

Original Research Article

Terrain Analysis of Elements using LISS-IV Satellite image in Bhainsa region, northwestern part of Nirmal district, Telangana State, India

Abstract

Terrain is considered one of the most important natural geographic features and is a vital factor in physical processes. This study focuses attention on terrain analysis of the study area. The effect of this terrain analysis on the surface characteristics were analyzed, this was achieved by generating and extracting data and a high-resolution 5.8m satellite image (IRS P6-LISS IV) of the area respectively. The Remote sensing satellite data and geographic information system (GIS) are used in terrain analysis is defined as the study of the nature, like drainage, digital elevation model (DEM), land use/ land cover, lithology, geomorphology features, and soil characteristics around Bhainsa region, northwestern part of Nirmal district. The drainage pattern is dendritic to sub-dendritic and the topography of the study region is undulating with a gentle slope towards southeast. The morphological features composition of land forms, the result of which is a land form or land component of the region. The diverse land use categories such as forest, agriculture, water bodies, drainage, and the land cover pattern are divided into agriculture land, barren land, forest, built up, mining and industrial, scrub land and water bodies. The major litho-units in the study area are occupied by granitic terrain and deccan traps basalt. The soils are covered in region black clayey, reddish brown, and gravelly clay red soils. IRS P6-LISS IV, 2016 satellite image made optimum utilization for the interpretation of terrain analysis. The terrain parameters were further used as input to analyze the surface characteristics in the locality.

Key words: Terrain analysis, Land use and land cover, Drainage and digital elevation model (DEM), lithology, geomorphological features,

INTRODUCTION

Remote sensing is the art of acquiring information from images and related data using aircraft or satellites, which record the interaction between electromagnetic energy and matter without physical contact with the object (Sabins, 1997). Remote sensing techniques are considered economical because it permits the recognition of large areas with high accuracy and speed (Ezzati et al., 2014). Remote sensing technique has been used since the last century in earth science and land use/land cover studies (El Khidir and Babikir, 2013).

Terrain is considered one of the most important natural geographic features and is a key factor in physical processes. Geomorphometry, the science of measuring the Earth surface shapes and the effects of these surface forms on human and natural forces (Hengl and Reuter, 2008), has become one of the most important disciplines in earth science research (Florinsky, 2017; Evans, 2019; Sofia, 2020; Xiong et al., 2022). Terrain analysis is usually considered a synonym of geomorphometry (Wilson, 2022). Geomorphometry and terrain analysis have provided important toolsets for geomorphology, hydrology, soil science, and geographic information systems (GIS) (Florinsky, 2017; Wilson and Gallant, 2000b; Xiong et al., 2022).

It is magnificent that scholars can use their knowledge of geomorphology and terrain analysis to not only solve traditional issues such as landform-related research but also aim to complete various studies spanning different fields and disciplines. We have noted that geomorphology and terrain analyses tend to involve close relations with other geoscientific subfields, such as the landscape, hydrology, ecology and geology (Florinsky, 1998b; Macklin et al., 2006; Florinsky, 2016; Ironside et al., 2018; Liu et al., 2020a; Jancewicz et al., 2022; Ma and Zhao, 2022; Xiong et al., 2022).

Land use/land cover change is most important to understand the natural resources, their utilization, conservation, and management (Nagamani and Ramachandram, 2003; Alekya et al., 2017; Linga Swamy et al., 2022). Land use is constrained by environmental factors such as soil characteristics, climate, topography, and vegetation. It also reflects the land as a key and finite resource for most human developmental activities such as agriculture, industry, forestry, energy, production, and settlement, recreation, water catchments, and

storage (Uma Maheshwari et.al., 2015; Udaya Laxmi et.al., 2016; Linga Swamy et al., 2022).

The present study emphasizes on the satellite imagery of the IRS P6-LISS IV analyses and interpretation in part Bhainsa region of Nirmal district, Telangana state, to assess terrain elements such as elevation, drainage, mapping of the inferred lithology/ geology, soil, and the land use/ land cover. The geographic location map of the study area shown in Figure 1.

