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MORPHOTECTONIC ANALYSIS FOR WATERSHEDS OF SHIKARIPURA TALUK, SHIVAMOGGA DISTRICT, KARNATAKA: USING RS AND GIS

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ABSTRACT

In this study examined the detail morph tectonic evaluation of watersheds of Shikaripurataluk with the significances on its implication for tectonic activity using remote sensing and GIS technique. In studies hill shaded images, stream networks were extracted from Cartosat-DEM data of 30m spatial resolution. Individual spectral bands of Landsat – 8 OLI data were processed and the layers are stacked into a single multispectral images using ERDAS, lineament map were extracted from ASTER using PCI Geomatics software and we extracted several Morphotectonic parameters such as Channel Sinuosity (The index value ranges between 1.0 to 1.5 indicates the sinuous shape of the river whereas the sinuosity value greater than 1.5 indicates the meandering river.), drainage basin asymmetry (The calculation of the transverse topographic symmetry of the current study area is carried out at seven locations and the values ranges from 0.043 to 0.289), mountain front sinuosity (The Smf values are less than 1.4 in the high tectonically active regions), basin elongation ratios. Qualitative analysis of morphotectonic parameter confirms that less to very less tectonic activity in the region result reveals that majorly dendritic and the parallel drainage pattern are observed which indicate that the fluvial system is mainly influenced by the slope of the terrain not by the lineament distribution of the areaand also argillite covers 71% of the total area. The Shikaripurataluk has majorly nine type of morphological units i.e. Ridges, Denudational hills, Residual hills, Pediment plain, Intermontane valley, Denudational slope, Structural hills, Water body, Valley floor. Therefore, structural entities and the tectonics have the contribution in the morphological classes which have the structural origin but no significant influence on the dynamic fluvial system is determined.

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INTRODUCTION

Morphotectonic (from Ancient Greek: morphe "form"; and tektonikos, "pertaining to building"), or tectonic geomorphology, is a branch of geomorphology that studies how landforms are formed or affected by tectonic activity (Doornkamp, 1986). Morphotectonic analysis is all about the study of the influence of the geological features on the geomorphology of the terrain. The nature of the rocks and their compositions place significant impact on the infiltration and runoff rate hence become the influential factor for the ground water analysis. The geologic condition and its influence on the fluvial system are analyzed by calculating the morphotectonic parameters such as channel sinuosity, asymmetry factor, mountain front sinuosity, basin elongation ratio. Systematic observation and analysis of remotely sensed data helps in quick identification and delineation of landforms, structural features and drainage characteristics. Significant improvement in resolution of satellite data and advancement in computing resources has enabled the investigators to carry out quantitative and more precise analysis of geo-spatial data (Bhatt *et al*., 2016). Remotely sensed products such as Digital Elevation Model (DEM), ASTER and Landsat Datasets with high spatial and spectral resolutions are really helpful while analyzing the location and distribution of the geological lineaments and in the calculation of the morphotectonic parameters. Chorowicz *et al*., (1991) calculated dip and fault lines from geological maps using DEM (Digital Elevation Model) data. Bhatt *et al*., (2016) carried out the morphotectonic analysis of Anandpur Sahib area of Punjab state and mentioned in the conclusion that Satellite based evidence like straightened river courses, abrupt changes in flow direction, flow against gradient, beheaded streams and river terraces reflect the strong structural control on the fluvial features. Satellite based evidence like abrupt changes in the flow direction, straightened course reflects the strong structural control on the fluvial features (Acharjee et. al.,2013).

Geology of the study Area: Shikaripurataluk comprises of the rock formations belonging to Archaean to lower Proterozoic and Recent age and the water bearing characteristics of schists are more or less similar to that of gneisses and granites. But the weathered zones of schists may not yield as granites, because of their compact and fine-grained nature. (Ground water Information Booklet Shimoga District, Karnataka., 2007).

DATA AND METHODOLOGY

The morphotectonic analysis is carried out using remotely sensed data and GIS software.

