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Relief and Slope Analysis of Upper Pindar River Basin, Central Himalaya

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ABSTRACT

Drainage basin, an open system with combination of numerous subsystems is shaped by various geomorphic processes. Relief and slope studies highlight the facts about changing nature of the river basins. The study area is located in central Himalaya under Bageshwar district in Uttarakhand state. The altitude of the study area is ranging between 1997 meter to 6855 meter. Geologically the study area is made up of Joshimath fm., Pandukeshwar fm., and Pindari fm., comprising gneiss, schist, quartzites, mica and biotite. In the study area there is one thrust (main central vaikrita thrust) and two faults. In the present study an attempt has been made to study the relief and slope characteristics of the upper Pindar catchment using DEM. For the analysis of relief and slope aspects the drainage basin has been sub- divided into 5 altitudinal zones, 5 relative relief zones, 5 absolute relative relief zones and 5 average slope zones. From the study of upper Pindar catchment it is found that the nature of relief and slope aspects are co-relative over the area. The Pindar River, lying in the eastern part of Kumaon Himalaya, is a dominant name in the drainage networks of it. For this reason, several attempts of study were made by various scholars for analysing the overall condition of the Pindar Basin from 19th century. Most of the works on the Pindar River are mainly on the basis of geology, morphology, chronological sequence of terraces and valley development, snout retreat, recent changes in the position of snout and impacts of flood.

Key Words : DEM, Catchment, Morphometry, Drainage, Relief, Slope, GIS

INTRODUCTION

Geomorphology as a branch of physical geography deals with the scientific study of origin, evolution, nature, form and mechanism of development of landform both at and near the earth surface (Nandy and Jha, 2016). 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 are erosional or structural (Joshi, 2007). The meaning of term relief may be defined as the difference in elevation of the any part of the earth's surface or relative vertical inequality of land surface. Worcester (1948), described the relief as the vertical irregularities both large and small of the surface of lithosphere. Relief and slope both are important factors for the occurrence of soil erosion and landslide in the hilly region. Thus the relief and slope analysis becomes essential for studying physiographic characteristics of the area. In this paper an attempt is made to carry out the study of of relief and slope by preparing DEM, altitudinal zone, absolute relief, relative relief, relief profile and average slope.

Study area:

The present study area lies in the Central Himalaya in Bageshwar district of Uttarakhand state. The area is situated in between 30º05'34'' north latitude and 79º47'51'' east longitude. The total study area is about 348 km². The altitude of area ranges from 1997m. to 6855m. The Pindar river is a tributary of Alaknanda river which make confluence at Karanprayag locality. The

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upper catchment of Pindar river is formed by the tributaries originating from the glaciers known as Pindari, Sundardhunga and Kafni. Sundardhunga river originates from sundardhunga glacier and join Pindar river at Khati. Kafni river originates from kafni glacier and make confluence with pindar river at Dwali (Fig. 1).

