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Research Paper

Morphotectonic Analysis of the Sandran watershed Southeast of Kashmir Valley,Northwest Himalayas

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ABSTRACT: *The Sandran watershed of Kashmir valley has been studied to understand its Morphotectonic evolution on the basis of various geomorphic indices complemented and validated with extensive field observations.Toposheets in digital format were used to obtain the data for the study,the digital elevation mode(DEM) was performed and several geomorphic parameters were evaluated,for instance: Mountain front sinuosity (Smf), Sinuosity index (Si), Hypsometric integral (Hi), Drainage basin asymmetry or Asymmetric factor (AF), Stream length gradient index (SL), River profile (H) and Valley-floor width to Valley height ratio (Vf) , Circulatory ratio (Rc), Elongation ratio (Re), Bifurcation ratio (Rb) along with field observations shows that the Sandran watershed is strongly elongated and is tectonically active. The derived values show that the overall assessment of the geomorphic indices revealed that the tectonic uplift, lithology and climate forcing played a significant role in the landscape evolution of the Sandran stream and the area has experienced differential uplift and erosion rates from time to time in the geological past.*
Keywords: *Active tectonics . Geomorphic indices. Drainage basin. Hypsometry*

I. INTRODUCTION

The unrelenting competition between tectonic processes that tend to build topography and surface processes that tend to tear them down represents the core of tectonic geomorphology. Anyone interested in the earth's surface has wondered why it has the shape it does and what forces are responsible for that shape. For more than a century, this natural curiosity has inspired numerous conceptual models of landscape evolution under varied tectonic and climatic regimes. In the past, our ability to assign reliable ages to geomorphic and tectonic features was very limited. In the absence of a chronologic framework,it was nearly impossible to test competing concepts of landscape evolution. As a consequence, these unquantified models were often viewed skeptically and treated as speculative notions(1). The application of tectonic geomorphology is significant in terms of earthquake hazard management and the subject has assumed societal relevance in recent decades (Keller and Pinter, 1996;Burbank and Anderson, 2001).The subject is a pivotal research in terms of societal consequence at a variety of scales, from regional to local.Tectonic processes in turn shape and evolve the geomorphology of any region. Tectonic geomorphology provides a whole kit of tools for deciphering the most recent activity on live structures (Keller and Pinter, 1996; Pinter, 1996).

Tectonic geomorphology is relatively new interdisciplinary field at the boundary between structural geology, tectonics and surface processes. The most common goal of tectonic geomorphology is to use quaternary landforms and stratigraphy to infer the nature, patterns, rates and history of near surface tectonic processes. Tectonic geomorphology is a key factor in determining land use planning, earthquake hazard management, mitigation and prediction,This kind of methodology has been proved very useful in various tectonically active areas such as the SW USA (Rockwell et al. 1985), the Pacific coast of Costa Rica(Wells et al. 1988), the Mediterranean coast of Spain (Cox1994), the south-western Sierra Nevada of Spain (El Hamdouni et al. 2007) and Kashmir Valley (Ahmad and Bhat 2012, 2013 & 2015). We also evaluated the results from the morphometric analyses based on field-based geo-morphological observation.

Study area: The Sandran drainage basin occupies the south eastern part of the Kashmir valley (Fig.1) and is situated between $33^0 20'$ to $34^0 15'$ north latitude and $74^0 15'$ to $75^0 15'$ east longitude. The Sandran stream is the important right bank perennial tributary of the Jhelum River, Having its birth from the Sarbal lake(2592m) on the gentler southern slopes of the Pir Panjal range of Kashmir Himalayas below the Kaukut peak, it receives several branches at Cheard(2306m) and Anganmando(2362m) passing through a deep carved channel, studded with big boulders from its source to a point close to Vernag. It merges with the Jhelum a little above Khanabal near Anantnag town after traversing a course of about 52 kms (Raza *et al.*, 1978). Extending over a total catchment area of about 368.61 km2 (i.e., about 3 percent of the total drainage basin of Jhelum stream), it flows in the direction of north-west and irrigates most areas of Dooru Shahabad.

