

Relief and slope characteristics of Lohawati river catchment in Kumaun Himalaya, Uttarakhand

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Abstract

Geomorphologists use river basin as an ideal unit of the earth surface for the study of its landforms. Relief and slope are essential factors which determine and control the origin and evolution of any river catchment. Relief and slope studies also highlight the facts about changing nature of the river catchment. The Lohawati River catchment is located in lesser Himalaya in Champawat district of Uttarakhand state. In the present study, an attempt has been made to study the relief and slope characteristics of the Lohawati river catchment using geospatial technique. The altitude of the catchment area decreases from west to east direction. The slope map indicates that Lohaghat and Champawat towns are situated in the gentle slope category.

The very low dissection index and very low relative relief in the Champawat area and in some parts of Lohaghat at the western side of the catchment are characterized by more aggradation processes and are less prone to soil erosion. Relief profiles show the surface undulations because of erosion by Lohawati River and its tributaries.

Keywords: Digital elevation model, Relief, Slope, Profile.

Introduction

Development of landform upon earth surface is result of various geomorphic processes. Geomorphology is the science of evolutionary process of the landforms; weather these landforms is erosional or structural². The term relief refers to the configuration of the earth's surface with reference to its elevation and slope variations.

Study Area Location

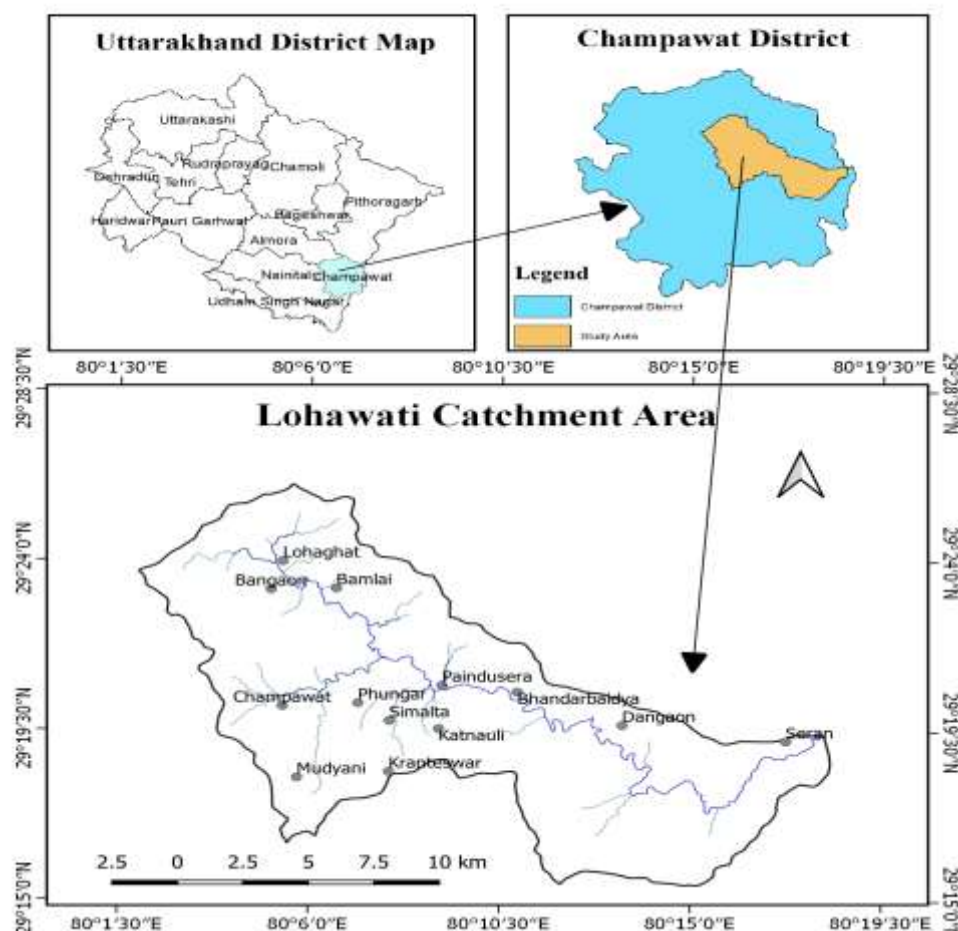


Fig. 1: Study area location map

It is the synthetic concept which denotes the nature of terrain³. Slope or gradient of a landform describes both the direction and the steepness of the landform. A first step to study the geomorphology of an area is to analyze its relief and slope characteristics. In this study, an attempt is made to identify the slope and relief characteristics of the study area.

Study area

The study area lies in the Lesser Himalaya in Champawat district of Uttarakhand state. The area is situated in between 29°15'25" to 29°26'00" North latitude and 80°01'55" to 80°18'18" East longitude. The total study area is about 222.40 km². The altitude of area ranges from 363 meters to 2209 meters. The Lohawati is a tributary of Kali River. Kali River forms the boundary between India and Nepal (Fig. 1).

Material and Methods

Relief and slope characteristics of Lohawati river catchment are based on the Survey of India topographical map. The contour map of the study area is scanned and vectorized with

the help of GIS software at 50 feet (15.24 meters) interval. The vector information is then rasterized by linear interpolation and a digital elevation model was generated. From Digital Elevation Model (DEM), all required maps and their statistical information are derived. In this study, an analysis of relief (altitude, absolute relief, relative relief and dissection index and relief profile) and slope (in degree and percentage, aspects) is carried out.

Results and Discussion

Altitudinal zone: The altitudinal zone map of the study area is prepared with the help of digital elevation model (Fig.2). It is utilized for defining the range of elevation above mean sea level. The Lohawati river catchment is divided into 7 altitudinal zones (Fig. 3). Altitude increases from east to west. Majority of area i.e. 90.64 km² out of total 222.40 km² falls in 1600-1800 meters altitudinal zone, which is 40.75% of the total area. The minimum area i.e. 8.23 km² falls under < 800 meters (Very Low Category of Absolute Relief) altitudinal zone which is 3.70% of the total area (Table 1).