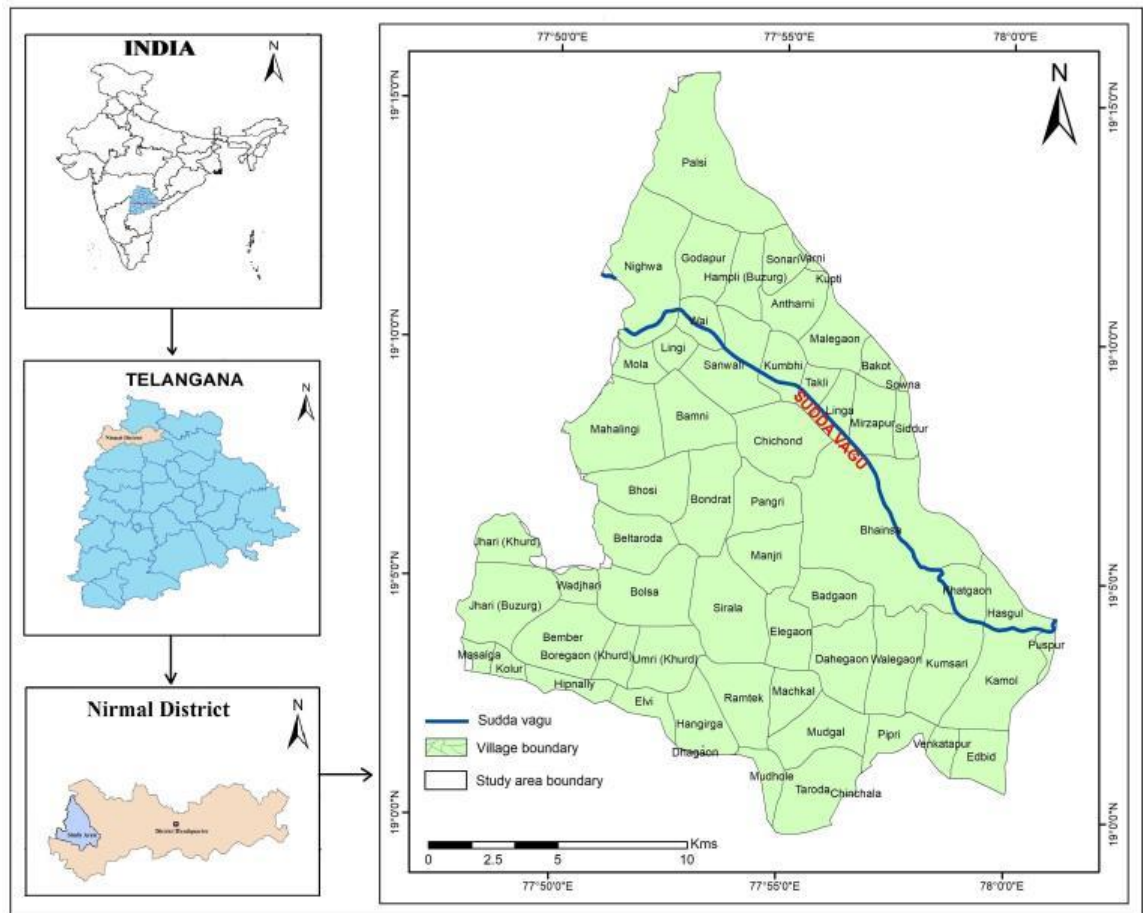


Figure 1. Location map of the study area.

MATERIALS AND METHODS

The present study area around Bhainsa region lie between $77^{\circ} 47' 00''$ to $78^{\circ} 02' 00''$ E longitude and $18^{\circ} 59' 00''$ to $19^{\circ} 17' 00''$ N latitude of Nirmal district, Telangana state covers to area of 323.8 sq.km (Figure 1). The IRS P6-LISS IV Satellite image (NRSC-National Remote Sensing Centre, Hyderabad) (Source: <http://bhuvan.nrsc.gov.in>) whose resolution is 5.8 m, along with three spectral bands (B2: 0.52-0.59 μm ; B3: 0.62-0.68 μm ;

B4:0.77-0.86 μm) accessed for the study area (Figure 2) and is utilized to examine the regional/ geological and geomorphological features to understand the groundwater potentiality in the region. The data base is made possible from different sources available and also freely available on internet through. The basic data collected are Survey of India (SOI) toposheets at scale of 1:50,000 (toposheet No's 56 E/15, 56 E/16, 56 F/13 and 56 I/04). Standard enhancement techniques (Image translation, Image enhancement, Image contrast, spectral and spatial filtering etc) as mentioned by Miller and Pearson, (1971); Goetz, (1975); Castleman, (1978); Hammond and McCullough, (1980); Singer (1980); Chavez et al., (1982); Short, (1982) and Price (1995). IRS-P6 data user's manual, 2003 were applied for image information of the earth's surface. Techniques like stratification, directional filtering, layered approach, composition, aggregation and refinements were also utilized wherever necessary to improve the quality of mapping.

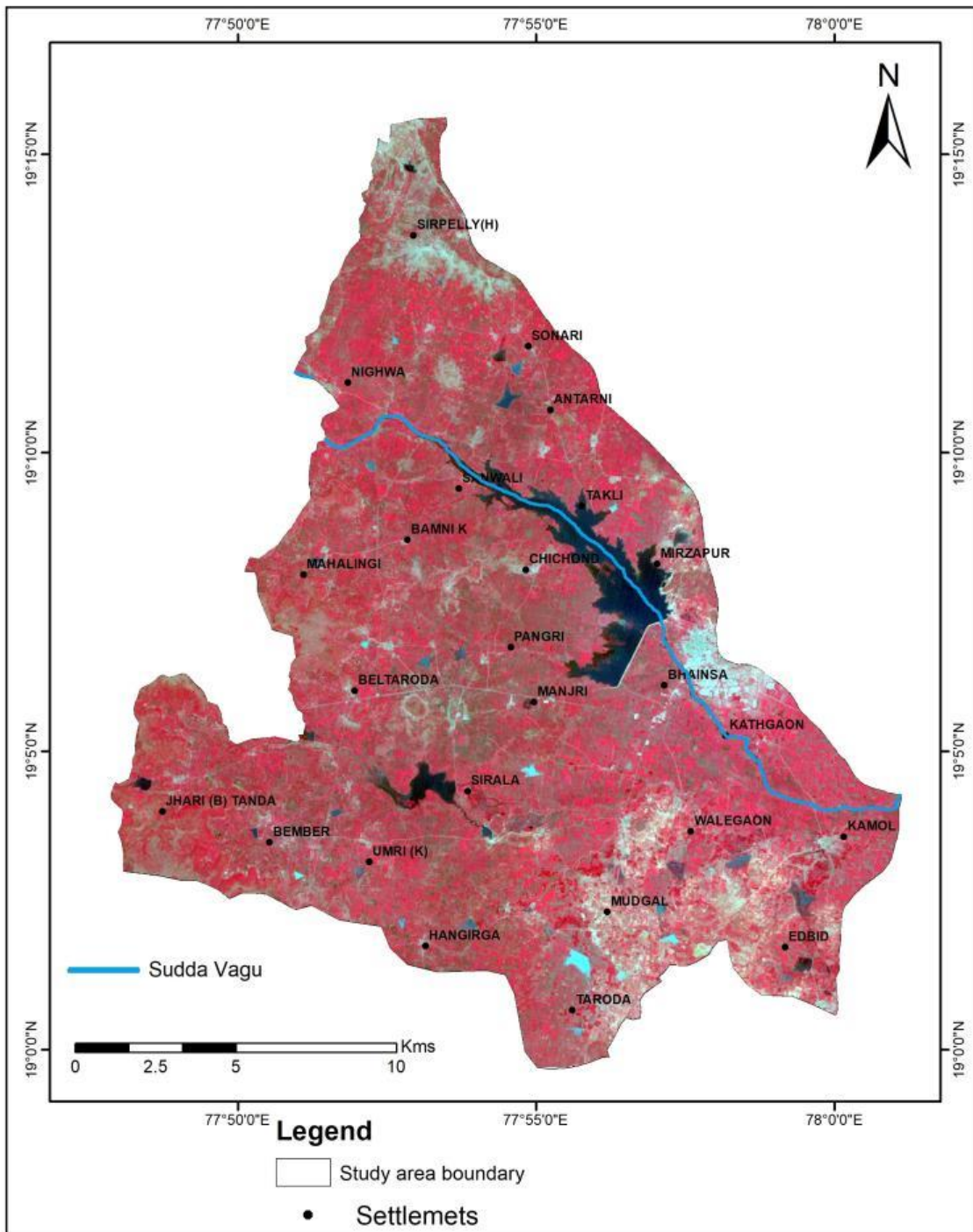


Figure 2. IRS-P6 LISS-IV Satellite map of the study area.

