

## GEOMORPHOLOGICAL ANALYSIS OF MANDAKINI RIVER BASIN USING REMOTE SENSING AND GIS TECHNIQUES

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**Abstract:** *Geomorphology is important for the understanding of Earth surface processes, geochronology, natural resources, natural hazards and landscape evolution. Present study analysis's the Geomorphological analysis of the basin like geomorphology, lineaments, lithology, land use/land cover, DEM, slope and aspects. The present study is based on spatial data acquired form of Survey of India topo-sheets, ASTER GDEM (2011) and BHAVAN (bhavan.nrsc.gov.in). Mandakini River is a major tributary of Alaknanda River and it originates from the Chorabariglacier. The total catchment area of the river is near about 1666.34 km<sup>2</sup>. The Remote Sensing and GIS techniques have been used to complete the work on present study. The geo-informatics-based study of Geomorphological analysis of river basin characteristics can be used by local people for sustainable development of this area.*

**Keywords:** Geomorphology, Lineaments, Lithology, Remote Sensing and GIS

  
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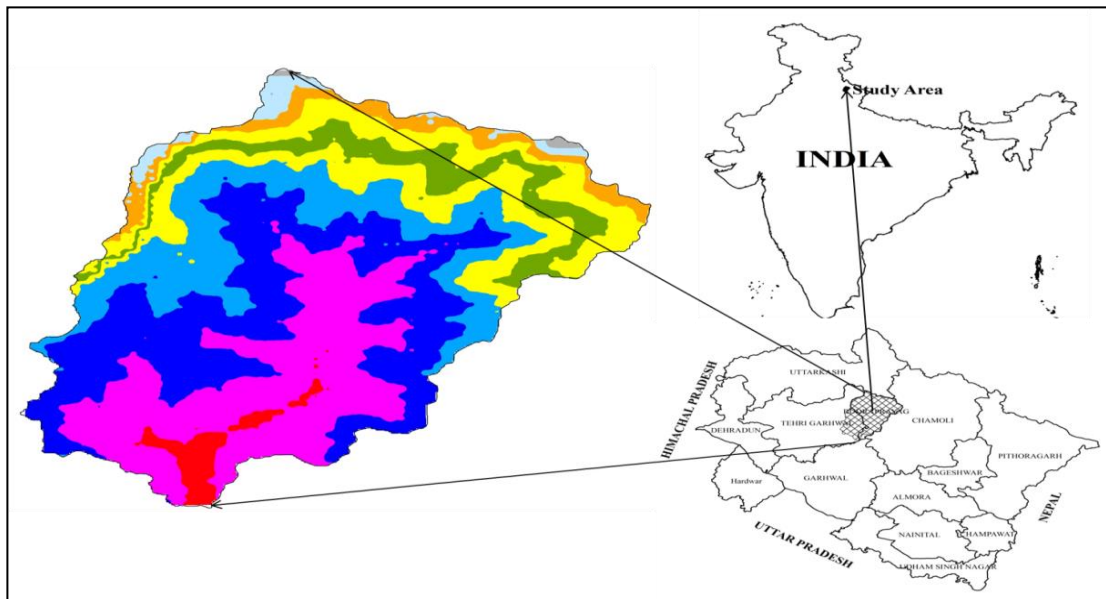
## Introduction

Geomorphology is defined as the science of landforms with an emphasis on their origin, evolution, from and distribution across the physical landscape. The geomorphological analysis involves delineation of distinct units from satellite data and classification of these units based on their nature of genesis, extent and their processes (Reddy et.al., 2002). It is important for the understanding of Earth surface processes, geochronology, natural resources, natural hazards and landscape evolution. It involves the partition of the particular area based on morphology, genetics, composition, structure, land cover, soil, ecology as well as landforms. Geomorphological studies in India have received great fill up by the works of geologist and geographers. There has been an emphasis on various aspects of Geomorphology from regional to coastal, structural, fluvial, climatic and Applied Geomorphology (Sharma H.S., 1982). The main objective of present study is to explore the geomorphological analysis of the Mandakini river basin by using remote sensing and GIS technology.

