Morphotectonic Evidences of Neotectonic Activity in the Lower Chambal Valley Region, India

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Abstract: ***Lower Chambal Valley Region makes western part of the Marginal Gangetic Alluvium Plain (MGAP) that falls in the Flexural Bulge of Central India. Due to thrust loading of Himalaya, there is continues upliftment in the region that is manifested by many geomorphic markers on the alluvium. Previously there is some speculative research work have been done, in this paper a attempt is made to presents a comprehensive work on geomorphic manifestations of Himalayan tectonics on the alluvium, structural and tectonic control on the drainage, gully erosion. In this work Field survey data, CARTOSAT1-DEM Data, topographic maps are used, this data processed, analysed and interpreted using QGIS Software. Study found that alluvium intensely dissected by ravines of Chambal and its tributaries, zigzag meanders show basement lineament control, incised valley up to 50 meters deep, river terraces, different topographic levels, abnormal drainage patterns, palaeocahnnels and cutoff meanders and scarps etc. these geomorphic features are formed due to peripheral bulge upliftment related to Himalayan thrust loading. This paper will elaborate these findings and will be useful in further academic studies and in understanding intense gully erosion problem of the region.***

Keywords: Lower Chambal Valley, Flexural Bulge, QGIS, CARTOSAT-DEM, Morphotectonic

1. Introduction

Alluvium of Indo-Gangetic plains deposited in the fore deep part of the Himalaya Foreland Basin (HFB) (Goswami and Mishra 2014)The foreland basin bounded from south by a regional gentle fore-bulge in the form of Bundelkhand–Vindhyan Plateau (Singh 1996), and from the north side by the Shiwalik Hills. The Ganga Plain made up of three geomorphic units: From north to south, (1) Piedmont Zone (PZ), (2) Central Alluvial Plain (CAP), and (3) Marginal Gangetic Alluvial Plain (MGAP) (Singh 1996; Agarwal et al. 2002; Goswami and Mishra 2014)where, the MGAP is bounded by the Yamuna River in the north and the Indian craton in the south. Marginal Gangetic Alluvial Plains are dissected by the most severe intricate network of gullies and ravines, thus forming badlands along the Chambal, the Yamuna, the Betwa rivers and their tributaries. The incision of rivers and presence of badlands are most striking evidences of neo-tectonic activities in the MGAP (Ahmad 1968; Sharma 1968; Mishra and Vishwakarma 1999; Agarwal et al. 2002).Alluvium tract of western MGAP has experienced up-warping and down-warping wherein the Chambal River follows an anti-formal up-warp (Mishra and Vishwakarma 1999). Along with the upliftment of the peripheral bulge area, intensification of SW monsoon in the late Pleistocene–Holocene may be a possible reason for badlands formation (T andon et al. 2006; Joshi 2014).Mishra and Vishwakarma (1999 observed a 74 km long palaeochannel on the left flank of the Lower reach Chambal river, that was a tributary to the Chambal River and it has dried up before the incision of the latter. In this study all these features are covered using satellite data, field survey and topographic maps on QGIS platform.

Regional setting and study area

The Chambal River originates from the Janapav Hills near Mhow MP, that lies over Vindhyan Range (Sharma 1979) and flows over the Malwa Plateau. It runs a total length of 960 km. Its catchment area is divided into three parts, i.e., Upper Chambal Valley (UCV) flows over the Malwa plateau , Middle Chambal Valley (MCV) flows over Vindhyan Escarpments and forms george and Lower Chambal Valley (LCV) flows over alluvium (Sharma 1979), where it makes part of Western Marginal Alluvium Plain. The lower reaches flows on the alluvium, deposited by the Chambal River itself. The major part of the Chambal River, in the LCV, flows in parallel to Great Boundary Fault (GBF) along Chambal Scarp (Sharma, 1979), up to Pinhat, from Pinhat to Yamuna confluence it flows in NW- SE direction, controlled by a basement lineament (Mishra and Vishwakrama 1999). Geologically Lower Chambal Valley flows over Quaternary alluvium deposited by the Chambal River, that makes western part of MGAP, alluvium overlies Vindhyan System of rocks (Sharma, 1979) .(Figure 3.) along with GBF on left flank, Mukundara Fault in Vindhyan separates Lower Chambal Valley from Middle Chambal Valley (Sharma, 1979).

2. Datasets and Methodology

Data for this study is gathered from field surveys, satellite imageries, topographic maps and these data processed and interpreted on QGIS software.

Field survey: Field surveys are done in two stages that is preliminary survey and detailed survey. In preliminary surveys we took road traverses across the rivers in parts of three states of Rajasthan, Madhya Pradesh, Uttar Pradesh and crosses four rivers of the Lower Chambal Valley Region these are the Chambal, the Parvati, the Kalisindh, the Yamuna and the Yamuna and the Chambal river confluence. We took observations on the Chambal at six locations and on the Kalisindh, the Parvati, the Yamuna, two location at each river. Route were Kota – Kalisindh- Baran- Parvati-MangrolParvati- Mangrol-Kota, Kota- Jawahar Barrage-Chambal- Kapren- Chambal- Kalisindh- Kota, Gwalior-Chambal- Gwalior, Gwalior-Etawa-Bhareh Village-YamunaChambal confluence. In these sections we took observation of geomorphic features, rock types and sediment charracterstic.

