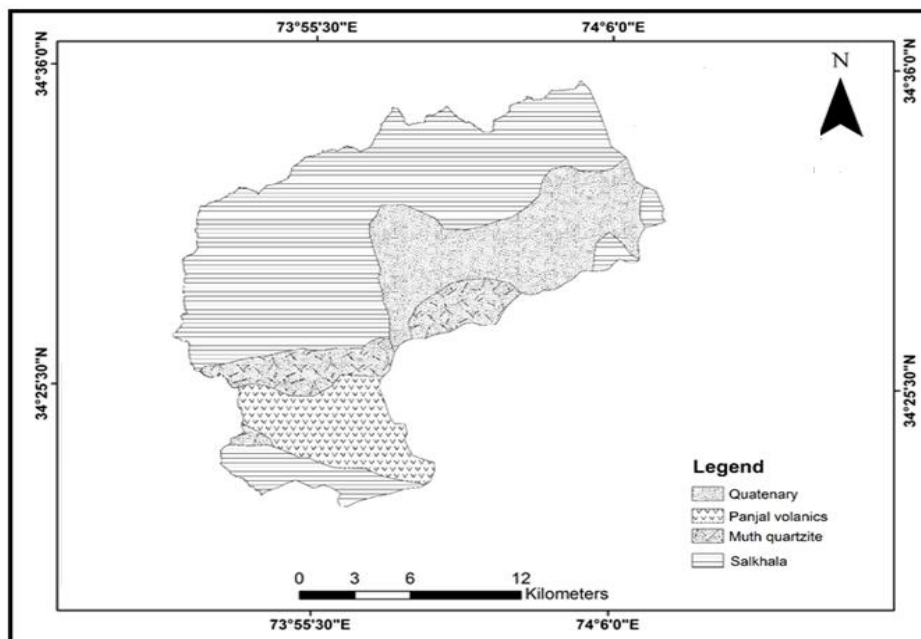


Fig 3 showing lithological map of study area.

III.METHODOLOGY

The present work is based on the Morphotectonic and Morphometric analysis of Kehmil Basin to examine the Neotectonic activity. The main objective of the study was fulfilled by computing the geomorphic indices by using remote sensing and GIS techniques. The Schematic flow chart detailing the methods employed to accomplish the present work is shown in Fig.4.