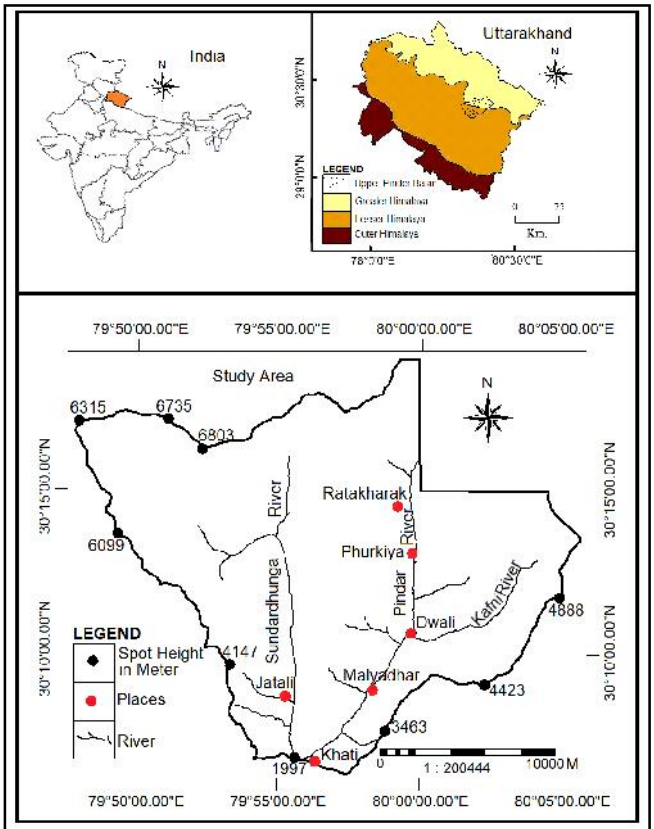

Fig. 1 : Study area

METHODOLOGY

Relief feature and slope characteristics of upper Pindar river basin is based on the survey of India topographical map on 1:50000 scale. The contour map of the study area is scanned and vectorised with the help of ILWIS software at 20 meter interval. The vector information is than rasterised by linear interpolation and a digital elevation model was generated. From Digital Elevation Model (DEM) all required maps and their statistical information was derived (Fig. 2 and 3).

Altitudinal Zone:

In the hilly areas there is a variation in vegetation, climatic condition and slope with respect to changing altitude. Temperature decreases with increasing altitude

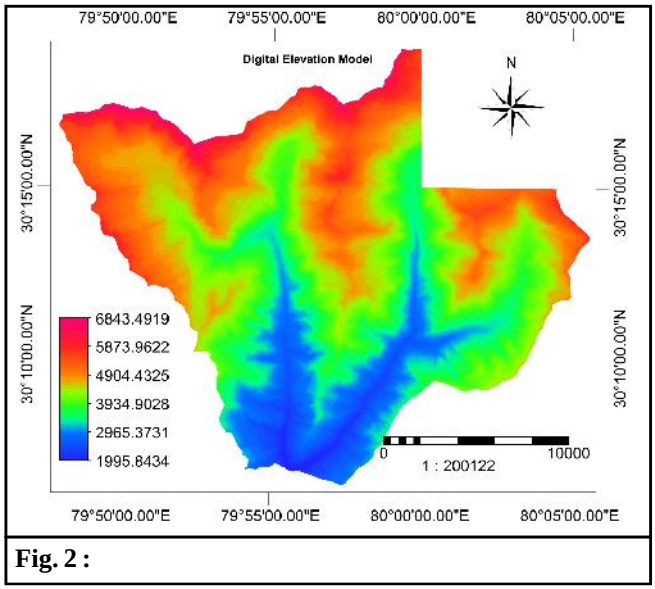

Fig. 2 :

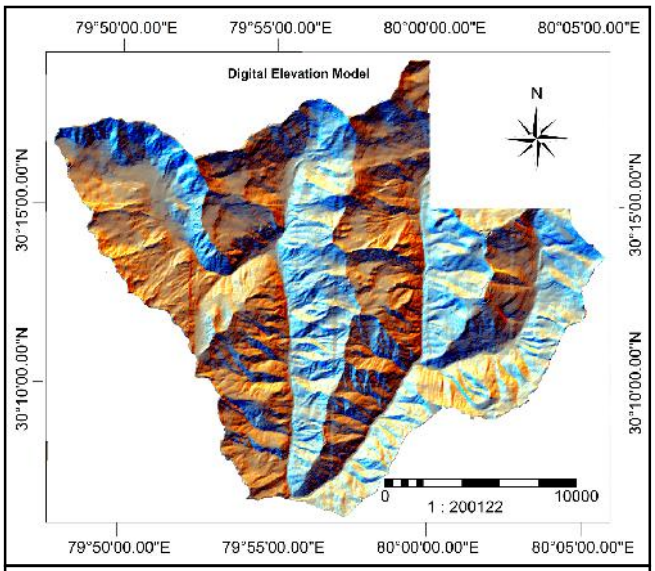

Fig. 3 :

resulting the impact on climatic and vegetation variation. The elevation of upper Pindar basin varies between 1997 meter (confluence of Pindar and Sundardhunga River) and 6855 meter (Mirgthuni peak). For detail study the entire basin is divided into five altitudinal zones of 800 meter contour interval (Fig. 4).