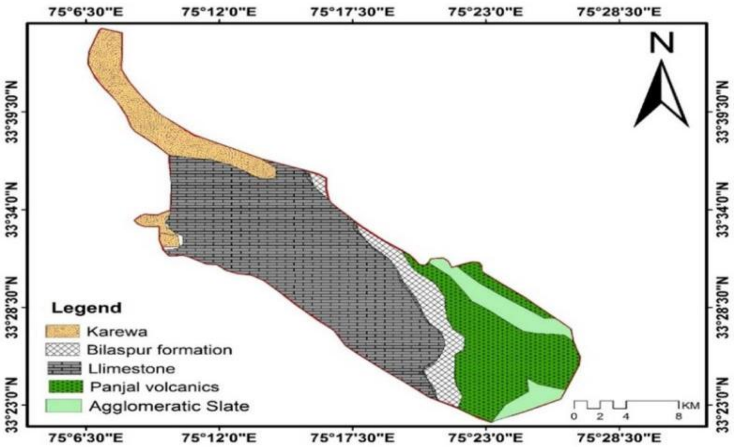


Fig. 1 showing location map of the study area

The study area is elongated in shape and has varied topography. The soils of the Sandran catchment belong to the groups of the brown forest soils, lacustrine (Karewa) soils and alluvial soils. Lithologically, the alluvium consists of blue, grey/silts and clay shales and sands of different textures and structures. The size of the grain varies from fine, medium to coarse. The valley possesses distinctive climatic characteristics because of its high altitude location and its geophysical setting, being enclosed on all sides by high mountain ranges. The valley is characterized by sub-Mediterranean type of climate with nearly 70% of its annual precipitation concentrated in winter and spring months (Meher,1971). Lithology of the study area: The study area comprises of various types of rock formations ranging in age from Upper Carboniferous to Plio-Pleistocene.In the study area ,the oldest rock formation present are Agglomeratic Slates,which are light grey to dark in colour and are highly crushed,the age of Agglomeratic Slate is Upper Carboniferous,the Agglomeratic Slates are followed by Panjal Volcanics ,which are of Carboniferous age.The Panjal Volcanics contain series of bedded andesitic and basaltic flows,the Panjal traps are followed by Triassic Limestones which are of light blue or grey tint,compact and heterogeneous in composition. The grain Lower part of the study area consists of Lower Karewas of Plio-Pleistocene age.The Lower Karewas (Hirpur Formation) of the study area comprises of Methowian Member, which mostly consists of succession of sand, sandy clay and clay.

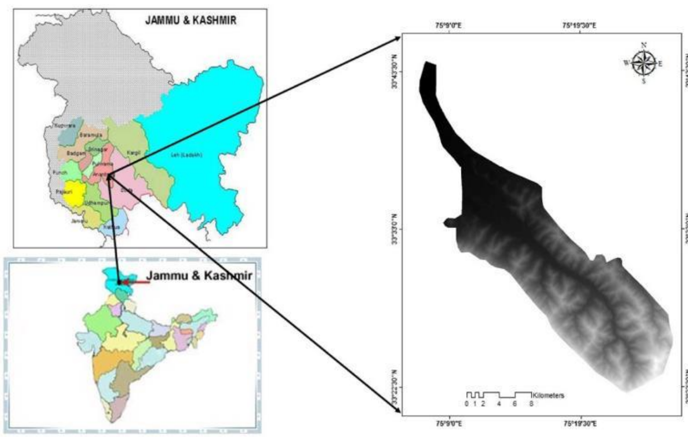


Fig 2 Showing lithological map of the study area

II. MATERIAL AND METHODS

The Morphotectonic analysis by the use of geomorphic indices has been developed as a basic reconnaissance tools to identify areas experiencing rapid tectonic deformation (Bull, W.B and McFadden L.D.1977, Keller and Pinter 1996). With the help of quantitative measurement of landscape shape of drainage watershed it becomes easy to compare different landforms to calculate less straightforward geomorphic indices /Morphotectonic parameters that may be useful for identifying a particular characteristic e.g, level of tectonic activity of an area, (keller and Pinter ;1996). The geomorphic indices that are most widely used to understand the active tectonics of a region are:

Mountain Front Sinousity

This index is based on the observation that tectonically active mountain fronts are often more straight than mountain fronts in regions where erosion dominates over tectonics. The index is defined as;

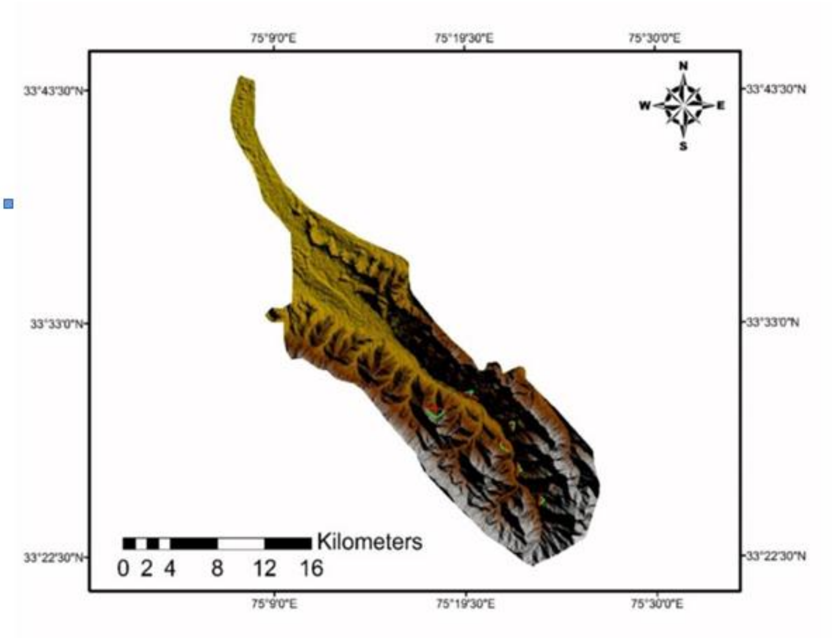
Smf=Lmf/Ls

Where Smf= mountain front sinuosity index, Ls = straight line distance along a contour line and Lmf = true distance along the same contour line.The morphology of a mountain front depends upon the degree of tectonic activity along the front. Active fronts will show straight profiles with lower values of Smf, and inactive or less active fronts are marked by irregular or more eroded profiles, with higher Smf values (Wells et al., 1988). In the present study Smf values has been computed for six fronts and generated Smf values are categorized according to(Bull, W. B., and

McFadden, L. D. (1977) (Table 1). Most active mountain fronts have Smf values ranging between 1.0 and 1.6, whereas less active and inactive mountain fronts have Smf values ranging between 1.4–3.0 and >3.0, respectively (Bull and McFadden, 1977).