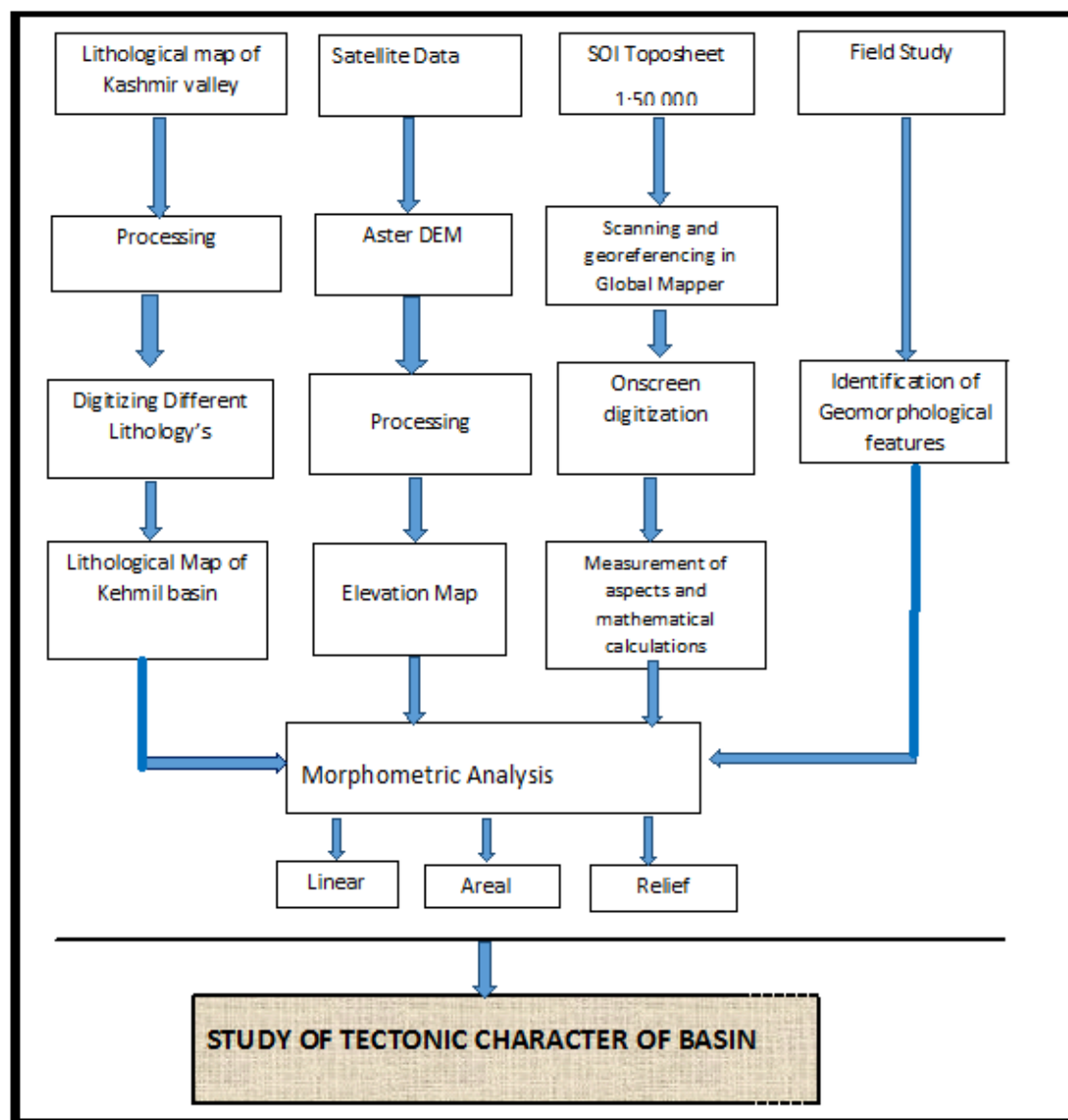


Fig 4: Schematic flowchart detailing the methods employed to accomplish the present work.

IV.RESULTS AND DISCUSSION.

In the present study, Morphotectonic and Morphometric analysis of the Kehmil Basin has been carried out using the mathematical formulas given in the Table 1.

S. No.	Morphometric Parameters	Formula	Reference
1	Stream order (Su)	Hierarchical rank	Strahler (1964)
2	Stream number (Nu)	No. of streams	Horton (1945)
3	Stream length (Lu)	Length of streams	Schumm (1956)
4	Mean Stream Length (Lsm)	$Lsm = Lu/Nu$	Strahler [1964]
5	Drainage density (Dd)	$Dd = Lu/A$	Horton (1932)
6	Drainage frequency(Fs)	$Fs = Nu/Nu+1$	Horton (1932)
7	Basin Shape	$Bs = Lb^2/A$	Horton [1945]
9	Bifurcation ratio (Rb)	$Rb = Nu/Nu+1$	Schumm (1956)
10	Form factor (Ff)	$F = A / L^2$	Horton (1932)
11	Drainage intensity (DI)	$DI = Fs / Dd$	Faniran(1932)
12	Circulatory ratio (Rc)	$Rc = 4\pi Au / Pr^2$	Miller (1960)
13	Elongation ratio (Re)	$Re = d/Lb$	Schumm (1956)
14	Relief Ration (Rhl)	$Rhl = H/Lb$	Schumm (1956)
15	Ruggedness Number (Rn)	$Rn = Dd * (H/1000)$	Patton and Baker(1976)
Geomorphic Indices			
16	Mountain front sinuosity (Smf)	$Smf = Lmf/Ls$	Bull (1978)
17	Sinuosityindex (S)	$S = CL/VL$	Bull (1978)
18	Valley floor width to valley height ratio (Vf)	$Vf = 2Vw / [(Eld-Esc) + (Erd-Esc)]$	Bull & Mc Fadden (1977)
19	Hypsometric Integral and Curve (HI)	$HI = HMean - Hmin / Hmax - Hmin$	Strahler (1964)
20	Stream length gradient index (SL)	$SL = \Delta H / \Delta L$	Hack (1973)
21	Drainage basin asymmetry (AF)	$AF = 100 * A_r / A_t$	Hare & Gardner (1984)

Table 1. Showing mathematical formulas and parameters used in this study.

