CHAPTER-IV
GEOMORPHOLOGY OF THE AREA

4.1 INTRODUCTION
Within the contemporary concern for environmental management, many problem relate to the interaction between man, land and water. Geomorphology normally involves a study of the latter two and frequently recognises that man is the most important geomorphological agent in some parts of the world. Whenever man uses land he has to accommodate its relief, materials and water resources to his purposes. The study of these things fall within the domain of the hydrologists, engineering geologists, pedologists and agriculturist and yet they maintain their identity under the title of geomorphology as well. It is with the form, materials and processes of the earth surfaces that geomorphology is concerned.

Geomorphology which is concerned with landform, materials and their related processes, is pertinent in all aspects of environmental management involving these physical phenomenon. Significant advances in the mapping of a land’s geomorphological characteristics have added another invaluable tool in assessing the potential of land for development and in providing a valid basis for sustainable land use planning. However the potential for applying geomorphological knowledge depends not only on the problem but also on the willingness of the environmental manager to appreciate the value of this knowledge (Cooke and Doornkamp, 1974).

The relation between landforms and processes with land (scape) elements such as soils, ground and surface water and vegetation through the landscape ecological situations and even including man, an agent through his use of land is a fascinating field of study (Verstappan, 1983).

4.2 UTILITY OF GEOMORPHIC CLASSIFICATION
The geomorphic classification of a terrain provides the basis for identifying the target areas for the exploration of natural resources and also for other economically viable human
activities like agriculture, construction of surface communication network, establishment of industrial and urban complexes, etc.

Such a classification of a terrain takes into consideration the surface form and the material like superficial soil and the parent materials (sediment and/or basement rocks) which have either undergone some type of climato-morphogenetic changes and have similar depositional or erosional history. The impact of the natural environmental hazard is also used to be different and varying on different segments of an area.

Geomorphological mapping is today an indispensable part of the research and is being used in assessing the potential of land for development both in urban and rural environment. Landforms along with the soil and vegetation form the primary factors in planning for various developmental activities. Different thematic maps can be prepared based on basic geomorphic maps interpreted from the study of remotely sensed satellite data.

With the landform mapping finding large range of application in various fields of resources and environmental surveys, the scope of geomorphology has widened. As a result, geomorphology has received considerable attention from geoscientists, pedologists, hydrologists, engineers and urban planners. The major applications of geomorphology can be considered and grouped as follows:

I. Geomorphology in Earth sciences: Geology, pedology, hydrology, forestry etc. This includes the topographic and thematic mapping related to the study of natural resources exploration, exploitation and management.

II. Geomorphology in environmental studies: i.e. studies and surveys specified to natural hazards such as landslides, earthquakes, volcanism, flooding, river migration etc.
III. Geomorphology in rural and urban developmental planning; i.e. mainly concerned with the land utilisation, conservation and planning.

With the advent of Remote Sensing techniques, acquiring synoptic information covering beyond visible range, application of geomorphology in recent years has gained in status (Young and White, 1984). Satellite data are found particularly useful in the mapping of landform as (i) they reduce the time required for reconnaissance, (ii) due to the vantage point, they reveal large scale landform patterns that are often not visible on the ground, i.e. providing synoptic view. (iii) They can record features which are at times obscured by the vegetation cover or cultural setting etc. They depict the diversified landforms elements of units and their spatial relationship. This gives enough scope for visualising the whole complex of natural environment and landscape ecology in the context of intricate interrelationships which exist between landforms, rocks and soils, ground & surface water, climatic condition, vegetation and land utilisation (Verstappen, 1983). Keeping this in view, an attempt has been made in the present study to map and analyse the landform features in Dala-Obra-Renukoot area.

