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TECTONO-MORPHOMETRY OF DRAINAGE BASINS ALONG MAJOR FAULTS AND LINEAMENTS OF WESTERN RAJASTHAN

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ABSTRACT

The post Mesozoic collision of the Indian and Eurasian plate resulted into deformation and segmentation of the Indian Plate. The differential movement of the segmented tectonic blocks of western Rajasthan in context to Indian Plate was evidenced by geomorphic indices at sub watershed level in the Jaisalmer, Luni Sukri and Banas-Sipu basins. The block uplift and tilting are due to movements of faults parallel to Jaisalmer-Barwani lineament/Kanoi Fault and Luni- Sukri lineaments which are intersecting the region. The geomorphic indices of sub watersheds along the active faults are higher as compared to other region of the basins.

Key words: Mesozoic Collision, Tectonic Blocks, Faults and Lineaments, Intraplate seismicity, Epicentres, Drainage Basins, Geomorphic Indices.

INTRODUCTION

Tectonically controlled drainage basin are classified by shape of basin, high or low relief (depending on dominant processes and tectonic control), hill slope processes and geological structures dominant in basin development, relative to fluvial processes (Burbank & Anderson, 2001; Molin *et al.*, 2004). To evaluate characterization of the drainage basins regarding the dominance of erosional or tectonic processes geomorphic indices are helpful. Geomorphic Indices provides quantitative description of the basin geometry to understand initial slope or inequalities in the rock hardness, structural control, and recent diastrophism, geological and geomorphic history of drainage basin (Strahler 1964). El-Hamdouni *et al.* (2008) developed and applied a model that use the Hypsometric Integral (HI), the Stream Length–gradient index (SL) and other geomorphic indices to evaluate the Relative Active Tectonics (Iat). Della-Seta *et al.* (2008) believed that Relative Active Tectonics index (Iat) is an indicator of morphotectonic features and landforms which useful in the interpretation of tectonic events of an area.

The aim of this study is to evaluate the tectonic control of Jaisalmer-Barwani Lineament (JBL) /Kanoi Fault (KF), Luni-Sukri Lineament and Sirohi-Deesa Lineament in modifying the geomorphology in the Jaisalmer, Luni-Sukri and Banas-Sipu basins of western Rajasthan using various Geomorphic Indices and Relative Active Tectonics index (Iat).

SEISMOTECTONICS OF WESTERN RAJASTHAN

The important lineament and faults in the NW Rajasthan traversing the study area are Jaisalmer- Barwani Lineament/ Kanoi Fault, Rajkot Lathi lineament, Luni Sukri lineament, Sirohi-Deesa lineament, Marginal Fault, few minor lineaments and neotectonic faults (GSI, 2000). The prominent directions of these linear features are NNW-SSE and NE-SW and have divided the western Rajasthan crust into a number of rectangular blocks (*Fig 1*). According to Dassarma (1988) the Neogene and Quaternary tectonics led to rejuvenation of the old basement faults in the Precambrian crust in NE Rajasthan and segmented blocks of crust were uplifted along faults. The post Mesozoic faults and lineaments were responsible for neotectonic activities in the region. Relationship of seismicity in the intraplate region of north-western Indian Shield has been evidenced by occurrences of earthquakes along these lineaments and faults. The intra-plate parts of Rajasthan too have a history of mild to moderate earthquakes intensities (*Table 1*) and the epicentres are located on the ancient lineaments represented by tectonic contacts or along the faults and lineaments (*Fig 1*).

Table 1: Earthquake Catalogue Of Western Rajasthan

EC	Lat	Long	Date	Ms	Mb	Depth (Km)	Magnitude (Mw)	Mb 1	Source
1	24.4	72.2	26.04.1848	-	-	-	-	-	OLD
2	24.4	72.7	26.04.1848	-	5.5	-	5.5	-	EPI
3	25.2	73.2	02.01.1849	-	4.1	-	4.1	-	EPI
4	24.2	72.2	01.01.1871	-	4.2	-	4.2	-	EPI
5	24.6	72.8	03.07.1876	-	3.3	-	3.3	-	EPI
6	24.9	72.7	15.12.1882	-	6.1	-	6.1	-	EPI
7	25	73	15.08.1906	5	-	-	-	-	IMD
8	25	71	15.08.1906	-	5.7	-	5.7	-	ASC
9	26	72	12.07.1907	5	-	-	-	-	TR2
10	27.5	70.25	31.10.1940	5.6	-	-	-	5.6	GR
11	24.1	70.9	12.03.1962	-	-	-	-	-	CGS
12	24.2	73	01.09.1962	-	4.7	-	4.7	-	EPI
13	24.9	70.3	13.07.1963	5.6	-	-	-	5.6	CGS
14	24.76	72.54	24.10.1969	-	4.9	31	-	-	ISC
15	24.8	72.4	24.10.1969	-	5	-	5	-	EPI
16	26.95	71.7	18.05.1974	-	5	-	-	5	GS
17	24.5	71	19.09.1975	-	3.8	-	3.8	-	EPI

EC	Lat	Long	Date	Ms	Mb	Depth (Km)	Magnitude (Mw)	Mb 1	Source
18	24.24	70.08	19.09.1975	-	-	105	-	-	ISC
19	24.97	70.38	03.03.1976	-	-	14	-	-	ISC
20	24.92	70.25	04.03.1976	-	-	39	-	-	ISC
21	24.96	70.47	13.09.1984	-	4.2	33	-	4.2	ISC
22	25.9	71.25	03.11.1985	-	4.4	33	-	4.4	ISC
23	24.45	73.6	15.11.1986	-	4.1	22	-	-	ISC
24	24.1	70.4	10.02.1987	-	3.6	10	-	3.6	ISC
25	24.33	70.08	10.04.1987	-	-	10	-	-	ISC
26	25.86	73.34	02.11.1987	-	-	113	-	-	ISC
27	24.67	70.99	10.12.1989	-	4.67	-	4.67	-	EPI
28	24.78	70.6	06.02.1990	-	-	33	-	-	ISC
29	26.85	70.56	08.11.1991	-	5.2	-	5.2	-	EPI
30	26.89	70.9	08.11.1991	-	3.8	215	-	3.8	ISC
31	26.38	70.66	08.11.1991	5.2	5.5	18	-	5.5	ISC
32	26.3	70.9	08.11.1991	-	3.8	33	-	3.8	ISC
33	26.9	71	08.11.1991	-	-	33	-	-	ISC
34	26.34	70.9	20.11.1991	-	4.3	19	-	4.3	ISC
35	26.5	70.9	25.11.1991	-	4.2	33	-	3.4	ISC
36	27.2	74	08.03.1992	-	-	33	-	-	ISC
37	24.52	70.1	04.05.1992	-	3.4	33	-	3.4	ISC
38	24.51	73.08	30.05.1992	-	-	33	-	-	ISC
39	24.13	74.12	30.05.1992	-	3.81	-	3.81	-	EPI
40	24.7	73.3	04.01.1996	-	4.2	-	4.2	-	EPI
41	25.46	73.72	10.11.2010	-	4.5	-	4.5	-	ASC

EPI: Earthquake catalog data for Peninsular India (10-26 N, 68-90 E) after removal of dependent events using Rao (2015), Rao and Rao (1984), Jaiswal and Sinha (2007).

ISC: International Seismological Centre

TR2, OLD, GR, CGS, GS : Seismotectonic Atlas of India and Its Environs, GSI 2000

ASC: Amateur Seismic Centre (ASC or www.asc-india.org)

IMD: India Meteorological Department

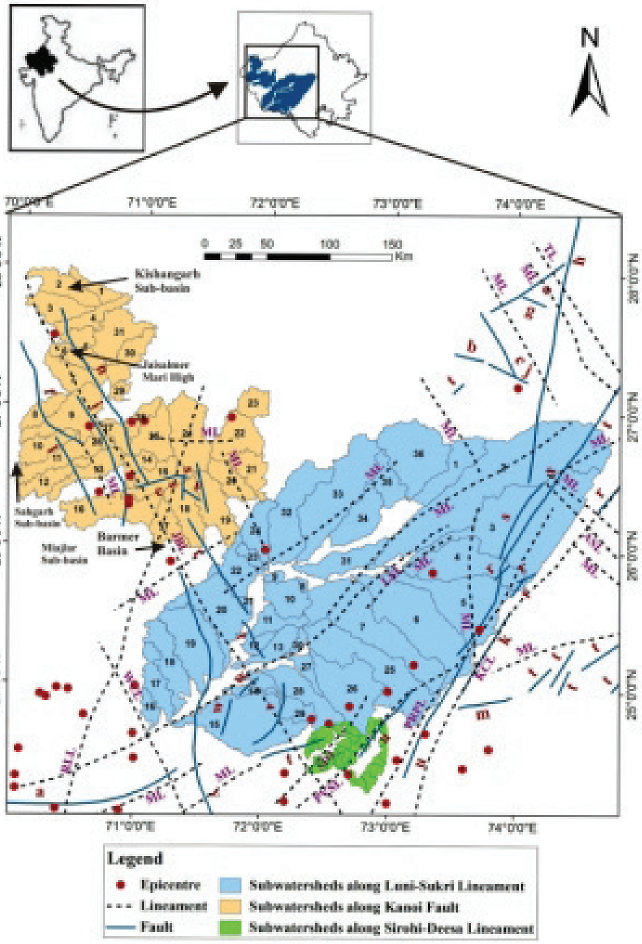

Fig. 1: Seisomotectonic map of the study area (modified after Seismotectonic Atlas, GSI, 2000) . (Abbreviations of Faults - a: Allah bund Fault, b: Bhagu Fault, c: Chau Fault, e: Fatehgarh Fault, f: Ghotaro Fault, g: Soniasar Fault, h: Sardar Shahar Fault, i: Kanoi Fault, jKhatu Fault, k: Kishanganj chipari fault, l: Manshuriyan Fault, m: Nathdwara Fault, n: Ramgarh Fault Manpiya Fault, o: Sadsar Fault, r: Fault involving Basement and Cover, s: Fault involving cover, t: Neotectonic faults, u: Fault Involving Basement).

(Abbreviations of Lineaments - ASL: Ajmer-Sadia Lineament, JBL: Jaisalmer Barwani Lineament, KCL: Kishangarh- Chhipri Lineament, LSL: Luni-Sukri Lineament, PRPL: Palanpur-Ranakpur-Phulad Lineament, PVSL: Pisangan-Vadnagar and Sadri- Palanpur Lineament, RLL: Rajkot Lathi Lineament, SDL: Sirohi Dessa Lineament, TL: Tonk Lineament, WCL: West Coast Lineament, ML: Minor Lineaments).

Jaisalmer Basin: In the Jaisalmer basin rocks of Jurassic age lie over a basement of Marwar Supergroup. The lowermost Jurassic rocks are represented by Lathi Formation which is overlain by Cretaceous and Tertiary Formations composed of sandstones, limestone and clay. The Quaternary sediments are mostly wind- blown and form sand dunes.