## Study Area

Mandakini river is a major tributary of Alaknanda River which flow in the part of Rudraprayag and Tehri Garhwal districts in higher Garhwal Himalaya (Fig. 01). It originates from the Chorabariglacier, located just 02 kms upstream from Shri Kedarnath shrine. The total catchment area of the river is near about 1666.34 km<sup>2</sup>. It geographically lies between 30° 35' to 30° 49' N latitudes and 78° 59' E to 79° 22' E longitudes. The major tributary of this river is Madhyamaeshwar, whereas smaller tributaries include are Laster Gad, Helaun Gad, Kakra Gad, Kyunja Gad, Kyar Gad, Ghasta Gad, Markanda Ganga, Kali Ganga and Vasuki Ganga. The Mandakini River finally merges into Alaknanda River at Rudraprayag.

**Figure 01: Location of Study Area**



## Data Sources and Methodology

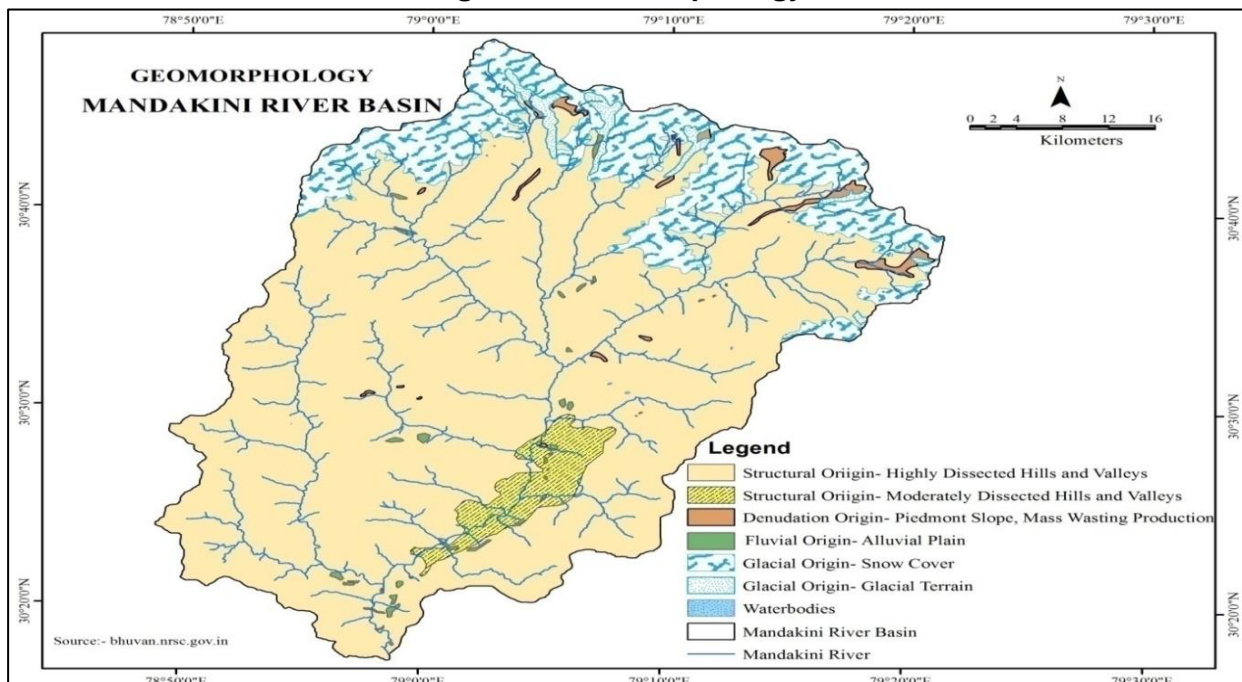
Both types of data primary (satellite data – LISS III (2013) and ASTER GDEM (2011) as well as secondary data (bhavan.nrsc.gov.in) have been used in this study. The boundary of study area has been demarked based on Survey of India Topo-sheet numbers (53J/14, 53/J15, 53N/1, 53N/2, 53N/3, 53N/4 and 53N/6) on 1:50,000 scale and Global Digital Elevation Model (DEM) generated from Advanced Space borne Thermal Emission and Reflection Radiometer (ASTER) data 2011 with 30 m resolution. Geomorphological and Lineaments map have been prepared using BHAVAN(bhavan.nrsc.gov.in) database. Lithology map has prepared the help of The Holy

Himalaya (A Geographical Interpretation of Garhwal) book. The map of land use and land cover is prepared by using data from Google Earth software (2017). Similarly Slope and Aspect map is also prepared by using Digital Elevation Model (DEM).