4.3 OBJECTIVES:

- to delineate various landforms of fluvial and denudational origin and understand their genetic significance
- to recognise landform which are potential from groundwater point of view
- to find out the interrelationship between soil erosion and landform
- to find out the interrelationship between land capability, landuse and landform

4.4 METHODOLOGY

For the preparation of the geomorphological map of the area, hard copy of IRS-IB LISS-II satellite image and digital CCT of IRS-IB LISS-II together with SOI toposheets were used for interpretation and delineation of landforms and geomorphic units. During the exercise different interpretation keys like geotechnical elements and terrain elements were
considered to delineate the various geomorphic features. These interpreted features were then transferred in 1:50,000 scale base map.

Limited field checks were carried out along with ground truth collection along selected field traverses. During the field study, landform features were verified and rejudged in order to update the pre-field geomorphic map. Additional data were collected in the field to find out the relationship of various geomorphic units with groundwater occurrence, soil and erosion condition. Various enhancement of digital data were done for better separability of various units. Image characteristics of various units together with their spatial characteristics have been given in Table 4.1.

4.5 PHYSIOGRAPHY

The area under study can be broadly classified into four distinct physiographic units having close bearing with geological set up.

(i) The Southern part of the area is occupied by schistose and phyllitic rocks characterised by ridge and valley topography. The low lying, linear, E-W trending ridges interrupted by narrow valleys are most common in this part; however at few places, linearity of the ridge are broken by transverse valleys which do not obliterate general topographic set-up of the area. The general elevation of the area ranges between 180m and 360m above m.s.l.

(ii) Gently and undulating plain in and around the village Bari in the northwest forms valley plain. It is covered with the soil mantle overlying Porcellanite of the Vindhyan. However, the gentle topography is broken by isolated hills here and there.

(iii) The Northern part of the area i.e. north of the Son river is marked with very high relief hills having steep scarp faces interspaced with intermontane valleys and structural valleys. The general elevation of the area is between 160m and 593m above mean sea level (m.s.l.).

(iv) The Northern plateau over the upper Vindhyan, which is having highest elevation in the study area. It rises upto the height of 593 metre above m.s.l.
### Table 4.1: IMAGE CHARACTERISTICS OF DIFFERENT LANDFORMS UNITS

