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Geomorphological mapping and its significance in some part of central India, using satellite image

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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. The Survey of India toposheet provide the basic topographic information required to interpret the geomorphology from the satellite imagery. Then, within each zone, different geomorphic units have been mapped based on the landform characteristics, their aerial extent, depth of weathering, thickness of deposition etc. For the preparation of geomorphic map, the information extracted from the various sources like Survey of India toposheets, geological map and interpretation of satellite image data and most importantly, the field observations.

Keywords: Geomorphology, satellite data. remote sensing and GIS

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,

Information about the landscape characteristics is important in estimations about changes of the landscape due to changing environmental conditions. The key to understand this development lies in understanding the past. By studying the landscape in a scientific manner, we can start building up knowledge about our surroundings that will help us understanding past development and maybe also predict the future. Since the development of computer based Geographic Information Systems (GIS), the discussion about how to present a detailed general description of the landscape development has faded away. This is surprising, since the data handling capacity in a GIS could be the tool solving previous problems with map sheets presenting too much data. Geologically the area mainly composed of Deccan trap the rocks belonging to other ages also form an important part of the geological sequence. They vary right from base with litho units like granites, gneisses, quartzite, and felspathic gneisses and are followed by Upper Gondwanas and Lametas belonging to Upper Cretaceous period. This formation is unconformably overlained by Deccan traps which in turn is overlained by the alluvium of Quaternary period. The rocks of Salbardi area belongs to Archaean and Upper Gondwana Super group. The Gondwana sediments of Salbardi and adjoining region are tectonically disturbed because of ENE-WSW trending fault. The Archaean quartzo-felspathic gneiss and granitic gneisses makes the basement while in the upper part Gondwana along with Lameta are exposed. The rock formation of the Salbardi and adjoining region is overlained by one another i.e. Archaeans overlained by younger formation Upper Gondwana and Gondwana overlained by Lameta of Upper cretaceous age with sedimentary rock such as sandstone, shale and limestone. Next to this, Lameta is overlained by Deccan trap of Upper Cretaceous to Eocene age and have basaltic rock with porphyritic to non-porphyritic texture. The Deccan is then superimposed by Quaternary deposit i.e. soil and alluvium. A small patch of NE-SW trending Upper Gondwana succession along with the Lameta is exposed in Salbardi area (Lat. 21^0 25' 15" N and Long. 78^0 00' 00" E). Though, the succession showing good preservation of sedimentary structures, patchy lithological units and grain size variations have not received much attention for sedimentological investigations in the study area. However, field based preliminary sedimentological details were documented about one and a half centuries back (Blanford, 1869). Subsequently, specific work on the area is inadequate and mainly focused on regional geological set-up, of which the Salbardi area represents a small patch of Upper Gondwana in the vast Deccan trap province and it includes a hot spring near to the Salbardi village (Saxena, 1987 and Ravi Shankar, 1991, Manjare, 2013a, Manjare, 2013b, Manjare, 2014, Manjare, 2017, Manjare, 2016, Manjare, 2019, Masurkar *et al*., 2019, Manjare *et al*. 2022, Paunikar *et al*. 2024, Manjare *et al*. 2024) [13, 14, 18, 20, 21, 22, 23, 24, 27, 30, 35]. The intrusive and extrusive igneous activity in the area i.e. both basalt and doleritic dyke are common and brought attention to the study area.

Geomorphology and geomorphological maps

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) [25]. 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, 1991, Shrivatra et., al, 2021a, Shrivatra et., al, 2021b) [37, 38, 40].

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.

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).