### Geomorphology

The Mandakini River basin is mountainous, forming a part of the Western Himalaya. Geomorphologically, the area of Mandakini river basin have been divided into seven different geomorphic regions characterized by different geomorphic elements and relief characteristics(Fig.02 and Table-01). These are Structural Origin- Highly Dissected Hills and Valleys, Structural Origin- Moderately Dissected Hills and Valleys, Denudation Origin- Piedmont Slope, Mass Wasting Production, Fluvial Origin- Alluvial Plain, Glacial Origin- Snow Cover, Glacial Origin- Glacial Terrain and Water bodies.

**Figure 02: Geomorphology**



The largest area is under structural origin- highly dissected hills and valleys. This category having an area of 1320 Km<sup>2</sup> out of geographical area 1666 Km<sup>2</sup> which is cover about 79.23 percent of total area basin.

**Table 01: Mandakini River Basin: Geomorphological Features**

Categories	Area in Km <sup>2</sup>	Area in Percent
Structural Origin- Highly Dissected Hills and Valleys	1320	79.23
Glacial Origin- Snow Cover	253	15.18
Structural Origin- Moderately Dissected Hills and Valleys	53	3.18
Glacial Origin- Glacial Terrain	19	1.14
Denudation Origin- Piedmont Slope, Mass Wasting Production	15	0.9
Fluvial Origin- Alluvial Plain	6	0.36
Water bodies	0.4	0.02
<b>Total Area</b>	<b>1666.34</b>	<b>100</b>

Source: Computed by Researcher with the help of Fig.02

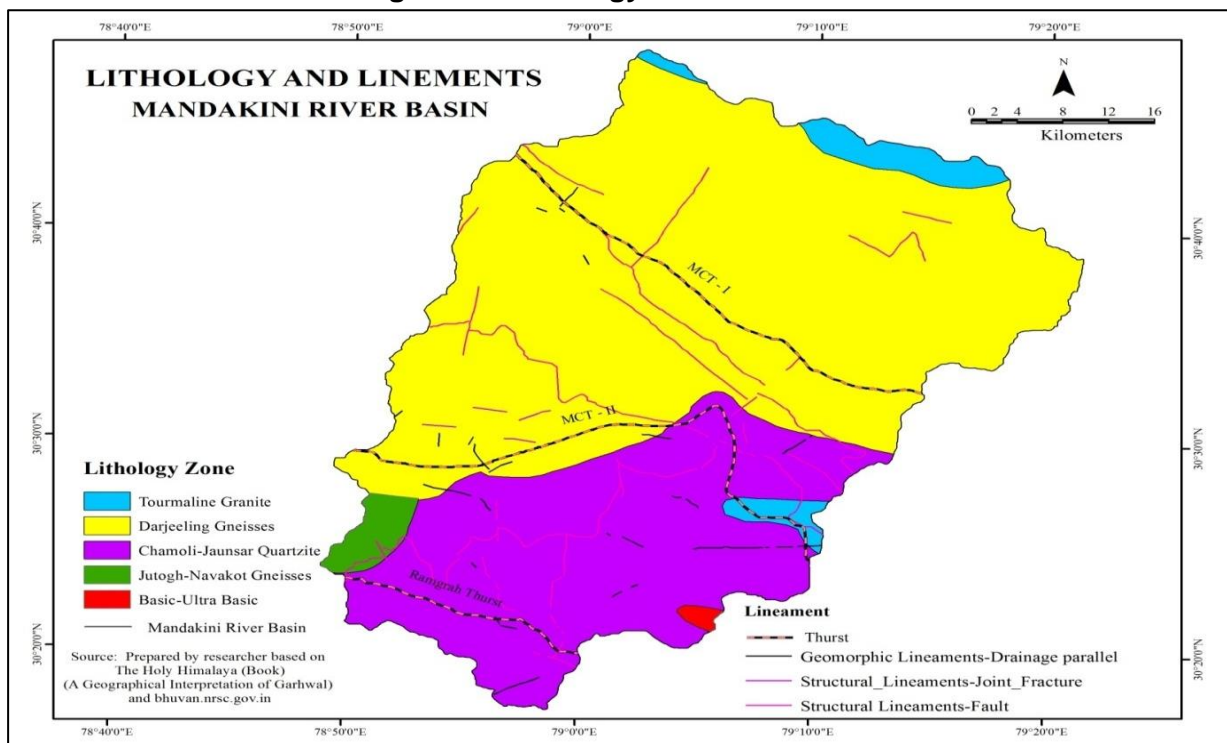
The Moderately Dissected Hills and Valleys are occupied by 53 Km<sup>2</sup> area which is about 3.18 percent of total area. This Category is near about Kund, Guptkashi and Ukimath. The glacial origin- snow cover and glacial terrain is mostly present in North, North–West and North-East.