S.NO.	Lmf	Ls	Smf=Lmf/Ls	Inferences
01	2.362	1.706	1.3	Tectonically Active
02	1.989	1.372	1.4	Tectonically Active
03	1.6	1.1	1.4	Tectonically Active
04	1.19	841.54	1.4	Tectonically Active
05	1.51	1.082	1.3	Tectonically Active
06	1.11	751.	1.4	Tectonically Active

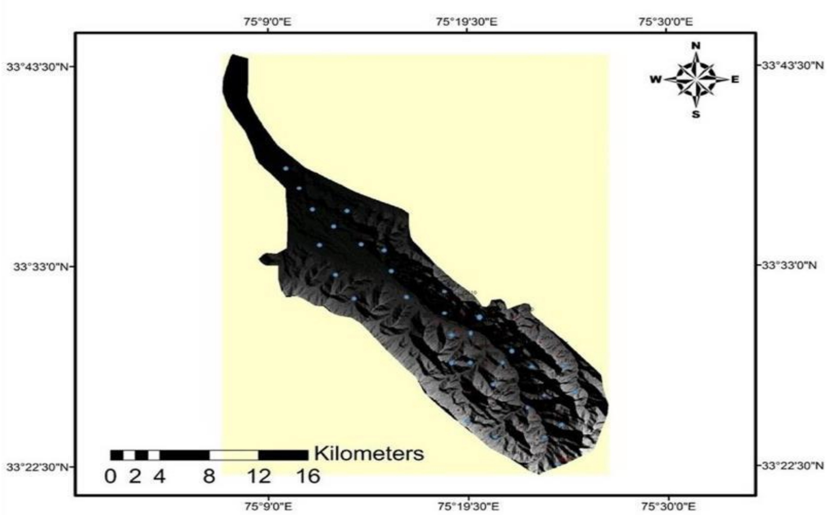
Table (1) showing Smf values of Sandran basin



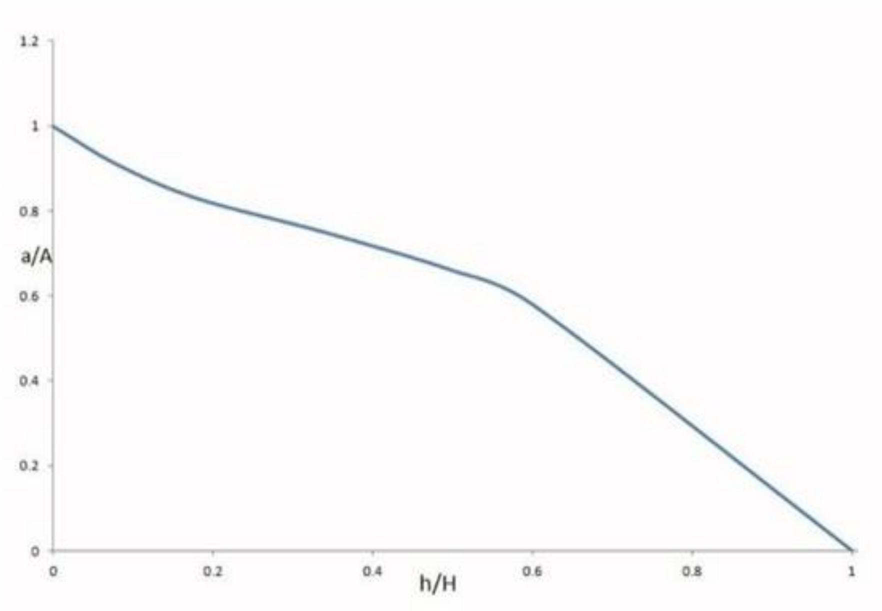
Figure(3) showing mountain front sinuosity of Sandran Drainage Basin

Hypsometric Integral (Hi) And Hypsometric Curve The hypsometric integral (Hi) is a quantitative measure of the degree of dissection of a drainage sub-watershed (Strahler, 1952). Its values are important elements in the analysis of landscape.Hypsometric integral (Strahler, 1952) can be easily obtained from topographic maps or by using Digital Elevation Models (DEM) (Pike and Wilson 1971). High values of hypsometric integral indicate that most of the topography is high relative to the mean, such as smooth upland surface cut by deeply incised streams.Intermediate to low value of the integral, reflect exposure of the terrain to extended erosion, are associated with more evenly dissected drainage basins. The hypsometric integral is calculated as;
Mean Elevation – Minimum elevation / Maximum Elevation – Minimum Elevation

The calculated hypsometric integral value (Fig) for the study area is 0.46, which is on the higher side indicating that the area is in youthful stage, high topography and incised streams thus suggesting that the area is tectonically controlled.The hypsometric curve describes the distribution of elevations across an area of land (Keller and Pinter). The curve is created by plotting the proportion of total basin height (relative height) against the proportion of total basin area (relative area) (Figure 5) the drainage basin spans eight contour lines. The total surface area of the basin (A) is the sum of the area between each pair of adjacent contour lines. The area (a) is the surface area within the basin above a given line of elevation (h). The value of relative area (a/A) always varies from 1.0 at the lowest point in the basin (h/H=0.0) to 0.0 at the highest point in the basin (h/H=1.0).