Regional distribution:

The study area is divided into 5 altitudinal zones. Table reveals that maximum part of the basin falls under 3800 meter to 4600 meter altitudinal zone which is 29.40 per cent of entire basin. Above 5400 altitudinal zone

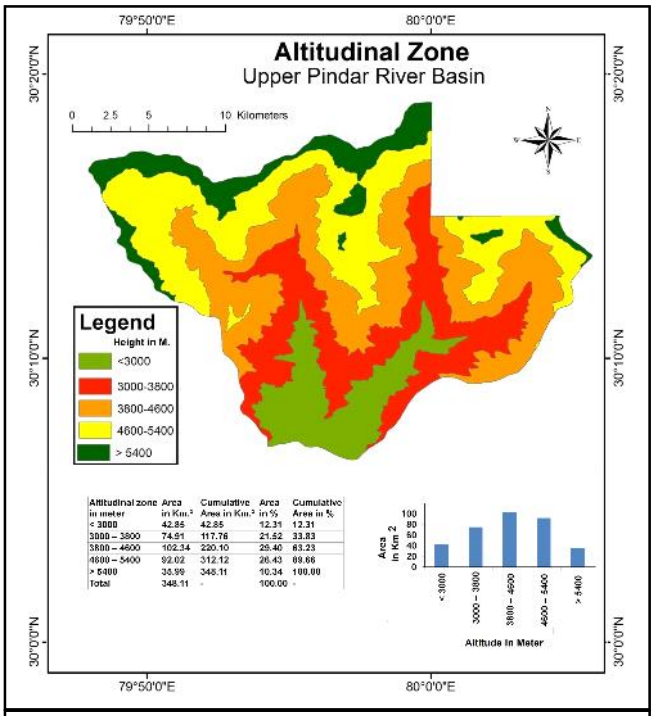

Fig. 4 : Altitudinal zone

occupied a less area which is only 10.34 per cent part of basin.

The lowest zone *i.e.* below 3000 meter zone contains 42.85 km² area which is 12.31 per cent part of the basin. This zone is situated in the southern part of watershed. The confluence of Pindar and Sundardhunga River and confluence of Pindar and Kafani River falls under this zone. The only settlement of watershed village Khati situated in this zone. This zone is rich in flora and fauna. Slope is moderate to steep and river flows in a narrow valley. At Khati land is cultivated and mainly potato, pulses and wheat etc. are grown. There is a huge landslide at Malyadhaur near the Khati village.

The highest zone *i.e.* above 5400 meter zone is glaciated and covered with snow for entire year. This zone has highest peaks of the basin such as Nanda khat (6545 meter), Panvali doar (6663 meter), Sundardhunga Khal (5550 meter), Mirgthuni (6855 meter) and Mangtoli. 35.99 km² area falls under this zone which is 10.34 per cent of watershed.

Statistical analysis:

The statistical analysis of altitudinal zone of study area has been carried out by dividing it into two groups. The first group includes mean, median and mode and second group of variability include range and quartile deviation, mean deviation, standard deviation and skewness. The mean, median and mode values are 4207.79, 3811.55 and 4381.30, respectively and there deviations are 719.33, 871.63 and 793.95, respectively. A positive skewness found in case of altitudinal zone which is moderately skewed. Different variable of statistical measurement has been shown in table.

Absolute relief:

Absolute relief is an important variable which helps in determining the maximum height of a unit area from the sea level. In the present work to calculate the absolute relief the grid method has been used. The study area has been divided into 366 grids of 1 km² on the survey of India topographical maps. The maximum height of each grid has been marked in the centre of grid. Isopleths have been drawn at the interval of 500 meter. Thus the entire region has been divided into different absolute relief zone. The value of absolute relief ranges between 1997 meter and 6855 meter. The highest elevation zone is found in northern, north eastern and north western part of the basin. While lowest elevation is found in southern part of the basin at the junction of Pindar and Sundardhunga River.

Regional distribution :

The entire watershed has been divided into five absolute relief zone from less than 4000 meter to above 5500 meter.

Those areas where the absolute relief is below 4000 meter have been classified as very low absolute relief zone. This absolute relief zone is found in the southern part of the basin. The only settlement of entire basin 'Khati Village' situated in this zone. This zone contains a relative relief value between 200 meter and 1120 meter and the slope angle is ranges between 19070 degree and 42.70 degree. This zone contains an area of 95.98 km², which is 27.57 per cent of entire basin.

Above 5500 meter group of absolute relief is classified as very low absolute relief zone. This zone is cover with snow for whole year. The highest peaks of the basin Nanda khat (6545 meter), Panvali doar (6663 meter), Sundardhunga Khal (5550 meter), Mirgthuni (6855 meter) and Mangtoli situated in this region. This zone contains an area of 58.48 km² which is 16.80 per cent of entire basin.

