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Geomorphological and Lineaments Mapping Using Indian Remote Sensing (IRS) LISS -III Satellite Data

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ABSTRACT

An investigative study of the geomorphology of some part of Betul district (M.P) and Amravati district (M.S) were conducted using satellite data, topographic maps and integrated approach of GIS. Spatial datasets, elevation data, physiography, geology and hydrography were acquired for incorporation and analysis with GIS technology. Toposheets and satellite data has been used to delineating the different geomorphic unit to understand the geomorphology of the study area. The synoptic view of satellite imagery facilitates better appreciation of geomorphology and helps in mapping different landforms and their assemblages. The interpretation criteria such as tone, texture, shape, size, location, association, physiography, genesis of the landforms, nature of the rocks, associated geological structures etc. are used for identification of different landforms and geomorphic units. Lineament analysis of the area around Salbardi fault and adjoining region of Betul District, Madhya Pradesh and Amravati District of Maharashtra was carried out using a remotely sensed IRS-LISS-3 satellite imagery for tectonic study of the area. There are 169 lineaments identified using RS-GIS data, from the Salbardi and adjoining region, out of which 137 lineaments are minor, 24 are intermediate and 8 are major lineaments.

Keywords: Geomorphology, Satellite data. Remote Sensing and GIS

I.INTRODUCTION

The study of landforms, their structure and development, includes the need to illustrate both the findings of an investigation and the character of the landforms investigated. Geomorphologists have used a variety of methods of illustration, including sketches, block diagrams, and various types of photography and other imagery, both from the ground and from the air, to show features of the Earth´s land surface. The geomorphological map, in its various forms, represents recent efforts of many geomorphologists.

Lineament studies have become an important tool in analysing such structural aspects. Lineament analyses are useful in seismic study, groundwater, mineral and oil exploration along with engineering geological applications. Remote sensing techniques have given additional boost to the lineaments studies. As identification of lineaments/linear feature turns out to be easy on satellite image/aerial photograph due to synoptic view and availability of data in different spectral bands. Satellite data has provided evidence to lineament identification and mapping. This study demonstrates the satellite lineament interpretation of study area. The result gets from the study area of the analysed lineament/fracture indicated that the area has numerous long and short fractures whose structural trends are mainly in north- east to south west

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direction. The cross-cutting lineaments are relatively high areas around the central, north-eastern and south-western parts of the study area but low in the other part of the study area (Manjare, 2013, Manjare, 2014).

II.STUDY AREA

The study area lies in the Survey of India toposheet No.55 k/2, 55 k/3, 55 G/14, 55 G/15 and bounded by latitude and longitude $21^0$10'to $21^0$50'and 77^0 44'to78^0 20'respectively. The area from the present study divided in to two parts: Part one falls under the state of Maharashtra while the other falls under the state of Madhya Pradesh (Figure1)**.**