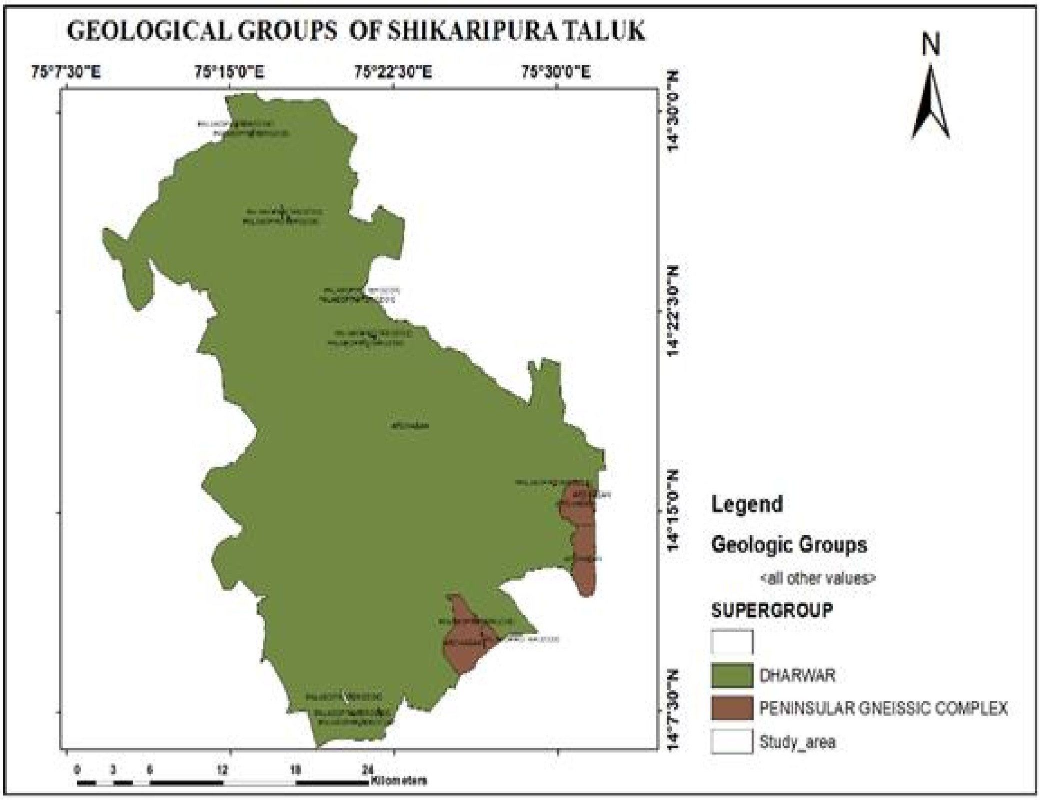

Figure 1. Geological groups of shikaripurataluk

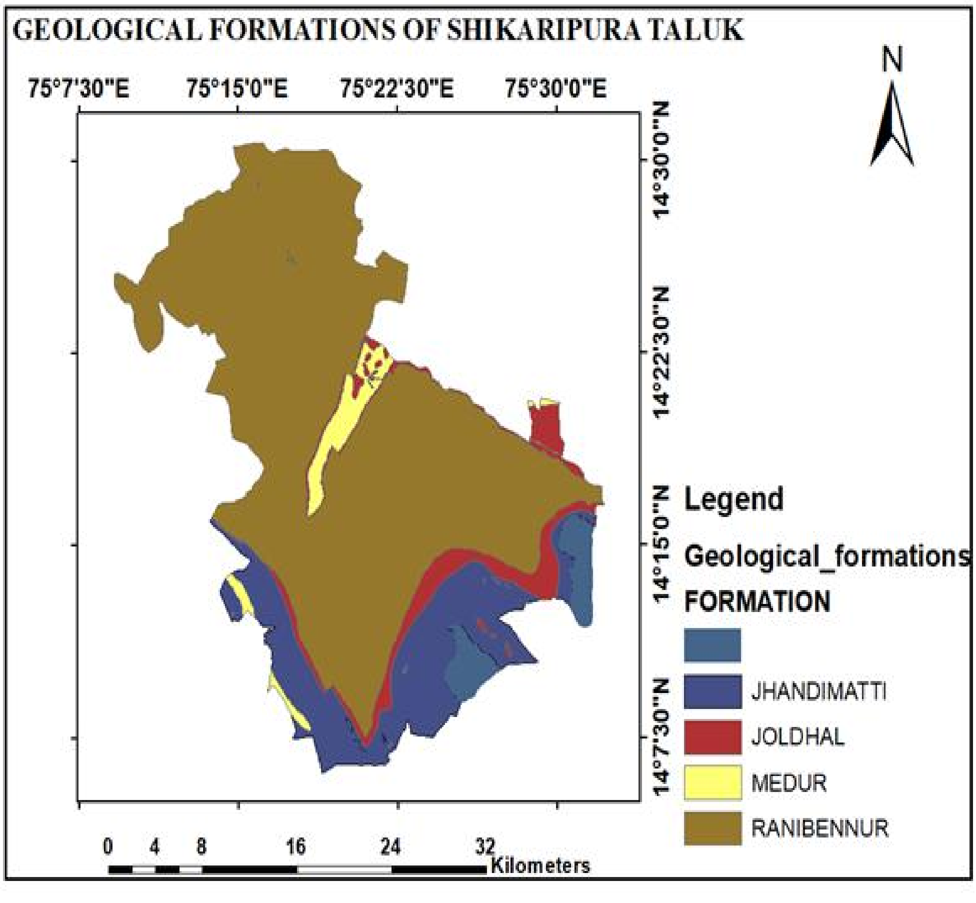

Figure 2. Geological formations of shikaripurataluk

Cartosat-DEM data of 30m spatial resolution was collected from Bhuvan web platform and using Arc map 10.2, hill shaded images of the study area have been extracted. Automatic extraction of the stream networks is performed using the spatial analyst tool (pre-defined algorithms) in the Arc map software. Landsat-8 OLI data sets of November 2018 and May 2019 were collected from USGS earth explorer platform and the spatial, spectral properties of the data sets are displayed in the table 3. These individual bands are processed (noise removal, haze reduction) and the layers are stacked into a single multispectral image using ERDAS (Earth Resource Development Assessment System) software. The visual interpretation of the terrain was performed by considering the shape, size, structure, tone, color, shadow of the spatial features. ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) data set was collected for the lineament extraction which was carried out using PCI Geomatica software with the help of LINE tool (Lineament extraction tool) which extracts the lineaments using pre- defined algorithms. The tool extracts curvilinear features from a single image channel and records the polylines in a vector layer by using six threshold parameters. lineaments is statistically analyzed using the rose diagram. Morphotectonic parameters such as Channel Sinuosity, drainage basin asymmetry, mountain front sinuosity, basin elongation ratios are calculated using the mathematical equations given by Muller (1968), Cox (1994) and Bull &Mc Fadden (1977).

RESULTS AND DISCUSSION