Fig(4) showing random sampling of elevation data.



Fig(5) showing several values a/A and h/H plotted to obtain a hypsometric curve

Drainage Basin Asymmetry (Af):

The drainage basin asymmetry factor was developed to detect tectonic tilting of small scale drainage basins as well as larger areas (Hare and Gardener; 1985).When AF>50, the main channel has shifted towards the downstream left side of the drainage basin. On the other hand, if AF < 50, it indicates that the channel has shifted towards the downstream right side of the drainage basin (Hare and Gardener; 1985). Drainage basin asymmetry helps to deduce the tilt block tectonics (Gardener; 1987). Following Strahler (1957) stream ordering scheme , the AF was extracted from 6th order stream for sandran basin. The calculated AF value of sandran basin 53% indicates that the basin has shifted up to the right side of the channel (Fig 12).The tilting of basin is evident by the presence of longer tributaries on the right side of the basin, the greater number of tributaries joining the river and high drainage density to the right divide. The calculated Af = 48 for Sandran basin (Fig 6)indicates that the has basin shifted up to the left side of the channel where again, the tilting of basin is evident by the presence of longer tributaries on the left side of the basin, the greater number of tributaries joining the river and high drainage density to the left divide.

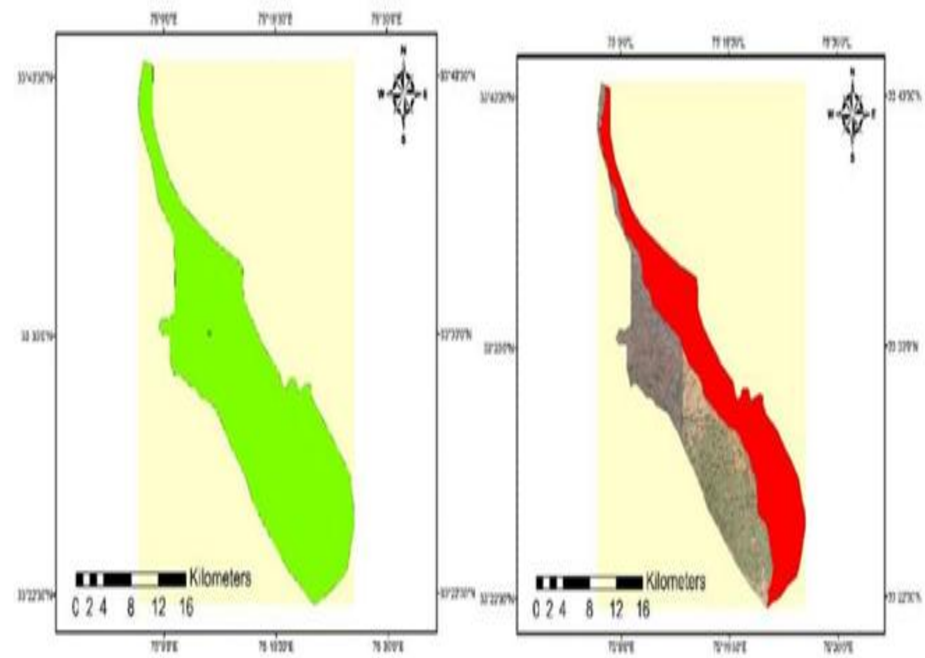
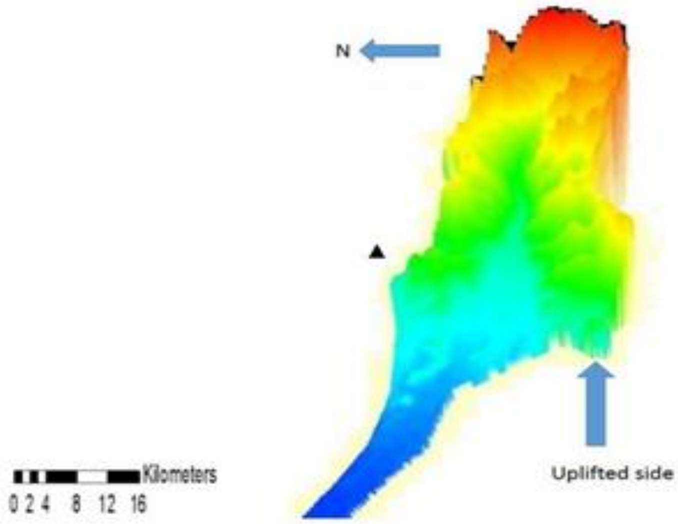