RESULT AND DISCUSSION

Terrain Elements Analysis

The study region was geo-referenced, digitally processed, and visually interpreted for terrain elements analysis of topography/ landform, drainage patterns, lithology, stream order and Land use/Land cover (Rao, 1995).

Topography: The topography of the study area is undulating with a gentle slope towards southeast. The maximum elevation is 471 m and the minimum elevation is 340 m above mean sea level shown in (Figure 3) The geology and geomorphological of a region comprise the preliminary database requisite for any geophysical/geochemical survey program. Based upon the parameters, exploration or investigation strategies are evolved. Similarly, another set of parameters that give a valuable input for designing survey methodologies. The various types of roads in the study area are metalled and non-metalled roads, cart tracks and foot tracks. All the settlements in the study area are connected by metalled and non-metalled roads.

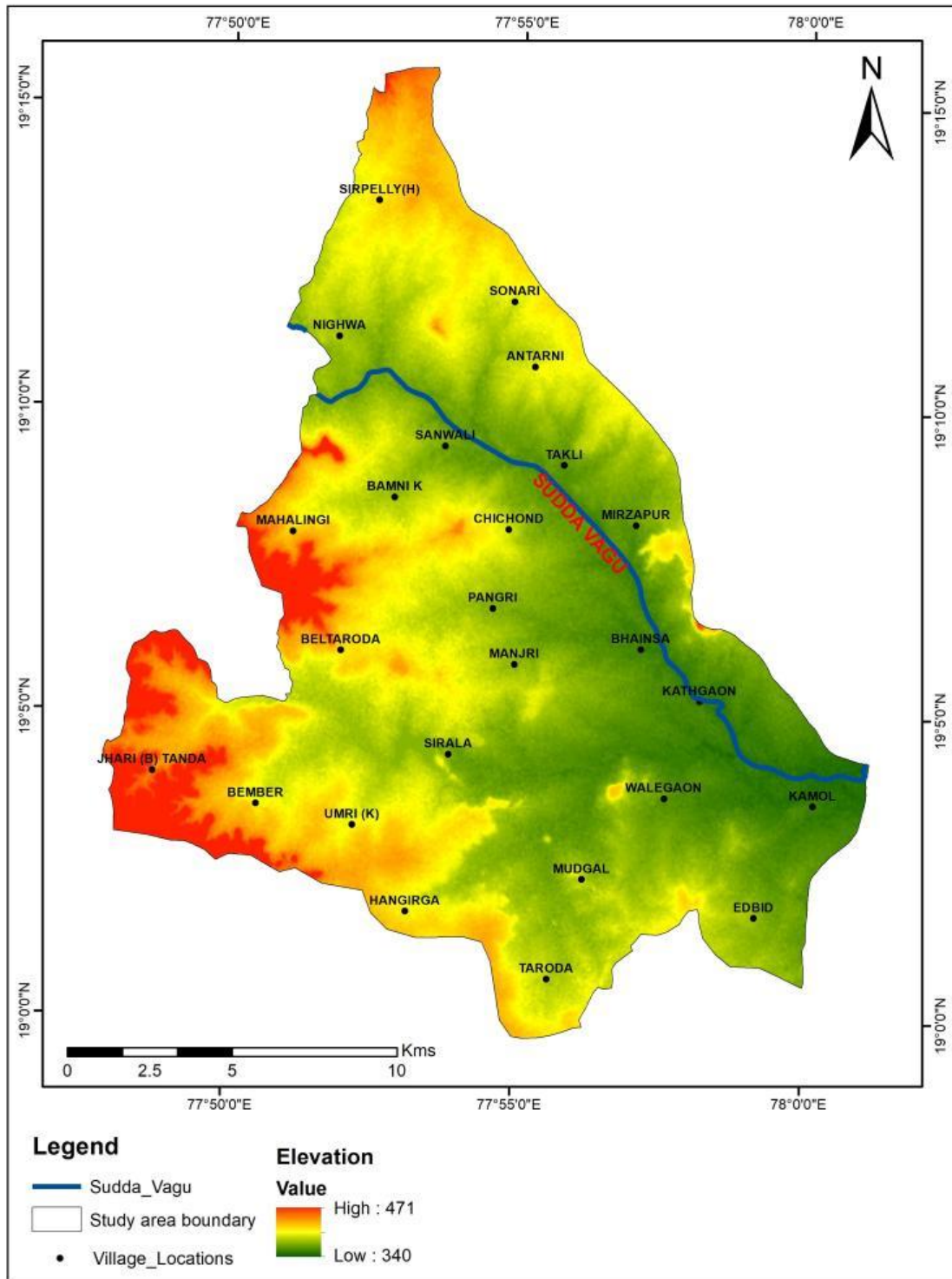


Figure 3. Digital elevation map of the study area

Lithology: The identification of topography/ landforms in an area will help to decipher the underlying lithology. Often many of the rock types have distinct topographic expressions. Type and composition of minerals determine the spectral response of the rock type (Miller and Pearson, 1971 and Singer, 1980, Price, 1995). IRS P6-LISS IV satellite imagery is used to analyze the various geological formations based on different FCC signatures. These signatures depend on several band combinations (B2: 0.52 -0.59; B3: 0.62-0.68; B4:0.77-0.86 in μm) and many band rationing/ indexing techniques adopted by several authors Miller and Pearson, (1971); Goetz, (1975); Singer, (1980); Chavez et al., (1982); Price, (1995); Subhash Babu et al., (2014) and made possible to correlate with the available lithology (Figure 4). This lithology map of the region is inferred from the satellite image. The major litho-units in study region are a part of the Upper Cretaceous to Paleocene age of Sahyadri Group of Deccan trap represented by basalt covers major Central, NW and SW part and, Peninsular Gneissic Complex, comprising of Archaean to Paleoproterozoic granites and gneisses and covers southeast part of study area (Figure 4). The geological formations encountered in the study area are granites, granodiorites and banded gneisses. The Archaean rock consists of mainly of pink granite, grey biotite granite, and grey hornblende biotite granite. The pink granites and grey granites are closely associated with each other. The pink granite is generally porphyritic with large phenocrysts of pink orthoclase feldspar. Biotite, Chlorite, hornblende, epidote and tourmaline occur as accessories. The pink granites are more susceptible to weathering than the grey granites.