Location of the lower Chambal valley in India

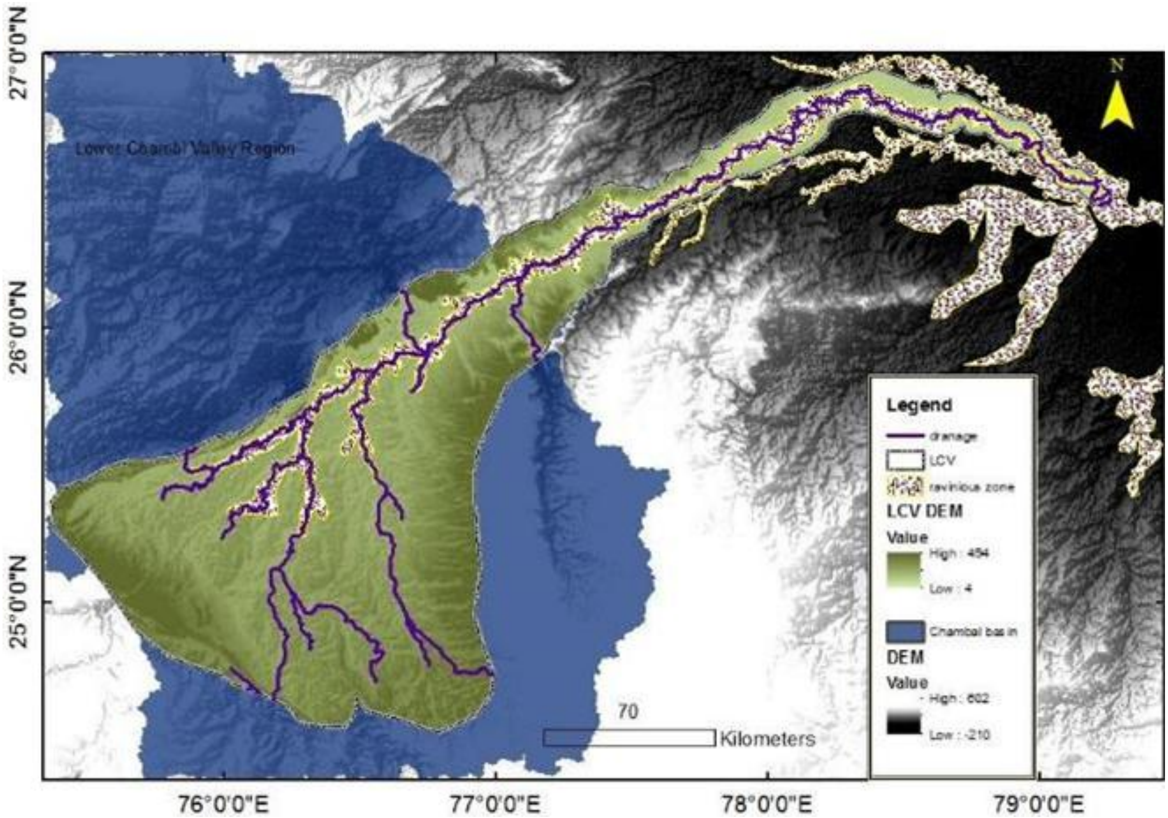

Figure 1: Location of the lower Chambal valley in India, Lower Chambal Valley, showing ravenous zone, drainage, Digital Elevation Modem of CARTOSAT1

Figure 2: Badland Topography on left flank of the Chambal River near Dholpur Rajasthan, showing ravine and summit point