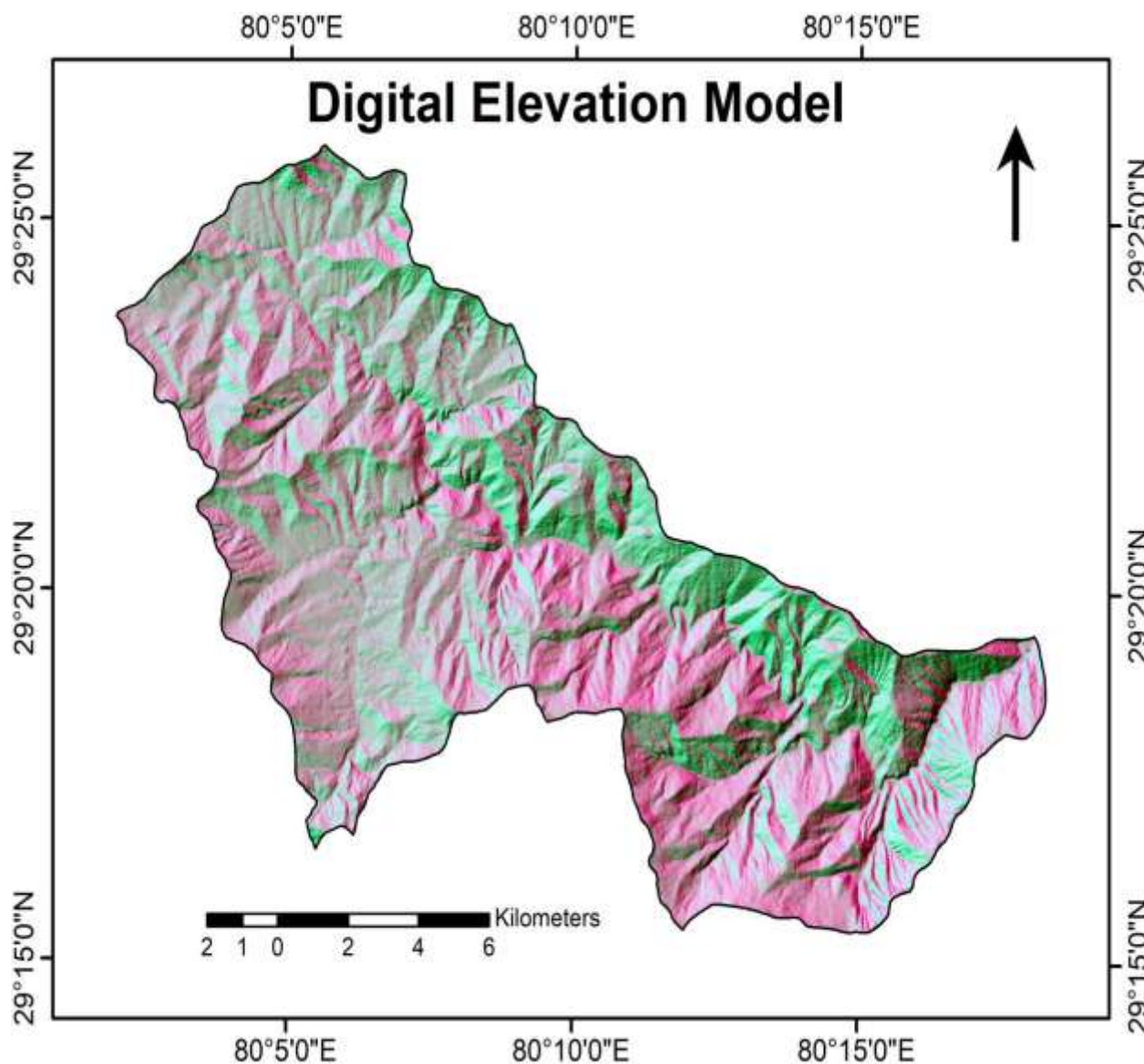


Fig. 2: Digital Elevation Model

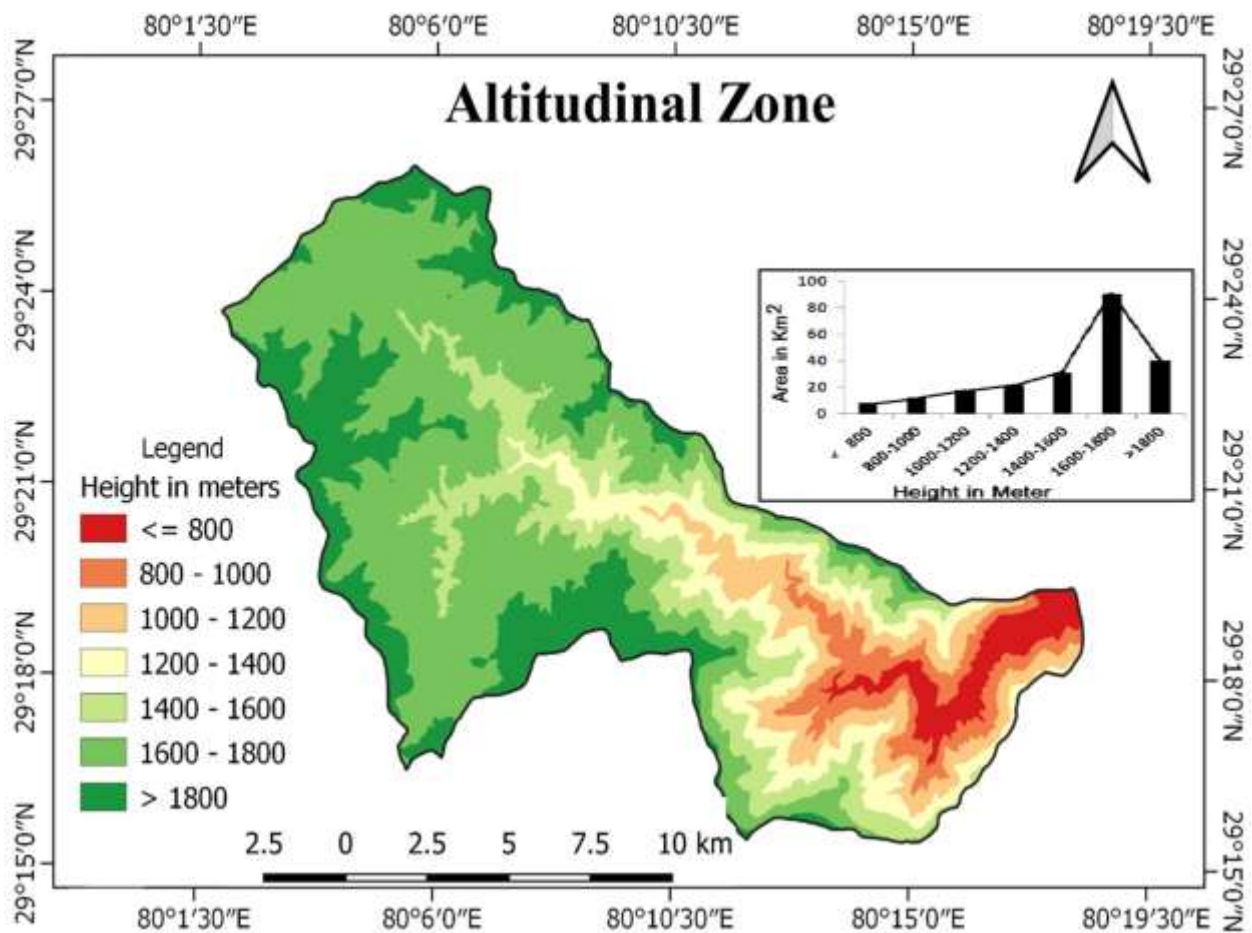


Fig. 3: Altitudinal Zone Map of Study Area

Table 1
Altitudinal Zone

Height in meters	Area in (Km ²)	Cumulative area (Km ²)	Area in percent	Cumulative area in percent	Absolute Relief Categories
< 800	8.23	8.23	3.70	3.70	Very low
800-1000	12.44	20.67	5.59	9.29	Low
1000-1200	18.01	38.68	8.10	17.39	Moderately Low
1200-1400	21.79	60.47	9.80	27.19	Moderate
1400-1600	30.91	91.38	13.90	41.09	Moderately High
1600-1800	90.64	182.02	40.75	81.84	High
>1800	40.38	222.40	18.16	100	Very High

Slope in degrees: Slope plays an important role in life history of a landscape. It determines the drainage pattern and transformation of terrain and thereby influences the flora and fauna of the land as well as its human occupancy. Slope represents a state in which one side of the land is higher than the other³. Slope in degrees is the measure of steepness or degree of inclination of an area relative to the horizontal plane. The slope is derived from the digital elevation model ranging in between flat to steep. This range of slope is sliced into seven taking an interval of 9 degree (Fig. 4). The maximum area of 67.08 km² falls under moderately low slope category of 18°-27°, which is 30.16% of total area

while minimum area of 2.04 km² falls under very steep slope category of >54° which is 0.92% of the study area.

Slope in percent: Slope in percent is another way of expressing slope steepness. Slope in percent expresses the ratio of difference in altitude between 2 points on a slope to the horizontal distance between the points multiplied by 100. Slope in percentage of the area is calculated and mapped using open-source GIS software (Fig. 5). The table 3 represents that the maximum area of 87.96 km² in the catchment falls under 40%-80% slope group which is 39.56% of the total area and minimum area of 1.03 km² in

the catchment falls under >160% slope group which is 0.46% of the study area.

Slope aspect: Slope aspect refers the orientation of the earth's surface with respect to sun. Aspect can be thought of as the slope direction. Aspect can be defined by using compass or by assessing the relative earth's surface with

respect to the magnetic north. Aspect affects the microclimate of an area by regulating the angle and the duration at which the sun's rays strikes the surface of the soil. The maximum area falls under east aspect with about 12.69% area of the catchment (Fig.6). The minimum area falls under north which covers 6.31% area of the Lohawati catchment (Table 4).