Lithological classes: The study area is characterized by the presence of schistose rock layer date back to the Archean and Paleoproterozoic age. The classified lithological classes are displayed in the table 4, depict that Argillite is the main component among them by covering 71% of the total area. Argillite is a fine-grained sedimentary rock composed predominantly of indurated clay particles. Argillaceous rocks are basically lithified muds and oozes.

Geomorphology: By using the Cartosat-DEM and the Landsat 8 OLI data are used to demark the geomorphological classes and listed in the table.

Table 1. Morphotectonic parameters with their equations and the inference

Parameters	Equations	References	Values, Inferences
Channel Sinuosity (S)	S=SL/VL, SL=Stream length, VL=Valley length	Muller (1968)	S=I.0, Straight Course
			S=1.0-1.5, Sinuous Course
			S> 1.5, Meandering Course
Drainage Basin Asymmetry: Topographic Symmetry factor (T)	T=Da/Dd, Where, Da=Distance from midline of drainage basin to midline of active channel, Dd=Distance from basin midline to basin divide.	Cox (1994)	T=0, Symmetric Basin
			T>0, Asymmetric Basin
			AF=50, Stable Setting Environment
Asymmetry Factor (AF)	AF=100(Ar/At), Where, Ar=Right hand side area of drainage basin looking downstream, At=Total area of drainage basin.		AF>50, Suggest tilt
Basin Elongation Ratio (Re)	$(R_e)= 1.128\sqrt{A} / L_b$ Where, R_e– Elongation ratio; A- Area of the basin; L_b- Length of the basin.	Schumm (1956)	Re<0.50, Tectonically active
			Re=0.50-0.75, Slightly Active
			Re>0.75, Inactive Setting
Mountain Front Sinuosity (Smf)	Smf=Lmf/Ls,Lmf=Mountain front length along mountain foot, Ls=Straight line length of mountain front.	Bull &Mc Fadden (1977)	Smf<1.4, tectonically active
			Smf=l.4-3, Slightly Active 4
			Smf>3, Inactive Setting