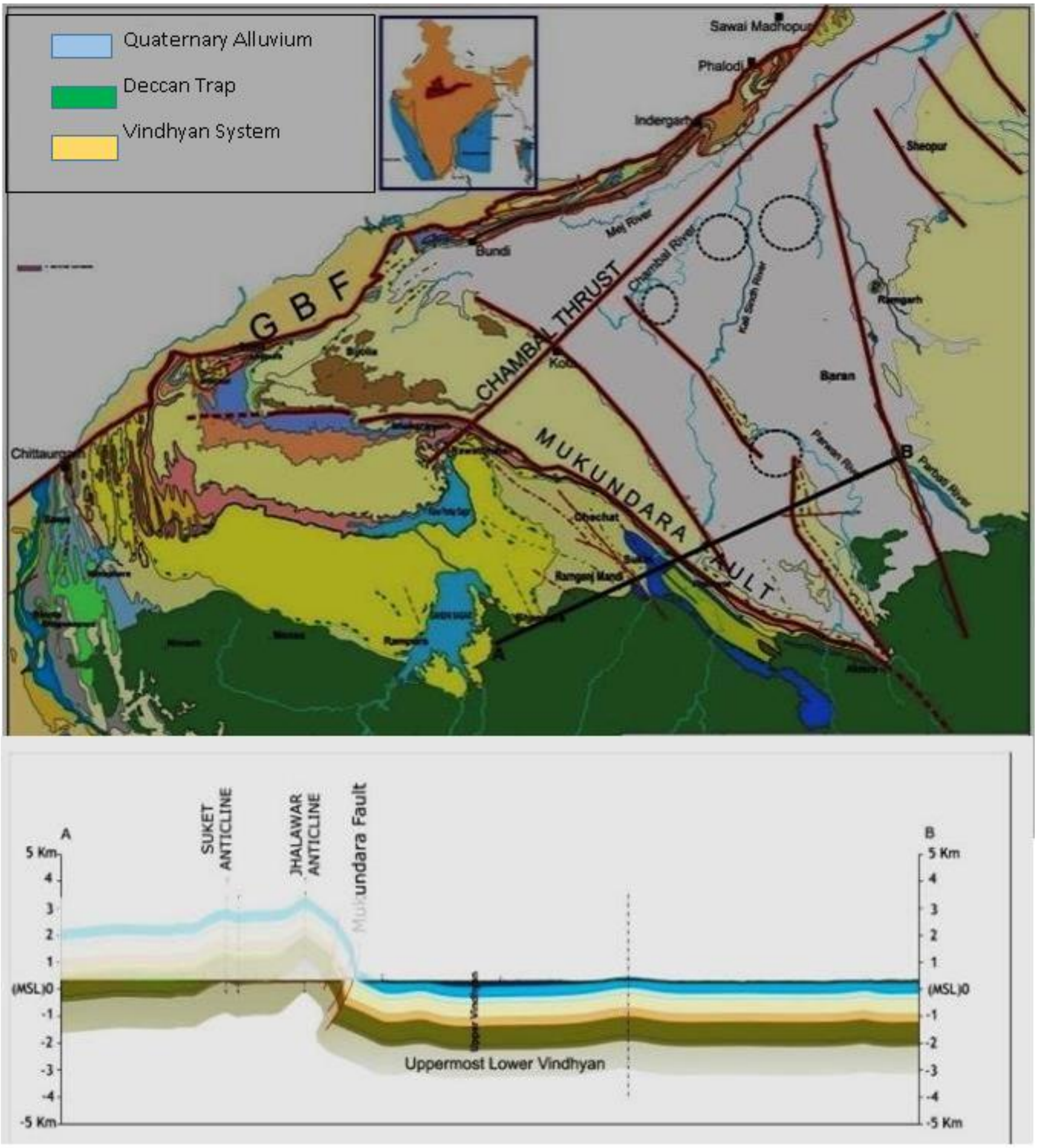

Figure 3: Geological and Structural setup of Lower Chambal Valley modified after Bhoj et al 2012

For detailed survey we selected the Dholpur section of the Chambal River at Morena Dholpur road and we observed river incision, nature of badland topography, nature of gully erosion, river terraces and different topographic levels.

Satellite Imagery: We used CartoDEM data for extraction of geomorphic information of the area. CartoDEM published by NRSC and available for free download on Bhuvan website, CartoDEM has 30m spatial resolution, and it is Digital Surface Model and have 8m absolute vertical accuracy and 15m absolute planimetric accuracy.

QGIS: We have extracted geomorphic information from DEM through QGIS software, we delineated badland topography, extracted drainage network, measured river cross section, river terrace and long profile of river valleys.

3. Results and Discussion

In whole study there are four major observations that are linked to peripheral bulge upliftment of the Himalayan tectonics in the MGAP region these are deep incised river valleys, intense gully erosion that led to badland (ravenous zone) formation, structural control on drainage and presence of palaeochannel on left bank of the Chambal in its lower reach.

Incised River Valleys: The Chambal and other rivers of the peripheral bulge region are deeply incised, in our observation of cross channel section of four rivers of the Lower Chambal Valley Region that is the Chambal, the Yamuna, the Sindh, the Kunwari River is that these rivers incised deeply from 10 to 50 meter. Total 49 cross section of these rivers are taken in the Lower Chambal Valley Region in these section channel depth varies from 11 to 50 meters deep (table no.1). The incision of the rivers in the region are due to upheaval of peripheral bulge have been taken to balance Himalayan thrust loading (Sharma1969, Mishra and Vishwakarma1999, Agrawal et al 2002, Ghosh et al 2017). Of these four rivers most of sections of the Chambal. River are deep in the 20 to 50 meters range, this supposed due to fact that Chambal River flows over upwarp (Mishra and Vishwakarma1999). These river incision are clear evidences of peripheral bulge upliftment that is Neotectonics.