<table>
<thead>
<tr>
<th>Landforms</th>
<th>Tone/Colour on FCC 432</th>
<th>Digitally Enhanced Products</th>
<th>Drainage Pattern</th>
<th>Texture</th>
<th>Structure</th>
<th>Landuse</th>
<th>Association</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recent</td>
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<tr>
<td>Alluvium</td>
<td>Bright red</td>
<td>Coarse</td>
<td>Smooth</td>
<td>Cultivation</td>
<td>Flood Bank</td>
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<tr>
<td>Point Bar</td>
<td>White</td>
<td>Yellow (FCC PC123)</td>
<td>Fine</td>
<td>Barren</td>
<td>Along river channel</td>
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<tr>
<td>Channel Bar</td>
<td>White</td>
<td></td>
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<td></td>
<td>Within river channel</td>
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<tr>
<td>River Channel</td>
<td>Blue to bluish black</td>
<td>Pink to red (FCC PC 123)</td>
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<td>Water Body</td>
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<td>Vindhyanas</td>
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<tr>
<td>Plateau</td>
<td>Reddish brown (Forest) to reddish yellow (cultivated)</td>
<td>Band 4 and PC2</td>
<td>Coarse sub-parallel</td>
<td>Medium</td>
<td>Flat top: gently sloping surface</td>
<td>Forest, agriculture, escarp face barren</td>
<td>Forming highly elevated hills with escarp</td>
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<tr>
<td>Structural Hill</td>
<td></td>
<td></td>
<td>Coarse parallel</td>
<td>Coarse to medium</td>
<td>Coarse trend line</td>
<td>Forest</td>
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<tr>
<td>Linear Structural Hill</td>
<td>Brownish grey</td>
<td>-</td>
<td>-</td>
<td>Medium to fine</td>
<td>Linear hill with single trendline</td>
<td>Degraded forest</td>
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<tr>
<td>Residual Hill</td>
<td>Brownish to grey</td>
<td>FCC PC123</td>
<td>Drainage divide</td>
<td>Medium</td>
<td>Broken linear structural hill</td>
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<tr>
<td>Residual Hill (Porcellane)</td>
<td>Greysish brown</td>
<td>-</td>
<td>-</td>
<td>Medium to fine</td>
<td>Linear hill with single trendline</td>
<td>Degraded forest</td>
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<tr>
<td>Residual Hill (Limestone)</td>
<td>Brownish grey to grey</td>
<td>-</td>
<td>-</td>
<td>Medium to fine</td>
<td>Linear hill with single trendline</td>
<td>Degraded forest</td>
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<td>Isletberg</td>
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<td>SV &amp; IMV</td>
<td>Lighter reddish to yellowish red</td>
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<tr>
<td>SBPP</td>
<td>Reddish to reddish yellow</td>
<td>Sub-parallel</td>
<td>Moderate to uneven and motiled</td>
<td>Surrounding hillocks</td>
<td>Sparse agriculture to stony wasteland</td>
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<tr>
<td>DBPP</td>
<td>Darker reddish to reddish yellow</td>
<td>-</td>
<td>-</td>
<td>Surrounding away from hillocks</td>
<td>Good cultivation</td>
<td></td>
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<tr>
<td>Pre-Vindhyanas</td>
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<tr>
<td>Structural Hill</td>
<td>Brownish to reddish and yellowish brown</td>
<td>Trellish pattern</td>
<td>Moderate to coarse</td>
<td>Clear parallel trend line, ridge &amp; valley topography</td>
<td>Dense to degraded forest</td>
<td>Sub-classified on the basis of degree of dissection</td>
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<tr>
<td>Residual Hill</td>
<td>Greysish brown</td>
<td>Drainage divide</td>
<td>-</td>
<td>Lesser extent</td>
<td>Degraded forest</td>
<td></td>
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<tr>
<td>Structural Valley</td>
<td>Yellow to reddish yellow</td>
<td></td>
<td></td>
<td></td>
<td>Agriculture</td>
<td></td>
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<tr>
<td>SBPP</td>
<td>White to reddish yellow</td>
<td>Trellish</td>
<td>Medium to motiled</td>
<td>Surrounding hillocks</td>
<td>Sparse agriculture to stony wasteland</td>
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<tr>
<td>DBPP</td>
<td>Reddish to yellowish red</td>
<td>-</td>
<td>-</td>
<td>Away from hillocks</td>
<td>Agriculture</td>
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</tbody>
</table>

SV: Structural Valley; IMV: Intermontane valley; SBPP: Shallow Burried Pediment Plain; DBPP: Deep Burried Pediment Plain
4.6 DRAINAGE

In addition to the main rivers, a number of streamlets are distributed throughout the area (Plate 4.1a).

The river Son, one of the major tributaries of Ganga, flows from West to East in the Northern part of the area. The Rihand and Kanhar rivers and their tributaries form the main drainage network in the area and they finally join the Son river in the North Western and North Eastern corners of the river. These rivers are ephemeral and effluent in nature. Even in dry season the Rihand and Kanhar rivers maintain bed flow.

The drainage pattern is typical trellis and bedding and joint controlled in the major part of the area comprising schist and phyllitic country rock. The joint controlled parallel to sub-parallel drainage pattern have been distributed in Vindhyans country rocks near the northern limit of the study area. On the escarpment face of structural hills, parallel to sub-parallel channels are seen, while on the cuesta face sub-parallel drainage following the deep slope have been developed.

The narrow valley plain occurring between Vindhyans and Mahakoshal structural belts is generally occupied by Son alluvium. This plain is generally characterised by lack of well developed surface drainage, except on the banks of Son Rihand and Kanhar river where fine dendritic drainage has developed in the alluvium.