Deccan basalts comprise in the major part of the study area. Nearly horizontal lava flows are considered as a result of fissure type of lava eruption during late Cretaceous to early Eocene period. The Deccan trap basalts in Peninsular India are the result of fissure eruptions of molten lavas which flowed to long distances covering hundreds of kilometres of the country to form extensive flows. These rocks are generally horizontal and layered and each layer ranges from a few meters to 40.0 meters in thickness. The Basalts, though generally uniform in composition, show variation in colour, texture and mode of weathering and the deccan traps unconformable overlying the PGC-II rocks. In the study area of limestone Penganga group of Neo Proterozoic age continue isolated patches are presented in western part of Mahalingi to Meltaroda areas and south part of

Umri area. The limestones are seen with typical elephant skin weathering. Special features of limestone like elephant skin weathering, bedding joints, caverns. Upper Cretaceous age Infratrappean bed N-S direction contact line of Takli to Taroda in continuous isolated patches exposed between the granite and overlying deccan trap basalt. A wide-ranging geological stratigraphic succession of the study area is presented in Table 1.

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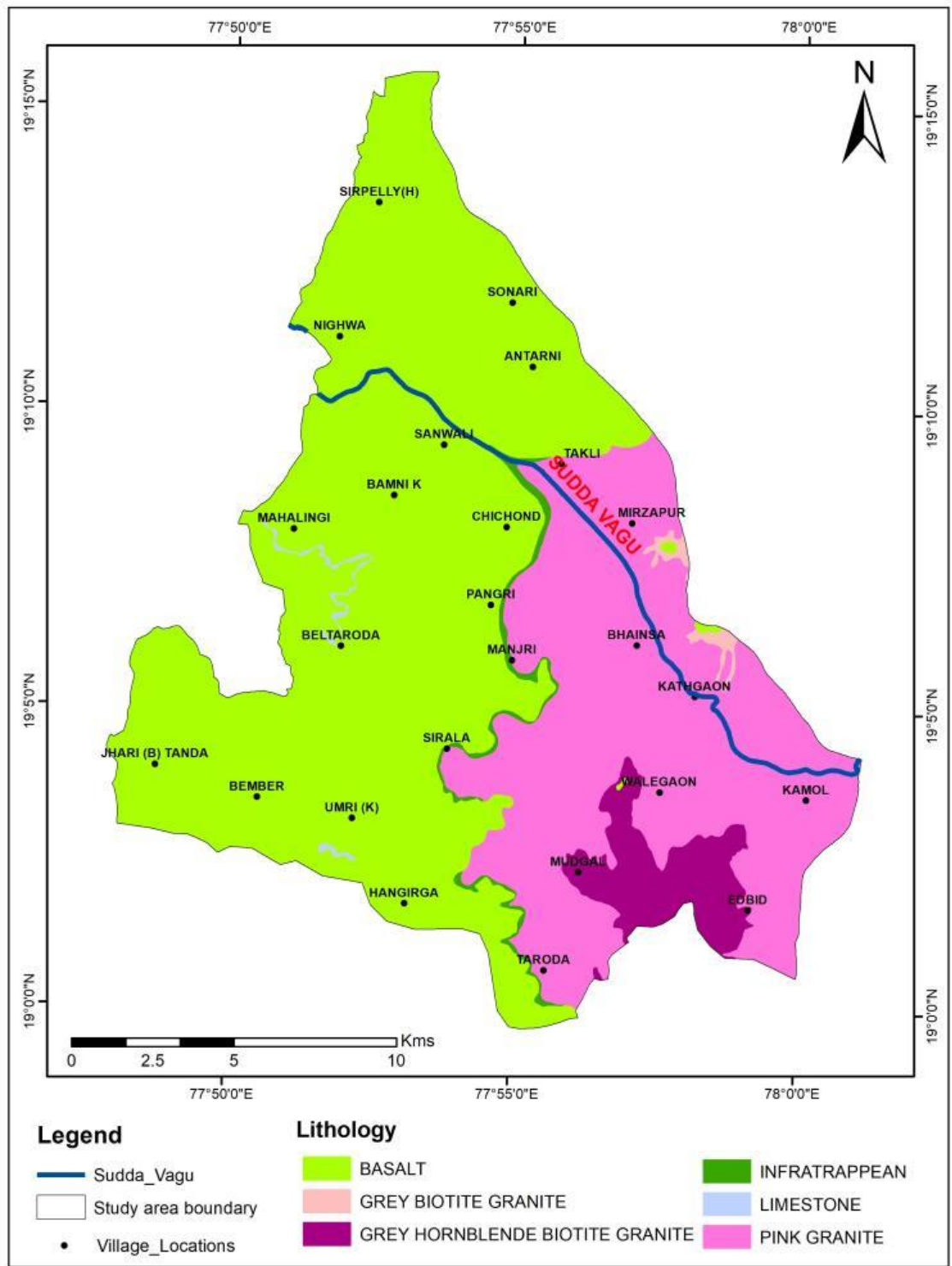


Figure 4. Lithology map of the study area.

Table 1. Stratigraphic succession of the study area.