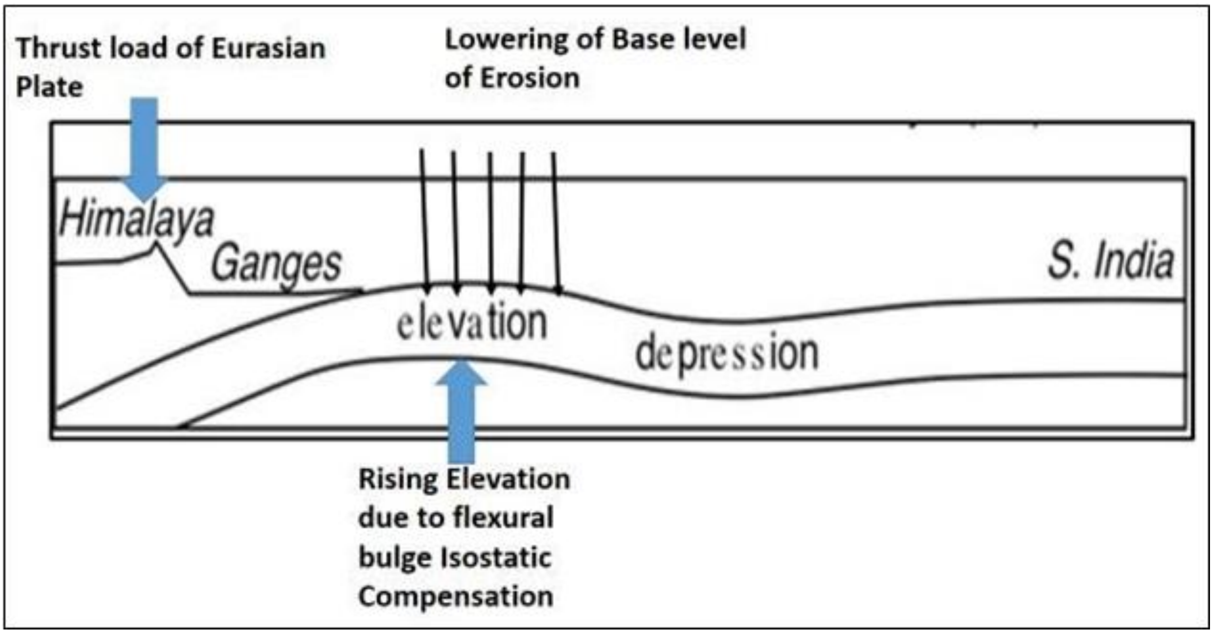

Figure 4: Schematic diagram showing flexral bulge upliftment, Himalayan thrust loading and incision and erosion on bulge region

Gully erosion and badlands formation: Due to Himalayan thrust loading rising of flexural bulge (Agrawal et al 2002) for isostatic compensation due to this effect it is supposed that base level of erosion lowered that cause intense gully erosion in the MGAP region. In our observation it is clearly visible in the form of badlands along river tracks of the region, and in whole
MGAP region

Lineament control on drainage: The LCV region is traversed by ENE -WSW, NW – SE, NNW – SSE, and NE – SW trending lineaments, mainly due to basement fractures and faults traversing the Precambrian rocks (Fig. 8). The upper reaches of the Chambal, Sind, Kunwari, and rivers are controlled by NE – SW trending set of lineaments. The abrupt easterly and South Easterly turn in their lower reaches, is due to the combined influence of the NW – SE, NNW – SSE, and ENE – WSW trending sets of lineaments. Zigzag courses with sharp kinks and abrupt bends along the main lineament trends of the region and absence of free meander show lineament control on drainage. The gullies and ravines with trellis, parallel drainage, and rectangular patterns too manifest controls of lineaments and bed rock joints. The Bhind earthquake of 1994 has been occurred due to the dextral transcurrent movement along a NNW – SSE trending (Mishra and Vishwakarma 1999). Abrupt shift in the course of Chambal and Gambhir rivers at Pinahat and Tikatpura respectively, a high order of meandering in the Yamuna where river crosses the lineament, a faster rate of headward erosion along gullies fthat follows this lineament provide manifestations of neotectonic deformation along this lineament(Mishra and Vishwakarma 1999). The Kunwari River also shows abrupt change in shift along this lineament.

Palaeochannel: There is a 74 km long palaeochannel, sub-parallel to the Chambal, on the left bank, near Dholpur observed in CartoDEM imagery on the older alluvium (Fig. 9), which once served as the left bank tributary of the Chambal is observed. Unlike the Chambal and other active entrenched river this palaeochannel have no such entrenchment, this suggests palaeochannel predates incision of rivers. We observed about 50m difference in elevation between the Chambal River and the paleochannel on CartoDEM there may be the role of neotectonics. Mishra and Vishwakarma, 1999, opined that atonement of once a tributary of the Chambal River the palaeochannel due to upwarping of alluvium surface along which uplifted axis the Chambal River is flowing.

Presence of many village settlement, temples, forts, Hindu and Buddhist deities and broken crockery are observed during the field survey suggest that most of the badlands formations are happen in historic period. Ghosh et al 2017 opined that intense gully erosion and badlands formation age is lower than 14k years.

