*Quest Journals*
*Journal of Research in Environmental and Earth Sciences*
*Volume 8 ~ Issue 8 (2022) pp: 01-10*
*ISSN(Online) :2348-2532*
www.questjournals.org

**Research Paper**

# Morphogenetic Analysis Using Geo-Informatics- A Case Study of Mandakini River Basin

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***Abstract***
*Geographical information systems are scientific tools that can be used to obtained detailed information of the earth's surface. A morphogenetic region is given full information of landforms and processes of the regions. The present study analyse the morphogenetic regions based on Peltier's model (1950). Its classification has been done based on two variables i.e. mean annual rainfall and mean annual temperature. The present study is based on spatial data acquired form of Survey of India topo-sheets, ASTER GDEM (2011) and www.worldclaim.org (1970 – 2000). Mandakini River is a major tributary of Alaknanda River and originates from the Chorabariglacier. The total catchment area of the river is near about 1666.34 km². The results of the study showed that the basin area is classified into five regions like, Glacial, Periglacial, Boreal, Maritime and Selva. The denudational processes of weathering play a vital role in these morphogenetic regions. The Remote Sensing and GIS techniques have been used to complete the work on present study. The geo-informatics based study of morphogenetic region of river basin characteristics can be used to plan the area for sustainable development.*

***Keywords:*** *Morphogenetic region, Denudational, Weathering, Geo-informatics*

***R**eceived 07 August, 2022; **R**evised 20 August, 2022; **A**ccepted 22 August, 2022 © The author(s) 2022. **P**ublished with open access at **www.questjurnals.org***

## I. Introduction

Morphogenetic region is climatic phenomena give a prominent feature to the land forms and the geomorphic processes. The concept of a morphogenetic region explains that it is a region under a certain set of climatic conditions, particular geomorphic processes which predominate; and hence, it determine regional characteristics to the landscape which set it off from those other areas developed under different climatic conditions (Thornbury 1954). A morphogenetic region is given full information of landforms and processes of the regions. The classification of morphogenetic region was proposed by many geographer like Julius Büdel (1944), L.C. Peltier (1950), C. Troll (1958), W.F. Tanner (1961) and L. Wilson (1969, 1973) etc. But this study is based on Louis C. Peltier's (1950). Their classifications have been done based on two variables i.e. mean annual rainfall and mean annual temperature. He defined seven graphs using these two variables that described different types of processes; they are chemical weathering, frost action, physical weathering, pluvial erosion, mass movement, wind action, and morphogenetic regions. Louis C. Peltier's (1950) was divided the world into nine morphogenetic regions. These Morphogenetic Regions classifications are:

Glacial – Freeze-thaw cycle less effective since temperatures stay very low year round
Periglacial – Freeze-thaw cycle is dominant and occurs often
Boreal – Warm but cycles between freeze-thaw cycle and enough precipitation to nurture hardy vegetation
Maritime – Wet and warm annually
Selva – Wet and hot annually
Moderate – Less precipitation but still warm
Savanna – Lower amounts of precipitation but temperatures range from low to high annually
Semi-Arid – Low precipitation amounts and warm to hot, and
Arid – Very little precipitation and hot

These regions define the different characteristics of the weathering process and landforms. Therefore in this study to explain different morphogenetic and geomorphic process region of Mandakani river basin based

paltier's(1950) model using geospatial technique. The goal of this present study is to generate maps of the Mandakani river basin for each of Peltier's graphs.

**Study Area**

Mandakini River is a major tributary of Alaknanda River which flow in the part of the Rudraprayag and Tehri Garhwal district in higher Garhwal Himalaya (Fig. 1). It originates from the Chorabariglacier, located just 2 km upstream from Shri Kedarnath shrine. The total catchment area of Mandakini River basin is about 1666.34 km²and total length 80 Km. The basin lies between 30º 17' 18" to 30º 48' 43" N latitudes and 78° 48'57" E to 79° 21'27" E longitudes. The altitude of Mandakini River basin catchment extends from 605 to 6600 m. The major tributary of this river is Madhyamaheshwar Ganga, whereas smaller tributaries include; Laster Gad, Helaun Gad, KakraGad, Kyunja Gad, Kyar Gad, Ghasta Gad, Markanda Ganga, Kali Ganga and Vasuki Ganga. The Mandakini River finally merges into Alaknanda River at Rudraprayag.