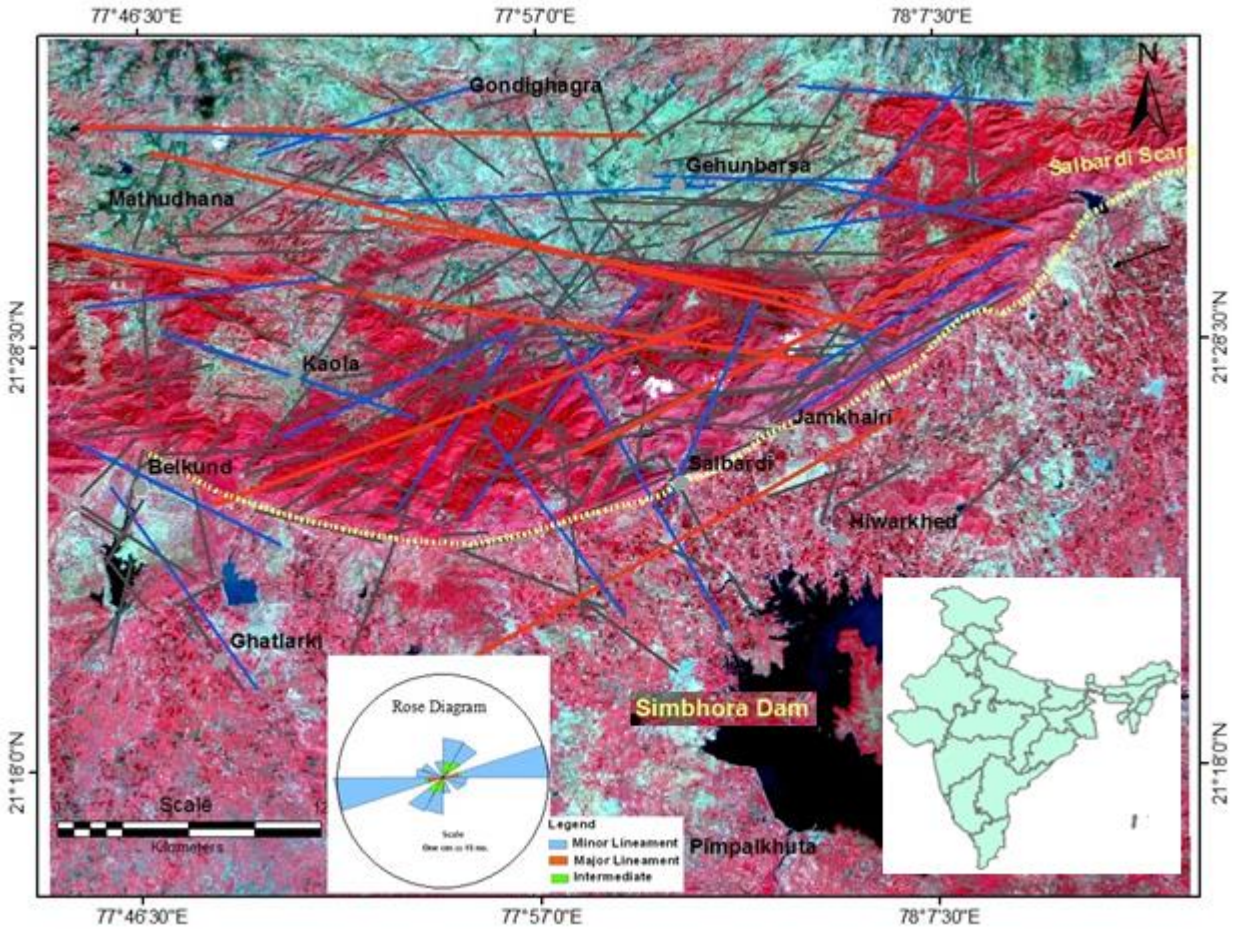

Figure 1: Location and Lineaments superimposed on IRS LISS III satellite image (23.5 mt spatial resolution) map of the study area

III.MATERIALS AND METHODOLOGY

Data Used

1. ASTER GDEM 30m (USGS/NASA ASTER DEM data), available from http://www.gdem.aster.ersdac.or.jp
2. Geomatica, ERDAS 8.4
3. ARC GIS 9.2

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4. SOI Toposheets (1972)
5. DRM -Betul District Madhya Pradesh and Amravati district Maharashtra (2000)

In order to delineate geomorphic unit the geo-coded IRS-LISS-3 satellite imagery was used. Basic image characteristics like tone, texture, shape, color, associations, etc were used along with field parameters such as topography, relief, slope factor, surface cover, soil and vegetation cover were considered while delineating geomorphic unit of the study area. Then suitable logical weights are assigned to each unit of thematic maps and integrated in geographic information systems (GIS) using the spatial overlap method to delineate groundwater potential zones. Depending on the lithological characteristics, climatic condition and hydrological condition the Salbardi area and adjoining region has been divided into different geomorphic units of trifacial origin, namely the structural, fluvial and denudation origin. The descriptions of the various geomorphic units are described below.