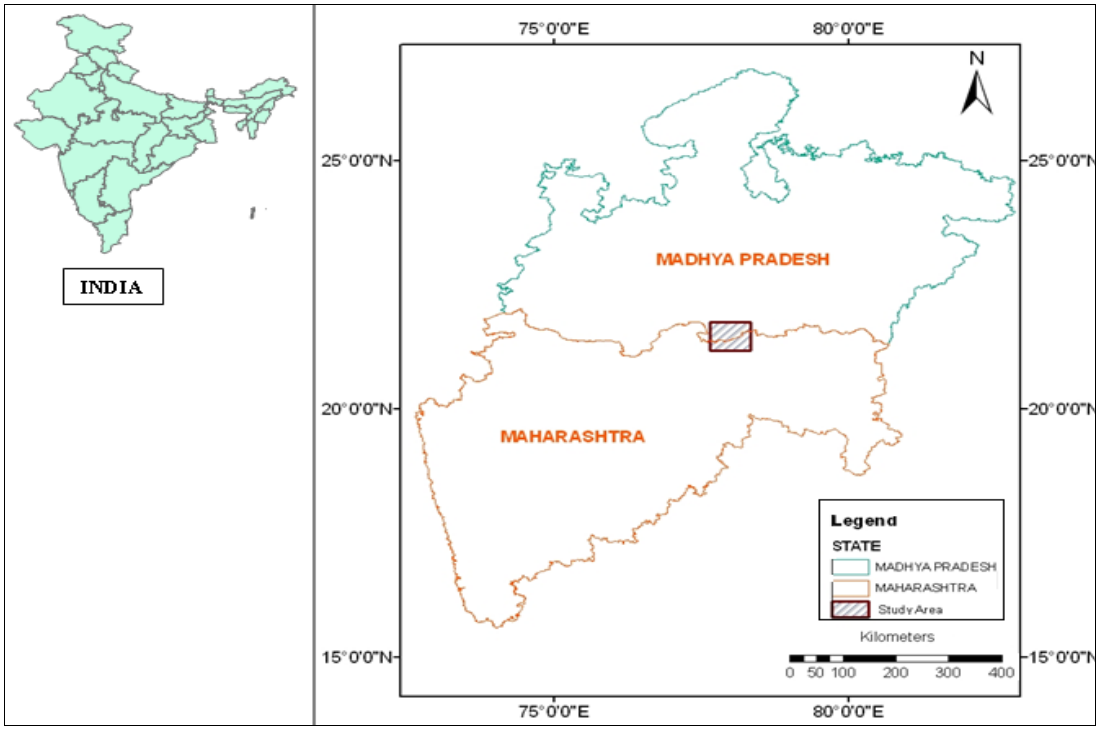

Fig 1: Location map of the study area

Use of GIS and Remote Sensing in Geomorphology

Geographic information systems (GIS) have enhanced the applicability of geologic mapping when integrated with data obtained by remote sensing using a wide range of formats and scales. In addition, advancement in image analysis provide geologists an opportunity to enhance, manipulate, and combine remotely-sensed digital data with several types of geographic information that in turn increases the amount of extracted information related to topographic and geologic features (Horsby & Harris 1992) [10]. Satellite imagery permits research at different scales, which is valuable in the investigation of lineaments and faults (Arlegui & Soriano 1998) [1]. Digital enhancement of satellite images yields much information about image features. GIS techniques enable the integration and analysis of multi spatial and non-spatial data that have the same geo-referencing scheme.

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
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.

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 (Figure 2). It is represented by high hills with severe dissection and thin soil cover 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. The Upper Gondwana sediments and Archaean granitic gneiss constitutes the structural hill as geomorphic unit in which the village namely Ghorpend, Jamkhari, Amari, Padhmahu, Sonmahu and Pata village are situated. The hill range shows the arc hill like structural trending ENW (Figure 2).

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).

Structural Scarp or Fault Scarp

The scarp is most diagnostic topographic expression the fault. The scarp associated with the faulting as either faulting scarp or fault line scrap. As originally defined by the Davis (1931) fault scarp is a scarp produced originally due to the faulting while the fault line scarp is originally produced by the erosion along the fault line.

The scarp from very conspicuous features bordering the major table land identified easily with presence of vertical steep slope. The field evidences proved the scrap are not only the expression of the geomorphic process but are associated with the major structural lineament.

Salbardi Fault Scarp

In the present study area, the prominent fault scarp is Salbardi scarp. The length of this scarp is about 56 kms in the study area and traced from village Belkund. Scarp is an abbreviation for 'escarpment' meaning an abrupt rise in relief of a cliff the abbreviated form has been used at least from the days of Hutton and Playfair. The fault line of the Salbardi fault scarp cut along the Maru River near Salbardi village. The trends of this scarp are ENE-WSW direction. A fault scarp is the topographic expression of faulting attributed to the displacement of the land surface by movement along faults. They are exhibited either by differential movement and subsequent erosion along an old inactive geologic fault (a sort of old rupture) or by a movement on a recent active fault. Fault scarps often contain highly fractured rock of both hard and weak consistency. In many cases bluffs form from the up thrown block and can be very steep (Saxena, 1987 and Ravi Shankar, 1991, Manjare, 2013a, Manjare, 2013b, Manjare, 2014, Manjare, 2016, Manjare, 2017) [13, 14, 16, 19, 21, 30, 35]. The height of the scarp formation is equal to the vertical displacement along the fault. Active scarps are usually formed by tectonic displacement e.g. when an earthquake changes the elevation of the ground, and can be caused by any type of fault including strike-slip faults whose motion is primarily horizontal. This movement is usually episodic with the height of the bluffs being the result of multiple movements over time.

Fault scarps are short-lived features in geologic study they are one of the purest tectonic landforms although the movements that raise scarps leave a large area of land on one side of the fault higher than the other side a persistent elevation difference that erosion can obscure but never

erase. As fault displacement is repeated thousands of times over millions of years, larger escarpments and whole mountain ranges. A fault scarp is one where the footwall surface is exposed in other words the feature must be very fresh so that erosion has not destroyed all traces of the actual plane of the fault.

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

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 change 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. The terraces have been noticed at more or less constant heights above the present flood plain or valley flat. The terraces T0 and T1 have been located along the Maru River near Salbardi village and Ghodev village.