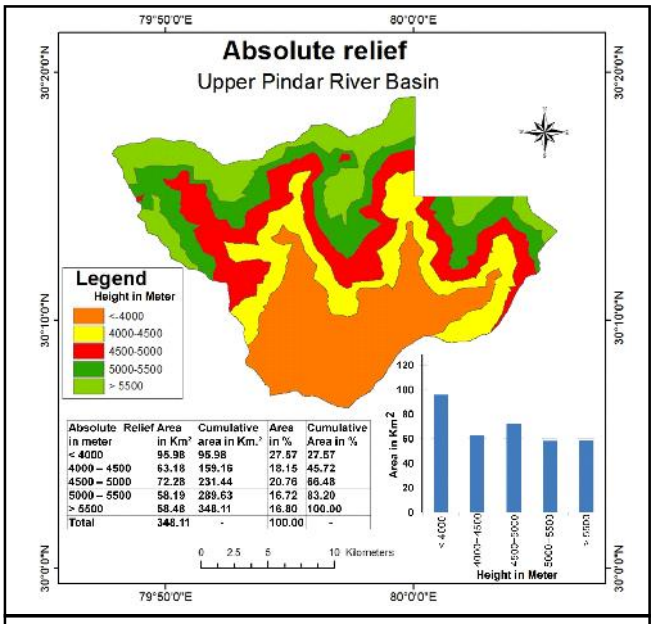

Fig. 5 : Absolute relief

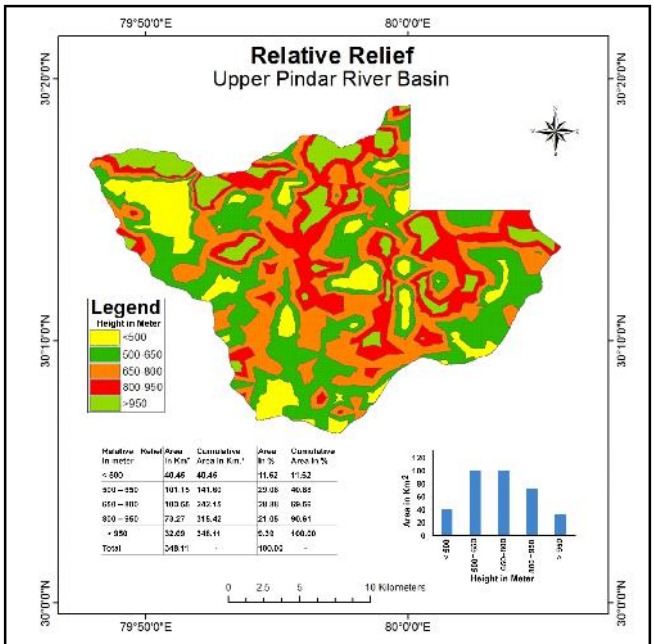

Fig. 6 : Relative relief

Statistical analysis:

Different variables of statistical measurement has been shown in table. Table reveals that there is a positive skewness found (+0.001), which is approximately symmetric. Mean, median and mode values are 4635.11, 4603.04 and 3872.65 and there deviations are 535.36 630.61 and 830.09, respectively.

Relative relief:

Relative relief is the differences between highest and lowest altitude in a unit area. G.S. Smith (1935) used the term relative relief and local relief in morphometric analysis. Relative relief is one of the most important morphometric attribute. It plays an important role in the determination of the degree of dissection and also the stages of basin development of a region (Fig. 6).

Regional distribution:

Relative relief ranges between 200 meter and 1600 meter in the study area. The watershed has been divided into five relative relief zone less than 500 meter to above 950 meter.

Very low relative relief zone – The areas having relative relief less than 500 meter have been classified as the very low relative relief zone. This relative relief zone is scattered in whole basin in small patches. 11.62 per cent area of entire basin falls under this very low relative relief zone which is 40.45 km².

Very high relative relief zone – Above 950 meter relative relief group is classified as very high relative relief zone. 32.69 km² area falls under this zone which contains 9.39 per cent part of entire basin.

Statistical analysis:

Mean, median and mode values of relative relief are 706.30, 698.41 and 648.53 while their deviations are 141.67, 143.13 and 152.44, respectively. A positive skewness found in case of relative relief which is approximately symmetric. The calculated value of statistical measurement has been presented in table.