Geomorphological mapping

Earlier than starting the discussion of how a geomorphological map can or should be designed it seems proper to first discuss or at least clarify what geomorphology is. Looking in a dictionary the term geomorphology is explained by the science of the forms of earth's surface and the processes creating and reshaping them (Nationalencyklopedin, 1992). Thus geomorphology incorporates parts of many different scientific genres (i.e. geophysics, sedimentology, geochemistry, hydrology, climatology, pedology, biology, and engineering) and binds them together in their common effect on our environment. Though the term geomorphology as a rather new term in science thoughts and ideas about the landscape and the mechanisms creating it are very old and written sources in the subject are available (Summerfield, 1999, Shrivatra, et al. 2021a). Topographic maps present information about the relief in form of morphometry and morphography but they do not include information about the age and the origins of landforms. To this they do not include important morphological features too small to be mapped at scale. To get a full picture of the landscape, its development and the processes affecting it a complete geomorphological map is needed, presenting this extra information (Summerfield, 1999, Shrivatra, et al. 2021b) .

Geomorphic Units of Structural Origin

This unit has been classified in to three categories namely highly dissected plateaus, moderately dissected plateau and slightly dissected basaltic plateau. In the study area all the features are observed.

Highly Dissected Plateau

The highly dissected plateaus are fractured and weathered surfaces and occurring in marginal part of the sub-basin. The land of this unit is severely dissected by the streams of Salbardi fault and Maru River giving rise to a terrain consisting of flat topped ridges and steep scarps. The dissected plateau is characterised by the shallow soil cover, moderately high relief, moderately steep slope, rocky and rugged terrain and hard and compact basalt bed rock, which makes them unsuitable for agriculture. The area has favorable sties for development of reservoirs, which can be utilized to store runoff water for groundwater recharge as well as for irrigation of plains in its vicinity. In highly dissected plateau unit the groundwater potentiality is moderate.

The landform of highly dissected plateau occurs in the north-eastern, central and south eastern part of the study area (Fig. 2). It is represented by high hills with severe dissection and thin soil cover

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and rock outcrops mark these landforms. The north east side of Salbardi area extensively occupied by the hilly terrain which is more deviated and highly dissected. The drainage density is more in this area and is transferred by Maru River through the valley.

Linear Ridges and Valleys

In the study area, the ridges are seen in the arc shapes and exhibited by many definite trend lines (Figure 2).This unit is mostly found on the in the north, northeastern and western parts of the study area. Mainly the Sutkund Reserve Forest (RF), Dabka Reserve Forest (RF) and Mosod Reserve Forest (RF) are covered by structural hills. These landforms occur along the north east of Salbardi scarp. These landforms are mostly elongated in shape and are structurally controlled by ENE-WSW trending lineaments. As these landforms are parallel to the Salbardi fault and these can be correlated with post-trapean tectonic disturbances.

This unit is structurally controlled by numerous joints, fractures and lineaments which facilitate some infiltration and mostly act as runoff zones. From the satellite imagery it is observed that the structural hills are interpreted by dark green tonal variation and by thick vegetation. There are few lineaments running more than 5 Kms in the structural hills.

Moderately Dissected Plateau

These are moderately fractured and weathered surfaces and occurring in three patches i.e. north-east, south- west; south eastern and central part of the sub-basin. The land of this unit is dissected by the streams of Maru River giving rise to a terrain consisting of gently sloping plateau surface. It is characterized by the moderately thick soil cover, moderate relief, gently sloping terrain and basaltic bed rock. It lies parallel to the stream course and it has high drainage density and elevation range of 660 m to 620 m above mean sea level. The weathered zone thickness ranges from 5 m to 15 m. The moderately dissected basaltic plateau landforms are seen surrounding the highly dissected basaltic plateau units in the south eastern part of the district. The moderately high hills and medium dissection are the characteristics of this landform and this serves as the recharge belt. The major land cover of this unit is the scrubs (Figure 2).

