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Geo-morphological Mapping for Land Resource Assessment Around Bagh village of Dhar District, Madhya Pradesh, India Using Remote Sensing and GIS Techniques

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Abstract

This study presents a geomorphological mapping using IRS-P6 LISS-III satellite data approximately 885 sq. km area around Bagh village, Dhar district, Madhya Pradesh has been mapped. Visual image interpretation technique has been employed to identify and delineate various geomorphic features based on tone, texture, size, shape and color extracted from false color composition LISS-III sensor images. The study is aimed at classifying such geomorphic units as pediplains, pediments, buttes, mesas and plateaus. The integration of remote sensing and GIS facilitates a time and cost-effective methodology to achieve the objectives of the study. Field verification of this produced maps was conducted to validate the interpretation results. The findings contribute to a comprehensive understanding of the geomorphology of the study area. The study area exhibits the following geomorphic features: Buttes (0.12 sq. km.), Mesas (0.83 sq. km.), Plateaus (less dissected) 11.93 sq. km., Plateaus (moderately dissected) 334.02 sq. km., water bodies proximately 14.13 sq. km., Pediments span 210.93 sq. km. and Pediplains cover a significant area (313.05 sq. km.)

KEYWORDS: Geomorphological Mapping, Land Resource Assessment, GIS & Remote sensing, Dhar District.

Introduction

Bagh village is located in the southwestern part of Dhar district, Madhya Pradesh, India. The district encompasses three distinct physiographic divisions: the Malwa plateau in the north, the Vindhyachal range in the central zone and the Narmada valley along the southern boundary. The Narmada valley covers a major portion of the study area, while the Vindhyachal range appears as disconnected patches, separated by the valleys of the Hatini River. The northern part of the study area, corresponding to the Malwa plateau, is characterized by relatively higher elevations, with an average elevation of around 563 meters above mean sea level. This region comprises flat and elevated terrain, contributing to its topographic diversity. As we move towards the southern part of the district, along the Narmada valley, the elevation gradually decreases. The average elevation in this area is approximately 149 meters, indicating a relatively low-lying landscape.

The geomorphological map serves as a fundamental resource for land use planning. It helps in understanding the spatial patterns of landforms such as valleys, plateaus, hills and river systems. This knowledge is inevitable for effective land management and decision-making regarding infrastructural development, agriculture, natural resource utilization and conservation efforts. By incorporating the Principles of geomorphology can be applied into land use planning, the unique characteristics and

constraints of the terrain can be considered, leading to sustainable and optimized land use practices in Bagh village and its surrounding areas ([2], [7], [8], [15], [17], [18]).

Aim and Objectives

The aim of this work is to achieve two primary objectives. Firstly, it aims to identify and delineate the geomorphic features present in the study area, using a detailed examination of satellite images, taking into account the local geology, topography, structures and field visits. This involves identification of landforms such as valleys, hills, plateaus and river systems and mapping them accurately. Secondly, the study aims at assessing the relationship between the existing geomorphic features and the local land use patterns. By examining how the landforms influence the distribution and types of land use activities in the area, valuable knowledge can be gained. This analysis helps understand the influence of geomorphology on land use decisions and the interplay between natural landforms and human activities. The findings of this study will serve as a valuable asset to the local community and developers engaged in the region for land use planning and developmental purposes. The geomorphic information and its relationship with land use patterns will provide a reasonable foundation for effective land management and decision-making. This knowledge can guide for sustainable development practices, optimize land use choices and minimize potential risks associated with inappropriate land use decisions. Overall, this work will contribute to the understanding of the geomorphological aspects of the study area and its implications on land use planning, providing valuable insights for both local stakeholders and developers involved in the region's development.

Study Area

The study area falls within the longitude 22°3'44" N to 22°34'23" N and latitude 74°33'19" E to 74°56'57" E. on the Survey of India Topographic sheets No. 46J/11 and 46J/15 it covers approximately 855 sq. km. area to locate in the south western part of Dhar District and bounded by Alirajjpur district.