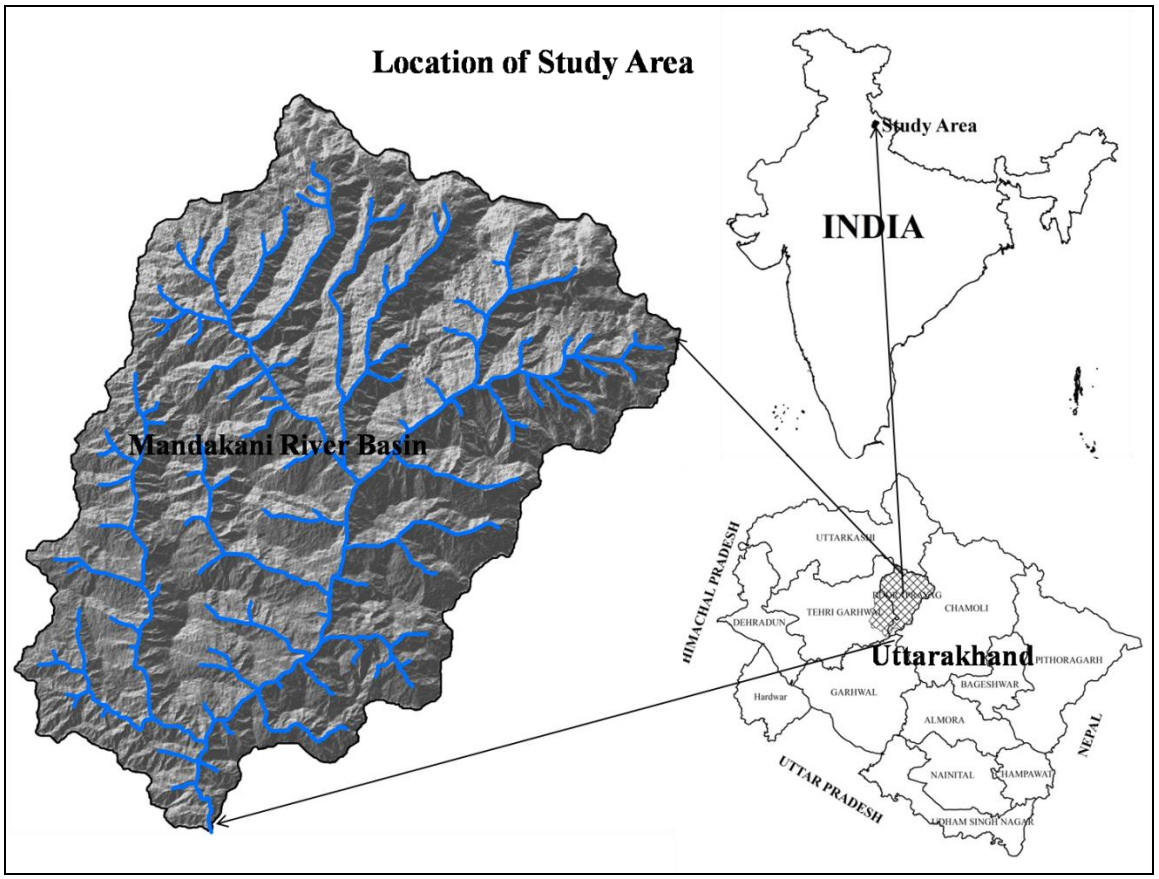


**Fig. 1**

**Data Source and Methodology**

The main source of data is the WorldClim (Global Climate Data) datasets for the Mean Annual Temperature and Mean Annual Precipitation. This dataset is global climate layers with a spatial resolution about 1 Km². The datasets are from the period 1970 to 2000. The file format are obtained in is precipitation in millimetres (mm) and the temperature is in degrees Celsius. The basin boundary has been demarked on the basis of 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. The basin is divided into 1 Km² grid format. Interpolation method is applied to prepare the precipitation and temperature map in Arc GIS 9.3 software. This study is based on Louis C. Peltier's 1950 and divided the world into nine morphogenetic regions. In this study area the Classification of Morphogenetic Regions Modified after Pelttier's (1950) based on table 1. The basin area is classified into five regions like, Glacial, Periglacial, Boreal, Maritime and Selva. The Remote Sensing and GIS techniques have been used to complete the work on present study.

**Table1: - Classification of Morphogenetic Regions Modified After Pelttier's (1950)**

| Sr. No | Morphogenetic Regions | Mean Annual Temperature ◦C | Mean Annual Rainfall (mm) | Morphological Characteristics |
|---|---|---|---|---|
| 1 | Glacial | 0 - -6.67 | 0 - 1143 | Glacial erosion, wind Action |
| 2 | Periglacial | -15 - -1.1 | 127 - 1397 | Strong Mass movement, Moderate to Strong Wind Action, Low Fluvial Action |
| 3 | Boreal | -9.44 - 3.3 | 254 - 1524 | Moderate Frost Action, Moderate to Low Wind Action, Moderate Fluvial Action |
| 4 | Maritime | 1.67 – 21.11 | 1270 - 1905 | Strong Mass movement, Moderate to Strong Fluvial Action |
| 5 | Selva | 15.55 – 29.4 | 889 - 1270 | Strong Mass movement, Low Slope Wash, Absence of Wind Action |
| 6 | Moderate | 1.67 – 29.4 | 889 - 1524 | Maximum Fluvial Action, Moderate Mass movement, Moderate Frost Action in Cooler Area, Insignificant Wind Action |
| 7 | Savanna | -12.22 – 29.4 | 635 - 1270 | Except Coastal Areas, Strong to Low Fluvial Action, Moderate Wind Action |
| 8 | Semi-Arid | 3.33 – 29.4 | 254 - 635 | Strong Wind Action, Moderate to Strong Fluvial Action |
| 9 | Arid | 12.78 – 29.4 | 0 - 381 | Strong Wind Action, Low Fluvial Action |

## II. Results and Discussion

Different morphogenetic regions of Mandakani River basin with the help of usual model of Peltier's(1950), precipitation and temperature data have been assessed in this study. The help of mean annual rainfall and temperature find out the speed of denudation any area.