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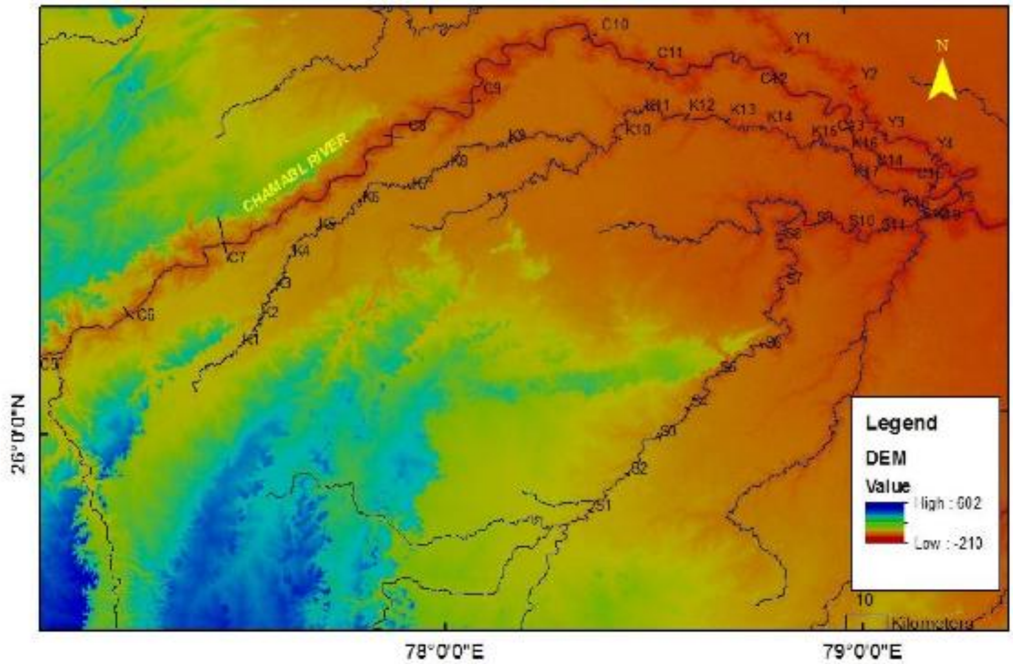

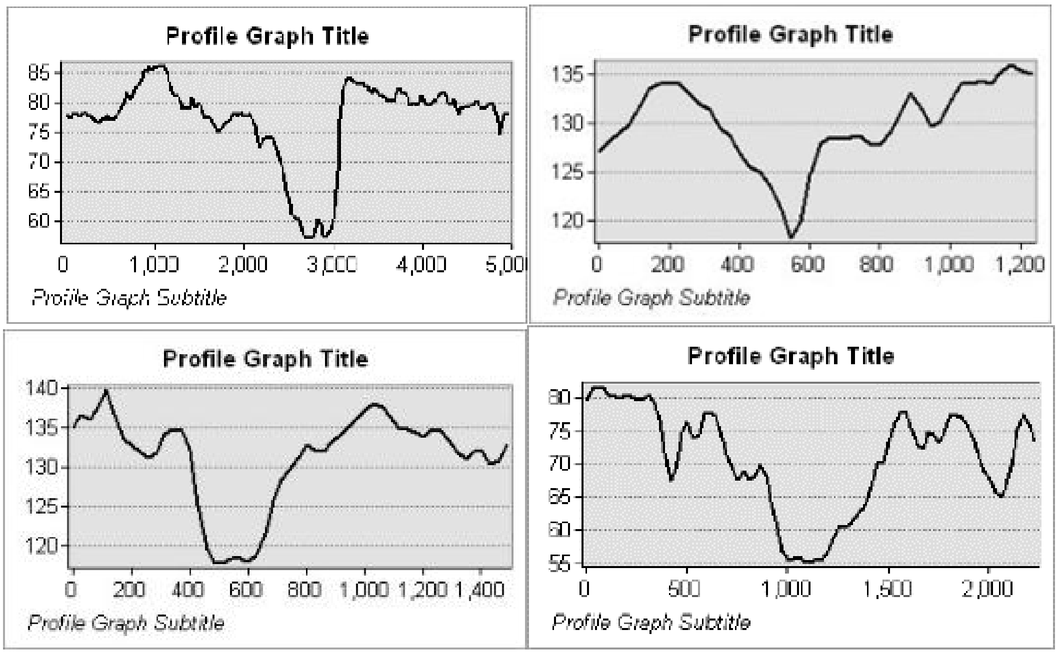

Figure 5: all figures showing river cross sections C for the Chambal, K for the Kunwari, S for Sindh, Y for the Yamuna River cross section, below are the sections are top left is C9, top right is K2, bottom left is S2, bottom right is Y2