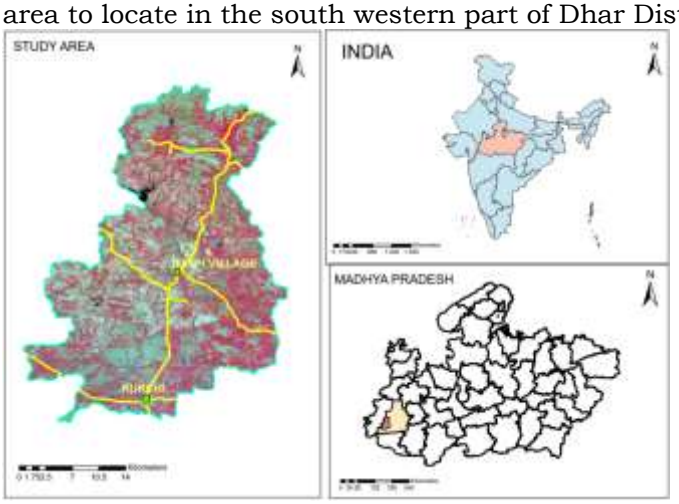

Fig. 1. Location map of the Study Area

Data used

In the generation of the geomorphological map, following data sources and tools have been utilized.

SOI Toposheets: Survey of India (SOI) toposheets have been used as a base reference for the study area. These toposheets provide detailed information about the topography, contours and other features present in the region.

DEM (SRTM, 30M): Digital Elevation Model (DEM) data from the Shuttle Radar Topography Mission (SRTM) with a spatial resolution of 30 meters has been utilized. This data provide elevation information in the study area, allowing for the visualization and analysis of the landforms.

IRS P6 LISS III data: Indian Remote Sensing (IRS) satellite, specifically the LISS III sensor, has been used to acquire satellite imagery. The imagery was obtained from the USGS Global Visualization Viewer, specifically for the date of 11th February 2019. LISS III provides multispectral data that can be used for various analyses, including land cover classification and interpretation of landforms.

The acquired LISS III imagery has a resolution of 23.5 meters and a swath of 141 kilometers. This high-resolution imagery has been utilized for mapping purposes, specifically at a scale of 1:50,000. The imagery was processed and analyzed using GIS software, specifically version 10.3.

By integrating these data sources and utilizing GIS software, a geomorphological map has been generated. This map displays various landforms

Table 1. Data used for the geomorphological mapping.

Serial No.	Toposheets No./ Satellite data	Scale/Resolution	Source	Year of Publication
1	46J/11, 46J/12, 46J/14, 46J/15, 46J/16.	1:50000	Survey of India	1974
2	IRS_LISS-III	Geocoded, 24 m	Bhuvan	11 feb 2019
3	SRTM	Geocoded, 30 m	https://earthexplorer.usgs.gov	September 24, 2014

such as valleys, plateaus and hills, derived from the analysis of the satellite imagery, DEM data and other available information. The map provides a visual representation of the geomorphic units and can serve as a valuable resource for land use planning and development in the study area.

Database and Methodology

The geomorphic features in the study area have been mapped using the visual interpretation technique on the IRS P6 (Resource sat) LISS III image. Standard visual interpretation elements such as color, tone, texture, pattern, shape and association were employed to interpret the geomorphic units present in the image. Ground truth verification was conducted by comparing the interpreted features with on-site verification. The methodology for generating the geomorphic map has been illustrated in Figure 2. besides, the area of each geomorphic unit has been calculated to provide quantitative information about their extent. This approach enables a comprehensive understanding of the study area's geomorphology and helps in land use planning.

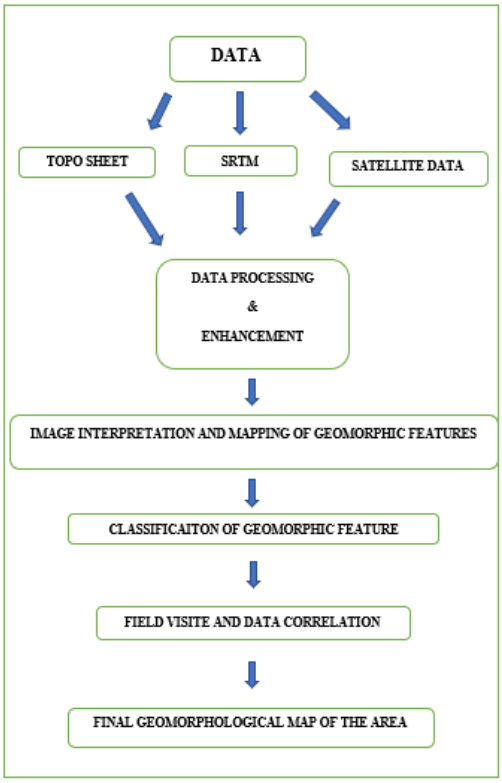

Fig. 2 Flow chart for geomorphological analysis

Geomorphological analysis

The geomorphic units are classified into two broad categories i.e. denudational and structural units identified through visual interpretation. The results of the geomorphological mapping have brought out the

presence of different type of geomorphic units and landforms in the area which have been classified as per their origin and shown in Fig. 4 and listed in table 2.