They Categories cover area of 253 Km<sup>2</sup>, 19 Km<sup>2</sup> and which is occupied by 15.18, 1.14 percent of basin area. Denudation origin is covering the area only 15 Km<sup>2</sup> which is about 0.9 percent. This area is mostly present in North and North-East. Alluvial plain is the result of deposition by the river. Mostly the alluvial plain found in central and lower part of river basin. Its cover 6 Km<sup>2</sup> which is about 0.36 percent. Water bodies are occupied by 0.4 Km<sup>2</sup> which is about 0.02 percent.

### Lithology and Lineament

Lithology is a broad physical characteristic of rocks such as understanding the structure and composition of a rock formation. In the study area of Rock types ranging in period from Palaeoproterozoic to Mesoproterozoic. In this area found basically five lithology zone like Tourmaline granites, Darjeeling gneisses, Chamoli-Jaunsar Quartzite, Jutogh-Navakot gneisses and Basic-Ultra Basic.

**Figure 03: Lithology and Lineaments**



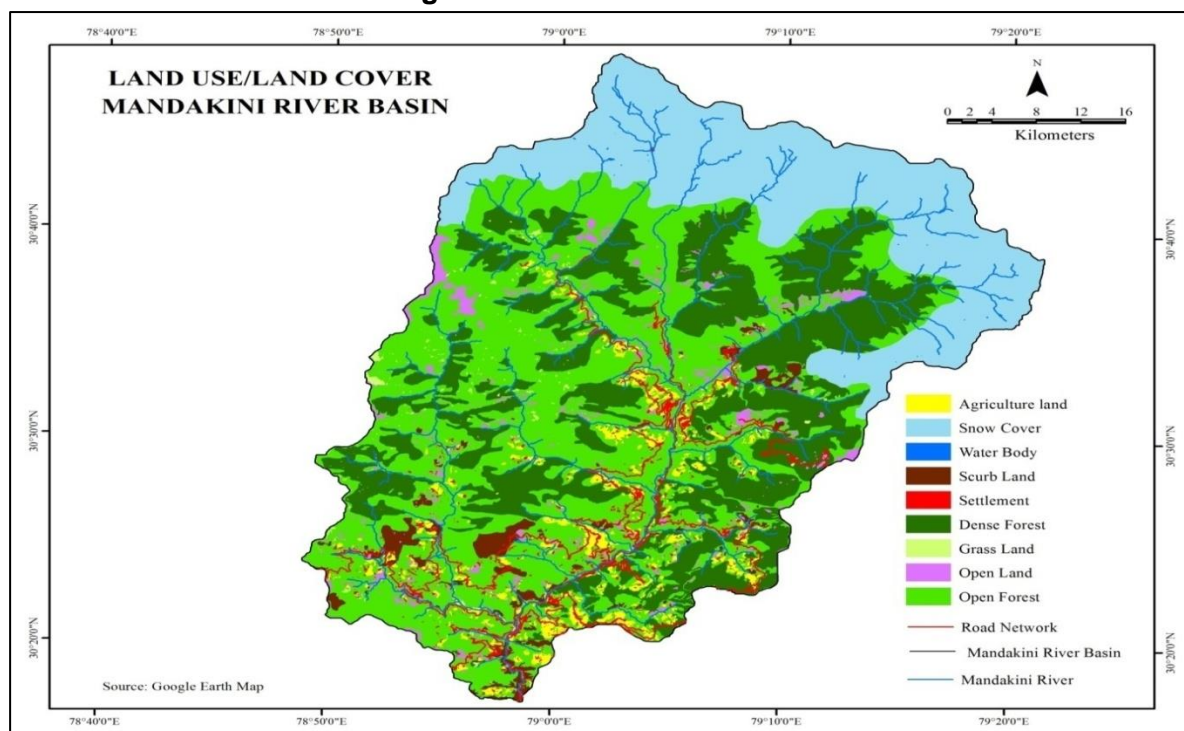
Lineament is a linear feature in a landscape which is an expression of an underlying geological structure such as a fault. Mandakini river basin is occupied five major thrusts Ramgarh Thrust, Berinag Thrust, Barkot- Bhatwari Thrust, Munsiari Thrust and Vaikrita Thrust, MCT– I, II and some major lineaments are along the Mandakini River. Lineament map are classified into three classes based on the using BHAVAN portal database ([www.bhavan.nrsc.gov.in](http://www.bhavan.nrsc.gov.in)). These are structural lineaments- joint Fracture, geomorphic lineament- drainage parallel and structural lineament- fault. The highest length occupied by the structural lineament- fault about 193.60 Kms of the basin area (Fig.03).