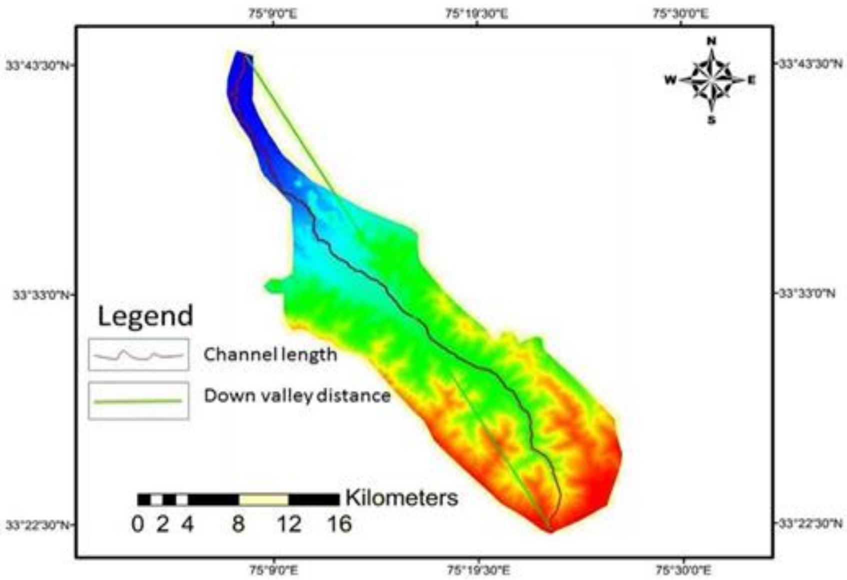
Fig 6 showing total area and right side area of Sandran watershed respectively



Fig(7) showing tilt of sandran watershed

Sinuosity Index (Si)

Sinuosity has been defined as the ratio of channel length to down valley distance. Sinuosity deals with the pattern of channel of a drainage basin. In general, its value varies from 1 to 4 or more. Rivers having a sinuosity of 1.5 are called sinuous, and above 1.5 are called meandering (Wolman et al. 1964). It is a significant quantitative index for interpreting the significance of streams in the evolution of landscapes and beneficial for Geomorphologists. Rivers meanderers in order to maintain a channel slope in equilibrium with discharge and sediment load. A river meanders when the straight line slope of the valley is too steep for equilibrium,the sinuous path of the meanders reduces the slope of the channel. Any tectonic deformation that changes the slope of a river valley results in a corresponding change in sinuosity to maintain the equilibrium channel slope, secondary effect of this adjustment is that, as river switches from one sinuosity to another, the rates of meander migration and floodplain reworking accelerate accordingly; this secondary effect has proved to be a diagnostic tool in identifying area of active tectonics. Sandran watershed has a sinuosity index value of 1.14 as calculated from (fig 8) which reflects that the study area is tectonically active.



Fig(8) showing sinuosity index of sandran stream

Valley-floor width to valley height ratio
The ratio of valley floor width to valley height (Vf) may be expressed as:

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

Where Vf is the valley-floor width to height ratio, Vfw is the width of valley floor, Eld and Erd are elevations of the left and right valley divides respectively, and Esc is the elevation of valley floor. This index differentiates between broad-floored canyons, with relatively high values of Vf and V-shaped valleys with relatively low values. Vf values <1.0 can be classified as V-shaped valleys with streams that are actively incising, commonly associated with uplift and Vf values between 1.0 and 1.5 indicates moderately active tectonics and Vf values >1.5 are classified as
U-shaped valleys subjected to major lateral erosion (Bull &Mc Fadden).