The Kehmil River is 7th order Basin (Fig 5). The drainage of study area is dendritic pattern and total length of river is 39km. The Kehmil River has 2,265 streams over an area of 511.07 km². The stream ordering for the study area (Table 2) reflects that the maximum frequency in the case of first order streams and goes on decreasing as the stream order increases. It is observed that the bifurcation ratio varies from 2 to 6.2 with the mean value of 3.72 (Table 3), suggests that the area has less geological structural control over the drainage pattern. The drainage density (Dd) of study area is 2.84 Km/Km² which is greater than 2.5 indicating that the drainage density has developed in response to tectonic upliftment of the study area. The stream frequency of

study area (Table 4), suggesting that the drainage pattern is structurally controlled and is developed in response to the tectonic activity in the area.

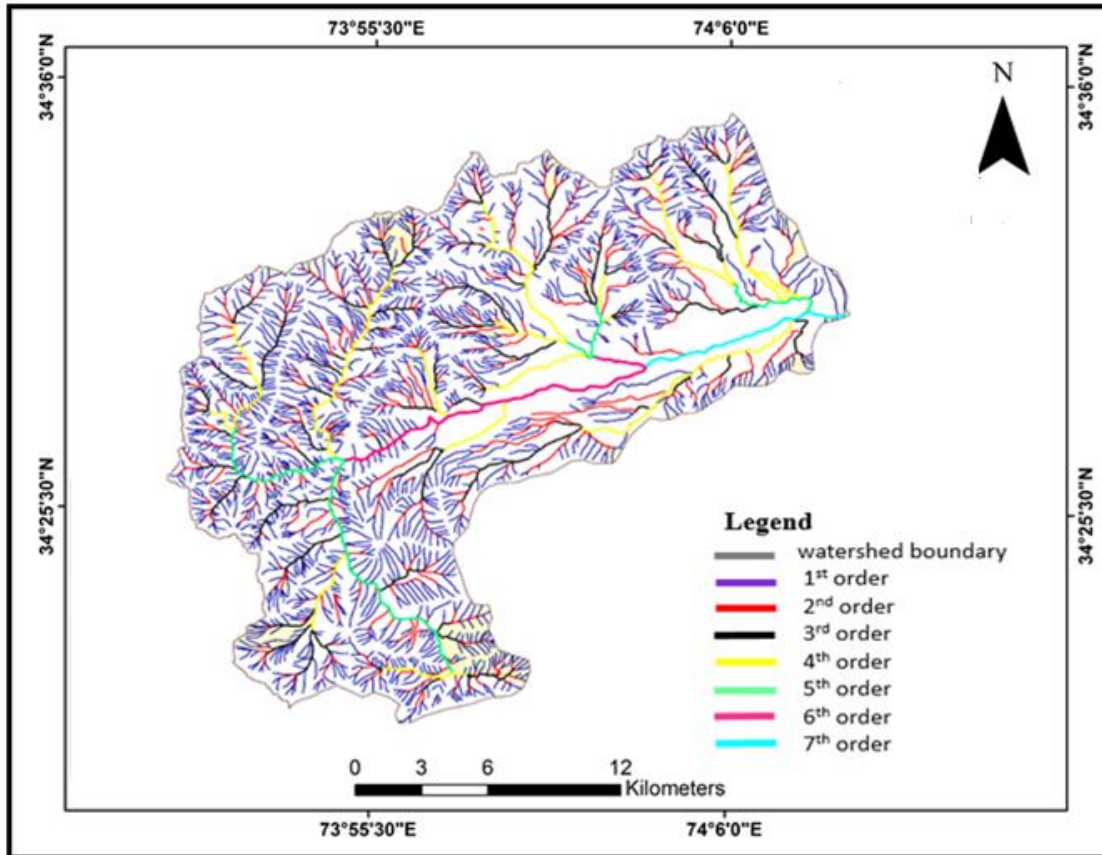


Fig 5: Drainage map of the Kehmil basin.