### Land Use/Land Cover

The land use and land covered are two important terms used in physical and human geography. Land is an important constituent of earth surface. Land cover is a physical entity which constituents natural vegetation, bare earth, water bodies, impervious surface, etc. whereas land use refer to these activities performed by human being for agriculture, economic purpose etc.



**Figure 04: Land Use/Land Cover**



The Fig.04 Shows classification the land use/land covers categories and table-02 show the under these categories. Out of this open forest has maximum area of 721.33 Km<sup>2</sup> which is 43.25 percent of total geographical area of basin. The forest cover mainly includes tree of Pinus logifolia & Sorea Robusta. The second category is dense forest of area 429.16 Km<sup>2</sup> and 25.81 percent of total area of basin. The main trees include Quercus incana etc. in these forests. These forest covers are mainly present in North-East and East part of basin. Under the Snow Cover area is 361.13 Km<sup>2</sup> and 21.88 percent of whole basin area. This occurred at high altitude zone which is North and North East region of basin. In this zone there is snow for more than 6 months in year, so habitants in this region are not permanent

**Table 02: Mandakini River Basin: Land Use/Land Covers**

Sr. No	Categories	Area in Km <sup>2</sup>	Area in Percent
1	Agriculture Land	48.78	2.93
2	Snow Cover	361.13	21.68
3	Water Body	1.50	0.09
4	Scrub Land	39.47	2.37
5	Settlement	15.32	0.92
6	Dense Forest	429.96	25.81
7	Grass Land	7.77	0.47
8	Open Land	41.36	2.48
9	Open Forest	721.33	43.25
<b>10</b>	<b>Total Area</b>	<b>1666.34</b>	<b>100</b>