Table 2. Details of the spectral bands of landsat 8 oli

Band number	Band Name	Band width (in µm)	Resolution (in m)	Band number	Band Name	Band width (in µm)	Resolution (in m)
Band1	Coastal	0.43-0.45	30	Band7	SWIR2	2.11-2.29	30
Band2	Blue	0.45-0.51	30	Band8	Pan	0.50-0.68	15
Band3	Green	0.53-0.59	30	Band9	Cirrus	1.36-1.38	30
Band4	Red	0.64-0.67	30	Band10	TIRS1	10.6-11.19	100
Band5	NIR	0.85-0.88	30	Band11	TIRS2	11.5-12.51	100
Band6	SWIR1	1.57-1.65	30				

Table 3. Lithological classes and their distribution in the study area

S. No	Lithologic classes	Area (in sq. Km)	% distribution	S. No	Lithologic classes	Area (in sq. Km)	% distribution
1	Chlorite schist	140.81	15.40	9	Andesite	22.00	2.41
2	Gabbro	0.841	0.091	10	Meta-ultramarine	0.09	0.01
3	Banded iron formation	8.072	0.88	11	Epidote granite	6.82	0.75
4	Argillite	650.77	71.18	12	Limestone	0.025	0.01
5	Rhyolite	5.44	0.60	13	Meta-gabbro	0.031	0.003
6	Ferruginous phyllite	53.22	5.82	14	Biotite gneiss	8.932	0.98
7	Meta-basalt	1.00	0.11	15	Migmatite gneiss	13.75	1.50
8	Quartzite	2.42	0.26				

The following input parameters were generally used i.e. RADI (Filter Radius) = 24; GTHR (Edge Gradient Threshold) = 70; LTHR (Curve Length Threshold) = 30; FTHR (Line Fitting Threshold) = 3; ATHR (Angular Difference Threshold) = 7 and DTHR (Linking Distance Threshold) = 70 (Radaideh *et al.,* 2016). The orientation of the

The Shikaripurataluk has majorly nine type of morphological units i.e. Ridges, Denudational hills, Residual hills, Pediment plain, Intermontane valley, Denudational slope, Structural hills, Water body, Valley floor.

Table 4. Geomorphological classes of shikaripura taluk

S.No	Classes	Area (in Sq Km)	S.No	Classes	Area (in Sq Km)
1	Ridges	72.57563	6	Denudational slope	375.4219
2	Denudational hills	161.66	7	Structural hills	240.2743
3	Residual hills	15.06393	8	Waterbody	2.15
4	Pediment plain	123.5103	9	Valley floor	10.45794
5	Intermontane valley	9.983281			

Table 5. Values of morphotectonic parameters

Section	Da	Dd	Topographic Symmetric Factor	Section	Mountain front sinuosity
1	0.41	9.60	0.04	A	1.66
2	1.49	9.90	0.15	B	1.59
3	3.17	10.93	0.28	C	1.33
4	3.88	13.56	0.28	D	1.50
5	3.05	14.68	0.20	E	1.17
6	1.66	12.11	0.13	F	1.66
7	1.59	12.68	0.12	G	1.64

Table 6. Values of morphotectonic parameters

River section	Stream length	Valley length	Channel sinuosity	River section	Stream length	Valley length	Channel sinuosity
1	1.181	0.91	1.29	11	1.67	1.32	1.26
2	2.718	2.66	1.02	12	1.84	1.38	1.34
3	2.88	2.70	1.06	13	1.41	1.16	1.20
4	2.61	2.23	1.17	14	1.24	0.86	1.43
5	2.40	1.93	1.24	15	1.72	1.13	1.51
6	1.43	0.80	1.78	16	1.48	1.10	1.34
7	3.50	3.01	1.16	17	1.51	1.21	1.24
8	0.81	0.73	1.12	18	1.23	1.15	1.06
9	2.22	1.83	1.21	19	1.09	1.09	0.99
10	2.27	1.28	1.76	20	1.35	0.98	1.37