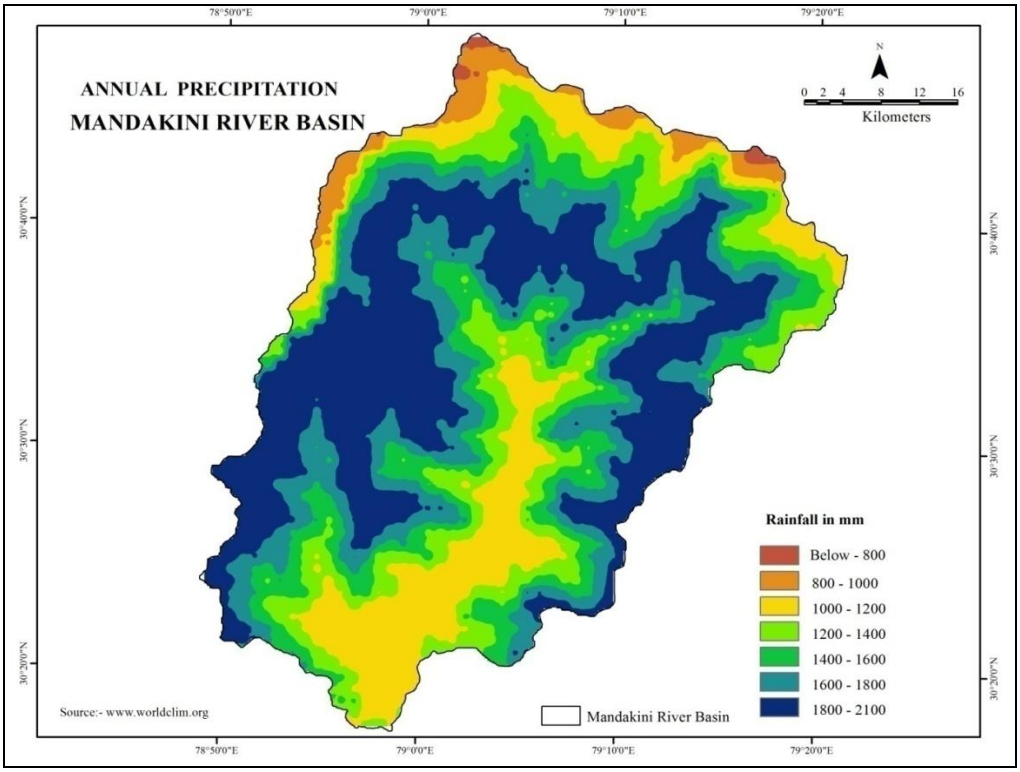


**Fig.2**

The annual precipitation ranges found in the area between below-800 to 2100 mm. The highest rainfall (1800-2100 mm) occupied the area 521.63 Km² which is 31.30 per cent as well as lowest rainfall (below-800 mm) covered area 6.55 Km² (Table-2). The rainfall is increased Rudraprayag to Kadearnath temple but upper part of the basin the rainfall decried continuously (fig.2).

**Table2: Distribution the rainfall of Mandakani River Basin**

| Sr. No. | Rainfall (mm) | Area in Km² | Area in Per Cent |
|---|---|---|---|
| 1 | Below - 800 | 6.55 | 0.39 |
| 2 | 800 - 1000 | 52.88 | 3.17 |
| 3 | 1000 - 1200 | 257.46 | 15.45 |
| 4 | 1200 - 1400 | 248.87 | 14.93 |
| 5 | 1400 - 1600 | 259.99 | 15.60 |
| 6 | 1600 - 1800 | 318.97 | 19.14 |
| 7 | 1800 - 2100 | 521.63 | 31.30 |
| | **Total Area** | **1666.35** | **100** |

Source: Calculated by researcher with the help of Global Climate Data.