Source: Computed by Researcher with the help of Fig.04

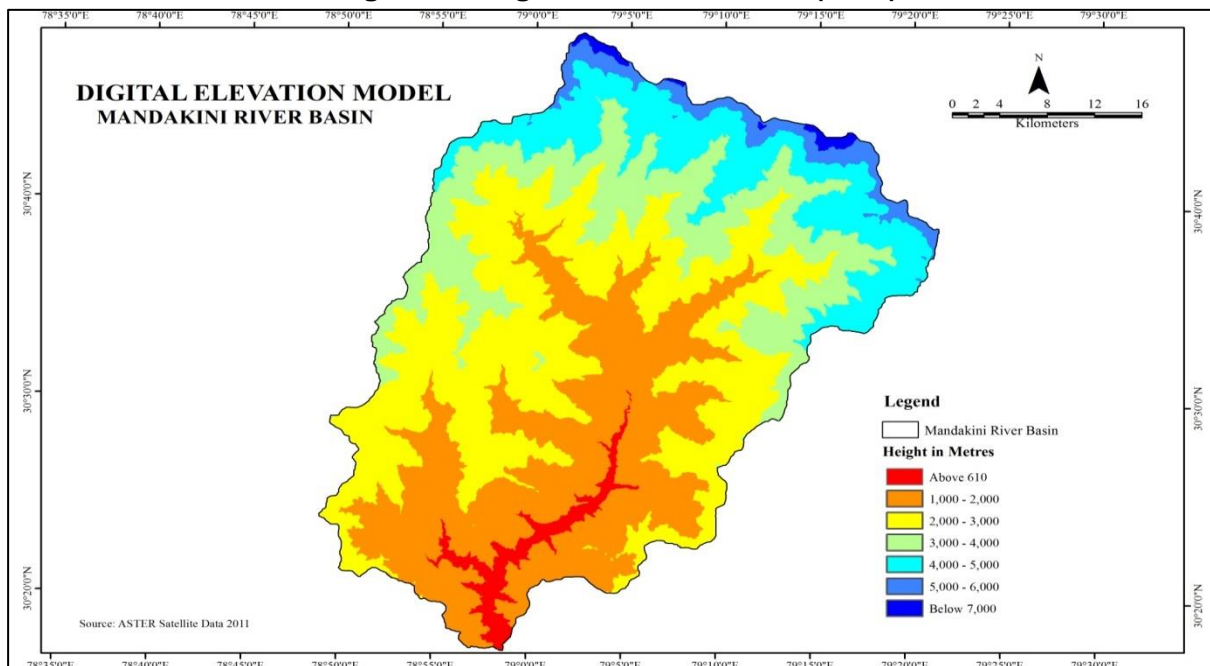
Some glaciers are persistent in this region like Chorawari bak, Dudhganga bak, etc. The area of agricultural land is 48.78 Km<sup>2</sup> which is 2.93 percent of basin area. The agricultural land mainly expended in lower region of basin. As height of basin increases due to low temperature and steep slope, the agricultural land decreases.

### Digital Elevation Model (DEM)

Digital Elevation Model (DEM) provides the description about three dimensional surfaces and data foundation for impressive three-dimensional visualisation of geographical data, but also

sets the foundation for deriving other surface morphological parameters such as slope, aspect, curvature, slope profile and catchment area (Zhou Qiming and Liu Xuejun, 2004). Using DEMs topographic attributes (elevation, slope, aspect etc) are easily calculated and can be shown as output image called DEM derived surfaces. With help of these images DEMs show the relationship between topography and geology. Digital Elevation Model (DEM) map are classified into seven categories based on using ASTER data (Fig.05 and table-03). These are 600-1000, 1000-2000, 2000-3000, 3000-4000, 4000-5000, 5000-6000 and 6000-6600 meter. The highest area is covered between 2000-3000 meters about 559 Km<sup>2</sup> which is about 33.55 percent of the basin.