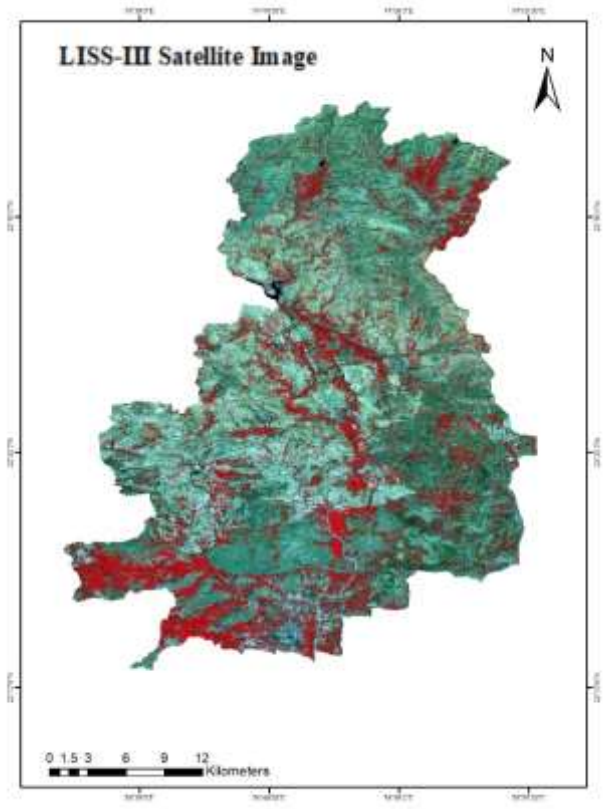

Fig. 3 Satellite image of the study area

Characteristics of Geomorphic features

In the present study, following geomorphic units have been identified the satellite imagery with the help of Survey of India Toposheets (Table 1). The Geomorphological units have been interpreted using the LISS-III imagery with the help of the image interpretation keys like tone, texture, pattern and association after processing the imagery.

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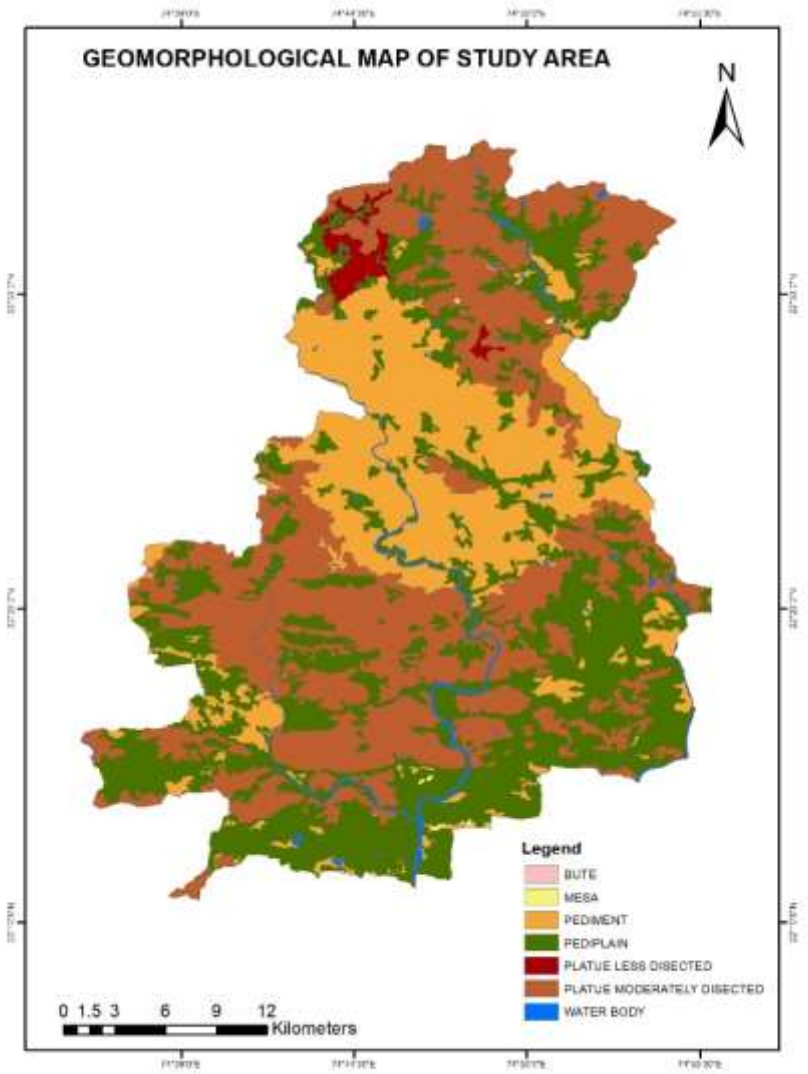