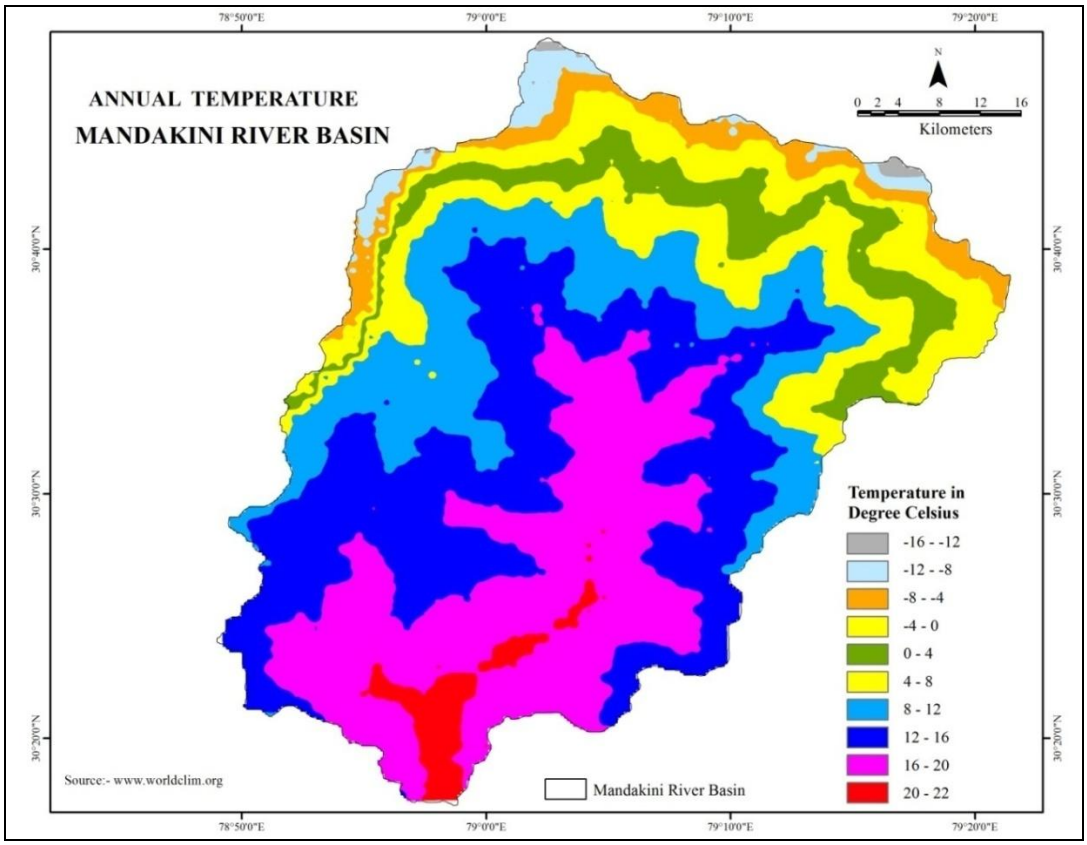


**Fig.3**

The mean annual temperature varies between -16 to 22◦C show in fig.3 and table3. The temperature is decries continually the height of the basin. The height temperature is found in lower part of valley near Rudraprayag city and lowest temperature is found upper part of the basin.

**Table3: Distribution the Temperature of Mandakani River Basin**

| Sr. No. | Annual Temperature(◦C) | Area in Km² | Area in Per Cent |
|---|---|---|---|
| 1 | -16 – -12 | 1.78 | 0.11 |
| 2 | -12 - -8 | 8.95 | 0.54 |
| 3 | -8 - -4 | 58.69 | 3.52 |
| 4 | -4 - 0 | 148.50 | 8.91 |
| 5 | 0 - 4 | 139.58 | 8.38 |
| 6 | 4 - 8 | 160.36 | 9.62 |
| 7 | 8 - 12 | 277.84 | 16.67 |
| 8 | 12 – 16 | 440.30 | 26.42 |

| | | | |
|---|---|---|---|
| 9 | 16 – 20 | 392.39 | 23.55 |
| 10 | 20 - 22 | 37.96 | 2.28 |
| | Total Area | 1666.35 | 100 |

Source: Calculated by researcher with the help of Global Climate Data.

**Different Morphogenetic Regions**

The basin area is classified into five regions like, Glacial, Periglacial, Boreal, Maritime and Selva which can be easily identified in Fig.4. This classification is based on the modified table 1. The highest area occurred by maritime1395.23 Km² which is 83.73 per cent of the total area (table 4). The area are represented Wet and warm annually climate condition which result the Strong Mass movement and Moderate to Strong Fluvial Action.