The Jaisalmer basin represents the eastern flank of the Indus basin and is divided into four N-S trending geotectonic blocks which have different tectonic features. The Kishangarh Sub basin forms the northwesterly dipping shelf. The Jaisalmer-Mari High is gravity high feature located along shoulder zone of Kanoi Fault and is attributed to upthrusting and wrench faulting and is a zone of lifted blocks. Two regional lineaments traversing the area are the Rajkot-Lathi Lineament (RLL) and Jaisalmer-Barwani Lineament (JBL) (*Fig 1*).

The Jaisalmer-Barwani Lineament demarcates the boundary between the Barmer Graben and Birmania Barmer Nagarparkar Horst and delimits the western boundary of the Mesozoic Cenozoic basin in the Barmer area. The western marginal fault of Cambay Graben merges with the Jaisalmer- Barwani Lineament near Barmer. It can be considered a surface trace of a deep fault controlling basin configuration on either sides of Jaisalmer-Barwani Lineament. Other faults like Kanoi, Ramgarh, Manpiya, Ghotaro and Manshuriyan are present near Jaisalmer. The Kanoi Fault which marks the boundary between the upthrown eastern block, forms part of Jaisalmer Mari Arch and the down thrown western block forms part of the Sahagarh sub basin lies close to the trace of JBL (*Fig. 1*). The Shahgarh Sub Basin is the deepest depression and is less disturbed. The Miajhar Sub Basin in the south of the Jaisalmer Basin is structurally simple. The structural style of Jaisalmer basin has been controlled by faults and the maximum effect of faulting is limited between and Kanoi Faults which can be traced on outcrops and in subsurface (Mishra and Sharma, 1986).

The unusual elevation difference not commonly found in horizontally bedded rocks is observed in Jaisalmer region. The inferred faults marked in the SRTM-DEM (*Fig 2*) indicate regions of abrupt topographical changes. The abrupt change in the ground water table in the same hydrogeological formations has also been reported (Sharma *et al.*, 2016).

Luni –Sukri Basin: The rock formations in the Luni–Sukri basin ranges from basement formed by Banded Gneissic Complex (Archaean), overlain by rocks of Delhi and Marwar Supergroups. The Quarternary sediments cover them consisting of alluvium and aeolian sand. The eastern margin of the basin consists of rocks of Kumbhalgarh/ Sidhreth group, Sendra Ambaji granite & gneiss, Phulad Ophiolites, Punagarh Group, and on the western part shows the exposures of Malani Volcanics are present. The central and southern part of the basin is occupied by Malani, Jalore and Erinpura granites. The rocks of Marwar Supergroup and Palana Formation (Tertiary) are distributed in the northern and north eastern parts. The western, central and southern parts of the Luni-Sukri basin are covered by Quaternary alluvium, blanketed by aeolian sand sheet and sand dunes.

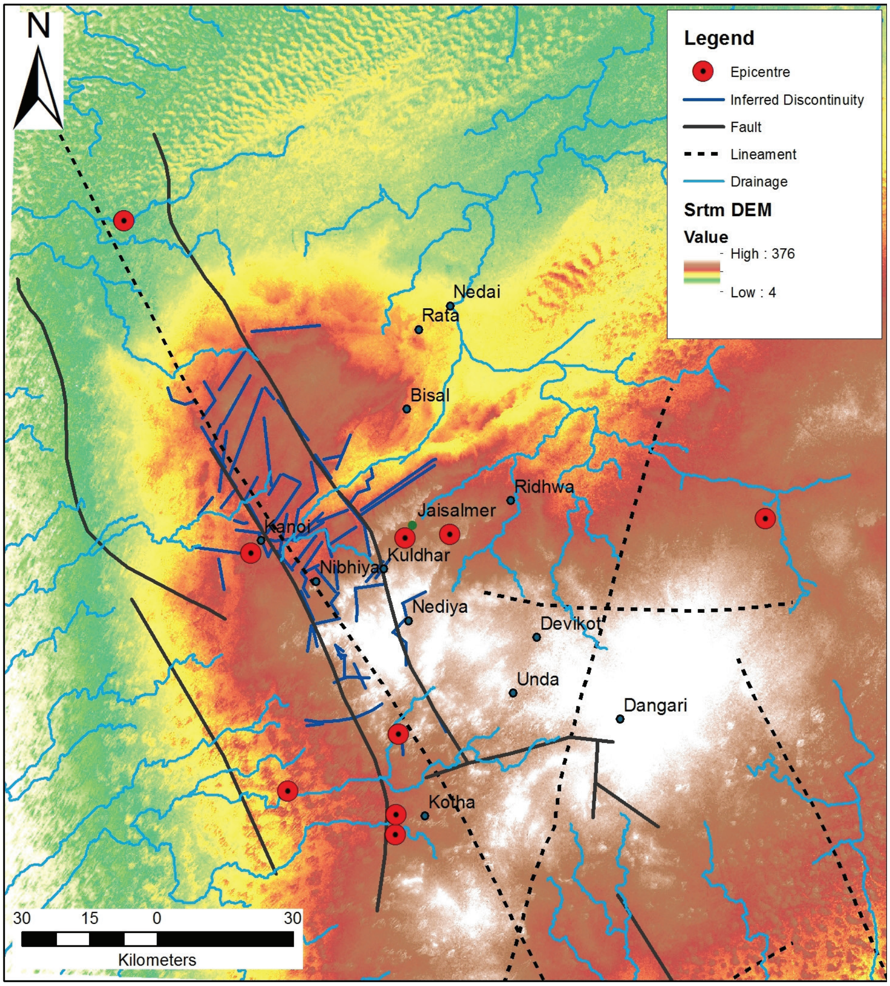

Fig. 2: Digital Elevation model of Jaisalmer Basin

The basin is traversed by two major lineaments; Jaisalmer-Barwani Lineament (JBL) trending NW-SE, and Luni-Sukri lineament trending NE-SW (Ramasamy *et al.* 1991; Dhir *et al.* 1992), which intersects in the south-western part of the basin at Jhab (Pal 1991). Several major and minor lineaments are also present parallel to them. The distributions of epicentres are in the southern part of Luni-Sukri Lineament, and in the vicinity of tectonically active linear domain in Barmer- Ramgarh Tract (*Fig 1*).

The Luni-Sukri River Basin being the major fluvial basin of the Thar Desert in western India is an active tectonic basin where more than 300m sediment accumulation has been reported (Bajpai *et al.* 2001). This is possibly due to subsidence in response to E-W faulting along the Sukri River (Henry *et al.*, 1983). The deposition of sediments in the basin has taken place over an uneven basement as indicated by negative gravity anomalies across the basin (Bajpai *et al*., 2001). The SRTM-DEM of the Luni-Sukri basin shows a gradual elevation decrease towards southwest and notable decrease in elevation is on the west of the Luni-Sukri Lineament. The Luni River has changed its path abruptly along inferred conjugate faults in this part (*Fig* 3).

Banas-Sipu River Basin: In the Banas-Sipu basin the rocks of Kumbalgarh Group, Phulad Opholite Suite, Sirohi and Sindhreth Groups are exposed. They are overlain by the Sendra -Ambaji granite, Erinpura Granite and Malani Igneous Suite and are covered by a blanket of Quaternary sediments in western part of the basin. The major lineaments and faults present in the basin are Jaisalmer- Barwani Lineament (JBL) cross cutting Sirohi-Disa - Pisangan- Vadnagar and Sadri-Palanpur lineaments which are trending NE-SW. A Neotectonic fault also cross cuts the Jaisalmer-Barwani lineament in the western part of the basin. The Banas-Sipu basin has a gradual lowering of topography towards the west and the river follows the tract parallel to the Siroh-Deesa Fault. Major drainage has changed its path along the inferred E-W trending inferred faults (*Fig. 4*).