Litho-units	Group	Super Group	Age
Basalt	Sahyadri	Deccan Trap	Upper Cretaceous to Paleocene
Infratrappean	–		Upper Cretaceous
Limestone	Penganga		Neo Proterozoic
Pink granite, grey biotite granite, and grey hornblende biotite granite	Peninsular Gneissic Complex		Archaean to Paleoproterozoic

Drainage: The drainage pattern and texture seen on images are good indicators of landform and bedrock type (Thornbury, 1986) and also suggest the soil characteristics and drainage conditions. The drainage pattern of an area refers to the design of the stream courses and their tributaries. It is influenced by the slope of the land, lithology and structures. The distribution and attitude of the rock systems and their arrangements also control the drainage pattern. The Sudda vagu/river flow direction from NNW-SSE in the study area. The area is occupied by numerous small and medium size streams and streamlets. General slope of the area is towards southeast part and the drainage pattern in the study area is dendritic to sub dendritic (Figure 5).

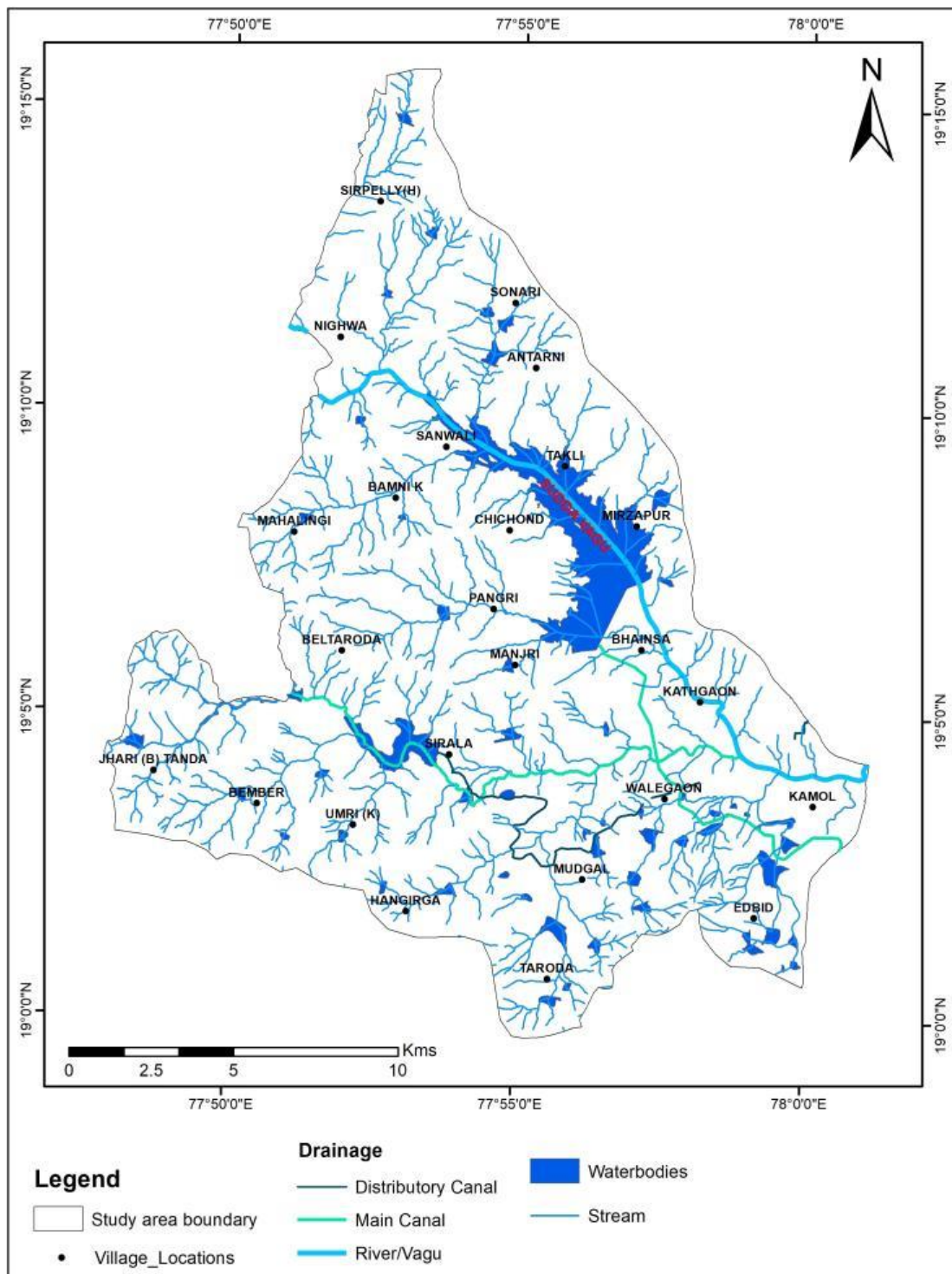


Figure 5. Drainage map of the study area.

Geomorphological features: The geomorphological features of an area provide strong basis to determine the water resource occurrence, distribution, and management. The geomorphological map of Bhainsa region (Figure 6) has been prepared using Indian Remote Sensing (IRS) satellite imagery data. Geomorphology comprises studying landforms, simulating the process that gave rise to them, and examining how tectonics have affected. The properties of the landform are crucial in the potential for groundwater and surface water in drainage basins. Additionally, the characteristic geomorphic units that characterize the drainage and weathering processes of the landform plays key role in the groundwater potential & recharge capability of particular regions. Long-term processes design a shallow layer with varying levels of porosity and porousness in tropical and central areas (Aboyeji et al., 2012). Research that combines data on lineaments hydro-morphology and hydrogeology have proven to be effective for identifying groundwater potential zones. The key landscape physical characteristics can be utilised to assess the spatial distribution of groundwater in various geological contexts and the distribution of different geomorphology units, which were categorized into i) Pediplain moderate, ii) Pediplain shallow, iii) Plateau high dissected, iv) Plateau moderate dissected, v) Plateau slightly dissected, vi) Plateau weathered, vii) Pediment, viii) Valley fill shallow, ix) Denudational hill, x) Inselberg, xi) Mesa, and xii) Butte. The geomorphology features cover is made conventional divisions in the present study and is shown in Table 2.