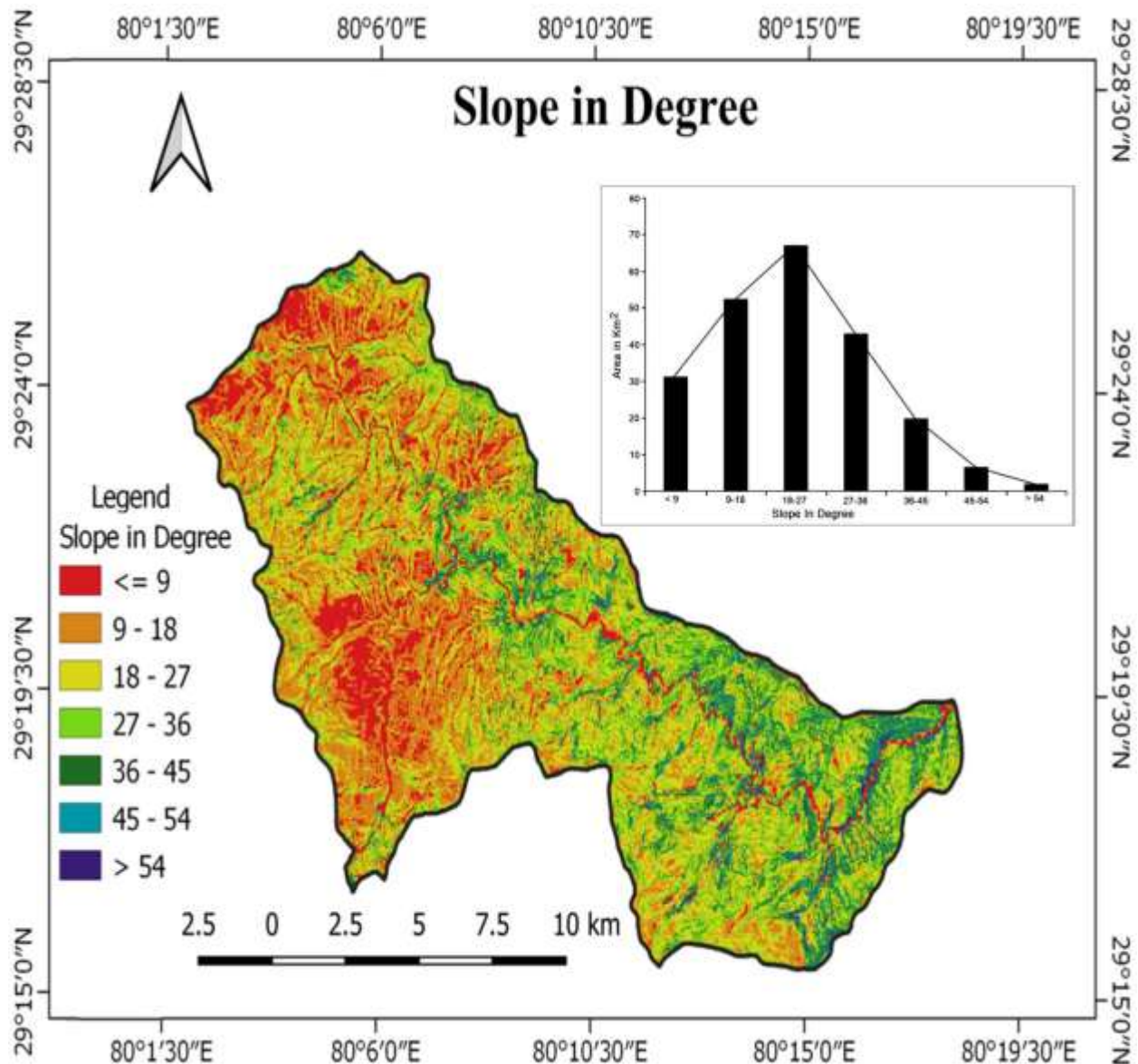


Fig. 4: Slope in Degrees

Table 2
Slope in Degrees

Slope in Degrees	Area (Km ²)	Cumulative Area (Km ²)	Area in percent	Cumulative area in percent	Slope Categories
< 9	31.33	31.33	14.09	14.09	Level
9-18	52.46	83.79	23.59	37.68	Gentle
18-27	67.08	150.87	30.16	67.84	Moderately low
27-36	42.98	193.85	19.32	87.16	Moderate
36-45	19.86	213.71	8.93	96.09	Moderately high
45-54	6.65	220.36	2.99	99.08	Steep
>54	2.04	222.40	0.92	100	Very Steep

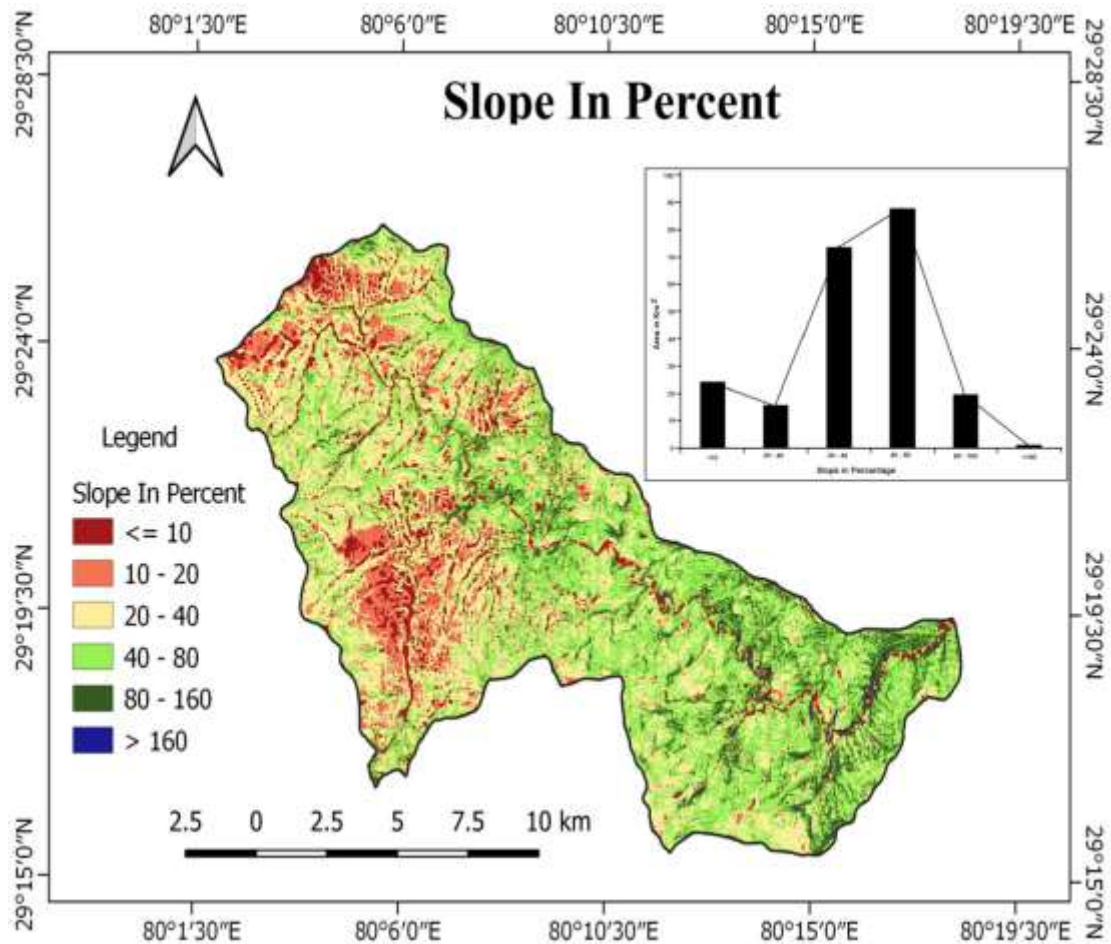


Fig. 5: Slope in Percent

Table 3
Slope in Percent

Slope in percent	Area (Km ²)	Cumulative area (Km ²)	Area (%)	Cumulative area (%)
<=10	24.27	24.27	10.91	10.91
10-20	15.75	40.02	7.08	17.99
20-40	73.64	113.66	33.11	51.10
40-80	87.96	201.62	39.56	90.66
80-160	19.75	221.37	8.88	99.54
>160	1.03	222.40	0.46	100