S.No	Stream Order	No. of streams	Stream Length(Km)
01	1 st order	1605	1010.19
02	2 nd order	526	282.56
03	3 rd order	95	41.99
04	4 th order	31	72.50
05	5 th order	5	28.07
06	6 th order	2	8.81
07	7 th orders	1	9.901
Total	7 orders	2265	1454

Table 2. Showing order wise stream number and stream length.

S.No	Order	Value
1	1 st and 2 nd	3.05
2	2 nd and 3 rd	5.53
3	3 rd and 4 th	3.06
4	4 th and 5 th	6.20
5	5 th and 6 th	2.50
6	6 th and 7 th	2

SNO	MORPHOMETRIC PARAMETERS	VALUES
01	Basin area (A)	511.07 sq.km
02	Basin length (L)	39.89 km
03	Basin perimeter (P)	119.21 sq.km
04	Drainage density (D_d)	2.84
05	Stream frequency (F_s)	4.3
06	Elongation ratio (E_b)	0.18
07	Circularity ratio (K_A)	0.45
08	Form factor (F_f)	0.33

Table 3. Showing Bifurcation and Mean Bifurcation ratio. **Table 4.** Showing calculated areal aspects of Aripal basin

The value of circulatory ratio and elongation ratio for Kehmil basin 0.45 and 0.18 indicates that the basin is tectonically active and is elongated in nature and tectonics of area overcomes the erosion activity of the basin. The form factor value for study area is 0.33, indicating elongated basin with lower peak flows of longer duration than the average. The calculated value of relief ratio of Kehmil basin is 0.059 indicating exposure of basement rocks as small ridges and mounds with lower slope value hence reveal upliftment of the study area. The value of ruggedness number in present basin is 6.75 which suggests that topography of the basin is steeper. According to Bull & McFadden (1977), the mountain front Sinuosity values ranges between 1.0-1.6 for active regions, 1.4-3.0 for slightly active regions and 5 for inactive regions. In the present study Smf values were calculated at eight locations. The calculated sinuosity front values for the Kehmil basin are 1.24, 1.12, 1.28, 1.03, 1.03, 1.10, 1.04 and 1.31 for front1, front2, front3, front4, front5, front6, front7 and front8 respectively. The calculated front sinuosity values suggest that basin is tectonically active and tectonics of the area dominates over erosion activity. Because tectonics on one hand creates straight fronts at the same time erosion cuts it into sinuous form. The Kehmil basins have a sinuosity index (Fig. 6) of 1.13 which reflects area of active tectonics. The Valley floor width to valley height ratio values of 0.11, 0.53, 0.13, 0.54 and 0.25 were calculated at five locations respectively (Fig 7), which indicates V-shaped, deeply incised valleys suggests that the area is tectonically active.