i) Pediplain moderately (PPM): Pediplains moderately is area characterized by flatter or gentle sloping surface of the south part, which is the end product of coalescence of several pediments at the foot of hill slopes. These pediplains regions are covered by reddish brown and black clayey soils. Groundwater potential in the weathered zones is reduced by deep weathering. Fractures with moderate potential that are appropriate for bore wells (Ram Krishan Desai, 2006).

ii) Pediplain shallow weathered (PPS): This sloping surface of pediplain shallow is notices in southwest, central, north covered large area, these plains are well characterized both sides of the Sudda vagu/river. The groundwater prospects for wells are good to moderate. The good yields are anticipated along the intersections of the lineaments and fractures.

iii) Plateau weathered (PW): The gradually sloping of plateau weathered is observed major part NNW-SSE trend, this plateau weathered is fit categorized along the Sudda vagu, and also small part of the covered in west side of Umri and Bember areas. The groundwater predictions for wells are very good to good, the harvests are predicted along the intersections of the lineaments and fractures. In addition to that, plateau slightly dissected is covered in central part of Pangri and Manjri, north part of Sirpelly areas, Similarly, the plateau moderate dissected and plateau high dissected features are covered in western part and north part of the corner.

iv) Pediments, inselbergs and denudational hills: The small part of the area is consisting of pediments and especially on the southeastern side. The general slope of the region is towards east and the impact of erosion is more intense leading to washout of soil and weathered material. Therefore, the bed rock is exposed to the surface. The undulating topography abounded with small moulds, hills or tors etc. The inselberg complex is permanently seen on the southeastern side around Walegaon, near Kamol and Edbid villages. Similarly, this unit of denudational hills is prominently seen on the southern region in west part of Edbid village.

v) Valley fill shallow (VFS): The valleys are most commonly drained by rivers and may occur in a relatively flat plains or between ranges of hills or mountains and the valley dimensions are varying and is wide at the river meandering and its covered southeast part. Further, the valley became a junction for merging with another channels. A flood plain is generally flat area of land next to river or stream it stretches from the banks of the river to outer edges of the valley and which experiences flooding during periods of high discharge. The soils in the area are derived from the disintegration and decomposition of parental rock granite. The soils are reddish brown and black clayey in colour. On the flood plain regions, the soils are mainly loamy and clayey while in the valley portions due to intense erosion and transportation only sand with little silt noticed.

Table 2. Spatial distribution of the geomorphology features

Geomorphology features	Area in Sq Km	Area in %
Butte (B)	0.53	0.16
Denudational Hill (DH)	3.34	1.03
Inselberg (I)	0.53	0.16
Mesa (M)	3.21	0.99
Pediment (PD)	17.62	5.45
Pediplain Moderate (PPM)	29.90	9.23
Pediplain Shallow (PPS)	11.45	3.54
Plateau Highly Dissected (PLH)	1.38	0.43
Plateau Moderately Dissected (PLM)	33.78	10.44
Plateau Slightly Dissected (PLS)	18.92	5.82
Plateau Undissected (PLU)	126.95	39.24
Plateau Weathered (PLW)	52.83	16.30
Valley Fill Shallow (VFS)	6.31	1.94
Water Body	17.06	5.27
Grand Total	323.81	100