Table 4
Slope Aspect

Slope aspect	Area (Km ²)	Cumulative Area (Km ²)	Area in percent	Cumulative Area in percent
Flat	22.25	22.25	10.01	10.01
North	15.20	37.45	6.84	16.85
North-East	26.15	63.60	11.76	28.61
East	28.23	91.83	12.69	41.30
South-East	27.05	118.88	12.16	53.46
South	24.69	143.57	11.10	64.56
South-West	17.60	161.17	7.91	72.47
West	21.26	182.43	9.56	82.03
North-West	25.93	208.36	11.66	93.69
North 2	14.04	222.40	6.31	100

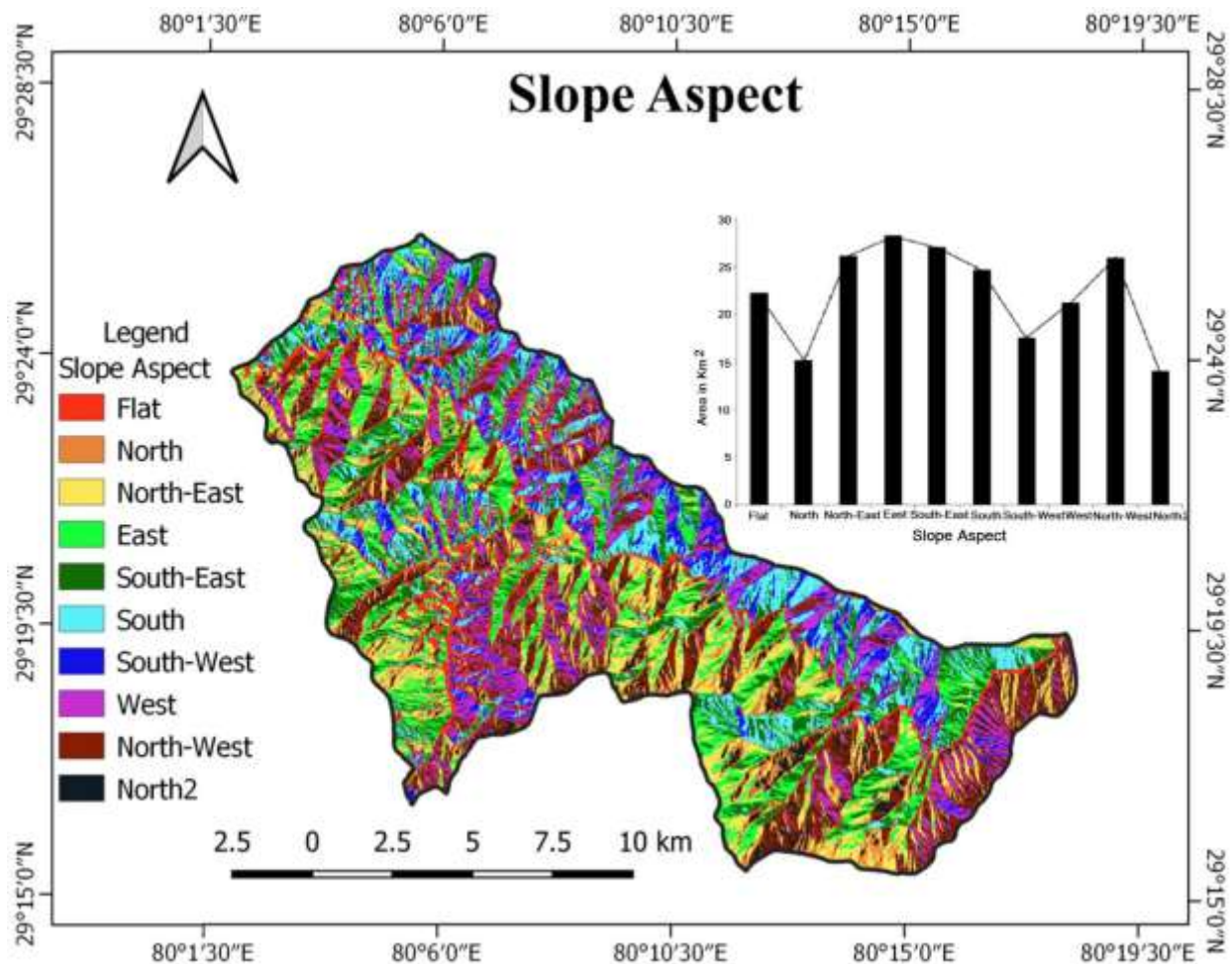


Fig. 6: Slope Aspect

Absolute relief: The absolute relief is the maximum elevation of an area. The maximum elevation for each grid (1 km²) is extracted from DEM (Fig.7). The absolute relief of Lohawati catchment ranges from ≤1000 meters to >2000 meters. The maximum area of 84.32 km² lies in the absolute relief group of 1800-2000 meter, which is about 37.92% of total area. The minimum area of 1.21 km² lies in the absolute relief group of ≤1000 meters which is about 0.54% of total area (Table 5). The patches of very high absolute relief > 2000 meters are found in the north of Lohaghat town in the west between Lohaghat and Champawat town and near Kranteshwar locality. The patches of very low absolute relief (≤1000 meter) and low absolute relief (1000- 1200 meter) are found in the eastern part of the catchment (Table 5).

Relative relief: Relative relief also termed as ‘amplitude of available relief’ or ‘local relief’ is defined as the difference in height between the highest and the lowest points in a unit area⁵. The relative relief depicts the relief of an area in relation to the surrounding area. Relative relief is a very important morphometric variable which is used for overall assessment of morphological characteristics of terrain and degree of dissection⁵. The area of very high relative relief of 596-686, 686-776 and 776-866 meters area is found in the eastern part of the catchment near the confluence of Lohawati and Kali Rivers (Fig. 8).

The very low relative relief of 56-146 meters is found in the western area of the catchment particularly around the township of Champawat and in the northern area of Lohaghat township. The maximum area of 50.74 km² lies in the relative relief group of 146-236 meters (Low relative relief category) which is 22.81% of the total area. The minimum area of 0.16 km² lies in the relative relief group of 776-866 meters (Very high relative relief category) which is 0.07% of the total area (Table 6).