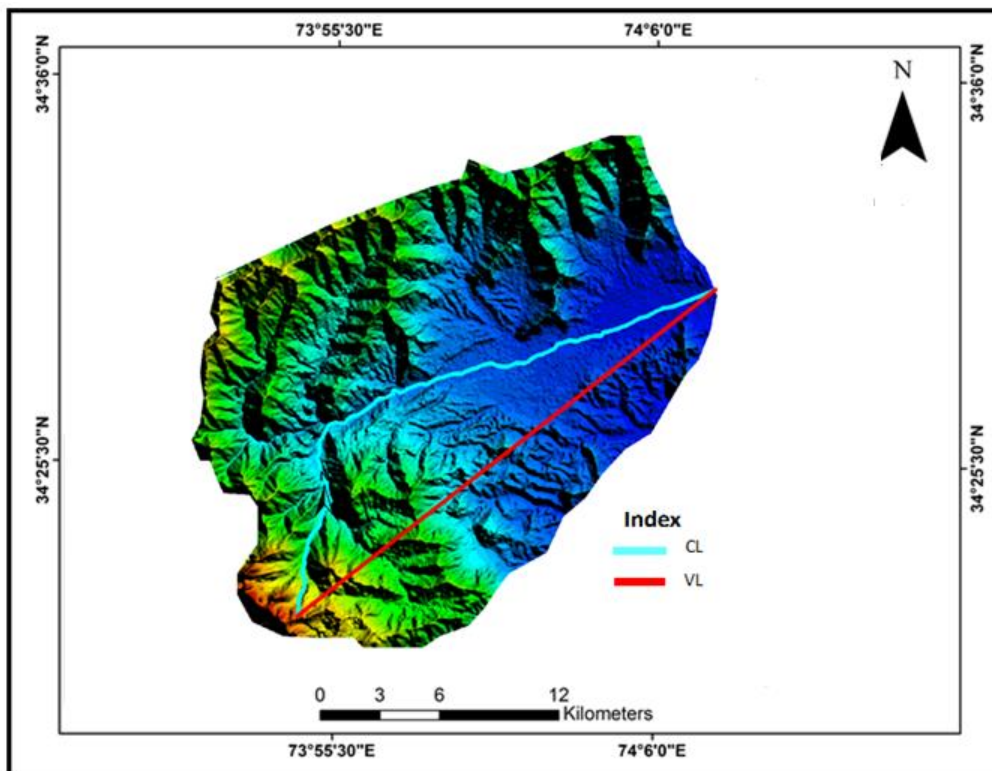


Fig 6 showing sinuosity of Kehmil basin.

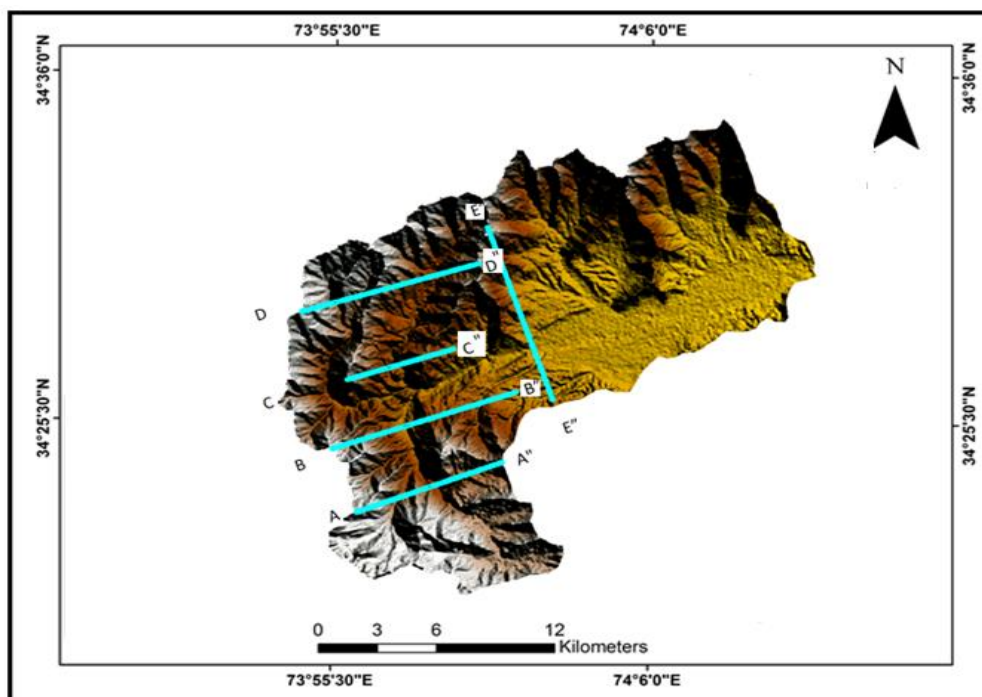


Fig 7. Transverse profiles of Valley floor (Vf) for Kehmil basin.

The calculated hypsometric integral value for Kehmil basin 0.38 collectively with the S- type hypsometric curve (Fig. 8 a, b, c) indicates the mature stage, high elevation relative to mean, tectonically active and highly dissected character of the Kehmil Basin. The calculated Stream length gradient index (SL) value for Kehmil River ranging from 480 to 2520, which infer active tectonics in terms of vertical deformation. The Longitudinal profile of the Kehmil River (Fig 9) showing two knick points at 3400m and 2400m at a distance of about 2 and 7 km respectively from its source are structurally controlled.