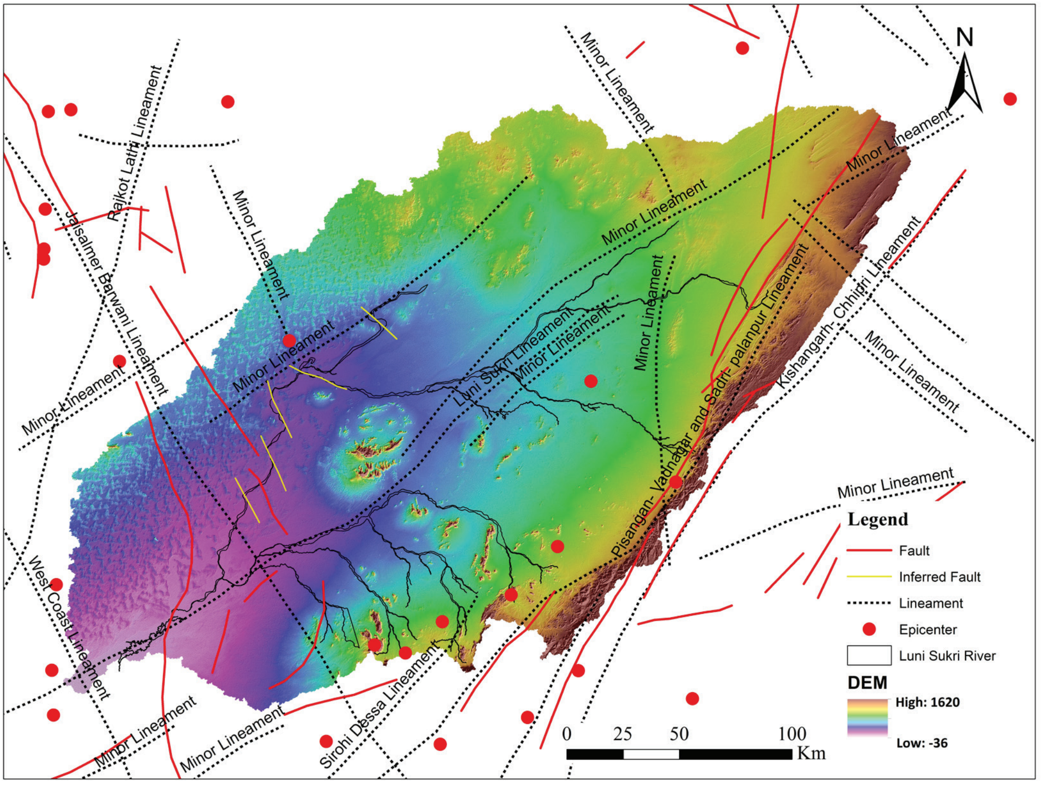

Fig. 3: Digital Elevation Model of Luni-Sukri Basin

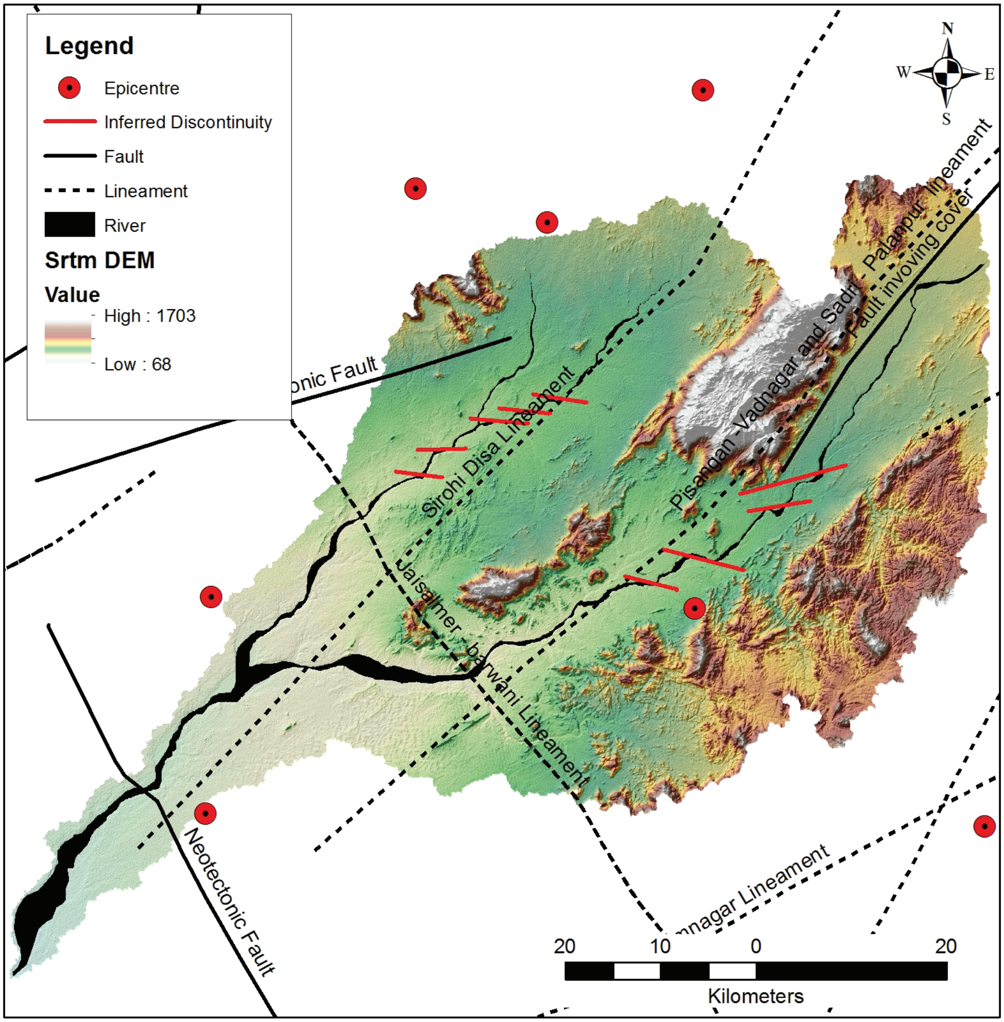

Fig. 4: Digital Elevation Model of Banas-Sipu Basin

METHOD AND MATERIAL

The basin boundary, sub watersheds and drainage of Jaisalmer basin, Luni-Sukri basin and Banas-Sipu basin were delineated from Digital Elevation Model (SRTM) in ArcGIS using ArcHydro and Spatial Analyst tools. The drainage rectification was performed by correlating it on Google Earth. The basic parameters were calculated for determining the geomorphic indices on ArcGIS. The watersheds of the Jaisalmer basin, Luni-Sukri basin and Banas-Sipu basin were divided into 31, 36 and 30 sub-watersheds respectively (*Fig. 1*).

Table 2: Formulas used for calculation of Geomorphic indices

Index	Formula	Definition	References
Hypsometric integral	$HI = \frac{H_{Mean} - H_{Min}}{H_{Max} - H_{Min}}$	The ratio of the difference between mean elevation and minimum elevation, to the difference of maximum elevation minimum elevation.	Strahler,1952
Asymmetry Factor	$AF = \frac{A_r}{A_t} * 100$	The ratio of the area, in the basin, on the right of the main stream (Ar) (downstream) to the area of the basin (At) multiplied with the percentage.	Keller and Pinter, 2002
Transverse Topographic Symmetry Factor	$TTSF = \frac{D_a}{D_d}$	The ratio Between Da is the distance from the stream channel to the middle of its drainage basin (measured perpendicular to a straight line segment fit to the channel) and Dd is the distance from the basin margin to the middle of the basin.	Cox, 1994
Stream length gradient Index	$SL = \frac{\Delta H}{Log_2 L2 - Log_2 L1}$	ΔH difference in elevation between the end of the reach and L1 and L2 are distance from the source to each end of the reach.	Hack, 1973
Drainage basin Shape Index	$Bs = \frac{Bl}{Bw}$	The ratio of the length of the basin measured from the mouth to the most distant drainage divide (Bl), to the width of the basin at its widest point (Bw).	Cannon, 1976
Elongation Ratio	$R_e = \frac{1.128 * A^{1/2}}{L_b}$	The ratio of the diameter of the circle with the same area as the basin to the basin length (Lb).	Schumm, 1956
Circularity ratio	$R_c = \frac{4\pi A}{P^2}$	The ratio of the basin area (A) to the area of a circle with the same perimeter (P) as the basin.	Miller, 1953
Form Factor ratio	$R_f = \frac{A}{L_b^2}$	The ratio between Area (A) of the basin and squared of the basin length (Lb).	Horton, 1945
Relief ratio	$Rh = \frac{H}{Lb}$	The ratio of the basin relief and the basin length	Schumm, 1956
Ruggedness Number	$Rn = H * Dd$	H = basin relief; Dd = drainage density within the basin	Strahler, 1956
Bifurcation ratio	$Rb = \frac{Nu}{Nu+1}$	The ratio of the total number of stream segment of order 'u' and number of segment of the next higher order	Strahler, 1957
Drainage density	$Dd = \sum \frac{Lt}{A}$	The ratio of the total length of all ordered stream and the area of the basin	Horton, 1945

Parameters like Hypsometry Integral (HI), Asymmetry Factor (AF), Transverse Topographic Symmetry Factor (TTSF), Stream Length Gradient index (SL), Drainage Basin Shape Index (Bs), Elongation Ratio (R_e), Circularity Ratio (R_C) etc. were calculated for the sub-watersheds (*Table 2*).

The regions are classified based on the values of geomorphic indices as: Class1- High tectonic activity; Class 2- moderate tectonic activity; Class 3- Low tectonic activity (*Table-3*).

Table 3: Classification of Geomorphic Indices (El. Hamdouni *et al.*, 2008 and Shukla *et al.*, 2013)

Geomorphic Index	Class 1 (High tectonic activity)	Class 2 (Moderate tectonic activity)	Class 3 (Low tectonic activity)
HI	Hi>0.5	0.4 <Hi<0.5	Hi<0.4
AF	AF<35 or AF>65	57<AF<65 or 35<AF<43	43<AF<57
TTSF	TTSF>0.8	0.7<TTSF<0.8	TTSF<0.7
SL-Index	SL>500	500>SL>300	SL<300
Bs	Bs>4	3<Bs<4	Bs<3
Re	Re<0.6	0.6<Re<0.7	Re>0.7
Rc	Rc<0.4	0.4<Rc<0.5	Rc>0.5
Rf	Rf <0.3	0.3< Rf <0.4	Rf >0.4
Rh	Rh >0.1	0.1> Rh >0.05	Rh <0.05
Dd	Dd >0.95	0.95> Dd >0.90	Dd <0.90

Several geomorphic indices were applied to assess the relative active tectonics. Relative active tectonic index (Iat) was obtained by computing the average of the different classes of geomorphic indices and divided into four classes.

$$I\,at = \frac{S}{n}$$

Where S = Total of Geomorphic indices classes, n = No. of Geomorphic indices.

Where Class 1 is very high tectonic activity with values of S/n between 1 to 1.5; Class 2 is high tectonic activity with values of S/n 1.5 but < 2; Class 3 is moderately active tectonics with value S/n 2 but <2.5; and Class 4 is low active tectonics with values of S/n >2.5 (El. Hamdouni *et al.*, 2008).

RESULTS

Jaisalmer Basin

The value of Hypsometric Integral (HI) for sub-watershed 9, 29 which are along the Kanoi fault and Ramgarh and Manpiya Faults respectively, and sub-watershed 23 and 24 along Rajkot-Lathi belongs to HI-Class 1 indicates more tectonically active regions due to these faults (*Fig. 5*). Most of the other sub-watershed belongs to HI-Class 2 and HI-Class 3 (*Table 4*). The Asymmetric factor (AF) for sub-watershed 1,2,10,12,25, 26, 27 and 28 belong to AF-Class 1 and the sub-watershed which are on either side of the JBL

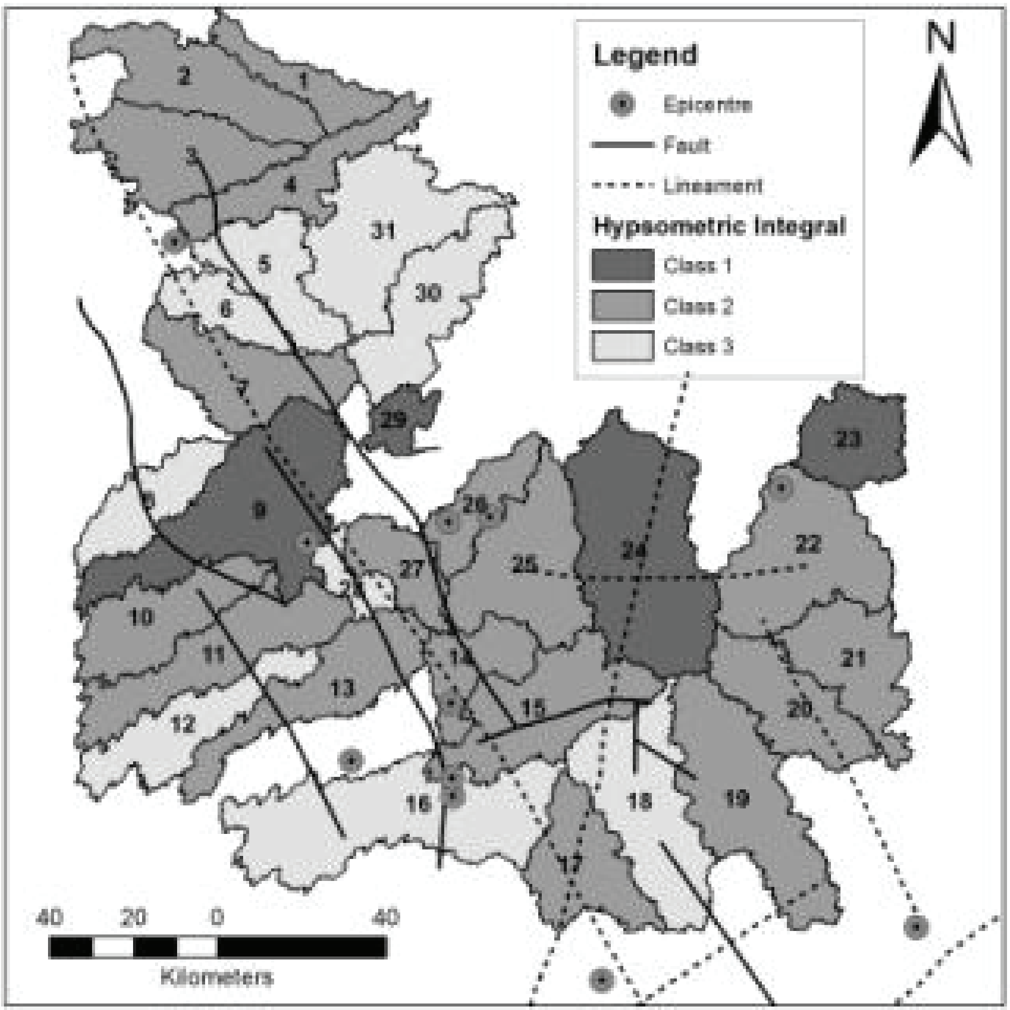

Fig. 5: Distribution of the Hypsometry Integral in Jaisalmer Basin

Table 4 : Values and Classification of Geomorphic Indices and Relative Active Tectonic Index of Jaisalmer Basin