Lineament Pattern: A lineament is a mappable linear or curvilinear feature of a surface whose parts align in a straight or slightly curving relationship (Hung *et al*., 2005). On the earth, lineaments could be (1) straight stream and valley, (2) aligned surface depressions, (3) soil tonal changes, (4) alignments in vegetation, (5) vegetation type and height changes, or (6) abrupt topographic changes. All of these phenomena might be the result of structural phenomena such as faults, joint sets, folds, cracks or fractures (Hung *et al*., 2005). The lineament distribution in the current study area is more generally dispersed but distribution is comparatively more in NE- SW, NNW-SE direction whereas WNE, ESE parts showed comparatively lesser lineament presence. The evaluation of the distribution is verified by observing with the lineament density map (Figure 5). The stream network and the drainage pattern of the area is compared with the lineament distribution to observe its influential factor.

Drainage pattern: Drainage pattern result from the variations in the conditions of the topography, porosity, permeability, geologic structure and the chemical composition of the soil and the rock (Argialas *et al*., 1988). Abrupt changes in slope along river profiles may indicate active faults that cross the river and the drainage pattern may infer the early stages of the tectonic evolution (Seeber&Gornitz, 1983). The drainage pattern is predominantly of dendritic and parallel type and observed throughout the study area (figure 6). The northeastern and the central part of the study area where the slope gradient is low, more dendritic pattern are observed. Parallel and sub-parallel drainage patterns are also common, especially in the in areas where the surface water flow is highly controlled by slope gradient and lack of structural interference (Howard, 1967). In the case parallel drainage patterns are observed in the southern and the southwestern part. High elevated regions of the northeastern part, southern and the south eastern parts along with the central ridge where the slope is comparatively high, making the streams to flow more dynamically. Slope gradient is influencing more on the streams than the tectonic activity in the region.

Morphotectonic Parameters: Morphotectonic Parameters of Kumudvati watershed of the Shikaripurataluk has been calculated using mathematical equations and discussed as follows.

Channel sinuosity: Channel sinuosity calculates the amount of deviation of the river system from its straight course. The index value ranges between 1.0 to 1.5 indicates the sinuous shape of the river whereas the sinuosity value greater than 1.5 indicates the meandering river. The straight course of the river or the sinuous value is equal to 1 indicate the very less or no tectonic influence on the river whereas the value greater than 1.5 shows the higher influence. In the current study, the Kumudvati river is divided into 20 parts (Figure) and the channel sinuosity value is calculated. As the result, three parts (6,7,10) among the twenty shows the meandering condition of the river and the thirteen segments indicated the index value in between 1.0 to 1.5 depict the partial influence of the tectonics. Only four parts indicated the index value near to 1 which depicts the very less tectonic influence.

Drainage Basin Asymmetry: Basin asymmetry factors are become helpful for analyzing the nature of the drainage basin and computed using two factors.

Transverse Topographic symmetry/ Topographic Symmetry Factor: Transverse topographic symmetry is a vector that has direction and magnitude ranging from 0 to 1 which reflects a perfect asymmetric basin or tilted one respectively (Burbank & Anderson, 2011). Perfectly symmetric basin has value of transverse topographic symmetry (T) as zero, as the asymmetry increases T increases and approaches the value of one (Bhatt *et al*., 2007). The calculation of the transverse topographic symmetry of the current study area is carried out at seven locations and the values ranges from 0.043 to 0.289. The majority of the values are nearer to the value zero.

Asymmetry factor: Asymmetry factor is sensitive to tilting perpendicular to the main channel of the basin. AF values more/less than 50 suggests a tilt (Bhatt *et al*., 2007). The asymmetric factor value of the study area is stays at 45.93 which is closer to the value 50 and shows the symmetrical nature of the basin.

Basin Elongation Ratio (Re): Basin elongation ratio is considerd as the proxy indicator of the tectonic condition of the region (Cuong and Zuchiwicz, 2001). Drainage basins in arid and semiarid climates show Re values of less than 0.50, between 0.50-0.75 and more than 0.75 for tectonically active, slightly active and inactive settings respectively Bhatt *et al*., 2007. The elongation ratio values are calculated using the mathematical equation and the resulted values are fall in the range between 0.7-0.9. The Kumudvati watershed showed the value of 0.98 whereas the portions of Tungabhadra and Dandavati watersheds showed the values as 0.89 and 0.78 respectively indicating the inactive tectonic nature of the region.