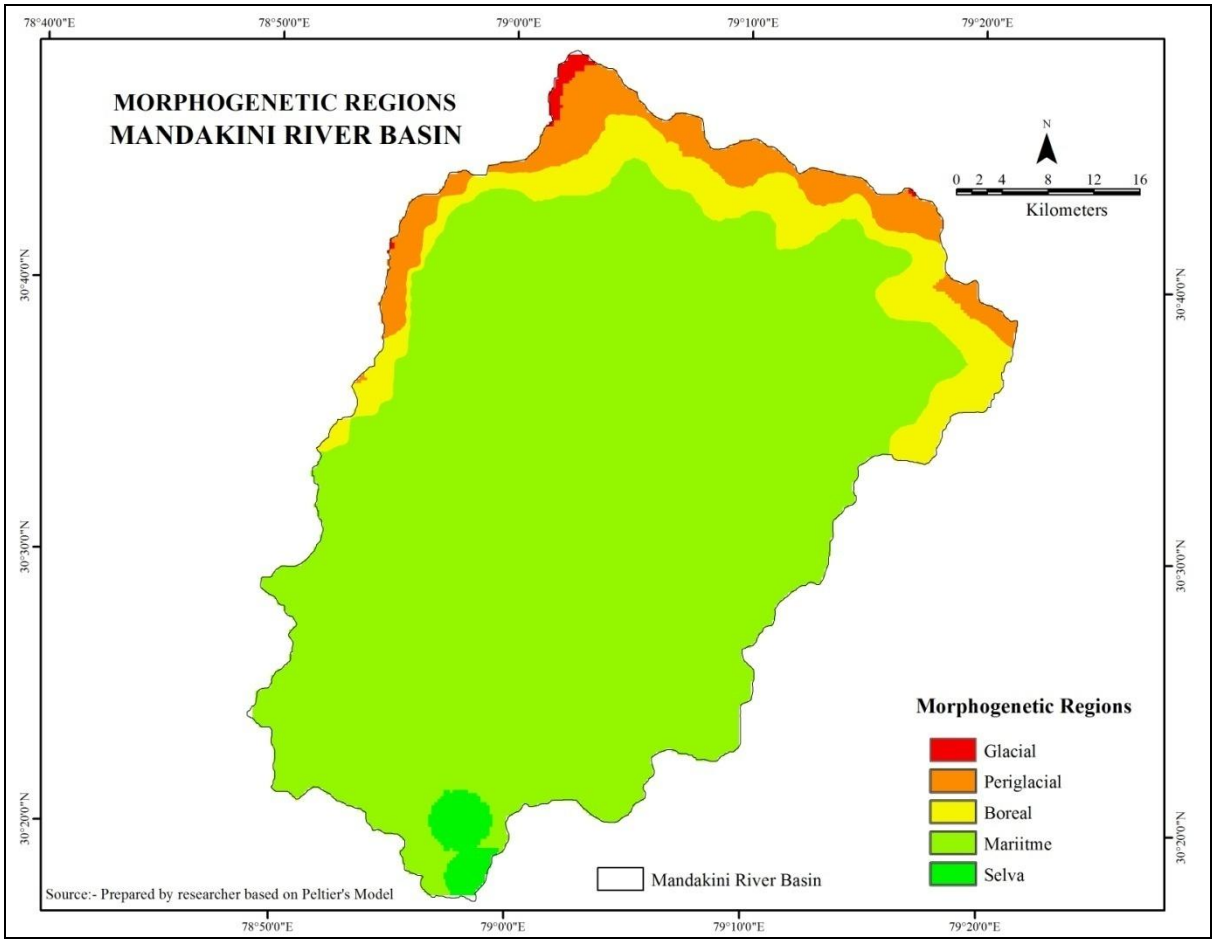


**Fig.4**

The second highest area covered by Boreal which are representing Warm but cycles between freeze-thaw cycle and enough precipitation to nurture hardy vegetation.

**Table4: Distribution the different Morphogenetic Region**

| **Sr. No** | **Morphogenetic Regions** | **Area in Km²** | **Area in Per Cent** |
|---|---|---|---|
| 1 | Glacial | 6.55 | 0.39 |
| 2 | Periglacial | 99.33 | 5.96 |
| 3 | Boreal | 145.67 | 8.74 |
| 4 | Maritime | 1395.23 | 83.73 |
| 5 | Selva | 19.57 | 1.17 |
| | **Total Area** | **1666.35** | **100** |

Source: Calculated by researcher based on table 1.

The lowest area occupied by Glacial 6.55 Km² which is 0.39 per cent. Its characterize a climatic condition of Freeze-thaw cycle less effective since temperatures stay very low year round which is result of Glacial erosion and wind Action.

**Different Geomorphic Process Regions**

Peltier's(1950) described different types of weathering phenomena, they are Pluvial Erosion, Wind Action, Mass Movement, and Weathering Regions. Pluvial Erosion is the total erosion of the area that is caused by higher rainfall amounts. Pluvial erosion is classified into four categories which are maximum, moderate, minimum and absent (Fig.5).

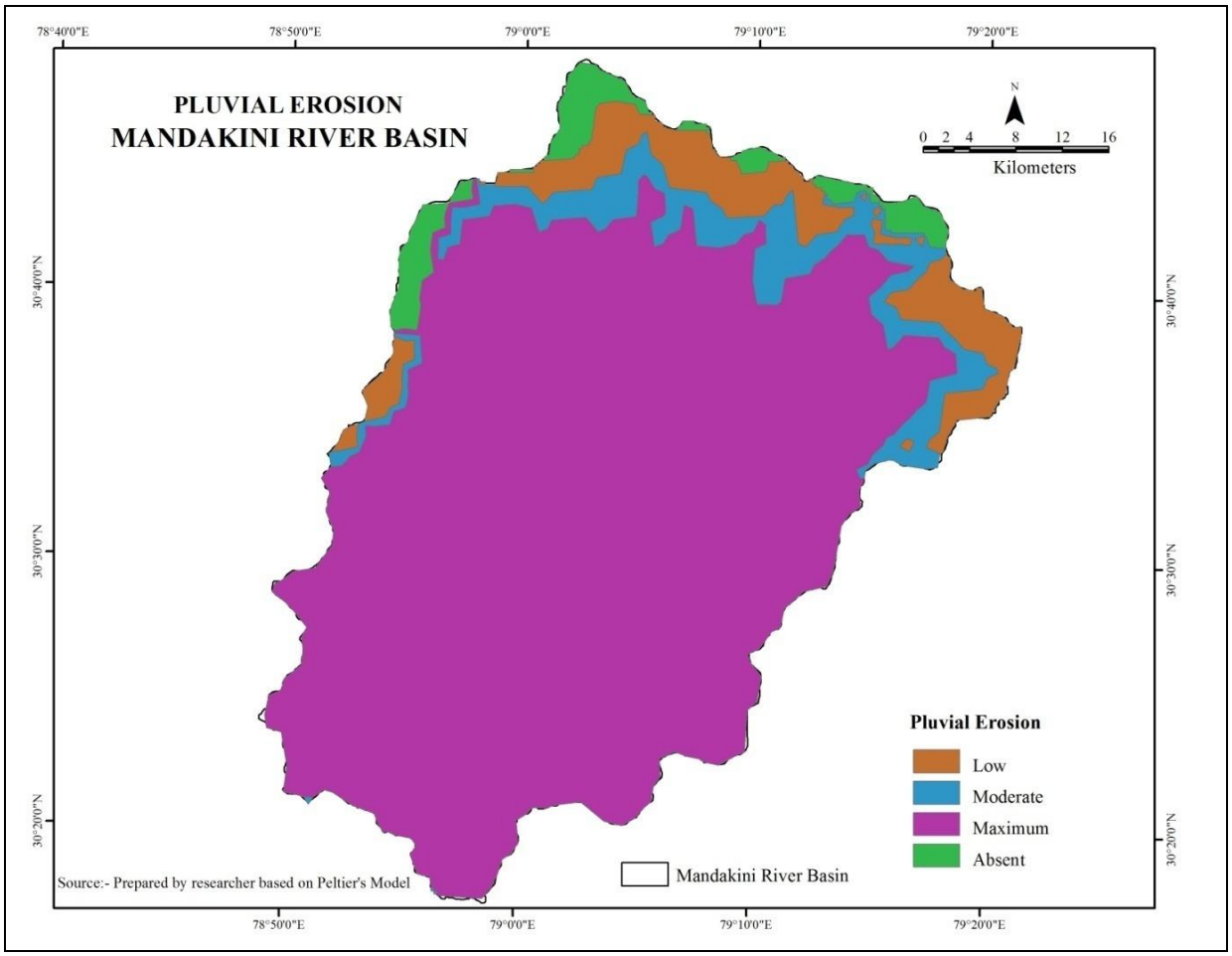


**Fig.5**

The highest area is found in maximum category which is located in central and lower part of basin. This area is 1354.54 Km². Absent category of pluvial erosion is found in North and West part of basin.