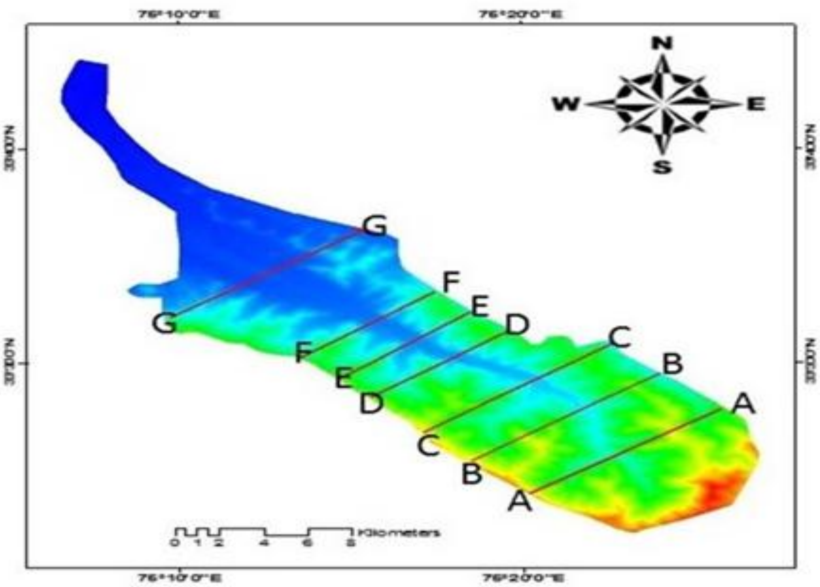
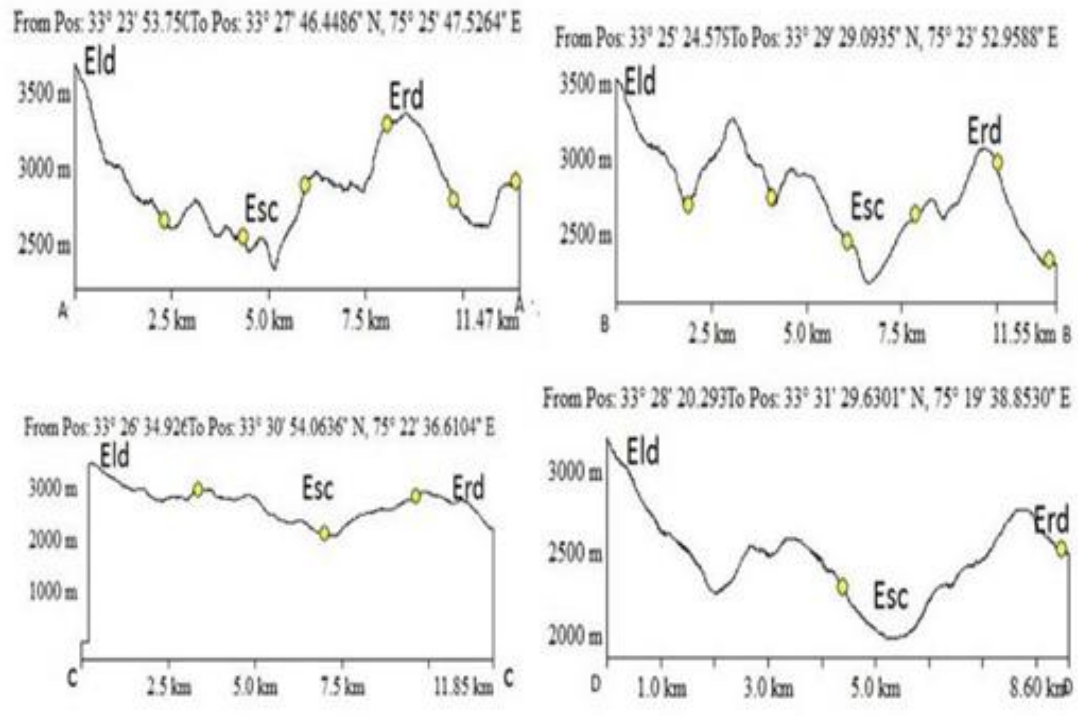


Fig 9 Showing how the ratio of valley-floor width to valley height for Sandran watershed has been calculated.

The Vf values for the Sandran watershed has been calculated for six section lines namely AA, BB, CC, DD, EE, FF (Fig 15). The calculated values are 0.193, 0.501, 0.126, 0.190, 0.285, and 0.107 respectively. The left and right is determined by looking downstream. The calculated values and profiles (Fig 10) shows that majority of the basin is V-shaped, deeply incised, associated with upliftment which in turn reflects that basin is tectonically active.



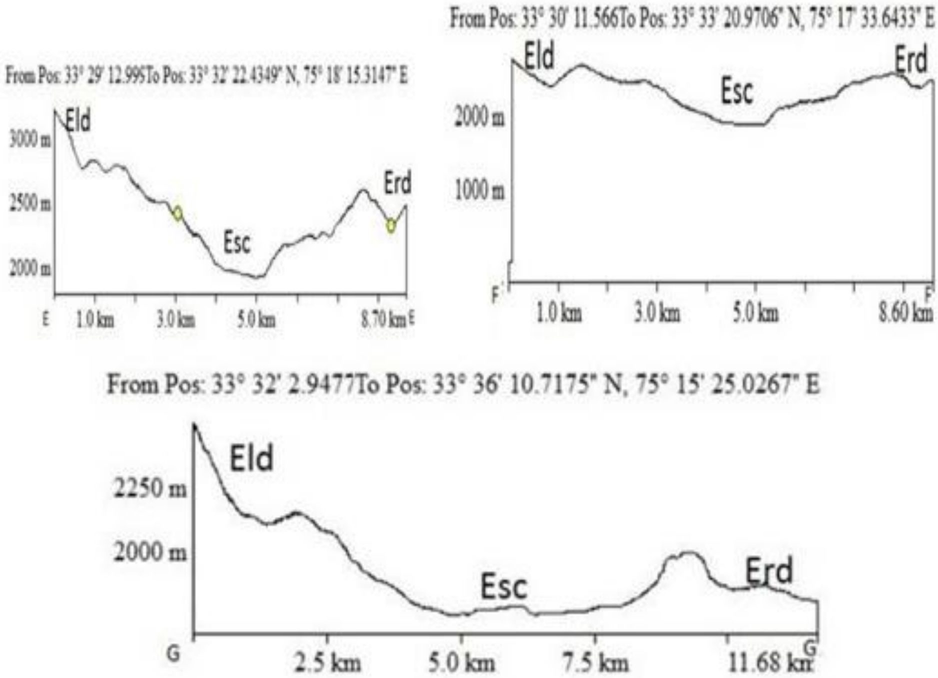


Fig (10) Cross section for transverse profiles (AA-GG)

Stream Gradient Index (Sl):