Table 1: Showing values of depth of river incision

Serial No,	Cross Section No.	River	Channel Floor Height in M1	Right bank Elevation in M2	Left bank Elevation in M3	Channel depth in Meter = 2 +3/2 -1
1	C1	Chamabl	137	160	162	24
2	C2	Chamabl	136	153	152	16.5
3	C3	Chambal	126	152	154	27
4	C4	Chambal	106	144	138	36
5	C5	Chambal	100	144	132	38
6	C6	Chambal	90	118	142	40
7	C7	Chamabl	79	137	133	56
8	C8	Chamabl	69	87	109	29
9	C9	Chambal	56	84	87	29.5
10	C10	Chambal	52	98	92	44
11	C11	Chambal	51	84	78	30
12	C12	Chambal	50	75	95	35
13	C13	Chambal	44	85	85	41

14	C14	Chambal	43.5	75	83	35.5
15	K1	Kunwari	122	142	135	16.5
16	K2	Kunwari	118	136	134	17
17	K3	Kunwari	114	133	128	16.5
18	K4	Kunwari	111	128	127	16.5
19	K5	Kunwari	106	124	119	15.5
20	K6	Kunwari	101	108	116	11
21	K7	Kunwari	99	117	110	14.5
22	K8	Kunwari	93	110	105	14.5
23	K9	Kunwari	87	103	96	12.5
24	K10	Kunwari	78	103	90	18.5
25	K11	Kunwari	71	84	85	13.5
26	K12	Kunwari	70	90	94	22
27	K13	Kunwari	68	85	78	13.5
28	K14	Kunwari	66	83	86	18.5
29	K15	Kunwari	61	77	75	15
30	K16	Kunwari	56	80	70	19
31	K17	Kunwari	54	66	63	11
32	K18	Kunwari	49	66	60	14
33	K19	Kunwari	46	70	64	21
34	S1	Sindh	118	137	140	20.5
35	S2	Sindh	116	135	133	16
36	S3	Sindh	113	130	127	15.5
37	S4	Sindh	97	113	110	14.5
38	S5	Sindh	80	95	112	23.5
39	S6	Sindh	70	110	100	35
40	S7	Sindh	61	85	80	21.5
41	S8	Sindh	58	73	77	15
42	S9	Sindh	56	73	68	14.5
43	S10	Sindh	49	66	65	16.5
44	S11	Sindh	48	62	68	17
43	S12	Sindh	46	64	64	18
44	Y1	Yamuna	60	87	87	27
45	Y2	Yamuna	55	82	78	25
46	Y3	Yamuna	51	78	80	28
47	Y4	Yamuna	50	80	76	28
48	Y5	Yamuna	44	62	68	21
49	Y6	Yamuna	41	72	75	32.5

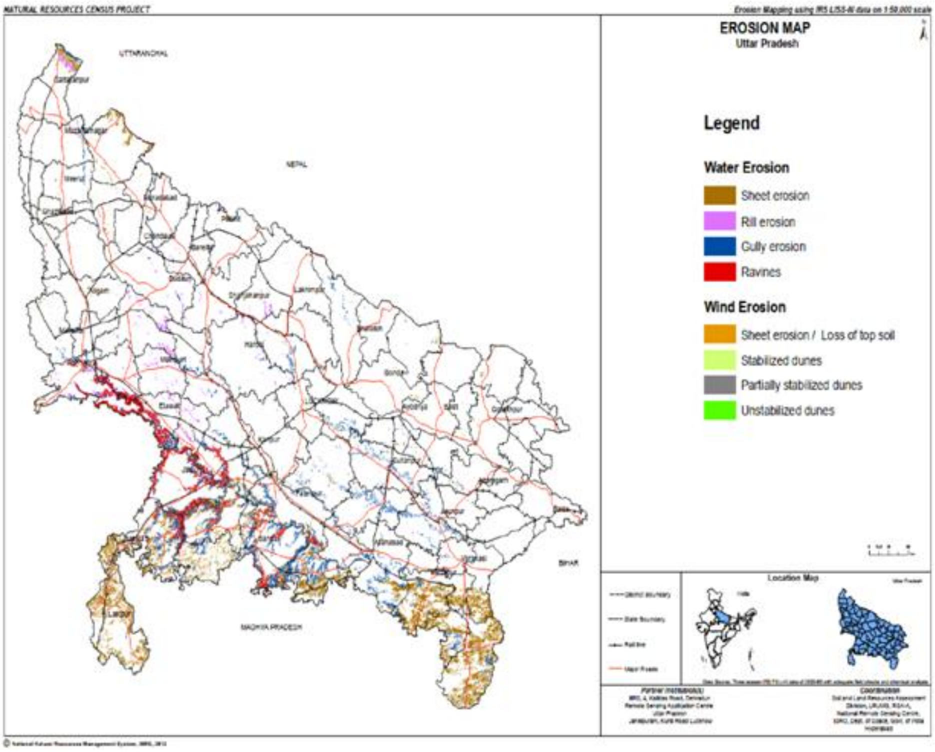

Figure 7: Erosion Map of UP, southern part of the Uttar Pradesh state fall in MGAP region, showing intense gully erosion
Source: Bhuvan portal, Government of India