Mountain front sinuosity: Mountain front sinuosity is a significant tool to identify the active regions of the tectonic activity. This index reflects the balance between erosion producing irregular/ sinuous fronts and tectonic forces creating straight mountain fronts coincident with an active range boundary fault (Raj *et al*., 2003).

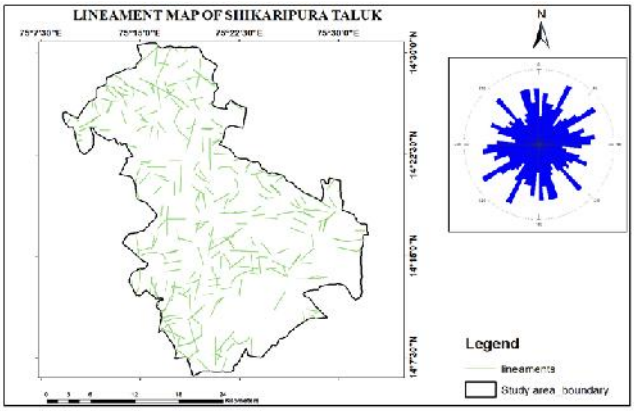

Figure 5. Lineament map of shikaripura taluk along with the rose diagram showing the lineament distribution

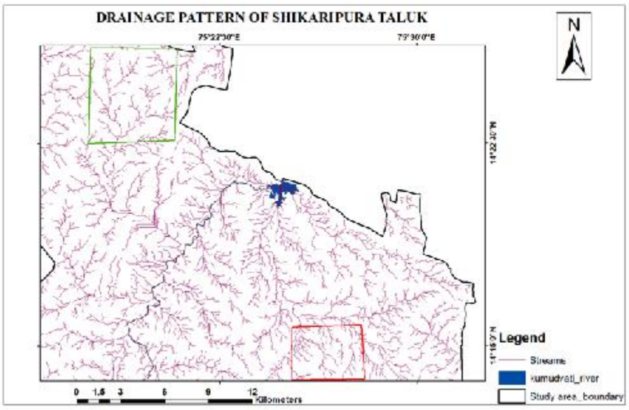

Figure 6. Drainage pattern of shikaripura taluk red and green box displaying the parallel and dendritic drainage pattern respectively