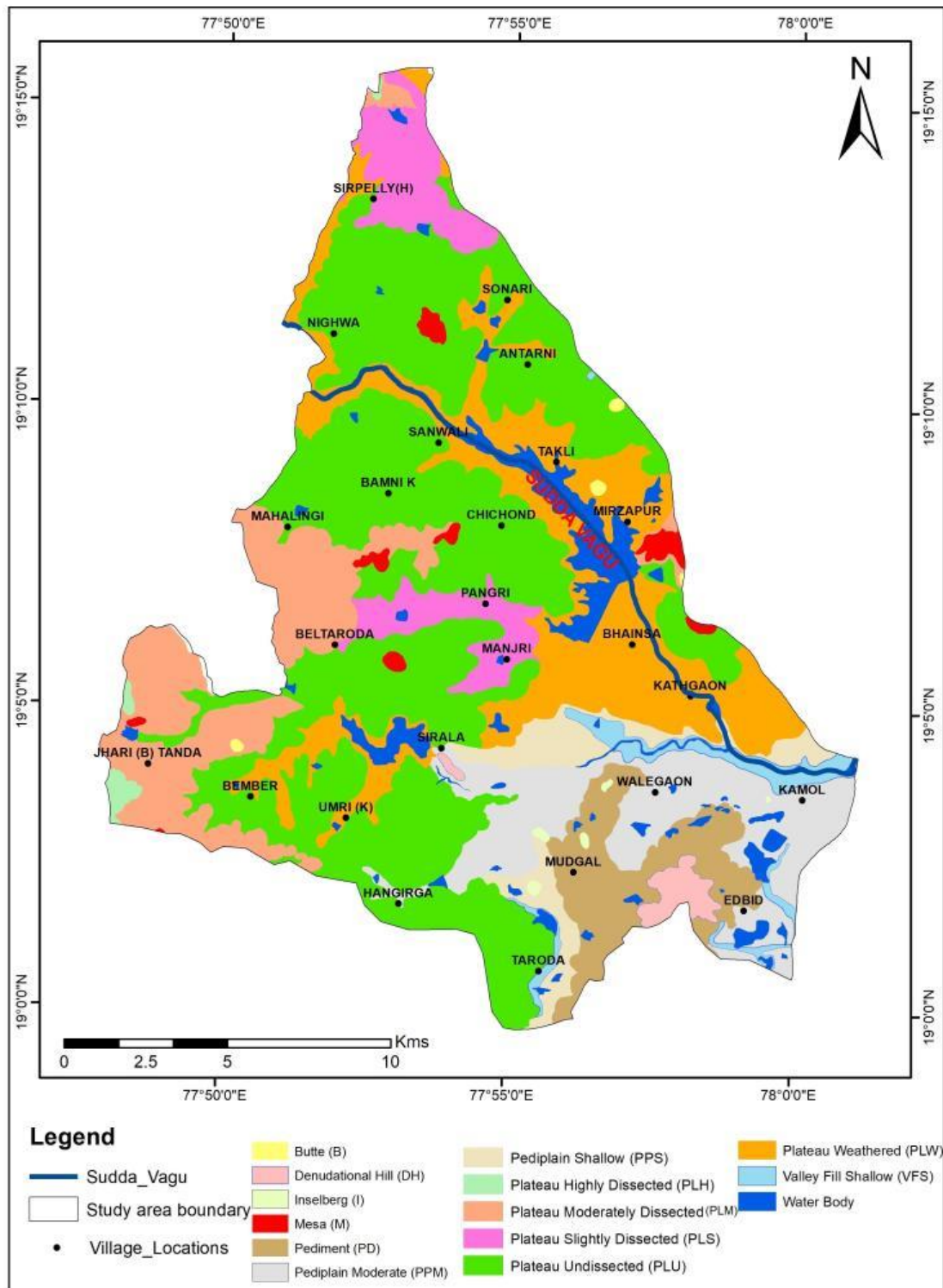


Figure 6. Geomorphology map of the study area

Land use land cover: Land use/ land cover refers to anthropogenic activities and uses that are carried out on land surface; however, this has good correlation with lithological and morphological units (Varde et al., 2011). The land use and land cover play a significant role in the development of groundwater resources. The nature of land surface and its pattern control infiltration and runoff (Kumar et al., 2007). Land use land cover (LULC) is an important attribute of the runoff process that affects water infiltration capacity, erosion, and evapo-transpiration. Land use land cover map was derived using LISS-IV IRS-P6 satellite image and generated by layer stacking, signature editing on images for LULC. The land use land cover map (Figure 7) of study region is categorized into different classes such as agriculture land, barren land, forest, built up, mining and industrial, scrub land and water bodies. The majority part of Bhainsa region is covered by crop land and scrub land followed by barren rocky and built-up land. However, at few places mining and industrial covers are also identified. The land use Land cover is made conformist divisions in the present study and is shown in Table 3.

Table 3. Spatial distribution of land use-land cover

Land use land cover type	Area in Sq Km	Area in %
Barren rocky	0.43	0.12
Built up	7.39	2.28
Crop land	248.47	76.80
Forest	9.27	2.86
Mining/Industrial	1.17	0.35
Reservoir/Tanks	21.78	6.73
River/Stream/Drain	4.14	1.28
Scrub land	31.16	9.58
Grand Total	323.81	100

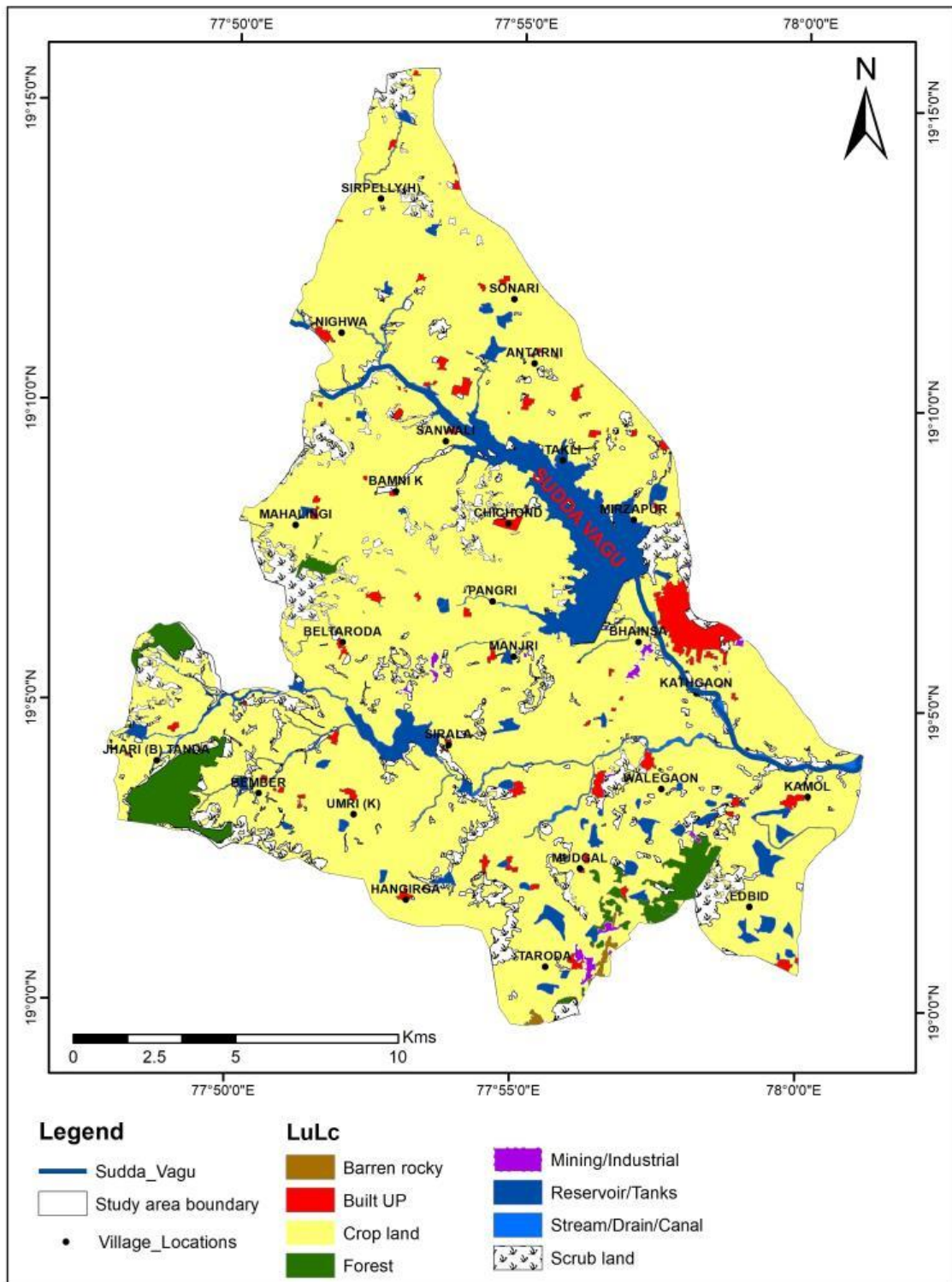


Figure 7. Land use land cover map of the study area

Soil: The soil is composed of mineral particles, organic matter, water, and air. Soil texture is commonly classified as sand, silt, or clay (Le Bas and Streckeisen, 1991). Soil properties such as depth to water table, depth to bedrock, flood potential, and permeability are important considerations in assessments. The major part of the area black clayey soils covering most parts of the hilly terrain to downstream, and forest areas, where the soil is thin may be the result of erosion and denudation mass wasting (Figure 8). The forest cover in plateau regions promotes the infiltration of rainwater to enhance the groundwater resource in the downstream region. Reddish brown soil is seen along the southeastern boundary of the study region. The remaining areas in the SW margin and north corner parts covered gravelly clay red soils. The soil cover is made obedient divisions in the present study and is shown in Table 4.