Wind erosion is the process of detachment, transportation, and deposition of soil particles by the action of wind (Doke Arjun, et.al, 2017). Wind action regions is categorized into four classes like maximum, moderate, minimum and absent found in Mandakani river basin (Fig. 6).

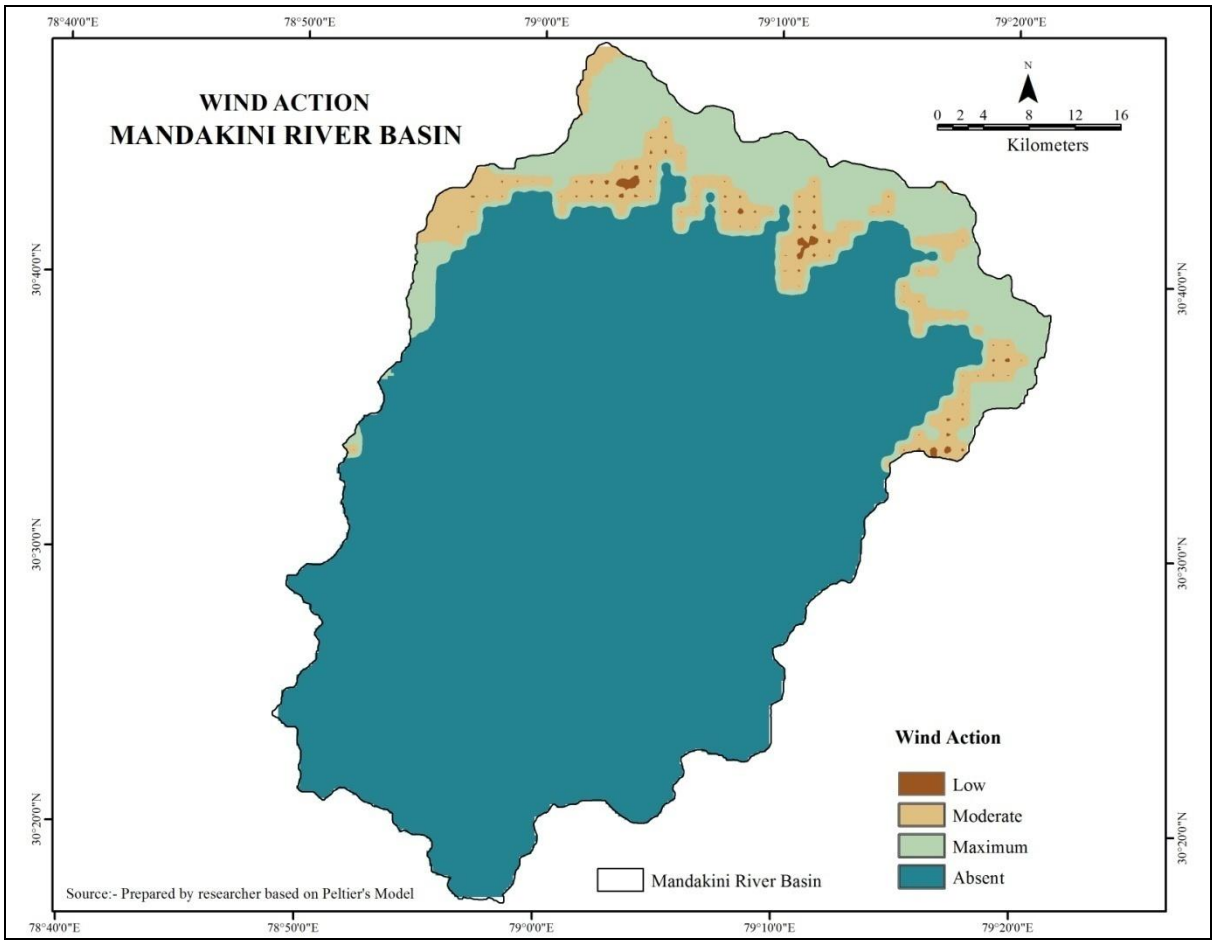


**Fig.6**

The glacial and preiglacial area represent the maximum wind action, maritime and selva region show absent wind action. 1357.21 Km² area is under the absent category which is 81.45 per cent of total area (table 5). The lowest category occupied by low which is found in upper part.