Stream gradient index (SL) reflects relationship among stream power, rock resistance and tectonics (Hack; 1973). SL is a parameter to evaluate if change in stream slope is due to rock resistance or tectonic deformation in particular, if it has a vertical component (Keller and Pinter; 2002). The SL values are high in areas where rocks are particularly resistant or where active tectonics has resulted in vertical deformation at the earth's surface. Therefore, high SL indices in rocks of low to uniform resistance are a possible indicator of active tectonics (Keller; 1986). In this study, the SL values were calculated along the Sandran stream for five segments with SL values 988, 1027, 1470, 800, 600 respectively by using a DEM in GIS environment (Fig 11), Our observations show that the Sandran stream has high SL values, which corroborate with the major rivers across the Himalayan mountain range indicating high tectonic activity in the study. The sensitivity of channel gradient to rock-uplift is also evident from knick points developed along the studied stream. The development of knick points cause erosion and bring about changes in the drainage pattern, which is also suggestive of tectonic and lithological control on the landform development in the area.

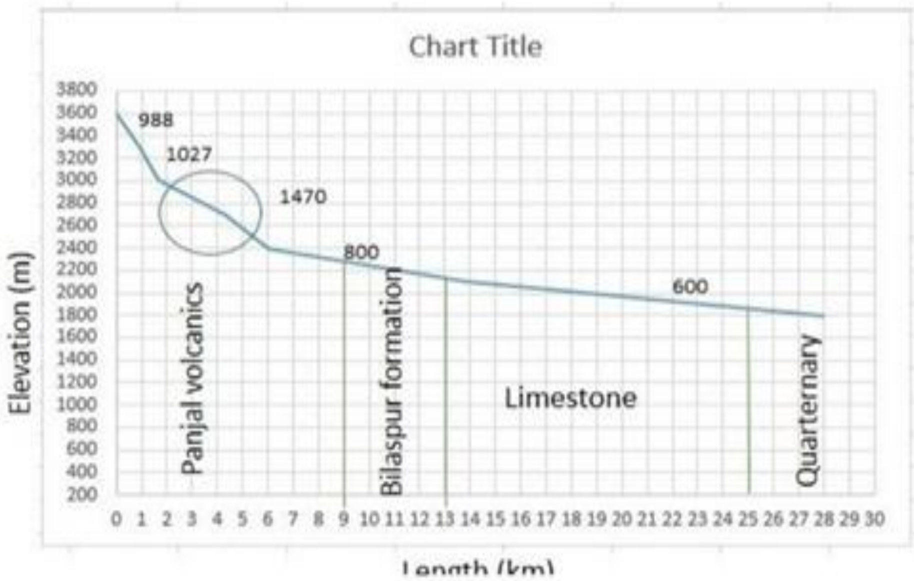


Fig (11) Longitudinal river profile of Sandran stream and plot of SL values.

III. CONCLUSION

The Sandran watershed of Kashmir Valley has been studied to understand its Morphotectonic evolution on the basis of various geomorphic indices complemented and validated with extensive field observations, as rivers are one of the most important landforms on the ground that are extremely sensitive to tectonic movements and also they are the fundamental units of fluvial landscape. The geomorphic indices has been calculated by the use of topographic maps,digital elevation model, satellite images and aerial photographs. The landform study analysis us to determine the impact of tectonics in the development of lineaments, erosion processes and consequent drainage development. The analysis and calculation of Morphotectonic parameters viz Mountain front sinuosity (Smf), Sinuosity index (Si), Hypsometric integral (Hi), Drainage basin asymmetry or Asymmetric factor (AF), Stream length gradient index (SL),Valley-floor width to Valley height ratio (Vf) ,along with field observations shows that the Sandran watershed is strongly elongated and is tectonically active.The low Mountain front sinuosity value and high Stream length gradient index values and the presence of Knick point at the SL value of 1470 on the longitudinal profile of stream which is developed not because of lithology change as the lithology at that area is same but has developed because of tectonics which shows that the watershed has steep slopes and its formation is controlled largely by tectonic activity rather than erosion. The observed values of Drainage basin symmetry(AF) in the area shows widespread drainage basin asymmetry related to tectonic tilting. Area elevation analysis or hypsometry is a powerful tool for differentiating tectonically active regions from inactive ones. Hypsometric integral is related to the degree of dissection of a landscape. The calculated hypsometric integral value for the study area is 0.4, which is on the higher side indicating that the area is in youthful stage with high topography and incised streams thus suggesting that the area is tectonically controlled.

Overall assessment of the Morphotectonic analysis revealed that the tectonic uplift, lithology and climate forcing played a significant role in the landscape evolution of the Sandran stream and the area has experienced differential uplift and erosion rates from time to time in the geological past and is tectonically active.