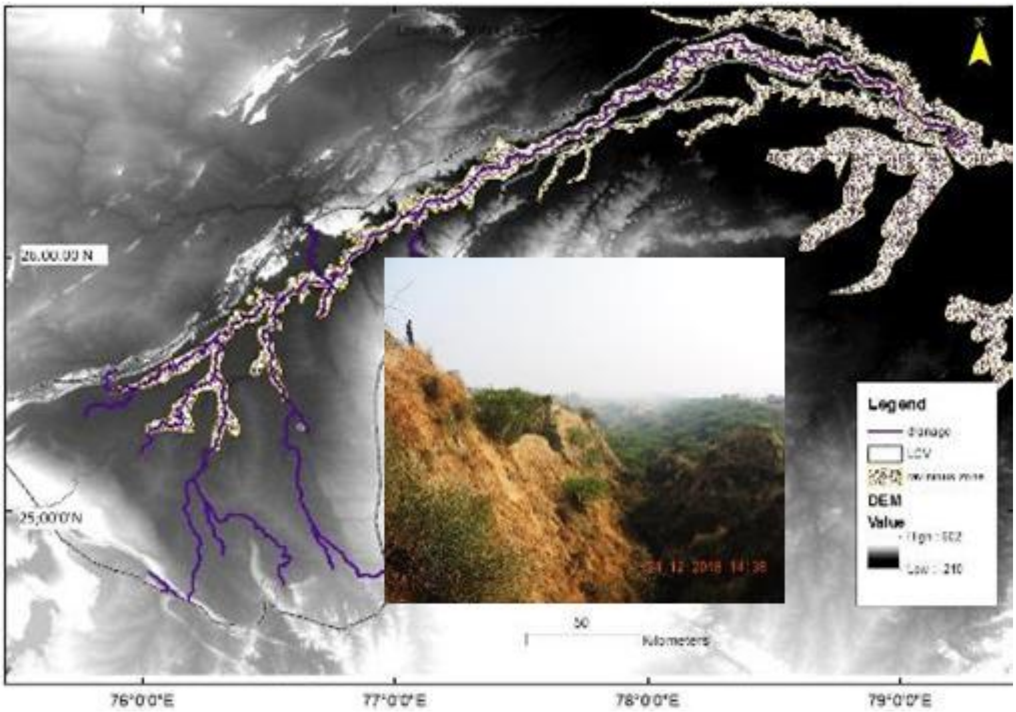

Figure 6: Map showing ravenous zone(badlands) formed due to gully erosion in the LCV region along the Chambal, Kunwari, Yamuna and Sindh river , photograph showing a ravine along left bank of the Chambal river near Dholpur, DEM showing elevation

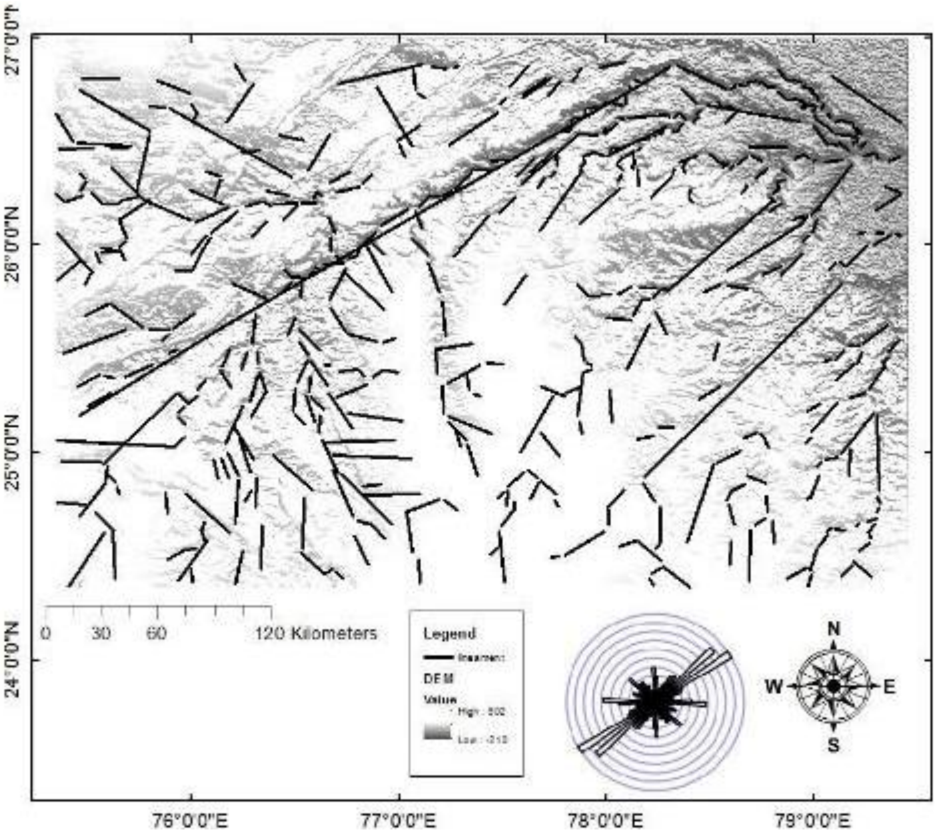

Figure 9: Lineament Map of the LCV region, rose diagram showing major lineament direction