**Table 5: Distribution the different Geomorphic Process Regions**

| Sr. No | Categories | Pluvial Erosion | | Wind Action | | Mass movement | |
|---|---|---|---|---|---|---|---|
| | | Area in Km² | Area in Percent | Area in Km² | Area in Percent | Area in Km² | Area in Percent |
| 1 | Low | 128.53 | 7.71 | 7.73 | 0.46 | - | - |
| 2 | Moderate | 125.70 | 7.54 | 104.89 | 6.29 | 12.98 | 0.78 |
| 3 | Maximum | 1354.54 | 81.29 | 196.53 | 11.79 | 1653.37 | 99.22 |
| 4 | Absent | 57.58 | 3.46 | 1357.21 | 81.45 | - | - |
| **Total** | | **1666.35** | **100** | **1666.35** | **100** | **1666.35** | **100** |

Source: Calculated by researcher

Mass Movement can be defined as the movement of a portion of the earth surface as a unit, such as in creep or landslide (Sharma K.V). This is also one of the important geomorphic processes used by Peltier in his study. The mass movement regions expressed in two zones maximum and moderate category (fig. 7). The areas having excess rainfall represent the maximum mass movement. The highest area occupied under the maximum category.

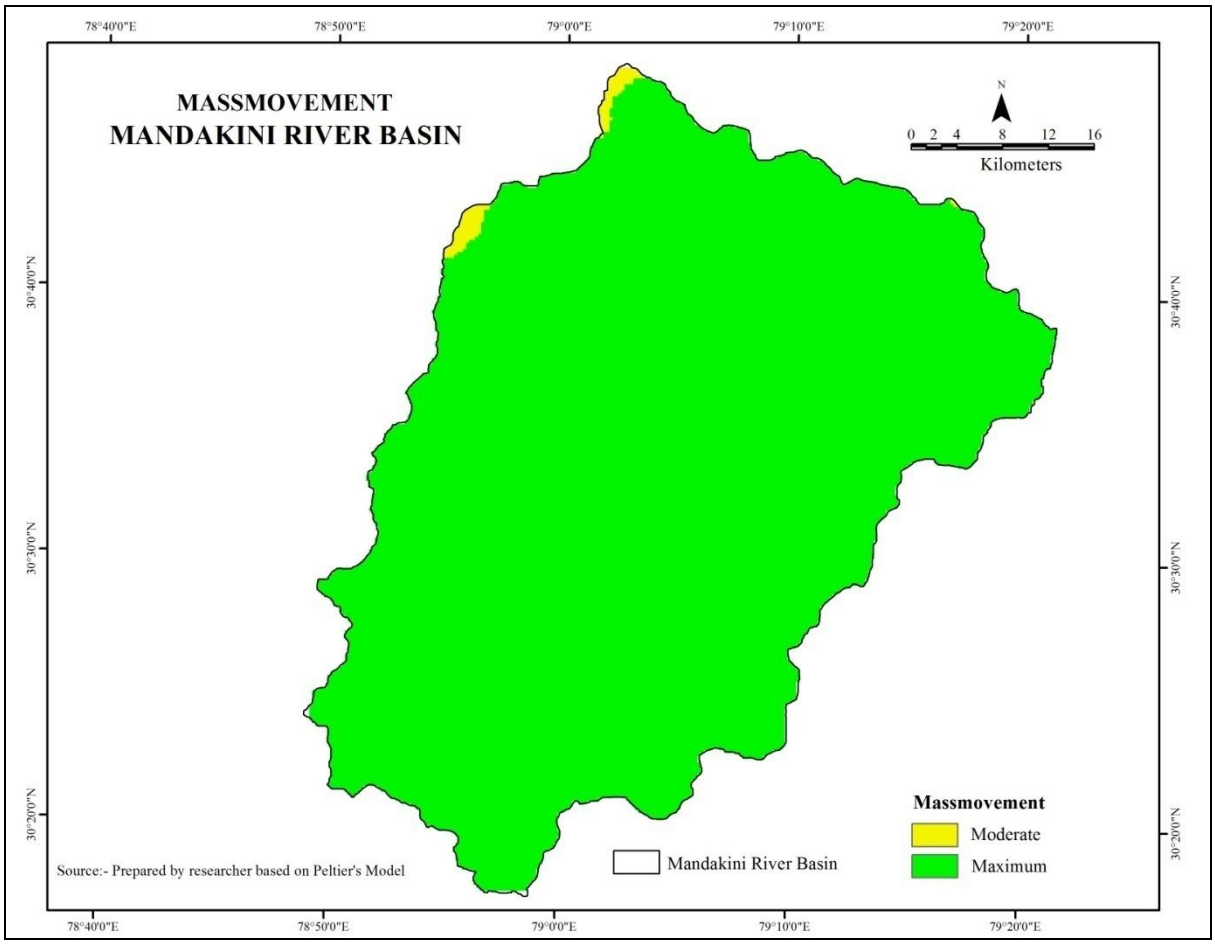


**Fig.7**

Weathering is defined as the "break down or alteration of rock in its natural or original position at or near the Earth's surface through physical, chemical and biological processes induced or modified by wind, water, and climate" (Reiche 1950). The zones of weathering are classified into six sections like Moderate Mechanical Weathering, Strong Mechanical Weathering, Slight Mechanical Weathering, Moderate Chemical Weathering Frost Action, Moderate Chemical Weathering and Strong Chemical Weathering (fig.8). The highest area covered by strong chemical weathering is 841.49 Km² which is 50.50 per cent. This category is located in the central and South-West part of basin area. Moderate chemical weathering is found in lower pert of valley and some part of central basin.