Sub-watershed	Hi	Hi-Class	AF	AF-Class	Bs	Bs-Class	Re	Re-Class	Rc	Rc-Class	Rf	Rf-Class	Rh	Rh-Class	Dd	Dd-Class	Rn	Rb mean	S/n	Iat class
1	0.454	2	25.83	1	3.05	2	0.576	1	0.146	1	0.260	1	0.0026	3	0.45	3	0.044	2.91	1.75	2
2	0.414	2	46.56	3	2.99	3	0.545	1	0.160	1	0.233	1	0.0020	3	0.44	3	0.051	3.41	2.12	3
3	0.448	2	69.79	1	2.10	3	0.545	1	0.172	1	0.233	1	0.0017	3	0.43	3	0.043	3.61	1.87	2
4	0.459	2	44.77	3	3.37	2	0.557	1	0.088	1	0.244	1	0.0014	3	0.38	3	0.026	4	2	2
5	0.277	3	62.53	2	1.80	3	0.557	1	0.161	1	0.243	1	0.0028	3	0.42	3	0.057	3.49	2.12	3
6	0.237	3	61.64	2	2.39	3	0.577	1	0.168	1	0.261	1	0.0038	3	0.46	3	0.065	3.01	2.12	3
7	0.480	2	38.10	2	2.39	3	0.547	1	0.177	1	0.235	1	0.0025	3	0.42	3	0.061	4.04	2	2
8	0.374	3	42.04	2	3.12	2	0.564	1	0.165	1	0.250	1	0.0028	3	0.50	3	0.061	3.46	2	2
9	0.562	1	47.79	3	1.97	3	0.525	1	0.134	1	0.216	1	0.0022	3	0.41	3	0.075	4.53	2	2
10	0.415	2	33.55	1	2.48	3	0.551	1	0.156	1	0.238	1	0.0030	3	0.46	3	0.076	3.71	1.87	2
11	0.477	2	62.72	2	3.37	2	0.541	1	0.106	1	0.230	1	0.0036	3	0.44	3	0.100	4.01	1.87	2
12	0.366	3	33.58	1	3.61	2	0.553	1	0.099	1	0.240	1	0.0035	3	0.43	3	0.080	4.15	1.87	2
13	0.433	2	48.69	3	3.43	2	0.546	1	0.125	1	0.234	1	0.0045	3	0.41	3	0.107	3.83	2	2
14	0.455	2	56.27	3	1.46	3	0.568	1	0.188	1	0.254	1	0.0036	3	0.43	3	0.065	3.41	2.12	3
15	0.479	2	56.49	3	2.25	3	0.538	1	0.170	1	0.227	1	0.0022	3	0.42	3	0.063	4.31	2.12	3
16	0.382	3	38.96	2	2.71	3	0.522	1	0.115	1	0.214	1	0.0031	3	0.40	3	0.105	4.77	2.12	3
17	0.458	2	59.90	2	1.80	3	0.553	1	0.192	1	0.240	1	0.0030	3	0.44	3	0.069	3.73	2	2
18	0.384	3	64.91	2	1.97	3	0.535	1	0.180	1	0.225	1	0.0028	3	0.45	3	0.086	5.11	2.12	3
19	0.425	2	60.50	2	2.46	3	0.531	1	0.145	1	0.222	1	0.0024	3	0.42	3	0.075	4.42	2	2

Sub-watershed	Hi	Hi-Class	AF	AF-Class	Bs	Bs-Class	Re	Re-Class	Rc	Rc-Class	Rf	Rf-Class	Rh	Rh-Class	Dd	Dd-Class	Rn	Rb mean	S/n	Iat class
20	0.460	2	42.37	2	2.13	3	0.552	1	0.171	1	0.239	1	0.0024	3	0.44	3	0.057	3.66	2	2
21	0.403	2	51.76	3	1.64	3	0.552	1	0.143	1	0.239	1	0.0020	3	0.43	3	0.045	3.76	2.12	3
22	0.451	2	50.09	3	0.88	3	0.534	1	0.258	1	0.224	1	0.0018	3	0.50	3	0.062	4.1	2.12	3
23	0.508	1	40.77	2	1.33	3	0.564	1	0.264	1	0.249	1	0.0018	3	0.46	3	0.037	3.3	1.87	2
24	0.500	1	46.49	3	1.95	3	0.521	1	0.226	1	0.213	1	0.0021	3	1.38	1	0.248	4.63	1.75	2
25	0.461	2	30.26	1	1.46	3	0.539	1	0.196	1	0.228	1	0.0028	3	0.44	3	0.080	4.33	1.87	2
26	0.423	2	67.34	1	2.56	3	0.573	1	0.174	1	0.258	1	0.0039	3	0.39	3	0.060	3.22	1.87	2
27	0.426	2	30.36	1	1.93	3	0.574	1	0.214	1	0.258	1	0.0046	3	0.41	3	0.073	3.23	1.87	2
28	0.326	3	29.64	1	1.56	3	0.600	2	0.199	1	0.283	1	0.0054	3	0.46	3	0.065	2.75	2.12	3
29	0.563	1	56.54	3	0.76	3	0.603	2	0.207	1	0.285	1	0.0033	3	0.49	3	0.041	2.33	2.12	3
30	0.396	3	60.90	2	2.69	3	0.548	1	0.145	1	0.235	1	0.0028	3	0.49	3	0.076	3.86	2.12	3
31	0.303	3	36.30	2	1.17	3	0.534	1	0.134	1	0.224	1	0.0017	3	0.41	3	0.050	4.44	2.12	3

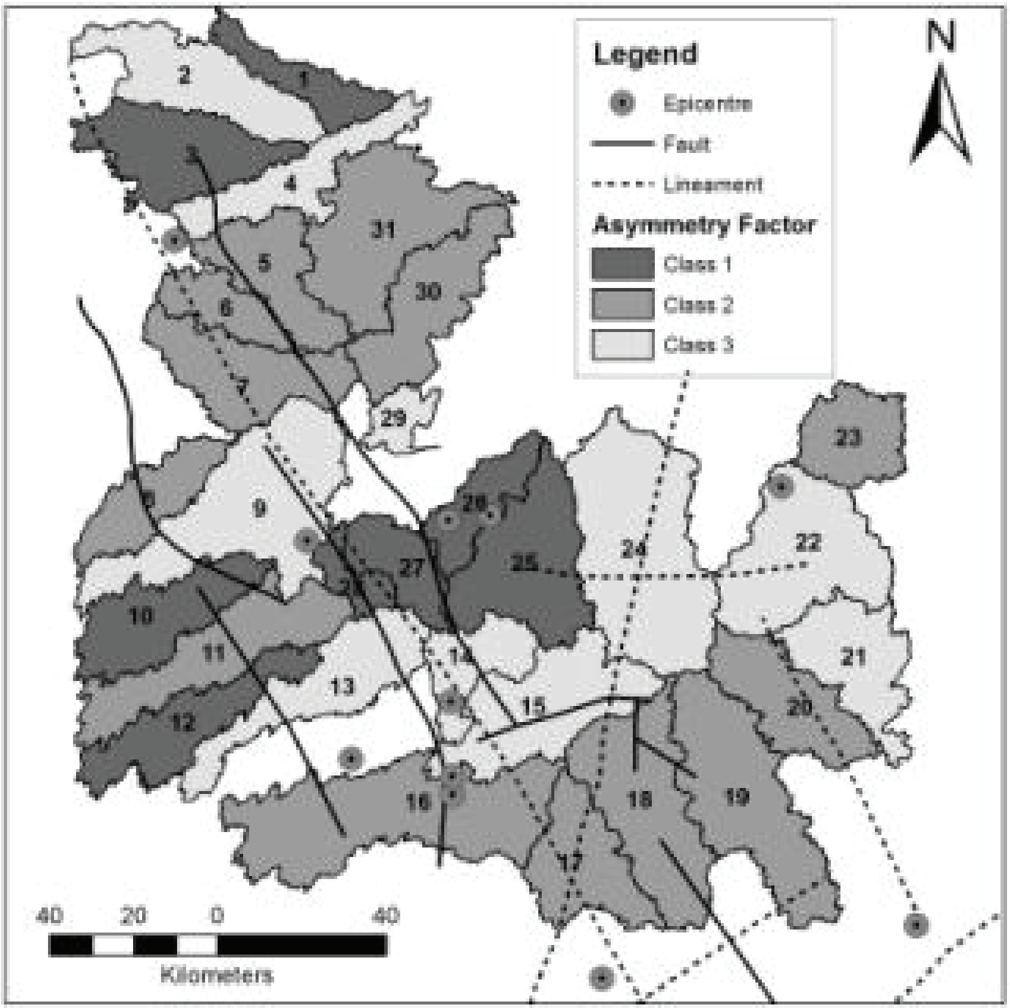

Fig. 6: Distribution of the Asymmetry Factor in basin

and belong to AF-Class 2 and AF-Class 3 (***Fig. 6***). The values of Drainage Basin Shape Index (Bs) of sub-watershed 1, 4, 8, 11, 12, 13 are greater than 3 and are classified in Bs-Class 2. They are more elongated sub basin whereas other sub-watersheds with value below 3 classified in Bs-Class 3 and are less elongated (*Table 4*). The elongated Bs-Class 2 sub-watersheds are lie on either side of KF and JBL (*Fig. 7*). According to ranges of Elongation Ratio (R_e) all sub-watersheds belong to Re-Class 1 have the high tectonic activity except sub-watershed 29 which belong to Re-Class 2, (*Table 4*). The values for Circularity Ratio (R_c) for subwatersheds on either sides of KF are lower than those on along the KF (*Table 4*) and belong to R_c-Class 1 show high tectonic index (*Table 6*) and