Geomorphic Units of Extrusive Origin

Region of Middle Level Plateau on Deccan Trap

Plateau landform is mostly undulating landform occupying the valley areas and the plains. Moderate to thick soil cover appreciable zone of weathering and less dissection are main characteristics of this landform. This is found in the north east part of the study area figure 3.4. The Elevation of this middle level plateau is about 750 to 550 m in the study area. Geologically this unit is covered by Deccan basalt (Figure 2).

Region of Low Level Plateau on Deccan Trap

This region found in the study area at north west side and have the average elevation is about 350 to 550 m. These are on the Deccan trap and moderate to thick soil cover with appreciable zone of weathering and less dissection are main characteristics of this landform. This also found in the north east part of the study area (Figure 2).

Table Land on Deccan Trap

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Mesa and Butte

The horizontally lying rocks on weathered basaltic rocks gives raised to flat top hills known as Mesa. The mesa with more or less circular outcrop and having small area by steeps escarpment is known as Butte and Mesa are recorded in south west to north west part while butte in the south east part only (Figure 2).

Geomorphic Units of Fluvial Origin

North south trending Maru River flow in to the lowering depression and negative land form which are surrounded by hill knows as valley. These are filled with quaternary sediments of silt gravel and pebbles. Valley fills are low linear areas occurring between hills. These units occupy the lowest reaches in topography with nearly level slope. The other important river basins are Tapi River, Purna River and Wardha River which makes the landform formed by the fluvial origin.

Erosional Landform

Alluvial Terraces

Fluvial terraces are topographic platforms or benches in the river valley that usually represent former level of the valley floor or flood plain. Consideration of the internal composition of the terraces which cuts in to valley which contribute significantly to understand the evolutionary trends and origin of the terraces. Terrace reflects in two parameters namely the base level and energy, which may changes independently or together. Two fundamental categories of the fluvial terraces exist namely erosional and depositional. The former formed by the erosion of preexisting formation and later result directly from accumulation of stream deposits. In the present study area the fluvial terrace of erosional type demarcated along the Maru River. These terraces situated on the side of river channel, exhibits an unpaired nature.

Alluvial Fans

This type of landform formed when the sudden drop of energy and stream dropped the sediments and deposits as fans. These are landform present on the south west and north east of Salbardi village and some part of it also found in small patches and along the Salbardi scarp in north east and northwest direction (Figure 2).

River Meandering

The meandering river, demarcated with the visual interpretation on the satellite image, indicating palaeo course of the river channels. The important location of the of the meandering are near to the Salbardi, Pachmuri, Palaspani village (Figure 2).

River Potholes

Potholes are very common feature in the study area exposed on bank of Maru River. A pothole is a circular depression on the river bed carved out of solid rock. It is formed by a kind of drilling action as pebbles are caught in eddy currents and whisked around within a small natural crack or hollow formed by corrosion. Pebbles carried by the river are swirled around on the river bed. This action erodes the rock on the river bed forming potholes. Over time, they may widen and join with other

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potholes to form larger potholes and the whole river bed is deepened. As time passes, the drilling action enlarges the hollow to form a pothole. The Maru River is in its youth stage and carrying the less sediments and more water action. Potholes in the study area are varying in size from a few centimeters to several meters in diameter.

Depositional Landform

In the study area there are four important rivers present namely Tapi River, Purna River, Wardha River and Maru River. Wardha, Purna Mar River makes the remarkable fans in the study is rest are not cover much more area.

Older Alluvium Flood Plain

The older alluvial plains are seen to occur between Purna River and Satpura hill ranges. This alluvial plain is a flat surface of large aerial extent and gently sloping towards Purna River. It represents earlier cycle of deposition and the basement rock beneath this plain is the Deccan traps with uneven basement topography. The alluvial material consists of clays, sand and gravels. In case of alluvium of Purna valley, the clay is interbedded with sands and gravels in thickness from 1-25 m. It is present on the south west part of the study area (Figure 2).

Younger Alluvium Flood Plain

This unit mainly differs from the older flood plain in the cycle of deposition and occurs at relatively lower level. The younger alluvium occurs along Wardha River, Maru River and Purna River and lies at south west part of the study area. The younger alluvial plain landform represents a landscape of badland topography resulting from severe soil erosion (Figure 2).