Dissection index (DI): Dissection index, expressing a ratio of the maximum relative relief to the maximum absolute relief, is an important morphometric indicator of the nature and magnitude of dissection of terrain⁵. Dov Nir¹, suggested the following formula for the derivation of dissection index:

$$Di = Rr / Ar$$

where Rr is relative relief and Ar is absolute relief.

The grid method is used for the computation of dissection index⁵. The value of DI obtained for the study area varies from 0.03 to 0.65. It is classified into 5 categories like very low (0.03-0.16), low (0.16-0.28), medium (0.28-0.40), high (0.40-0.52) and very high (0.52-0.65) (Fig. 9). Very low DI is found in the western, north-western and south western

parts of the catchment. Low DI occupies the central position in the catchment. Medium DI covers the south eastern part of the catchment whereas the high and very high DI cover the eastern and extreme eastern part of the catchment. The

maximum area of 104.10 km² lies in the very low category of DI km² which is 46.81 % of total area. The minimum area of 2.78 km² lies in the very high category of DI which is 1.25% of total area (Table 7).

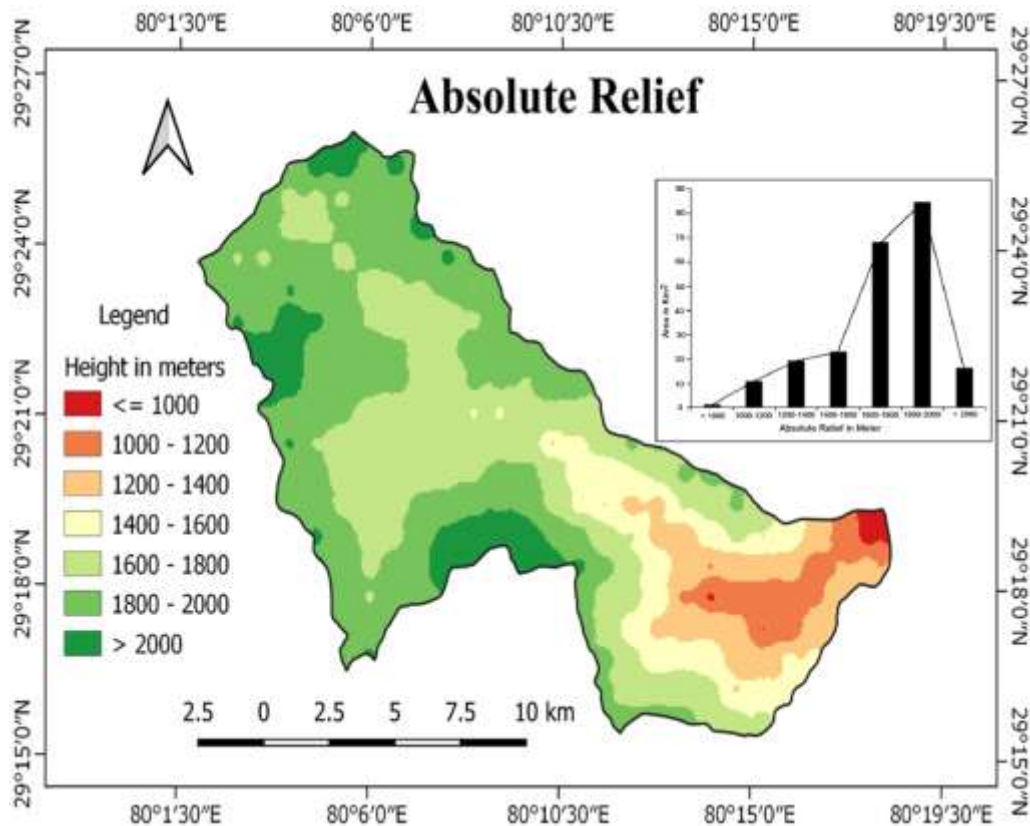


Fig. 7: Absolute Relief

Table 5
Absolute Relief

Absolute Relief in meters	Area (Km ²)	Cumulative Area (Km ²)	Area in Percent	Cumulative Area in %	Absolute Relief Categories
< 1000	1.21	1.21	0.54	0.54	Very Low
1000-1200	10.70	11.91	4.81	5.35	Low
1200-1400	19.13	31.04	8.60	13.95	Moderately Low
1400-1600	22.95	53.99	10.32	24.27	Moderate
1600-1800	67.92	121.91	30.54	54.81	Moderately High
1800-2000	84.32	206.23	37.92	92.73	High

Table 6
Relative Relief

Relative Relief in meters	Area (Km ²)	Cumulative Area (Km ²)	Area in Percent	Cumulative Area in percent	Relative Relief Categories
56-146	14.06	14.06	6.32	6.32	Very Low
146-236	50.74	64.80	22.81	29.13	Low
236-326	49.14	113.94	22.10	51.23	Moderately Low
326-416	37.08	151.02	16.67	67.90	Moderate
416-506	44.94	195.96	20.21	88.11	Moderately High
506-596	20.55	216.51	9.24	97.35	High
596-686	5.26	221.77	2.37	99.72	Very High
686-776	0.47	222.24	0.21	99.93	Very High
776-866	0.16	222.40	0.07	100	Very High