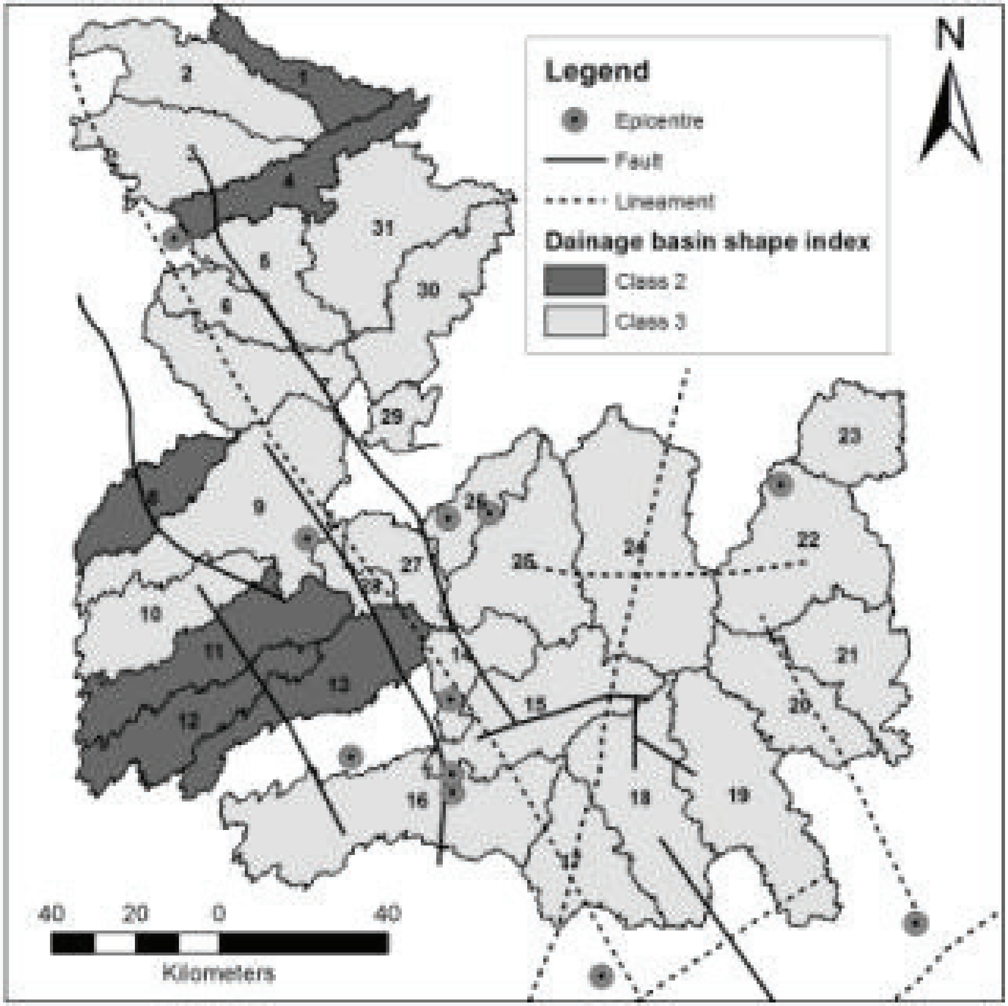

Fig. 7 : Distribution of the Drainage Basin Shape Index in Jaisalmer Basin

are lying along the Kanoi Fault. The Form Factor (R_f) value lie between 0.21 to 0.28 indicate elongated basin and belong to the R_f -Class 1 show high tectonic index (*Table 4*). The Relief Ratio (R_h) value of sub-watershed on either side of the sub-watersheds 9 and 15 are higher and suggest relative steepness along the KF and JBL and are classified in R_h-Class 3 (*Table 4*). The Ruggedness number (R_n) of the subwatershed indicates the steepness is more pronounced in the southern part as compared to northern part along the JBL and KF. The Mean Bifurcation ratio (R_b) of sub-watershed 1, 28 and 29 have value less than 3 and sub-watershed 18 has more than 5 (*Table 4*) indicating structurally disturb sub basin (Strahler, 1964).

Luni-Sukri Basin

The values of Hypsometry Integral (HI) for all sub-watersheds range from 0.09 to 0.54. There are seven sub-watershed situated on the western side of Luni-Sukri lineament of which sub-watershed 24 has been classified into HI-Class 1 and the sub-watersheds 21, 22, 23, 32, 33, 16 in HI-Class 2 (*Table 5*). The value of Asymmetry Factor (AF) vary from 16.03 (sub-watershed 20) to 81.98 (sub-watershed 5) (*Table 5*). Maximum number of sub-watershed on the west side of Luni-Sukri Lineament belongs to AF-Class 1 (High tectonic activity). The watershed 26 has AF = 50 and is not tilted. The average minimum value of TTSF is 0.23 for sub-watershed 19 indicates symmetrical drainage and maximum value is 0.94 for sub-watershed 28 indicates asymmetrical drainage. Some watersheds are tilted in opposite direction to each other and their boundaries are demarcated by inferred faults (*Fig. 9*). The Stream Length gradient Index (SL) value ranges from 51.78 for sub watershed no. 08 to s 659.12 for sub-watershed no. 25 (*Table 5*). The Eastern margin of Luni-Sukri basin is composed of high resistant rocks of Malani Igneous Suite and Delhi Supergroup and the SL-index anomalies of subwatersheds 3,4,5,6,7,25,26 associated with these high resistant rock are not considered for calculation of Relative Active Tectonics Index. The sub-watersheds on the western side of the Luni-Sukri lineament fall in SL-Class 1 (High tectonic activity) and SL- Class 2 (moderate tectonic activity) categories (*Table 5*) and are composed mainly low resistance sediment of fluvial and aeolian origin (*Fig 10*).

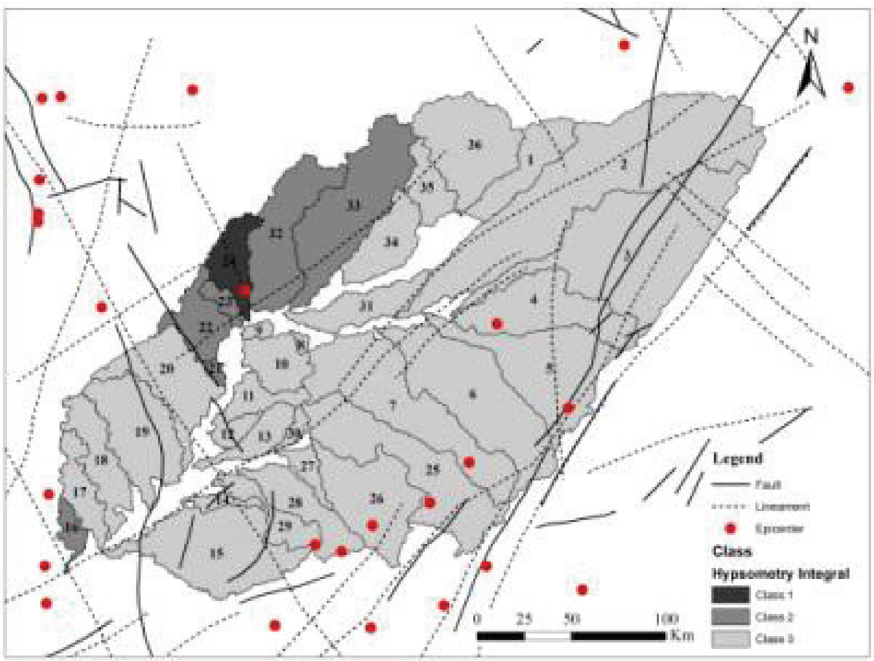

Fig. 8: Distribution of the Hypsometry Integral in Luni-Sukri Basin

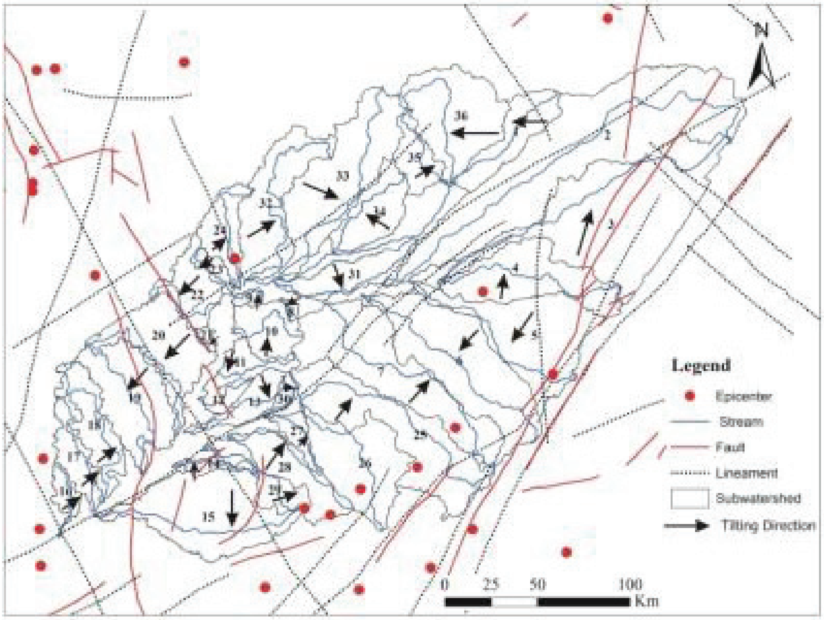

Fig. 9: Tilting Direction of Luni-Sukri sub-watersheds according to AF and TTSF

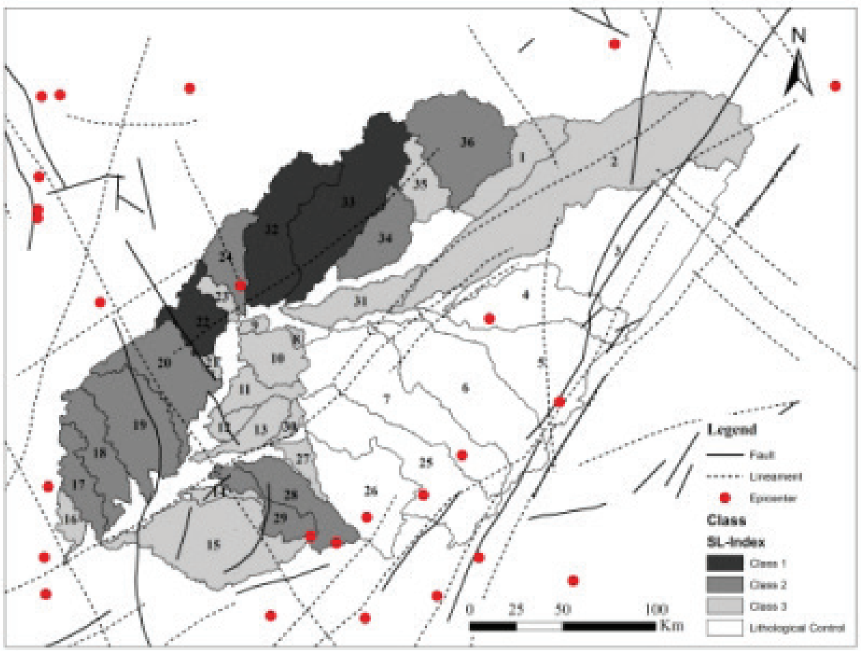

Fig. 10: Distribution of the Stream Length Gradient Index in Luni-Sukri Basin

Table 5: Values and Classification of Geomorphic Indices and Relative Active Tectonic Index of Luni-Sukri Basin