Fig 4. Geomorphology of the study area

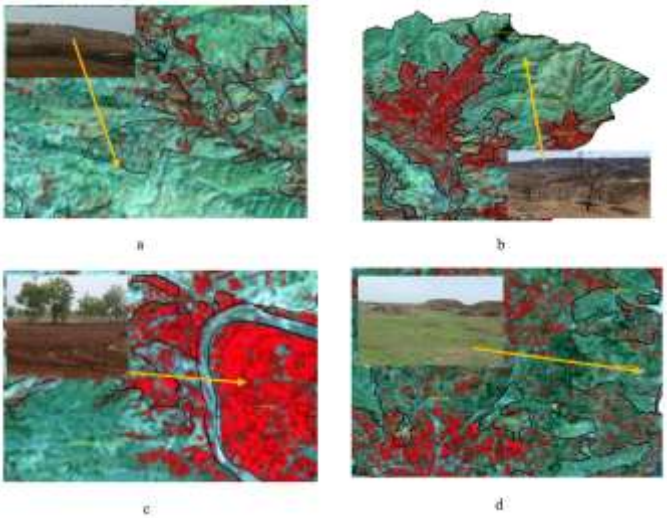

Fig. 5. Field Photographs of the study area a. Plateau, b. plateau (moderately dissected), c. Pediplain d. Pediment.

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Denudational units

Geomorphic Units	Geomorphic Features
Denudational Origin	Butte
	Mesa
	Pediments
	Pediplains
Structural Origin	Plateau (Moderately dissected)
	Plateau (Less dissected)

Denudational landforms are present mainly in the sedimentary rocks. This type of units is formed by the combined effect of weathering, erosion and
transportation. Denudational landforms are in the form of pediment, pediplain, mesa and butte. They are identified by the relatively high terrain and further confirmed by the SOI toposheets, DEM and field check. Denudational landforms, occupying south and central portion of the study area, cover about 524.93 sq. km. (Fig. 4 and Table 4). The denudational units may be categorized as follows:

Butte: It is an isolated, generally flat-topped hill or small mountain with steep slopes or cliffs. Buttes are often capped with a resistant layer of rock and surrounded by talus. They represent remnants of erosion carved from flat-lying rocks. Buttes, in the study area, exhibit a smooth texture and appear light brown and green in tone on satellite images.

Table 2. Geomorphic Units of the study area.

Mesa: A mesa is an isolated, nearly level land mass that stands distinctively above the surrounding terrain. It is characterized by abrupt or steep erosion scarps on all sides and is capped by layers of resistant, nearly horizontal rocks. Mesas, too in the study area, show a smooth texture and light brown and green tones on satellite images.

Pediments: Pediments are gentle sloping erosional surfaces that develop at the foot of receding hill or mountain slopes. They often have a slightly concave-upward profile and cut across underlying rock or sediment layers. In the study area, a pediment is noticeable in the central part (fig.4 and 5d). Pediments occupy about 24% of the total area.

Pediplaines: Pediplaines are a series of coalescing pediments and the term was first proposed by Anderson et al. (1976). They are extensive in low-lying areas associated with hills and pediments. Pediplaines covered with a thick overburden are referred to as buried plains. These landforms are identified in the study area based on their smooth texture, thick vegetation, square shape due to agriculture activities, large aerial extent and the thickness of weathered zones. Pediplaines cover 35% of the total area and are primarily found in sedimentary and basaltic rock areas (fig.4 and 5c).

Thus, it is evident that the study area exhibits a variety of landforms, showcasing the geological diversity and erosional processes that have shaped the landscape.