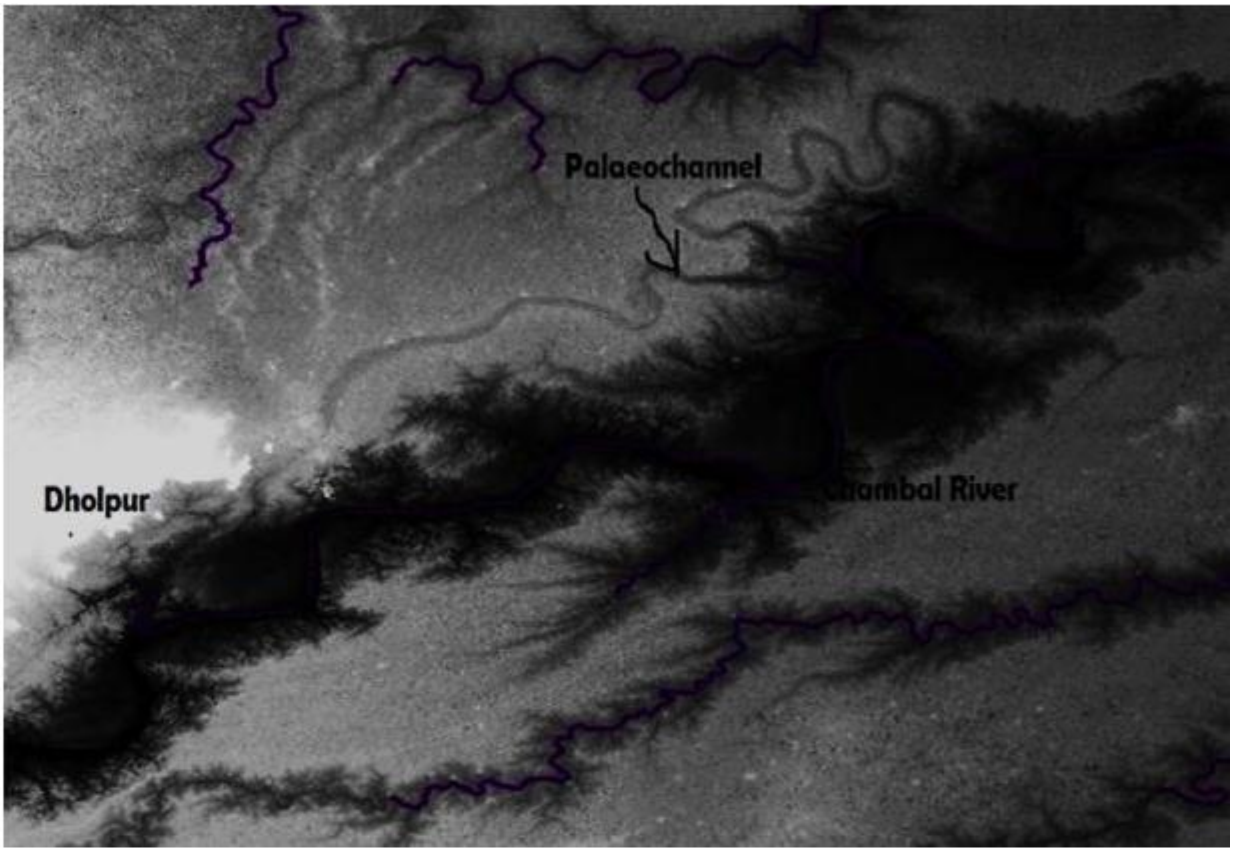

Figure 9: Showing a Palaeochannel near Dholpur, sub- parallel to the Chambal River, on CartoDEM

4. Conclusion

Role of neotectonics activity in the geomorphic evolution of the Lower Chambal Valley region reported various time previously. In this study an attempt has been made to identify, delineate and quantify various Morphotectonic indicators to evaluate the role of neotectonics in the region. Delineation of badlands along river track and in interfluve areas, quantification of incision in various river valleys, demarcation, length measurement, and elevation measurement of paleochannel and mapping of lineament of the region and their major trend identification all these findings and observations suggest that the thickalluvium of the Lower Chambal Valley of Quaternary Period, is an extension of Marginal Gangetic Alluvial Plain, which is sensitive to regional crustal movement occurring due to Himalayan Tectonics that is manifested in the region in the form of gully erosion, deep incision of meandering rivers, presence of palaeochannel, lineament control on drainage.

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