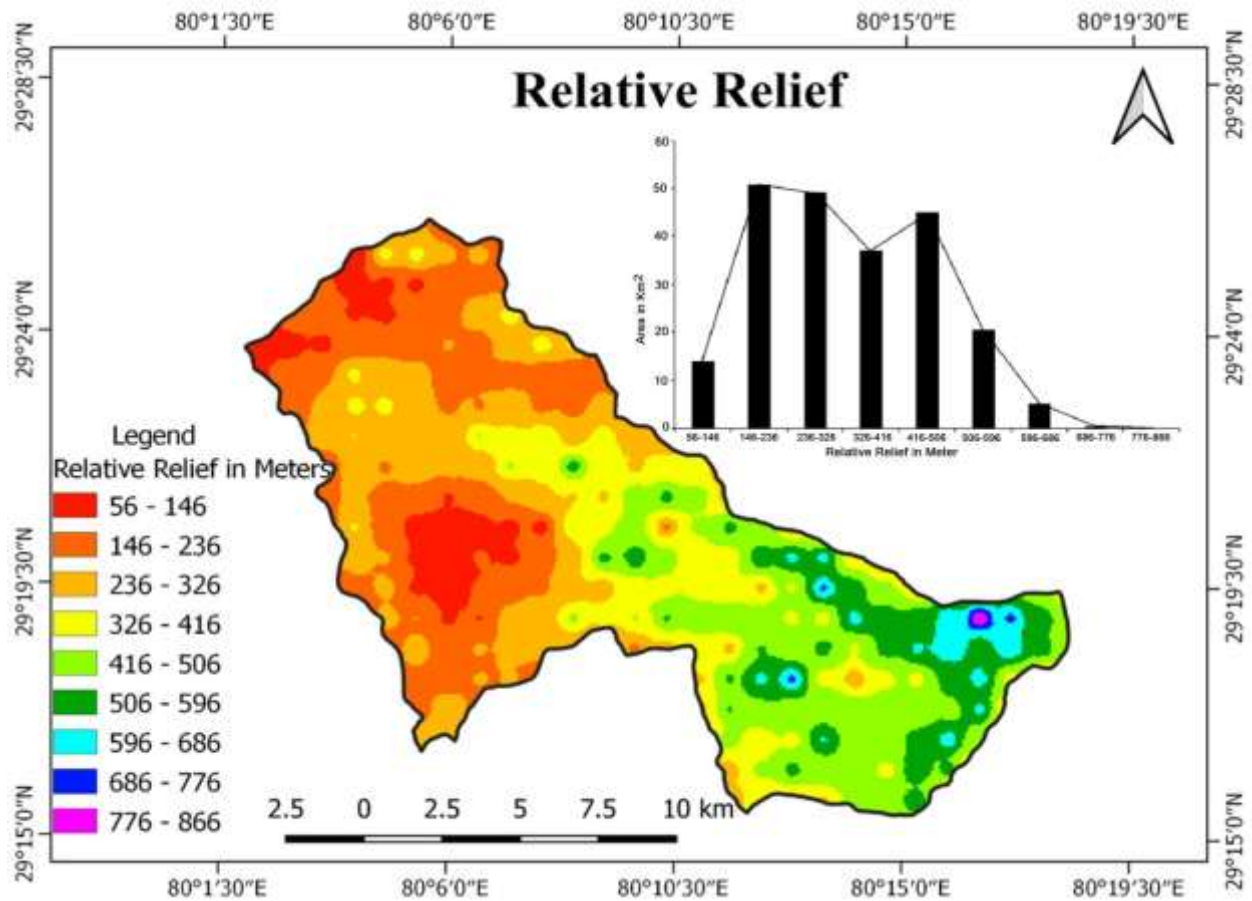


Fig. 8: Relative Relief

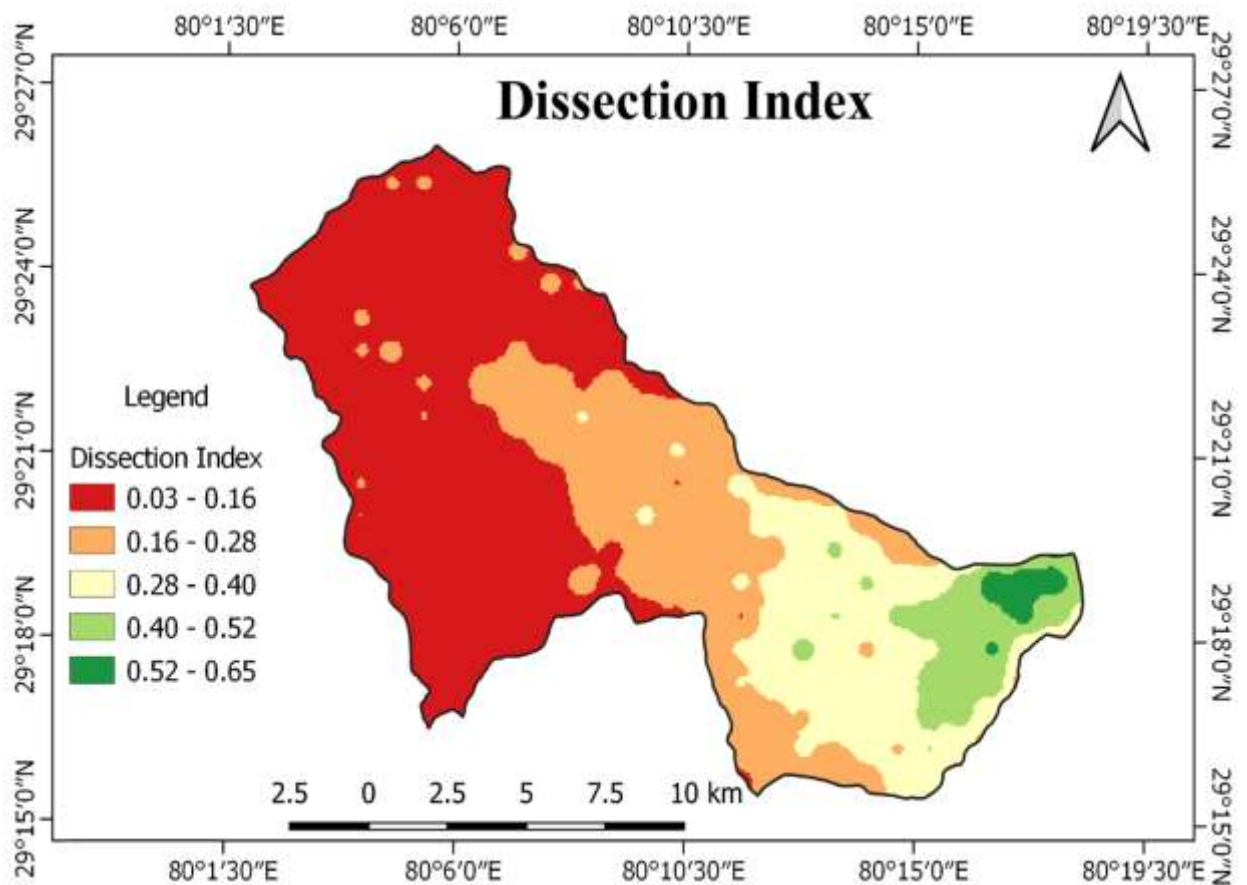


Fig. 9: Dissection Index

Profiles: The easiest method of showing various landforms is profile drawing. The area under study may be imagined as cut into thin slices at some intervals and a series of profiles along parallel lines may be drawn for clear understanding of the land forms⁴. Broadly speaking, a profile or section means an outline of relief feature (elevation or depression) along a selected base line³. For drawing serial profiles, the contour map is divided into successive strips of uniform width and