Geomorphic Units of Denudational Origin

Pediments

Pediment as the term suggests, is a feature usually formed at the foot of a mountain. Pediments occur as gently undulating plains with moderate slope 10-150 in the study area and dotted with outcrops with thin layers of soil. The pediment is a terrestrial erosional foot slope surface inclined at a low angle and lacking significant relief in all three dimensions. It usually meets the hill slope at an angular neck line and may be covered by transported material. The low moisture content of this unit gives a bright signature in the satellite imagery especially around the hills. This unit is scattered around the study area and mostly seen in the north south part of the area (Figure 2).

Pediplain

Pediplains are the result of coalescence of pediments predominantly occupying large area and called a Morshi surface (Tiwari, 1985) in the study area (Figure 2). It spread very long area on the south east of the study area. The pediplains are characterized by the presence of relatively thicker weathered material. The extent and thickness of weathering depends on the slope resistance of the underlying rock to weathering, presence of joints and fractures and precipitation and climatic conditions of the area and in the continuous process of pedimentation. When pediment gets buried by detritus and regolithic cover it is termed as a buried pediment in which the sub-surface

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rock subsequently undergoes weathering. Most of the agricultural lands in the study area are constituted by buried pediplains. Depending upon the thickness of the weathered zone, the groundwater potential is moderate to good (Figure 2).(Kowalik and Gold, 1976. Manjare, 2020)

Classification of Lineaments

In general there is no minimum length for lineaments but significant crustal feature are typically measured in tens or hundreds of kilometers. Kowalik and Gold (1976) suggested a lengthwise classification of lineaments or linear features (Kowalik and Gold, 1976. Manjare, 2020) . The classification is as follows: short or minor- 1.6 to 10 km; intermediate- 10 to 100 km; long or major- 100 to 500 km; mega- more than 500 km. Other classifications scheme as per Ganesha Raj (2001) are: micro- less than 2km; minor- 2-10 km; medium- 10-100 km; major- 100-500 km and mega- more than 500 km. However no uniform classification system has been evolved yet (Kowalik and Gold, 1976. Manjare, 2020) . However, keeping in mind the high resolution data or large scale of mapping (up to 1:50,000) during the present study, the possible lineaments of the study area that can be classified based on their length are (a) minor lineament: 2 to 10 km (b) intermediate lineament: 10 to 50 km (c) major lineament: 50-100 km (d) mega lineament: more than 100 km (Table 1 Fig.1).

Table 1: Classification of lineament of the Salbardi and adjoining region

Lineament class	Numbers	Percentage (%)	Cumulative length (m)
Minor lineament	137	81.06	733886.98
Intermediate lineament	24	14.20	249336.79
Major lineament	08	4.73	234264.91
Mega lineament	00	---	---
Total	169		1217489.00

IV.CONCLUSION

The comprehensive information in geomorphological maps makes them useful in a wide range of applications, from pure scientific documentation to solving local administrative problems related to the environment. The Salbardi and adjoining area shows the dendritic to subdendritic, parallel and rectangular drainage pattern are more come in the study area. The parallel drainage pattern is well developed near Salbardi scrap while rectangular drainage pattern is seen in patches .The dendritic drainage pattern is well developed throughout the study area. Salbardi and adjoining region has been divided into different geomorphic units of trifacial origin, namely the structural, fluvial and denudation origin. The lineament intersection density are shows the tectonic activity in the study area. Mapping and analysis of lineaments help in understanding the structural and tectonic set-up of an area. Lineaments, which represent faults, fractures, shear zones, joints, litho-contacts, dykes etc. Can be mapped easily using remote sensing data. The major sets of lineaments in the study area trends NE-SW, NW- SE, NE-SW. The most conspicuous Salbardi and other major lineaments trends ENE-WSW and NNE-SSW, which imprints the neotectonic activity in the study area as these are parallel to the SONATA lineaments.