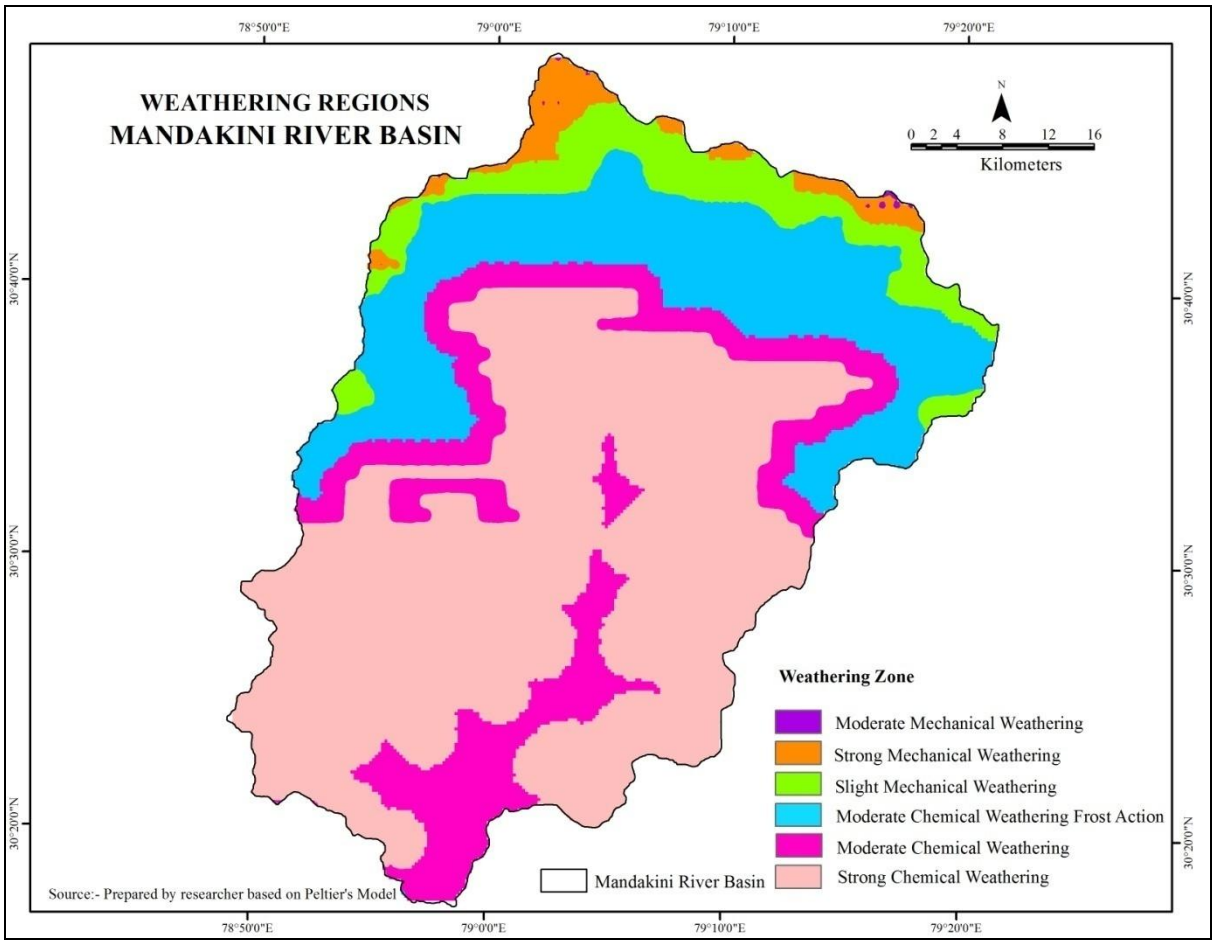


**Fig.8**

Moderate mechanical weathering is covered a minimum part of the region. This area is 1.45 Km² (table 5) which is located in upper part of basin.

**Table 5: Distribution the different Weathering Regions**

| Sr. No. | Weathering Region | Area in Km² | Area in Per cent |
|---|---|---|---|
| 1 | Moderate Mechanical Weathering | 1.45 | 0.09 |
| 2 | Strong Mechanical Weathering | 47.47 | 2.85 |
| 3 | Slight Mechanical Weathering | 127.50 | 7.65 |
| 4 | Moderate Chemical Weathering Frost Action | 367.57 | 22.06 |
| 5 | Moderate Chemical Weathering | 280.87 | 16.86 |
| 6 | Strong Chemical Weathering | 841.49 | 50.50 |
| | Total | 1666.35 | 100 |

Source: Calculated by researcher

The second highest category of moderate chemical weathering is covered 367.57 Km² which is located East, West and upper central part of basin area.

## III. Conclusions

The morphogenetic regions are known as complete information of landforms and processes of the region. These processes are dynamic, therefore these regions will change. The result of the study showed that area is classified into five regions like, Glacial, Periglacial, Boreal, Maritime and Selva. Maritime region is covering the maximum area of the basin. It means the climatic condition is Wet and warm annually. Peltier's(1950) described different types of weathering phenomena by graphing the Mean Annual Rainfall and the Mean Annual Temperature. They are Pluvial Erosion, Wind Action, Mass Movement, and Weathering

Regions. Weathering is classified into six sections like Moderate Mechanical Weathering, Strong Mechanical Weathering, Slight Mechanical Weathering, Moderate Chemical Weathering Frost Action, Moderate Chemical Weathering and Strong Chemical Weathering. The highest area covered by strong chemical weathering is 841.49 Km² which is 50.50 per cent. Engineers and planners can use this type of data in his projects for materials life expectancy and corrosion rates.

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