REFERENCES

[1]. Tectonic Geomorphology **Douglas W. Burbank** Department of Geosciences The Pennsylvania State University **Robert S. Anderson** Department of Earth Sciences University of California, Santa Cruz.
[2]. Keller EA, Pinter N (1996) Active tectonics: earthquakes uplift and landscapes. 2nd. Prentice Hall, New Jersey, p. 338; Burbank W, Anderson RS (2001) Tectonic geomorphology. Science,Blackwell
[3]. Keller EA, Pinter N (1996) Active tectonics: earthquakes uplift and landscapes. 2nd. Prentice Hall, New Jersey, p. 338
[4]. Rockwell TK, Keller EA, Jhonson DL (1985) Tectonic Geomorphology of alluvial fans and mountain fronts near Ventura, California. In: Morisawa M, Hack JT (eds) Pr. Allen Unwin Boston Binghantom (15th Ann. Tec.. geomorph.. symp.) Sept. 1984, pp 183–208
[5]. Wells SG, Bullard TF, Menges TM, Drake PG, Karas PA, Kelson KI, Ritter JB, Wesling JR (1988) Regional variations in tectonic geomorphology along segmented convergent plate boundary, Pacific Coast of Costa Rica. Geomorphology 1:239–265
[6]. Cox RT (1994) Analysis of drainage basin symmetry as a rapid technique to identify areas of possible Quaternary Tilt-block tectonics: an example from the Mississippi Embayment. Geol Soc Am Bull 106: 571–581
[7]. El Hamdouni R, Irigaray C, Fernandez T, Chacón J, Keller EA (2007) Assessment of relative active tectonics, southwest border of Sierra Nevada (southern Spain). Geomorphology 96:150 173
[8]. Ahmad S, Bhat MI (2012) Tectonic geomorphology of Rambiara basin, SW Kashmir Valley reveals emergent out-of-sequence active fault system. Himalayan Geol 33(2):162–172
[9]. Ahmad S, Bhat MI, Madden C, Bali BS (2013) Geomorphic analysis reveals active tectonic deformation on the eastern flank of the Pir Panjal Range, Kashmir Valley. India Arabian J Geosci. doi:10.1007/ s12517-013-0900-y Alam A, Ahmad S, Bhat MS, Ahmad B (2015) Tectonic evolution of Kashmir basin in NW Himalayas. Geomorphology 239:114–126
[10]. Raza M, Ahmad A, Mohammad A (1978) The valley of Kashmir, a geographical interpretation of the land, vol 1. Vikas Publishing House Pvt, Ltd New Delhi:
[11]. Meher-Homji, V.M. 1971. The climate of Srinagar and its variability.
[12]. Bull WB, Mc Fadden LD (1977) Tectonic geomorphology north and south of the Garlock Fault California, in arid regions. Proceedings eighth Annual Geomorphology System, State University, New York, Binghamton, pp. 115–138: Keller EA, Pinter N (1996) Active tectonics: earthquakes uplift and landscapes. 2nd. Prentice Hall, New Jersey, p. 338
[13]. Keller EA, Pinter N (1996) Active tectonics: earthquakes uplift and landscapes. 2nd. Prentice Hall, New Jersey, p. 338
[14]. Wells SG, Bullard TF, Menges TM, Drake PG, Karas PA, Kelson KI, Ritter JB, Wesling JR (1988) Regional variations in tectonic geomorphology along segmented convergent plate boundary, Pacific Coast of Costa Rica. Geomorphology 1:239–265
[15]. Bull WB, Mc Fadden LD (1977) Tectonic geomorphology north and south of the Garlock Fault California, in arid regions. Proceedings eighth Annual Geomorphology System, State University, New York, Binghamton, pp. 115–138
[16]. Bull WB, Mc Fadden LD (1977) Tectonic geomorphology north and south of the Garlock Fault California, in arid regions. Proceedings eighth Annual Geomorphology System, State University, New York, Binghamton
[17]. Strahler AN (1952) Hypsometric (area-altitude) analysis of erosional topology.Geol Soc Am Bull 63(11):1117–1142
[18]. Pike RJ,Wilson SE (1971) Elevation relief ratio, hypsometric integral and geomorphic area-altitude analysis. Geol Soc Am Bull 62:1079–1084
[19]. Hare, P. W., and Gardner, T. W., 1985. Geomorphic indicators of vertical neotectonism along converging plate margins, Nicoya Peninsula Costa Rica.
[20]. Hare, P. W., and Gardner, T. W., 1985. Geomorphic indicators of vertical neotectonism along converging plate margins, Nicoya Peninsula Costa Rica.
[21]. Gardner, T. W., Bullard, T. F., et. al. 1987. Geomorphic systems of North America.

[22]. Strahler AN (1957) Quantitative analysis of watershed geomorphology. Am Geophys Union Transac 38:913–920
[23]. Leopold ,luna B.,wolman,M.G.,and miller,J.P.,1964,fluvial processes in Geomorphology,san Francisco,W.H.freeman and co.,522p
[24]. Bull WB, Mc Fadden LD (1977) Tectonic geomorphology north and south of the Garlock Fault California, in arid regions. Proceedings eighth Annual Geomorphology System, State University, New York, Binghamton
[25]. Hack JT (1973) Stream-profile analysis and stream gradient index. US Geological Survey J Res 1:1421–1429
[26]. Keller EA (2002) Active tectonics: earthquakes, uplift, and landscapes 2nd Edition. Prentice Hall, New Jersey, p. 362
[27]. Keller EA (1986) Investigation of active tectonics: use of surficial earth processes. in: Panel on active tectonics. National Academy Press, Washington, D.C., pp. 138–147

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