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 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.

A Mushroom Rock

It is also called rock pedestal or a pedestal rock which is a naturally occurring rock whose shape as its name implies strikingly resembles a mushroom. The rocks are deformed in a number of different ways the processing of erosion and weathering, glacial action or from a sudden disturbance. These features are formed over thousands of years when wind erosion of an isolated rocky outcrop progresses at a different rate at its bottom to that at its top. Abrasion by wind-borne grains of sand is most prevalent within the first 3 feet of the ground, causing the bases of outcrops to erode more rapidly than their tops. In the study area it is found towards north- west direction and it is 3.2 Kms from the Salbardi village.

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).

Palaeochannels

The scars of palaeo channels have also been observed along the Maru River which if field with the channel deposit and evidences along the Maru River north west to the Salbardi village. Another palaeo channels have been delineated north to the Salbardi village and it approximate 2.5 kms (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 (Morshi surface)

The pediplains are formed as a result of weathering under arid and semi-arid conditions, representing the end stage of cyclic erosion (Sparks 1960) [39]. A Pediment is developed by a combination of process including stream erosion, weathering sheet wash and lateral plantation. When the sediment developed over a large area as a result of continuous process of pedimentation, it is normally termed as a pediplain.

Pediplains are the result of coalescence of pediments predominantly occupying large area and called a Morshi surface (Tiwari, 1985) [41] 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 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).

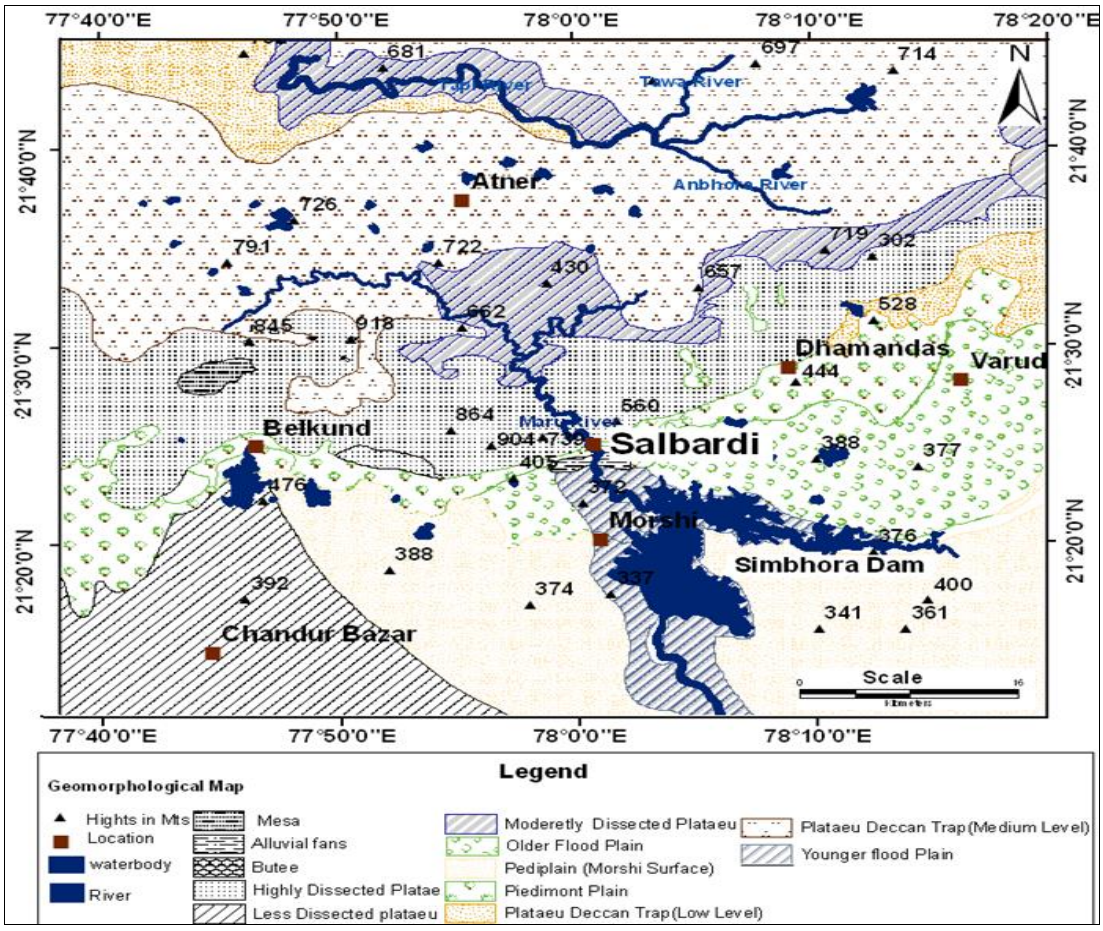

Fig 2: Geomorphological map of study area

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 Salbardi and adjoining area experiences the good geomorphic features, due to Salbardi fault and other structural disturbances.

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