**Figure 05: Digital Elevation Model (DEM)**



**Table 03: Mandakini River Basin: Elevation in Meters**

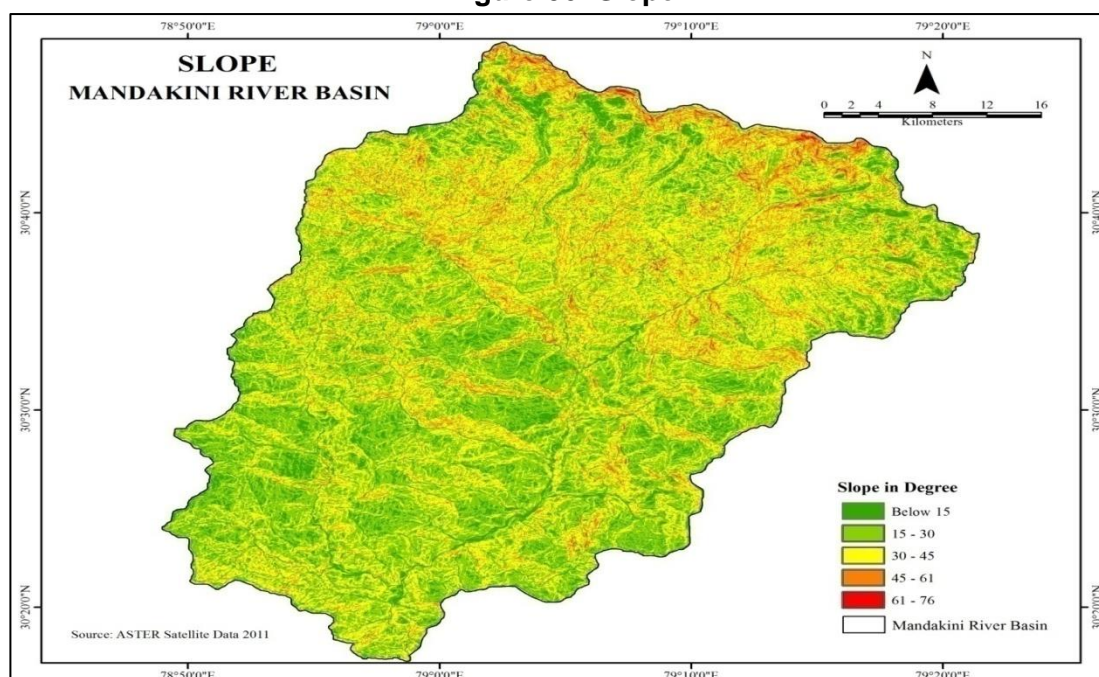
Height in Meters	Area in km <sup>2</sup>	Area in Percent
600 - 1000	44	2.64
1000 - 2000	495	29.71
2000 - 3000	559	33.55
3000 - 4000	288	17.28
4000 - 5000	217	13.02
5000 - 6000	56	3.36
6000 - 6600	7.34	0.42
<b>Total Area</b>	<b>1666.34</b>	<b>100</b>

Source: Computed by Researcher with the help of Fig. 05

### Slope

Slope is an important parameter for the measurement of surface. The term slope has two commonly used meanings, one referring to the angle of inclination of the surface, express in degrees or a percent, and the other is the inclined surface itself (Chorrley Richard, 1984). Slope map of Mandakini river basin is generated from the GDEM ASTER (2011) using Arc GIS 9.3 software (Fig. 06). The slope ranges between 0°-90° shows table-04. Slope map are classified into 5 classes that are 0°-15°, 15°-30°, 30°-45°, 45°-60°, 60°-76°. It is observed that the area 202 km<sup>2</sup> less than < 15° and 676.34 km<sup>2</sup> of the area is a slope 15°-30°. An area of 600 km<sup>2</sup> of total area is a slope of 30°-45°, similarly 177 km<sup>2</sup> area is slope of 45°-60°. The lowest area is covered between 60°-76° about 11 Km<sup>2</sup> which is about 0.66 percent of the basin.

**Figure 06: Slope**



**Table 04: Mandakini River Basin: Slope in Degrees**

Slope in Degree	Area in km <sup>2</sup>	Area in Percent
0 - 15	202	12.12
15 - 30	676.34	40.58
30 - 45	600	36
45 - 60	177	10.63
60 - 76	11	0.66
<b>Total Area</b>	<b>1666.34</b>	<b>100</b>