Sub-watershed	SL	SL-class	HI	HI-class	AF	AF-Class	TTSF	TTSF-Class	Bs	Bs-Class	Re	Re-Class	Rc	Rc-Class	Rf	Rf-Class	S/n	Iat Class
1	180.37	3	0.37	3	41.33	2	0.49	3	2.64	3	0.53	1	0.12	1	0.22	1	2.13	3
2	114.57	3	0.27	3	49.90	3	0.36	3	4.58	1	0.47	1	0.09	1	0.18	1	2.00	3
3	141.83	0	0.26	3	21.70	1	0.73	2	1.61	3	0.48	1	0.10	1	0.18	1	1.71	2
4	220.99	0	0.16	3	47.50	3	0.86	1	3.24	2	0.51	1	0.11	1	0.20	1	1.71	2
5	250.04	0	0.20	3	81.98	1	0.82	1	1.91	3	0.50	1	0.10	1	0.20	1	1.57	2
6	344.05	0	0.13	3	58.51	2	0.40	3	3.30	2	0.50	1	0.12	1	0.19	1	1.86	2
7	352.89	0	0.11	3	39.14	2	0.78	2	2.53	3	0.50	1	0.09	1	0.19	1	1.86	2
8	51.78	3	0.09	3	79.45	1	0.78	2	1.89	3	0.64	2	0.18	1	0.33	2	2.13	3
9	65.97	3	0.11	3	23.04	1	0.75	2	2.04	3	0.62	2	0.18	1	0.30	2	2.13	3
10	157.48	3	0.11	3	45.64	3	0.71	2	1.86	3	0.54	1	0.18	1	0.23	1	2.13	3
11	273.24	3	0.09	3	60.78	2	0.68	3	2.05	3	0.56	1	0.11	1	0.25	1	2.13	3
12	246.58	3	0.37	3	49.52	3	0.75	2	1.86	3	0.58	1	0.12	1	0.27	1	2.13	3
13	213.21	3	0.20	3	55.87	3	0.66	3	3.14	2	0.55	1	0.10	1	0.24	1	2.13	3
14	185.13	3	0.32	3	36.95	2	0.73	2	3.06	2	0.59	1	0.06	1	0.28	1	1.88	2
15	209.17	3	0.12	3	68.93	1	0.48	3	2.45	3	0.50	1	0.10	1	0.20	1	2.00	3
16	96.26	3	0.46	2	68.07	1	0.63	3	2.54	3	0.58	1	0.08	1	0.27	1	1.88	2
17	456.85	2	0.38	3	69.63	1	0.76	2	3.27	2	0.55	1	0.07	1	0.24	1	1.63	2
18	461.92	2	0.39	3	57.99	2	0.76	2	3.34	2	0.53	1	0.06	1	0.22	1	1.75	2
19	361.27	2	0.17	3	46.97	3	0.23	3	2.52	3	0.51	1	0.11	1	0.21	1	2.13	3

Sub-watershed	SL	SL-class	HI	HI-class	AF	AF-Class	TTSF	TTSF-Class	Bs	Bs-Class	Re	Re-Class	Rc	Rc-Class	Rf	Rf-Class	S/n	Iat Class
20	442.15	2	0.18	3	16.03	1	0.84	1	1.77	3	0.52	1	0.08	1	0.21	1	1.63	2
21	85.50	3	0.43	2	32.88	1	0.87	1	1.72	3	0.63	2	0.15	1	0.31	2	1.88	2
22	558.75	1	0.43	2	22.50	1	0.68	3	5.94	1	0.54	1	0.09	1	0.23	1	1.38	1
23	269.41	3	0.45	2	32.34	1	0.54	3	1.22	3	0.59	1	0.11	1	0.28	1	1.88	2
24	438.72	2	0.54	1	65.88	1	0.63	3	2.14	3	0.54	1	0.11	1	0.23	1	1.63	2
25	659.12	0	0.18	3	34.07	1	0.67	3	3.17	2	0.50	1	0.08	1	0.20	1	1.71	2
26	463.54	0	0.09	3	50.11	3	0.72	2	2.21	3	0.51	1	0.15	1	0.21	1	2.00	3
27	269.46	3	0.14	3	32.80	1	0.81	1	2.16	3	0.58	1	0.10	1	0.26	1	1.75	2
28	439.80	2	0.15	3	16.90	1	0.94	1	2.75	3	0.53	1	0.11	1	0.22	1	1.63	2
29	349.97	2	0.16	3	45.49	3	0.66	3	2.45	3	0.55	1	0.08	1	0.24	1	2.13	3
30	161.99	3	0.23	3	79.89	1	0.91	1	2.79	3	0.61	2	0.11	1	0.29	1	1.88	2
31	184.02	3	0.27	3	78.09	1	0.85	1	3.20	2	0.54	1	0.09	1	0.23	1	1.63	2
32	593.42	1	0.42	2	66.24	1	0.78	2	2.58	3	0.51	1	0.11	1	0.21	1	1.50	2
33	532.30	1	0.47	2	66.33	1	0.80	1	3.18	2	0.50	1	0.11	1	0.20	1	1.25	1
34	317.18	2	0.29	3	30.65	1	0.81	1	2.47	3	0.53	1	0.17	1	0.22	1	1.63	2
35	177.74	3	0.31	3	72.60	1	0.65	3	2.08	3	0.55	1	0.12	1	0.24	1	2.00	3
36	358.78	2	0.34	3	33.05	1	0.42	3	2.03	3	0.51	1	0.18	1	0.20	1	1.88	2

The Drainage Basin Shape Index (Bs) value ranges from 1.22 to 5.94 (*Table 5*) and the highest values are along the Luni-Sukri Lineament in the NE of the basin and along a minor fault parallel to KF and JBL. The values of Elongation Ratio (R_e) for all 36 sub-watersheds ranges from 0.47 to 0.64 (*Table 5*), indicate high to moderately elongated basin and high to moderate tectonic activity (El. Hamdouni *et al*., 2008). The Circularity Ratio (R_c) of all sub-watersheds of Luni- Sukri basin is very low indicates the elongated shape of the basin. The value of R_c is ranges from 0.09 to 0.18 shown in Table 4. The value of R_c fall in R_c-Class 1 (*Table 5*). The value of Form Factor Ratio ranges from 0.18 to 0.33 also indicate elongate basin and fall in R_f Class 1 (*Table 5*).

Banas-Sipu Basin

The value of Hypsometry Integral (HI) for Sub-watershed 18 is belonging to HI-Class 1, and sub-watershed 19 in HI-Class 2. They indicate high HI values and are lithologically controlled. All other sub-watersheds have value less than 0.4 which belong to HI-Class 3 (*Table 6*). According to the value of Asymmetry Factor (AF) most of the sub-watersheds belong to AF-Class 1 and only sub watershed 1 belongs to AF-Class 2 (*Table 6*) (*Fig. 11*). According the value of AF some of the sub-watersheds is tilted in opposite direction to each other. On the basis of average of Transverse Topographic Symmetry Factor (TTSF) the sub-watershed 3, 5, 12 & 18 belong to TTSF-Class 2 (*Table 6*) suggests more asymmetrical drainage and all other sub watersheds belong to TTSF Class 3 with less asymmetrical drainage. All sub-watersheds have Drainage basin shape index (Bs) values range from 1.4 to 3.3 except sub-watershed 8 which belong to Bs-Class 2 (*Table 6*). All sub-watersheds are classified as Bs-Class 3 (***Table 6***). The Elongation Ration of sub-watershed 4 is classified in R_e-Class 1 others are in R_e-Class 2 (*Table 6*).

The circularity ratio (R_c) values in all sub-watersheds varies from 0.12 to 0.28 and fall in R_c-Class1 (*Table 6*). The sub-watershed 3 is lying along a Neotectonic fault shows low value of circularity ratio (*Table 6*). All sub-watersheds are having the values of Form factor ratio (R_f) ranging from 0.28 to 0.38 (*Table-6*). Sub-watershed 4 has a lowest value and is classified in R_f-Class 1 others are in R_f-Class 2 (*Table 6*). Relief ratio (R_h) value of sub-watershed 3 and 30 are high (Table 6) and belong to R_h-Class 2 and the adjacent sub-watershed which is in R_h-Class 3 and show relatively more steepness. The Ruggedness number (R_n) value of sub-watershed 4 and 14 are high and has relatively more steepness (*Table 6*) All other sub-watersheds have high value of R_n and R_h due to the high hill ranges of Mount Abu.

The sub-watersheds 2, 3, 13, 22, 23, 25, 30 have value of Mean Bifurcation ratio less than 3 and sub watersheds 4, 16, 14 have value more than 5 which indicate structurally disturb basin (*Table 6*) and are situated at Mount Abu hill and are lithological controlled.