Profile analysis:

Profile analysis is an essential part of geomorphological study. Relief profiles are the combined result of the tectonic and various geomorphic processes, working on the land surface which regularly modifies these structures. Profile prepared from a contour map is helpful in the explanation of landforms and relief visualization. Profiles also provide a significant contribution in the comprehension, interpretation and description of the landforms or geomorphic features. Thus the profiles are helpful for visual perception of a terrain of the basin and as a morphometric tool for determining the erosion surfaces. Topgraphic profiles are used in highway and railway planning to estimate the degree or filling needed

to establish a smooth grade. Profiles are very helpful in the military operations to determine the limits of visibility from the key observation point.

In the present work six serial profiles have been drawn on a regular interval from the source of river to its mouth. With the help of these serial profiles the superimposed, projected and composite profiles have constructed to analyze the varied nature of terrain and identification of summit level.

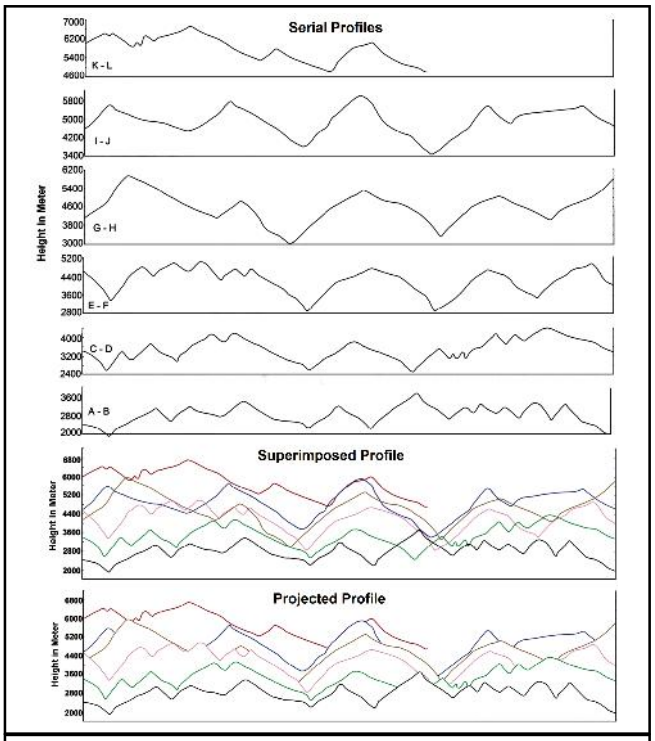

Fig. 7 : Profile analysis

1. Serial profile – The entire basin is divided into six segments at equal intervals and a systematic plate of profile is prepared. The base line obtained through contour map to help in presenting the arrangement of serial profile. The serial profiles reveal the changes in relief of a drainage basin. For clear identification the profiles base lines are named as A – B, C – D, E – F, G – H and I – J.

2. Superimposed profile – To draw superimposed profile all serial profiles are superimposing one upon another serially on a single frame following one common base line. Every serial profile lines are marked by different signs to show their individual existence. This type of drawing represents approximately the true character of the landform. Figure shows a picture of superimposed profile. Figure reveals that there is spacing in the profile in upper parts which show moraine deposition while in the middle part of the basin it shows a steeper slope.

3. Projected profile – The projected profile is drawn with the help of serial profile. Like superimposed profile all lines of serial profile have been traced in a single frame but the portion of each serial profile which is not observed by higher intervening landforms left untraced. Figure shows that projected profile gives a realistic picture with a distant skyline, a middle ground and a foreground.

4. Composite profile – The composite profile is the composition of the superimposed and projected profile. The composite profile shows the uneven form of the skyline. To construct composite profile only the uppermost part of every serial profiles have been traced. The objectives of the construction of this profile to represent the surface of the area of relief as viewed in the horizontal planes of summit levels from an infinite distance and include only the highest part of a series of parallel profiles.

Slope analysis:

The angle of proclivity of the ground surface on the horizontal plane *i.e.* the plane parallel to the earth surface is defined as slope. In other words slope is an angle between hill crest and valley bottom. Slopes are interdependent with stream channels and the geometry of the drainage basin. But if initially one looks only at the characteristics and processes which are operative on the slopes themselves, it is possible to describe the hills and begin to isolate some of the factors which control their form and development. In the hilly area slope is a significant part of landscape so the slope analysis become essential for the interpretation of landforms. Geohydrological properties of a watershed also can express by the slope map, such as the amount of moisture content. Generally the moisture content in the soil reduces with the increasing slope because in those areas where steeper slope found the layers of soil are thin. Thus the thickness of soil layers and the moisture content in the soil both are inversely connect with steepness of slope.