Table 4. Spatial distribution of the soil types

Soil Type	Area in Sq Km	Area in %
Deep black clayey soils	266.79	82.43
Loamy to clayey skeletal deep reddish brown soils	24.54	7.56
Shallow loamy to gravelly clay red soils	32.48	10.01
Grand Total	323.81	100

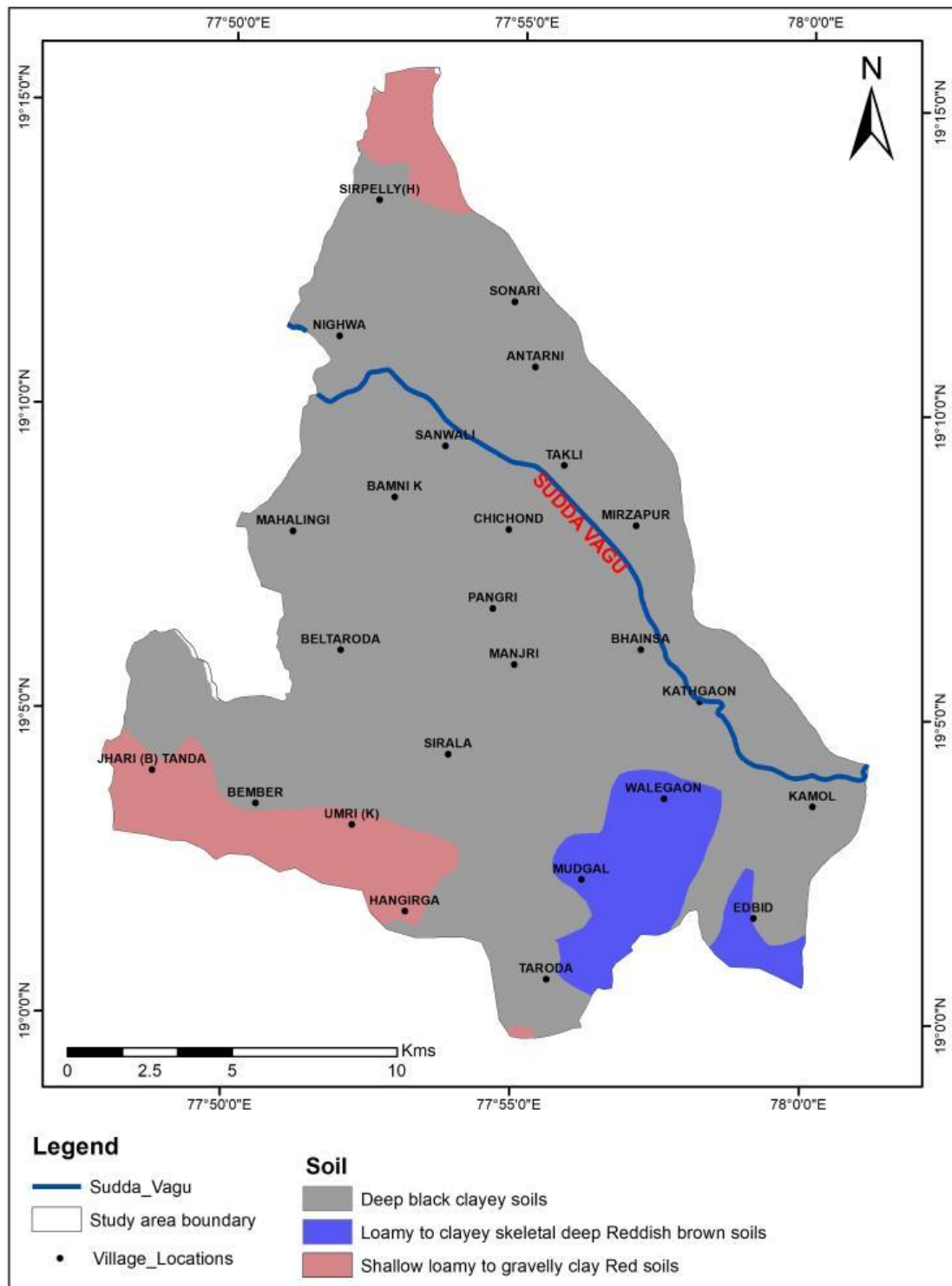


Figure 8. Soil map of the study area.

CONCLUSIONS

Elucidation of lithological, drainage, geomorphology, land use land cover and soil units and demarcation of their boundaries are made possible by utilizing satellite imagery IRS-P6 LISS-IV with a spatial resolution of 5.8m. Satellite image digitally processed and interpreted using Arc GIS to achieve structural fabric. After the amalgamation of all the units, a detailed land use-land cover map is attained. Agricultural cropland area is around 76.80% and forest area is 2.86% which needs further forestation in the area of investigations. Undeveloped open scrubland area 9.58% required more attention to bring the land into utility. Satellite images in combination with topo sheet of the similar scale of Survey of India used for analyzing the land use and land cover studies. The Sudda vagu/river flow direction from NNW-SSE and slope of the study area is towards southeast part. The drainage pattern in the study area is dendritic to sub dendritic. The geomorphological units such as pediplain moderate to shallow, plateau weathered, valley fills are most prospective zones for the groundwater development in the locality.

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