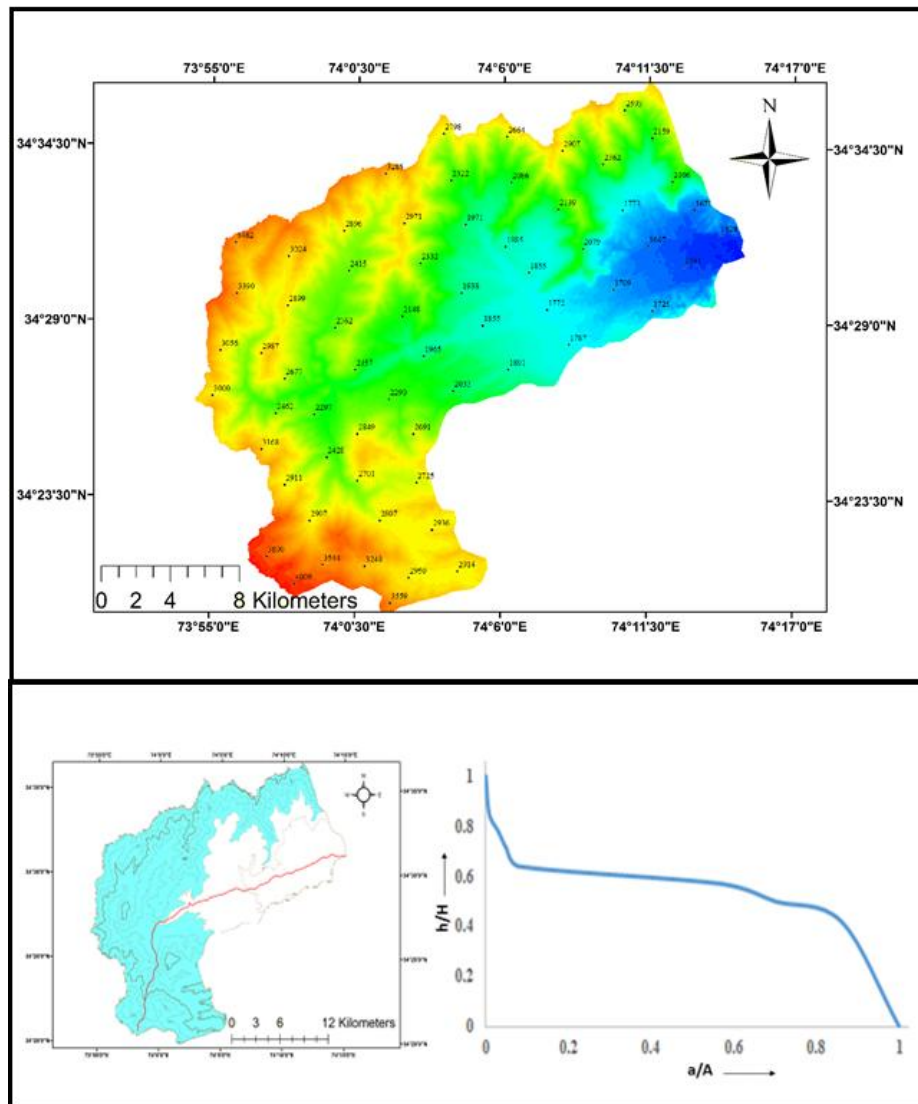


Fig 8 (a) Random sampling for elevation

Fig 8 (b) a/A and h/H values for 2100 m contour. **Fig 8 (c):** Hypsometric curve for Kehmil basin

The calculated Drainage basin asymmetry (AF) value of Kehmil basin is 29.94% indicates that the basin has shifted up to the left side of the channel (Fig 10), as is evident from unpaired river terraces and longer length of the left side tributaries of the basin.