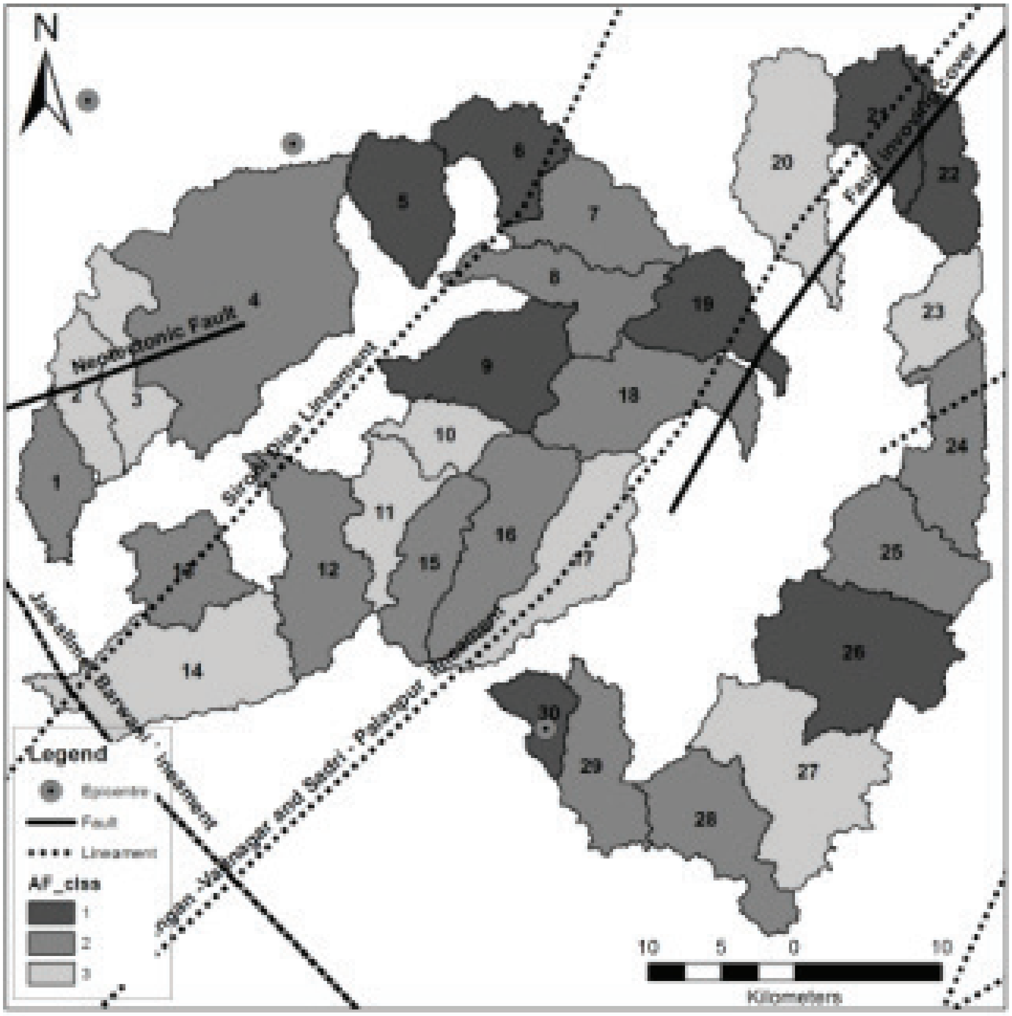

Fig. 11: Distribution of the Asymmetry Factor in Banas- Sipu Basin

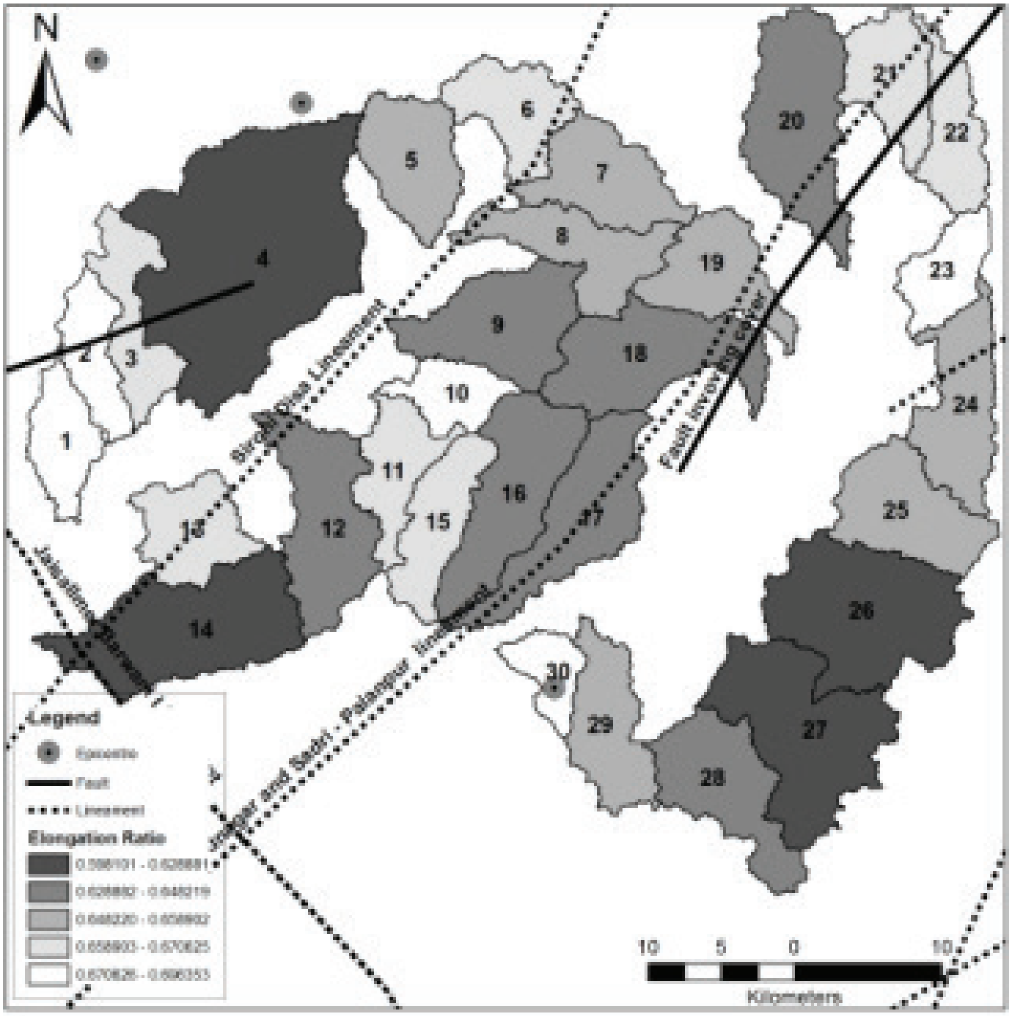

Fig. 12: Distribution of the Elongation Ratio in Banas- Sipu Basin

Fig. 13: Distribution of the Mean Bifurcation Ratio in Banas-Sipu Basin

Table 6: Values and Classification of Geomorphic Indices and Relative Active Tectonic Index of Banas-Sipu Basin

Sub Watershad No.	HI	HI-Class	AF	AF-Class	TTSF	TTSF-Class	Bs	Bs-Class	Re	Re-Class	Rc	Rc-Class	Rf	Rf-Class	Rh	Rn	Rb mean	S/n	Iat Class
1	0.379	3	40.1	2	0.51	3	1.78	3	0.676	2	0.193	1	0.358	2	0.013	0.089	3.16	2.28	3
2	0.326	3	51.3	3	0.4	3	2.73	3	0.677	2	0.198	1	0.360	2	0.019	0.136	2.25	2.42	3
3	0.178	3	50.2	3	0.74	2	2.66	3	0.666	2	0.127	1	0.348	2	0.055	0.273	2.75	2.28	3
4	0.124	3	35.9	2	0.52	3	1.74	3	0.598	1	0.230	1	0.281	1	0.029	0.574	6.18	2	2
5	0.393	3	32.6	1	0.8	2	1.77	3	0.658	2	0.299	1	0.340	2	0.009	0.086	3.16	2	2
6	0.375	3	17.6	1	0.63	3	1.97	3	0.665	2	0.224	1	0.347	2	0.008	0.065	3.75	2.14	3
7	0.091	3	62.4	2	0.42	3	1.72	3	0.656	2	0.214	1	0.338	2	0.107	0.898	3.75	2.28	3
8	0.213	3	62.4	2	0.56	3	3.37	2	0.656	2	0.138	1	0.337	2	0.114	1.107	3.5	2.14	3
9	0.156	3	22.0	1	0.48	3	1.97	3	0.645	2	0.238	1	0.326	2	0.081	0.963	4.33	2.14	3
10	0.113	3	53.6	3	0.36	3	1.67	3	0.685	2	0.221	1	0.369	2	0.085	0.610	2.83	2.42	3
11	0.114	3	55.4	3	0.28	3	2.16	3	0.670	2	0.134	1	0.352	2	0.047	0.348	3.5	2.42	3
12	0.121	3	57.9	2	0.7	2	2.38	3	0.642	2	0.170	1	0.324	2	0.040	0.393	4.25	2.14	3
13	0.372	3	58.7	2	0.41	3	1.41	3	0.665	2	0.230	1	0.347	2	0.012	0.084	2.75	2.28	3
14	0.120	3	47.7	3	0.61	3	2.20	3	0.629	2	0.201	1	0.310	2	0.049	0.613	4.5	2.42	3
15	0.184	3	61.3	2	0.59	3	2.20	3	0.664	2	0.199	1	0.346	2	0.048	0.388	3.33	2.28	3
16	0.169	3	35.8	2	0.25	3	2.68	3	0.641	2	0.214	1	0.323	2	0.076	0.805	5.25	2.28	3
17	0.152	3	44.8	3	0.41	3	2.27	3	0.643	2	0.163	1	0.325	2	0.075	0.727	5.25	2.42	3

Sub Watershad No.	HI	HI-Class	AF	AF-Class	TTSF	TTSF-Class	Bs	Bs-Class	Re	Re-Class	Rc	Rc-Class	Rf	Rf-Class	Rh	Rn	Rb mean	S/n	Iat Class
18	0.547	1	35.1	2	0.7	2	2.31	3	0.639	2	0.208	1	0.320	2	0.073	0.742	3.75	2.14	3
19	0.452	2	21.7	1	0.31	3	1.70	3	0.658	2	0.225	1	0.340	2	0.116	0.974	3.33	2	2
20	0.133	3	46.8	3	0.54	3	2.42	3	0.636	2	0.234	1	0.318	2	0.056	0.653	4.37	2.42	3
21	0.221	3	33.5	1	0.54	3	2.18	3	0.664	2	0.249	1	0.346	2	0.025	0.221	3.33	2.14	3
22	0.133	3	49.0	3	0.27	3	2.19	3	0.671	2	0.170	1	0.353	2	0.020	0.156	2.83	2.42	3
23	0.114	3	45.7	3	0.27	3	1.99	3	0.679	2	0.275	1	0.362	2	0.039	0.239	2.75	2.42	3
24	0.215	3	39.8	2	0.44	3	2.38	3	0.652	2	0.162	1	0.334	2	0.031	0.316	4.2	2.28	3
25	0.297	3	62.3	2	0.47	3	1.63	3	0.650	2	0.284	1	0.332	2	0.039	0.311	3	2.28	3
26	0.280	3	15.8	1	0.62	3	2.14	3	0.628	2	0.261	1	0.309	2	0.034	0.396	4.62	2.14	3
27	0.299	3	46.9	3	0.41	3	2.34	3	0.628	2	0.184	1	0.310	2	0.034	0.393	4.62	2.42	3
28	0.263	3	42.7	2	0.24	3	1.93	3	0.648	2	0.210	1	0.330	2	0.039	0.343	3.5	2.28	3
29	0.298	3	58.9	2	0.3	3	2.62	3	0.659	2	0.201	1	0.341	2	0.047	0.427	3.5	2.28	3
30	0.116	3	78.1	1	0.27	3	1.96	3	0.696	2	0.252	1	0.381	2	0.075	0.393	2.5	2.28	3

Relative Active tectonic Index (Iat)

Jaisalmer Basin: The values of S/n in all 31 sub-watersheds was calculated using geomorphic indices value (*Table 4*) range from 1.75 to 2.12 and belong to Iat-Class 2 for area having lineaments and faults and Iat-Class 3 (*Fig-14*). The average of Iat-Classes is 2.14 which indicate the tectonic activity is of moderate level. About 58.48% of the study area belong Iat- Class 2 (High activity) and 41.52% to Class 3 (Moderate activity).