Source: Computed by Researcher with the help of Fig. 06

### Aspect

Aspect identifies the down-slope direction. Aspect images may enhance landforms such as fluvial network, alluvial fans, faceted fault related scarps etc (Cires J.et. al, 1994). Aspect is usually known to the horizontal direction to which a mountain slope faces. Aspect map describes the distribution of aspect within the study area. Aspect is measured clockwise in degrees from 0° North to 360° North coming full circle. Aspect map is generating using the same ASTER GDEM (2011) of the using Arc GIS 9.3 (Fig.07). The Map is classified into eight categories divided equal interval at 45°. These are NNE (0°-45°), ENE (45°-90°),ESE (90°-135°), SSE (135°-180°), SSW (180°-225°), WSW (225°-270°), WNW (270°-315°) and NNW (315°-360°)

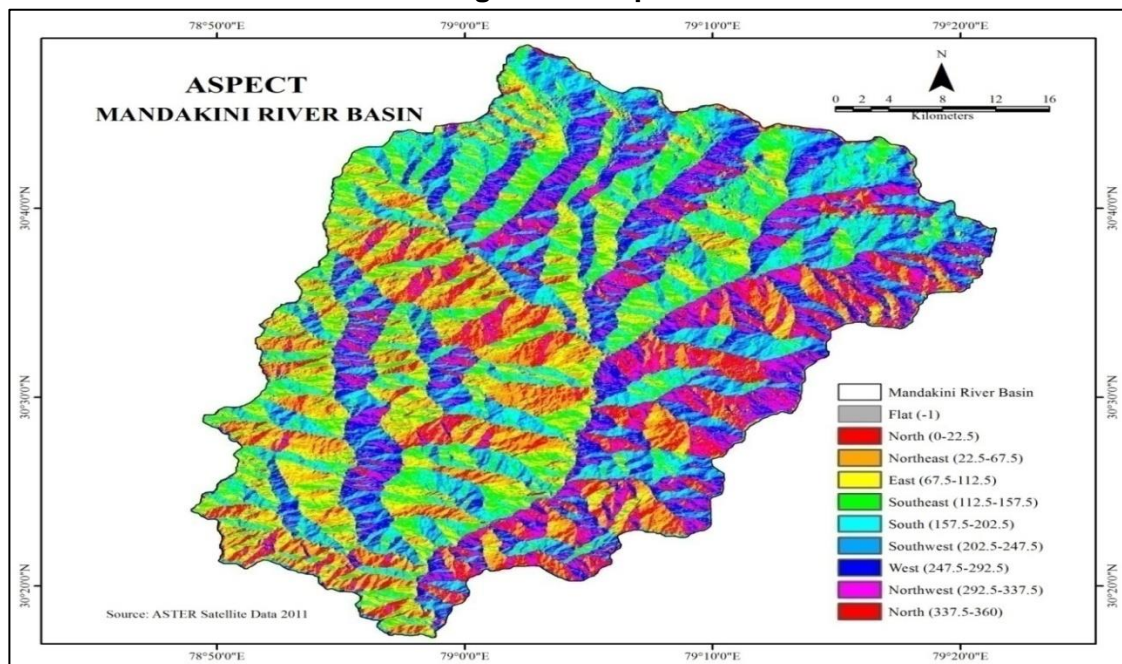
### Conclusion

Geomorphology is a systematic and organised description and study of landforms of the Earth surface. Geomorphologically, the area of Mandakini river basin have been divided into seven different geomorphic regions characterized by different geomorphic elements and relief characteristics. The highest area occupied by Structural Origin- Highly Dissected Hills and Valleys are 1320 Km<sup>2</sup> as weel as the lowest area is water bodies 0.4 Km<sup>2</sup>. Geologically, the area have been divided into four categories i.e. Munsiri Formation area is 547 Km<sup>2</sup>, Vaikrita Group is 601 Km<sup>2</sup>, Ramgarh Group is 417 Km<sup>2</sup> and the area occupied by Berinag Formation is 101 Km<sup>2</sup>. Slope is derived Global Digital Elevation Model (DEM) generated from Advanced Space borne Thermal Emission and Reflection Radiometer (ASTER) data 2011 with 30 m resolution and further Aspect has been used for finding the direction of slope. The contour of minimum height is 600 meters and maximum height is 6600 meters. The lowest part of slope



exists in mainly in Mandakini valley near Rudraprayag while the highest slope occurs mainly in North and North-East.

**Figure 07: Aspect**



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