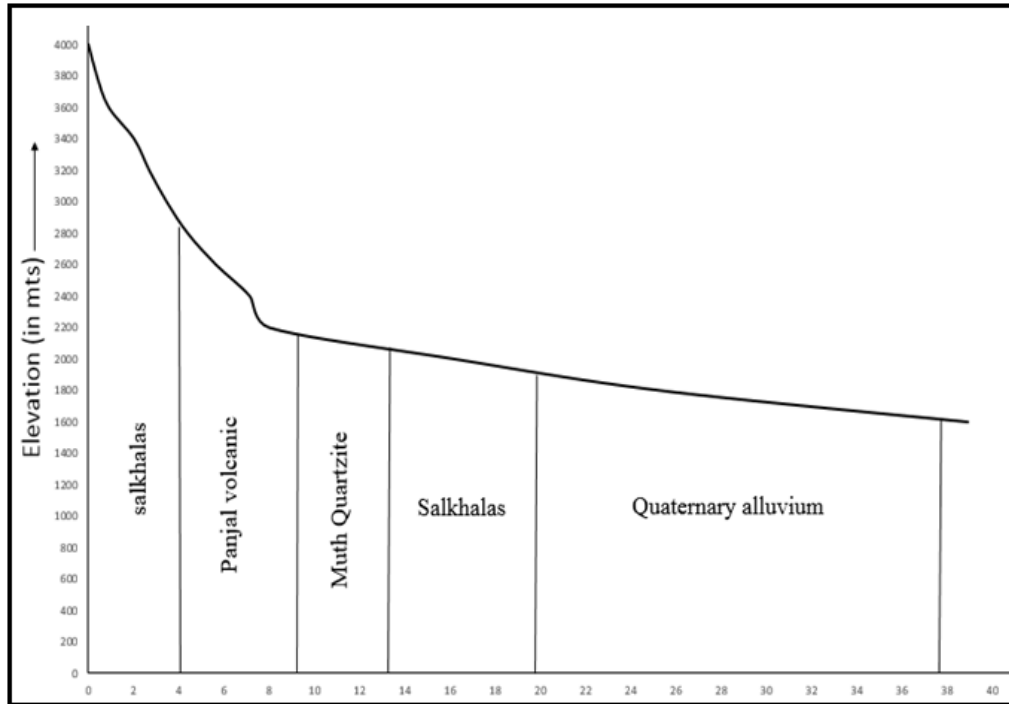


Fig. 9 longitudinal profile of Kehmil River, together with calculated SL values. Small circles are showing knick points

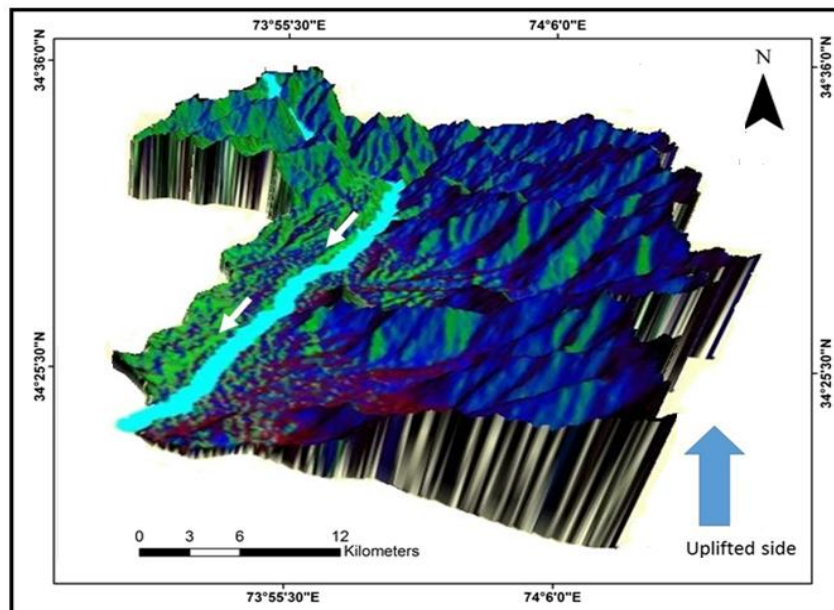


Fig 10 Tilt of Kehmil basin.

V. CONCLUSION.

The calculated geomorphic indices indicates that the Kehmil Basin is strongly active. The effect of tectonics on the geomorphology was well explained and observed on the basis of field observations in the form of landforms present in the area. Some of the indices has direct impact on the geomorphology of the watershed (Elongation ratio and Circularity ratio). The straight mountain fronts present in the area were found to be the result of tectonic forces dominating over erosional activity. However, detailed structural analysis, geophysical studies of subsurface lithology is needed to understand tectonics and erosional processes of an area more appropriately.

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