4.7 CLASSIFICATION AND DISTRIBUTION OF GEOMORPHIC UNITS

The geomorphic units (plate 4.1b) in the area of study have been classified on the basis of variations in lithology, geomorphic expression, slope morphometry, relief, soil cover and vegetation/landuse/landcover.

The Geomorphic units have been broadly classified into three categories on the basis three broad geological groups. They are, geomorphic units in (i) Quaternary, (ii) Vindhyans and (iii) Pre-Vindhyans.
Plate 4.1a: Drainage and Watershed Map

Plate 4.1b: Geomorphological Map
4.7.1 Geomorphic Units in Quaternary (Recent) Formations:
These are of fluvial origin and confined into a very limited area along the river courses. These have been developed by the major river Son and its tributaries, the Rihand and Kanhar rivers. There are two types of fluvial landforms that are normally developed. They are as follows:

(i) **Fluvial landforms of overbank environment:** These are formed of the detrital material transported by a river and deposited usually temporarily at point along the flood plain of a river, which is commonly composed of sand and gravel (Whitten and Brooks; 1985; Dictionary of Geology, Penguin books). This is of aggradational type which have been formed due to channel flooding and environmental changes like dam construction.

(ii) **Fluvial landforms in channel environment:** Due to aggradational and degradational phases of rivers, various fluvial landforms are formed in the stream channel. The numerous deposits of sand and gravel occurring in the channel environment are commonly designated by such names as channel bars, point bars etc. The studies of these landforms give clues regarding the various stages of channel evolution. The following fluvial landforms have been formed in the study area:

(a) **Alluvial Plain:** Alluvial plain is normally a flat or gently undulating surface formed by extensive deposition of alluvium by the river. It constitutes gravel, sand, clay and silt. In the study area alluvial plains are developed along the Son, Rihand and Kanhar rivers and are under extensive cultivation.

(b) **Point Bar:** Point bars are sand deposits along the stream banks within the present flood plain. As the carrying capacity of the stream is reduced when the flood water recedes or the amount of water is reduced, the sediment load is dumped along the sides of the channel. In satellite images, these sand bodies appear bright tones. Point bars are found along the Son and Kanhar rivers.

(c) **Channel Bar:** These are sand bars made up of coarse grained deposits within the stream course (Thornbury, 1954). In general, channel bars are composed of coarser
materials which could not be transported by the river flow. On the image these have been identified by their nature of occurrence in the stream as sandy patches, their elongated shape and overall lighter tone. Mostly these are formed in river Son and Kanhar especially where these rivers start developing braided streams. In the Riband river, due to the overbank flooding by the dam construction, the channel bars are submerged.

(d) River Channels: In the area, the main rivers show braiding of the channels within the flood plain, resulting in formation of point bars and channel bars.

4.7.2 Geomorphic units in Vindhyans:

4.7.2.1 Plateau: These are flat topped uplands with steep slopes, normally developed over horizontally layered rocks. In the North of the area, the Upper Vindhyan Dhandraul Quartzite form the plateau north of the Son river. Drainage over this region is coarse and sparse. Soil thickness over the plateau is thin and it supports dry cultivation.

4.7.2.2 Structural Hills: These are the hills where morphology is controlled by the structure of the rocks (Fairbridge, 1968). They evolve on the surface of the earth by the combined processes of tectonism and denudation. In the present case, the Vindhyan sandstone (Quartzite), shale and limestone constitutes this unit in the form of linear hills and slopes with distinct trend lines. These are mostly covered with forest. The general elevation ranges between 200m to 500 m and slope gradient ranges between 3% to 30%.

4.7.2.3 Linear Structural Hills: Conglomerate of Patherwa formation (Basal formation) and Kajarahat limestone form narrow E-W trending linear structural ridge with steep slopes. Average elevation is 240 metre above m.s.l. Vegetation is sparse and bushy in character. Soil thickness is very thin at ridge portion.