In those areas where soil erosion is more effective or accelerated the slopes study essential. Slope analysis is highly useful in estimating the amount of water discharge in streams and springs. Slope also has its

Table 1 : Different variable of statistical measurement

Statistical variables	Values			
	Altitudinal Zone	Absolute Relief	Relative Relief	Average Slope
Mean	4207.79	4635.11	706.30	34.77
Median	3811.55	4603.04	698.41	34.86
Mode	4381.30	3872.65	648.53	34.94
Mean deviation from mean	719.33	535.36	141.67	4.09
Mean deviation from median	871.63	630.61	143.13	4.11
Mean deviation from mode	793.95	830.09	152.44	4.14
Co-Mean deviation from mean	0.17	0.11	0.20	0.12
Co-Mean deviation from median	0.23	0.14	0.20	0.11
Co-Mean deviation from mode	0.18	0.21	0.23	0.12
Standard deviation	941.60	719.49	172.72	5.37
Co- standard deviation	0.22	0.15	0.24	0.15
Quartile first	3471.79	3953.36	569.07	31.15
Quartile third	4956.29	5254.70	838.76	38.77
Quartile deviation	742.25	650.67	134.85	3.81
Co – quartile deviation	0.18	0.14	0.19	0.11
Co – variation	22.38%	15.52%	24.45%	15.46%
Skewness	+0.54	+0.001	+0.04	+0.03

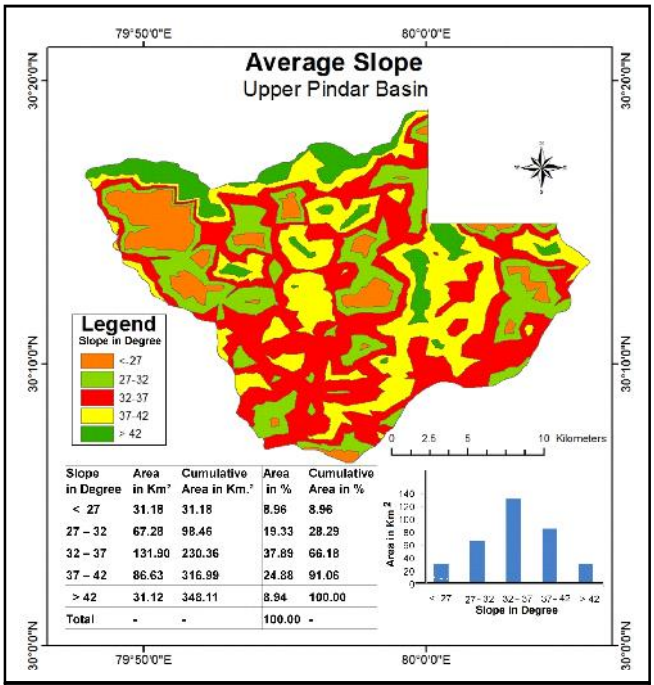

Fig. 8 : Average slope

geological importance as many of the controversial geological features *i.e.* faults are easily recognized or explained with the help of slope angle. Obliviously the study of slope has its unique importance in land use and environmental study.

Regional distribution:

The regional distribution of the average slope in the study area presents a large variation from region to region but in general entire basin contains moderate to steep slope. In the study area average slope ranges between 12.1 degree and 54.95 degree. The entire basin is divided into five slope zone ranging from below 27 degree to above 42 degree.

Moderate slope zone : The areas having slope angle below 27 degree has been classified as moderate slope zone. 31.18 km² area falls under moderate slope zone which is 8.96 per cent part of entire basin. This slope zone is scattered in entire basin in small patches mainly near the mouth of the river. These areas constitute depositional landforms such as river terraces, fans and moraine deposits.

Very high steep slope zone : Those areas having slope angle above 42 degree is classified as very high steep slope zone. About 31.12 Km² area which is 8.94 per cent part of entire basin falls under very high steep slope zone. This zone is found in high altitudinal areas mainly glaciated areas in the northern part of the basin. Pindari glacier, Sundardhunga glacier and Kafani glacier situated in this zone.

Statistical analysis:

A positive skewness found (+0.03), which is

approximately symmetric. Mean, median and mode values are 34.77, 34.86 and 34.94 and their deviations are 4.09, 4.11 and 4.14, respectively. Different variable of statistical measurement has been presented in table

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