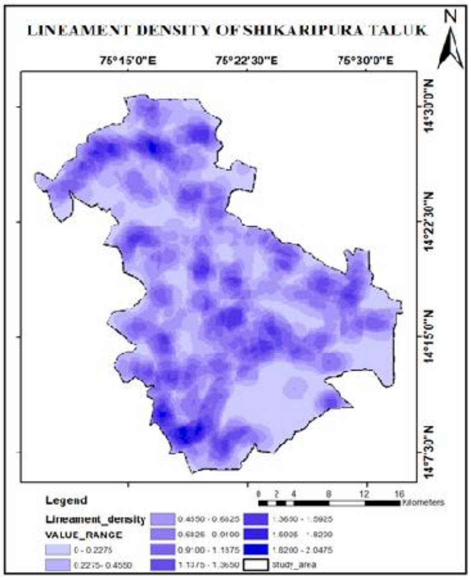

Figure 7: Lineament density map of shikaripura taluk

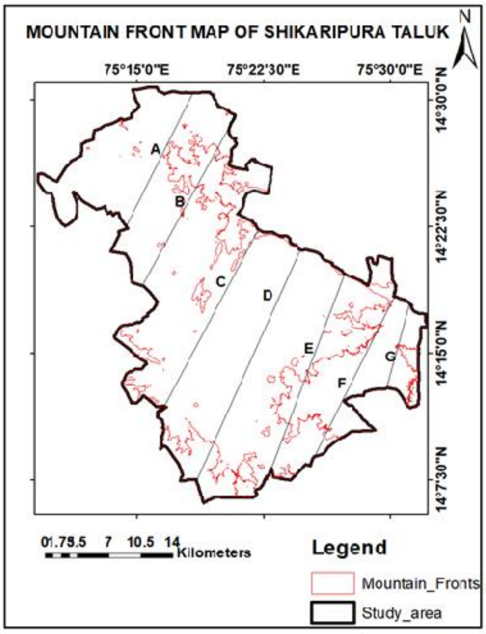

Figure 8. Mountain front map of shikaripura taluk

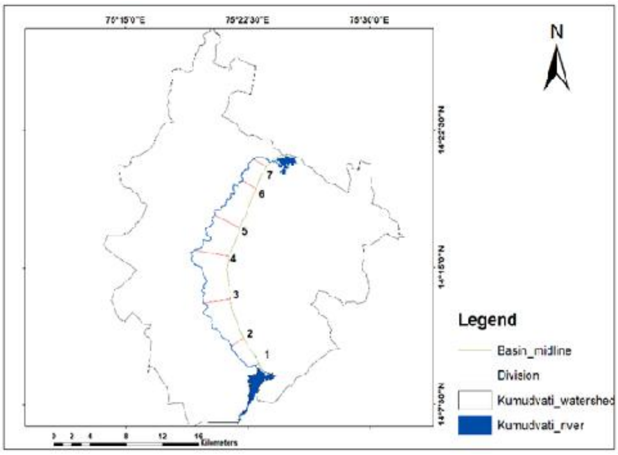

Figure 9. Displaying the sub-divisions made for the calculation of the transverse topographic symmetry

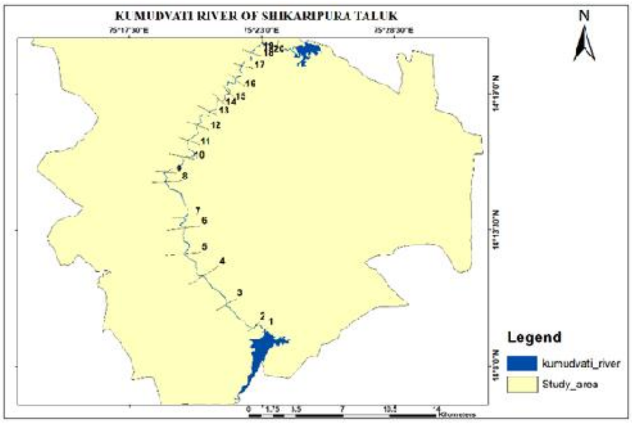

Figure 10. Displaying the sub-divisions made for the calculation of channel sinuosity

The Smf values are less than 1.4 in the high tectonically active regions. The value ranges between 1.4 to 3, those mountain fronts will display less activity but still show active tectonics whereas Smf values more than 3 are associated with inactive fronts (Bull and McFadden, 1977). In the current study, the study area is divided into seven divisions marked from A to G (Figure). The Smf values are computed and the among the seven values five are (A, B, D, F, G) lie in the range of 1.4 to 3 whereas the other two values (C&E) are nearer to the value 1.4 i.e 1.33 &1.17 respectively.

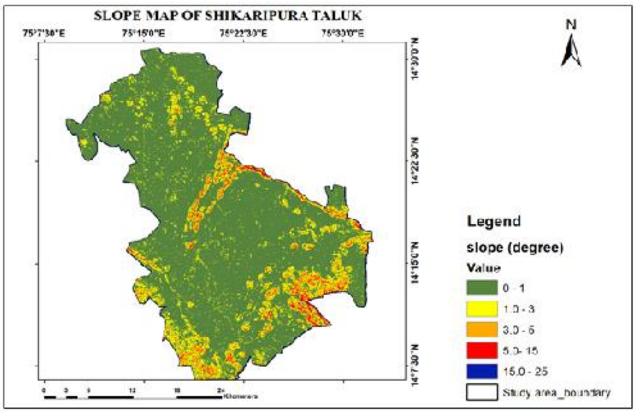

Figure 11. Slope map of shikaripura taluk

CONCLUSION

The morphotectonic analysis of the study area is carried out to determine the tectonic influence on morphology and the fluvial system of the study area. majorly dendritic and the parallel drainage pattern are observed which indicate that the fluvial system is mainly influenced by the slope of the terrain not by the lineament distribution of the area. The morphotectonic parameters of the area are calculated by using the mathematical expressions. The channel sinuosity value shows that part of the river is slightly influenced by geological/ geographical factors displaying medium sinuosity, whereas the basin elongation ratio value shows inactivity of the tectonics in the region. The asymmetric factor value and the topographic symmetry factor value are also depicting less to very less tectonic activity in the region. Therefore, structural entities and the tectonics have the contribution in the morphologicalclasses which have the structural origin but no significant influence on the dynamic fluvial system is determined.

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