4.7.2.4 Structural Valley: These are narrow valleys between structural ridges. These can be identified on the basis of their shape and mode of occurrence. On image it is being identified on the basis of light red tone implying agricultural practice. This is underlain by shale of Vindhyans.
4.7.2.5 Intermontane Valley: These are valleys formed within the mountainous region. Due to differential erosion of sandstones, limestones and shale, these have been formed within the structural hills of Vindhyan limestone, olive shales and sandstones. The slope of the valley maintain general configuration of the hills.

4.7.2.6 Residual Hills: Residual hills are isolated hills formed due to differential erosion resulting in the more resistant rocks standing out as residues. Here erosion process is very active and base of the hill is usually strewn with talus material. They are generally low in elevation and do not show much influence of structural features of the underlying rocks. They are generally surrounded by pediments/pediplain.

On the basis of lithology and landcover these units have been further classed into three categories:

(a) Residual hills (Arenaceous): These are having good forest cover, e.g. near Piprahwa village.

(b) Residual hill (Porcellanite): Soil cover is 1 to 2 m thick. These are covered with degraded forest.

(c) Residual hills (Limestone): Soil cover is generally less than 1 m thick. There are being mined for limestone and dolomite.

4.7.2.7 Inselberg: Inselberg are small residual hills which stand out in isolation from the general level of the surrounding erosional plains (Fairbridge, 1968). In general, they are found in tropical regions. Inselbergs display considerable morphological variations with varying shape and size. They project starkly, abruptly and dramatically above the flatness of the surrounding plains (Fairbridge, 1968).

In the study area, few inselbergs have been identified mainly in the north-eastern part of the area. These are made up of massive limestone which is jointed and fractured.

4.7.2.8 Weathered Pediment Plain (Pediplain): In general a pediment is a broad, flat or gently sloping rock-floored erosional surface or a plain of low relief, developed due to the process of denudation by the subaerial agents including running water in an arid or semi-
arid regions at the base of an abrupt mountain front of plateau escarpment (Fairbridge, 1968). A pediplain is such a surface of large areal extent, normally formed by the coalescence of several pediments. During the process of weathering and erosion, the sloping surface of the pediment gets gradually covered with a mantle of soil and colluvial materials thereby the pediment is buried. When the pediment is covered under a thick weathered mantle, it is termed as buried pediment (Bhattacharya & Chakraborthy, 1980). On the basis of thickness of weathered mantle, the pediment plains in this zone have been classified into two categories:

1. **Shallow Weathered Pediment Plain**: These are best observed around Billi, Dala, Kajarahat, Garaidih. The pediment slopes are gentle to moderate (<1-2%) signified by an undulating topography adjacent to the hills, with bouldery, coarse sandy and light reddish brown to greyish soils and isolated outcrops. The zone of weathering varies from 1 to 5 m. These are cultivated for dry crops such as Jowar, Bajra, Maize, Millets etc.

2. **Deep Weathered / Deep Buried Pediment Plain**: These have been best observed around Kota, Bari, Obra. The pediment slopes are relatively gentle (<1%) and are covered with coarse sandy, light brownish to greyish soil. The zone of weathering varies from 5 m to 10 m and it is being cultivated for dry crops such as Jowar, Bajra, Maize, Millets etc.

4.7.3 Geomorphic Units in Pre-Vindhyan Terrain

The whole regions south of Dala is occupied by schist, phyllite and quartzite rocks of Mahakoshal group, forming east-west running alternate ridge and valley topography where the harder rocks are forming ridges and the softer materials like shale and phyllite underlying valley portion. On the basis of degree of dissection and its position the geomorphic units in the terrain have been classified into the following categories:

4.7.3.1 **Less Dissected Structural Hills (LDSH)**: They are represented by E-W trending structurally controlled linear hills. This unit has been formed in the southern parts around Ningha village and south of Belguri nala, and it is underlain by schist and quartzite of Lotan formation of rocks. Slope varies widely from 3% to 30% and the soil cover is less than 20
cm in depth. These hills are covered with dense forest. The general elevation of the unit ranges from 180m to 440m above m.s.l. and dissection is minimum.