then drawn a profile along each base line (Fig.10). The vertical scale is suitably exaggerated to project each feature in its correct perspective. Serial profiles present the true picture of the terrain in a particular area. The whole catchment is divided into 5 parallel base lines A-B, C-D, E-F, G-H and I-J, after that the serial profiles are drawn for each base line. Along these profiles, one can see the configuration of the terrain.

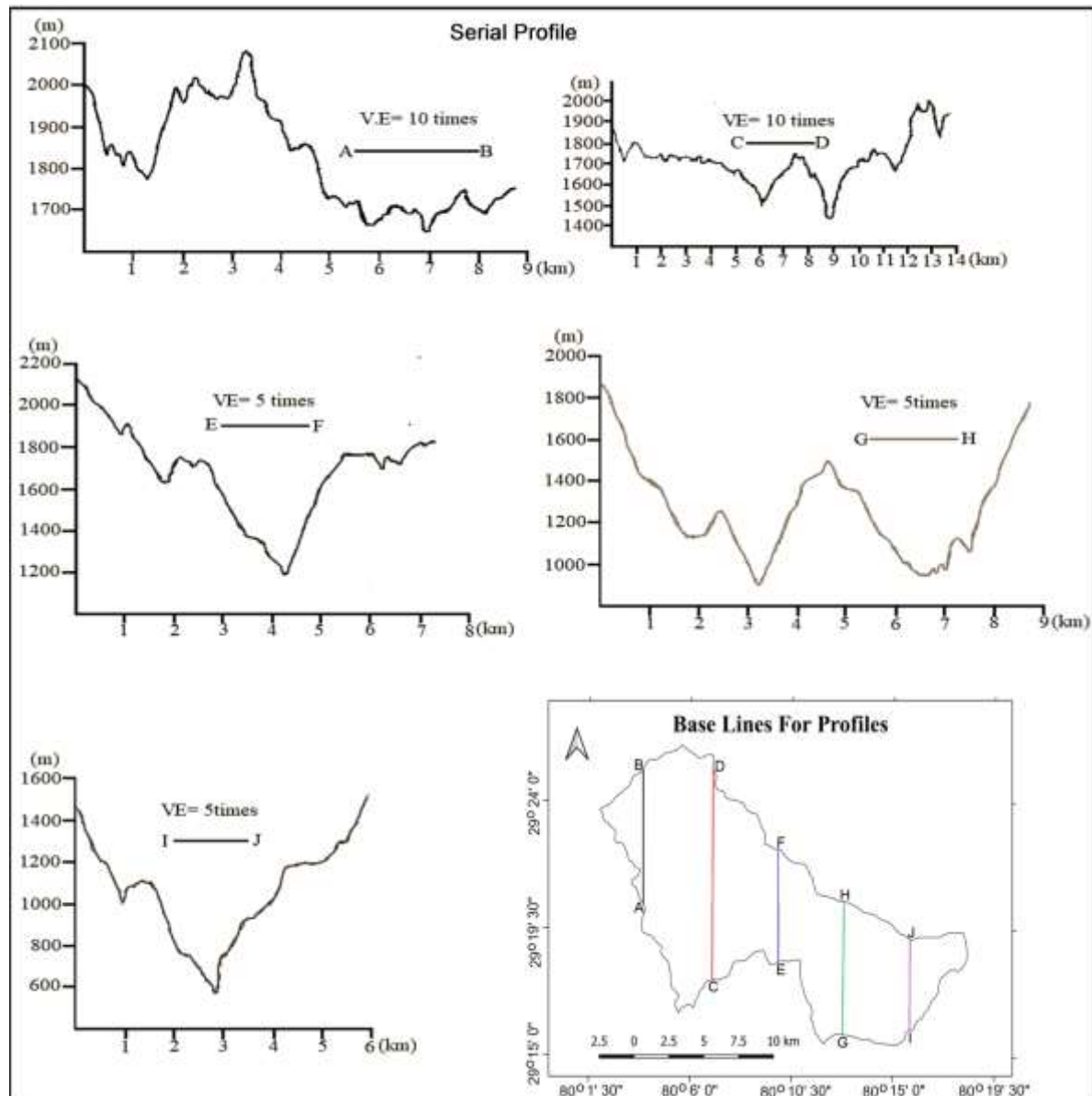


Fig. 10: Relief Profile

Table 7
Dissection Index

Dissection Index	Area (Km ²)	Cumulative Area (Km ²)	Area in Percent	Cumulative Area in Percent	Dissection Index Categories
0.03-0.16	104.10	104.10	46.81	46.81	Very Low
0.16-0.28	59.88	163.98	26.92	73.73	Low
0.28-0.40	41.59	205.57	18.70	92.43	Medium
0.40-0.52	14.05	219.62	6.32	98.75	High
0.52-0.65	2.78	222.40	1.25	100	Very High

Conclusion

The altitude of the catchment area decreases from west to east direction. The slope in degree and slope in percent maps reveal that the localities of Lohaghat and Champawat in the western side of the catchment have level and gentle slope categories. The very low dissection index and very low relative relief in the Champawat area and in some parts of Lohaghat at the western side of the catchment are characterized by more aggradation processes and appear to be less prone to soil erosion. Relief profiles drawn along base line indicate the relief variation because of the erosion caused by Lohawati River and its tributaries.

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(Received 28th April 2022, accepted 02nd June 2022)