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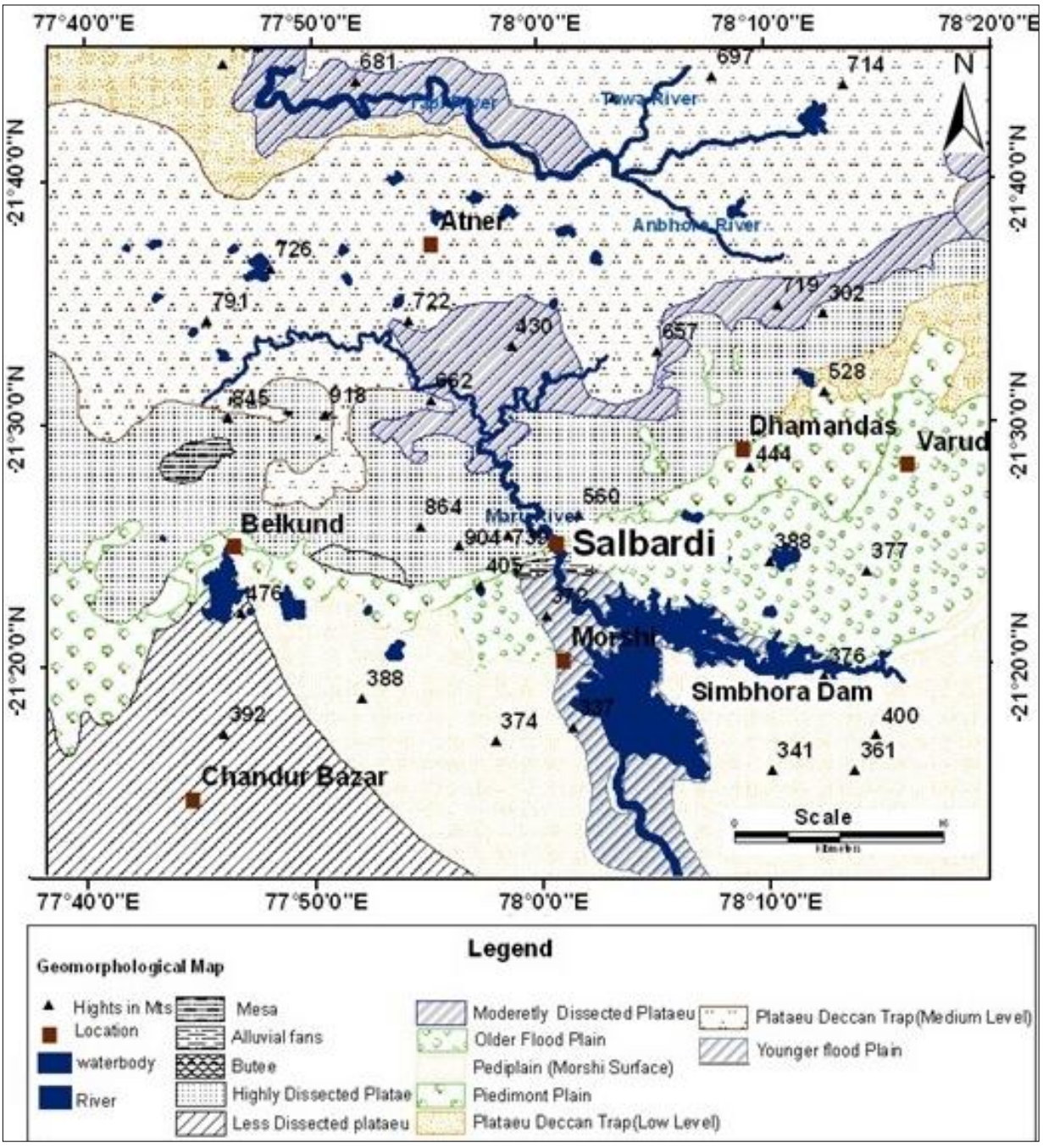

Figure 2: Geomorphological map of study area

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