4.7.3.2 Moderately Dissected Structural Hills (MDSH): In this unit, the degree of dissection is more than in the LDSH and is formed north of Belguri nala around Ranitali, Kandari, Hathinala, Gurmura villages in the central part of the area. These are covered with soil and colluvial material along the slopes and support moderately dense forest. Slope gradient also varies from 3% to 30% and elevation from 180 to 330 m above m.s.l. This unit is locally cultivated at places of lesser slope by terracing.

4.7.3.3 Highly Dissected Structural Hills: This unit is found surrounding Paraspani, Basudha, Kandopani, Patgari and Garbani villages with an elevation ranging from 120 to 320 m above m.s.l. These are covered with colluvial material in most of the area. Slope gradient ranges from 3% to 20%. The areas are under degraded forest and stony waste. Dry terrace cultivation is done at few places on the relatively gentle slope. Soil development is very poor as these are being washed out due to poor vegetation.

4.7.3.4 Residual Hills: These are found around Ningha village in the north-west. Mostly these are barren in terms of vegetation growth. Erosional process is very active and base of the hills is usually strewn with talus material. These are moderately low in elevation with the structural features obliterated and are generally surrounded by weathered pediments.

4.7.3.5 Inselbergs: Isolated hills of phyllite-quartzite occurs as inselberg in the weathered pediments zones of the areas near Jargakhari, Dakhudandi and Basudha villages. These hills are of different sizes and shape but comparatively smaller than residual hills.

4.7.3.6 Structural Valley: E-W trending structural valleys are very conspicuous in the satellite images, especially along Belguri nala. The valley portion is strewn with both alluvial and talus material coming from the ridge portion.

4.7.3.7 Shallow Weathered Pediment Plain: Mostly these are found above the phyllite of the Parsoi formation. General slope varies from 2% to 5%. In general, the depth to
weathering including top soil mantle is less than 5 meter which has been verified from the well sections. This unit is being used for dry land agriculture except the areas covered with stony waste and bushy vegetation.

4.7.3.8 Deep Weathered Pediment Plain: This is confined near Auradandi and Kota villages in the phyllite of Parsoi formation of Mahakoshal group occurring in a low lying area. Soil cover is thick which retains soil moisture. The weathered zones including top soil mantle extends more than 5 meter in depth.

4.8 SUMMARY OF THE RESULTS

- Interpretation of FCC 432, false colour composit of PC 123 (RGB), PC2 and Band 4 along with various geotechnical elements like drainage, slope, contours and landuse/landcover were found to be useful in delineating and demarcating various landform units in the study area.

- There are four physiographic domain associated with different lithology: (a) ridge and valley topography formed by schistose and phyllitic rocks of Mahakoshal Group of rocks in the northern part; (b) gently and undulating plain overlying porcellanite of Vindhyan in the northwest part of the area; (c) very high relief hills having steep scarp faces interspersed with intermontane valleys and structural valleys occupying area north of the river Son and (d) northern plateau formed by Dhandraul quartzite of Upper Vindhyan.

- Broadly, there are three geomorphic units based on three geological groups exposed in the area: (a) geomorphic units in Quaternary includes alluvial plain, point bar, channel bar, river channel of fluvial origin; (b) geomorphic units in Vindhyan includes plateau, structural hills, linear structural hills, structural valley, intermontane valley, residual hills, inselbergs, shallow and deep weathered pediment plains and (c) geomorphic units in Pre-Vindhyan includes various degree of dissected structural hills, residual hills, inselbergs, structural valley, shallow and deep weathered pediment plane.