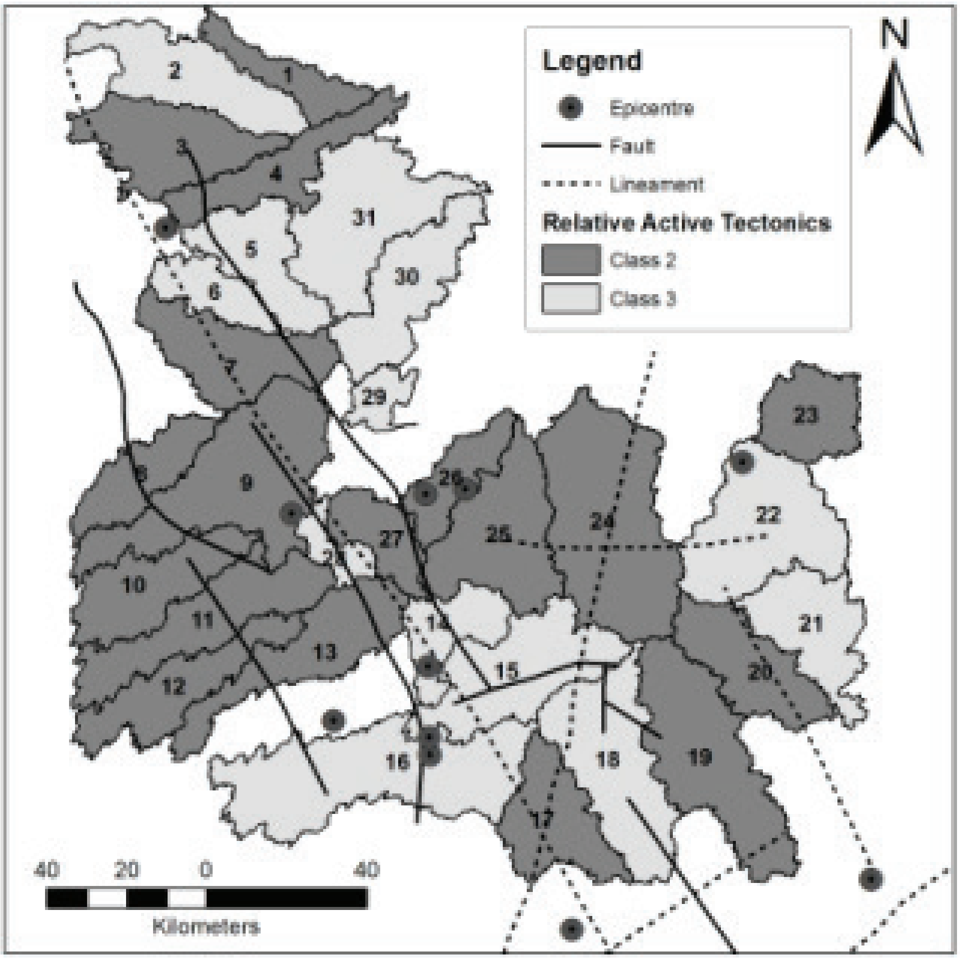

Fig. 14: Distribution of Iat-classes in Jaisalmer Basin

Luni Sukri Basin: The average of Iat index in 36 sub-watersheds is 2.30 indicates that the tectonic activity is of moderate level (Table 5). About 6.74% of the study area belongs to Iat-Class 1 (Very High activity); 59.44% to Class 2 (High activity) and 33.81% to Class 3 (Moderate activity) (*Fig. 15*).

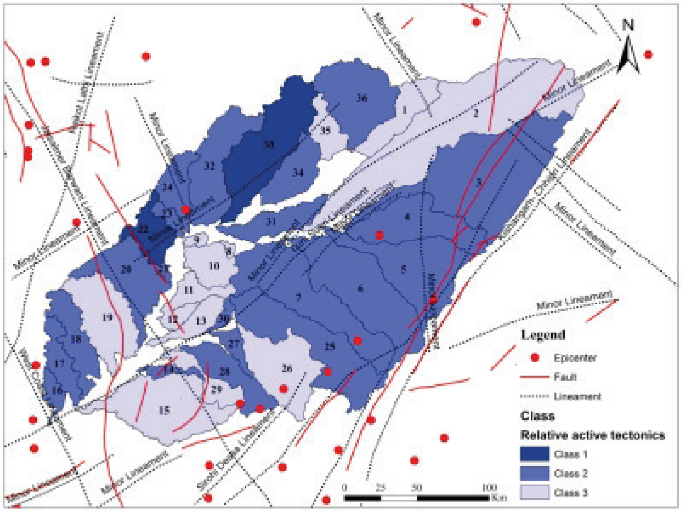

Fig. 15: Distribution of Iat-classes in Luni-Sukri Basin

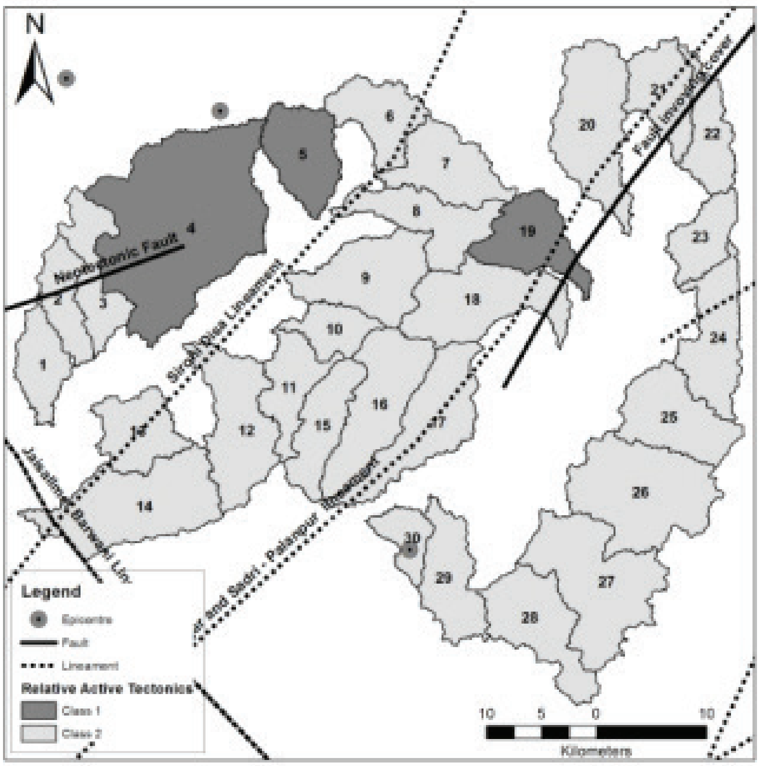

Fig. 16: Distribution of Iat-classes in Banas-Sipu basin

Banas-Sipu basin: The average of Iat index in 30 sub-watersheds is 2.90 which show the tectonic activity is of low level (*Table 6*). According to Iat 16.71% sub-watersheds belong to Iat class-2 and are situated on the western side of Sirohi-Disa lineament and on the Neotectonic Fault, and the other sub-watersheds are classified in Iat-Class 3 (83.29%) are moderately active (*Fig 16*).

DISCUSSIONS AND CONCLUSION

Geomorphic tools were used to calculate geomorphic anomalies and relate them to active tectonics by using GIS and Remote Sensing techniques. The conclusions derived from geomorphic indices are summarized basin wise in the following paragraphs and related to tectonics of the NW Indian Plate.

High Hypsometric Integral (HI) values generally means that not as much of the uplands have been eroded, and may suggest a younger landscape, perhaps produced by active tectonics. High values of HI could also result from recent incision into a young geomorphic surface produced by deposition (El. Hamdouni, *et al.* 2008).The HI values in Jaisalmer basin indicates higher values in the sub basins on JBL/KF and RLL. In the Luni-Sukri area the sub basins on the western part of the Luni Sukri lineament are more active Maximum sub-watersheds have low value of HI indicates the low upland, flat topography and less resistant rock (*Fig-8*). The higher Hi values obtained in the eastern part of the Banas-Sipu basin are due to control of lithology.

The Asymmetry Factor (AF) value should be equal to about 50 whereas tectonically unstable basin would give a deflection from normal value of AF either <50 (river flowing closer to right watershed boundary) or >50 (river flowing closer to left watershed boundary) (Keller and Pinter 2002) depending on tectonic intensity, since lithological reasons are isolated. In the Jaisalmer basin the sub-watersheds across the JBL/KF are tilted on an NE-SW axis. In the Luni- Sukri basin the tilting has maximum in the sub-watersheds of western part. The direction of tilting of the sub-watersheds on either sides of a Minor Lineament (parallel to JBL) is in opposite directions (*Fig-9*). In the Banas-Sipu basin some of the sub-watersheds are tilted in opposite direction to each other.

The Transverse Topographic Symmetry Factor (TTSF) records the net direction and degree of lateral migration of trunk streams (Cox 1994). When the trunk stream is in middle of the drainage basin it indicates symmetrical drainage basin then the TTSF= 0, as the trunk stream migrate away from the middle of the basin towards margin, the value of TTSF will approach towards 1 indicating asymmetrical drainage basin. In the Luni Sukri basin the sub-watershed lying adjacent to JBL shows maximum asymmetry. Some of the watershed in the Banas-Sipu basin shows asymmetrical characters and may be along some unmarked fault or lineament.

The High Stream Length Gradient Index (SL-index) of rocks of low or uniform resistance is a possible indicator of active tectonics (Keller, 1986). The SL index will increase in value as rivers and streams flow over active uplifts and may have lesser values when flowing parallel to features such as valleys produced by strike–slip faulting (Keller and Pinter, 2002). The sub-watersheds of west side of Luni-Sukri lineament are relatively more active than sub-watersheds of Eastern side of the lineament.

High Basin Shape Index values of Drainage Basin Shape Index (Bs) are associated with elongated basins, generally associated with relatively higher tectonic activity. Elongate basins are developed in active tectonics area (Bull and McFadden, 1977). Low values of Bs indicate a more circular shaped basin, generally associated with low tectonic activity (Ramírez-Herrera, 1998). The sub-watersheds lying on either side of JBL/KF are moderately active. The higher values are along the Luni-Sukri Lineament in the NE of the basin and along a minor fault which is parallel to Kanoi fault and Jaisalmer Barwani-Lineament.

The Elongation Ratio (R_e) quantitatively describes the planimetric shape of a basin and indirectly provides information about the degree of maturity of the basin landscape. The value of basin ranges between 0 (elongated) to 1 (circular) (Schumm, 1956). The lower Circularity ration (R_c) values indicate elongated sub-watersheds representing youth stage of the river basins which are tectonically controlled and higher ratio values indicate circular shape of the sub-watersheds and similar erosion (Vijith and Satheesh 2006). The lower value of Form Factor ratio (R_f) indicates elongated basin and higher value indicate circular basin. On the basis of Elongation Ratio, Circularity Ration and Form Factor Ratio all sub-watersheds in the Jaisalmer basin show high tectonic activity. Similarly all sub watersheds of Luni-Sukri basin also indicate high to moderately elongated basin and high to moderate tectonic activity. The sub watershed near the Neotectonic Fault shows high tectonic activity. In Banas-Sipu basin also all sub watershed are moderately activity

Relief ratio (Rh) measures the overall steepness of a drainage basin and is an indicator of the intensity of erosion process operating on slope of the basin (Schumm, 1956). The values of Relief Ratio (R_h) and Ruggedness number (R_n) of sub-watershed along the KF and JBL are higher suggestive of relative steepness.

The Relative Active Tectonic Index (Iat) in the Jaisalmer basin is high for all regions intersected by lineaments and faults particularly the JBL and KF. In the Luni Sukri basin the moderate values are along the Luni-Sukri Lineament and higher values are present on either side of this lineament and the sub watershed along the Minor Lineament on the west of Luni- Sukri lineament also having highest value of Iat. In the Banas-Sipu basin the watershed along the Neotectonic Fault has high Iat value..

In western Rajasthan the drainage anomalies were developed due to reactivation of two sets of lineaments. The JBL traversed major part of the area, demarcated the boundary between Barmer Graben and Birmania- Nagarparkar Horst and is a surface expression of a deep seated fault. In the Luni-Sukri region the drainage anomalies are produced adjacent to the NNW-SSE trending JBL/KF, a Minor Lineament and

NE-SW trending Lathi- Rajkot Lineament, Luni Sukri Lineament and a Neotectonic Fault. These faults are forming a compressional regime in the NW part of the Indian Plate due to the influence by Cambay Basin Tectonics on the localized active faults. Mahadevan (1995) also suggested that there is probability of extension of Cambay rifting in Rajasthan Platform.

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