Structural Landforms

These landforms develop due to tectonic movements and modified later on by erosion. The landforms of this category are observed in the region where Bagh sediments are present. They are located in the northern and western part of the study area having greenish and reddish tone with rough texture on the satellite image (Fig. 3). The area covered is approximately the 345.94 sq. km. (Table 4). The structural landforms are

present in the southern part of the area. Some of the structural landforms observed in the area are as under:

Geomorphic Landform	Tone	Texture	Patterns	Land use/ Land Cover	Relief	Association
Butte	Light yellowish	Smooth due to flat top	Nearly circular but sometimes elliptical	Sparse bushes	high	Plateaus
Mesa	Light red	Smooth	Regular and circular with table top	Scrub, shrubs and forest	High	Structural plateaus and Homocline
Pediment	Light brown	Coarse and uneven	Gentle slop	Dry cultivation at lower part	Low	Plateaus and pediments

Plateau is comparatively a flat area of great extent and elevation.it is an elevated land region (more than 100 meters) above adjacent low-lying terrain and is commonly limited on at least one side by an abrupt descent it has a flat or nearly flat top. A comparatively large part of a plateau surface is near summit level (fig. 5a).

Plateau dissection refers to the process by which valleys, ravines, or other forms of erosion cut through the surface of a plateau, creating a more intricate and complex topography. Dissection occurs when external forces such as rivers, glaciers or weathering, gradually erode and remove material from the plateau, forming channels and valleys that intersect and divide the previously flat or nearly level surface. The dissection of a plateau is typically influenced by several factors including the type and resistance of the underlying rock layers, the erosive power of water or ice and the tectonic activity of the region. Over the time, these factors shape the landscape and contribute to the formation of distinct landforms within the plateau region.

In the study area, there are two types of plateau which are either less dissected or moderately dissected and a large part of the study area is covered with this landform about 40% (Fig. 4).

Table 3: Characteristics of Geomorphic Landforms

Pediplain	Reddish due to cultivation grey without cultivation	Fine and uneven	Rectangular field patterns	Intensive cultivation	Low	Residual hills, butte, pediments
Plateau (less dissected)	Light brown to light green	Moderate to smooth	Irregular	Agriculture, forest, waste lands	Moderate	Plateaus
Plateau (moderately dissected)	Light brown to light green	Moderate	Irregular	Agriculture, forest, waste lands	Moderate to low	Plateaus

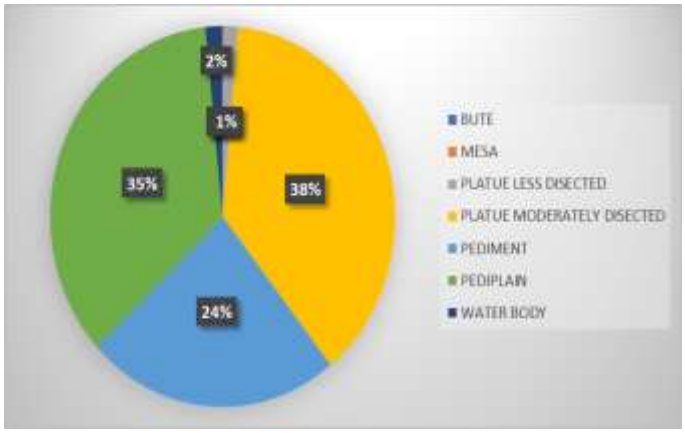

Fig. 6. Pie chart representing distribution of Landforms

Result and discussion

Geomorphology is the science and study of landforms on the earth. Both the disciplines are exhaustively covered in literature [3]. Today all land use planning processes in most of the countries are based on geomorphological units [5]. The detailed geomorphological mapping of the area reveals the presence of various landforms. They are mostly formed due to denudational, depositional and structural processes. Butte, Mesa, Pediments, Pedi plains and Plateaus (moderately and less dissected) present in the study area are shown in Fig. 4 and Table 2. These geomorphic units are shown in Pie diagram (fig. 6).

Conclusion

Using LISS III imagery and image interpretation keys such as tone, texture, pattern and association in GIS, remote sensing software, various geomorphic units have been identified. These include structural landforms in the northern and southern parts, pediments along the central portion, pediplains in the southern region of the map. This mapping of geomorphic units provides a valuable information for the future land use. With this knowledge, local and government authorities

can take decisions regarding suitable land use for human activities. The use of remote sensing and

GIS technology, in accurately identifying and mapping these geomorphic units, plays a a significant and reliable role in facilitating effective land use planning and management.

Table 4. Area of Geomorphic features covered in study area

This study is useful for various applications such as groundwater exploration, land use planning, disaster management and geoengineering. In addition, this study will help in geomorphological mapping in near future. In the study area, Butte occupies 0.12 sq. km., Mesa covers 0.83 sq. km., Plateau (less dissected present) occupies 11.93sq. km., Plateau (Moderately dissected) 334.02 sq. km. the water bodies occupy approximate 14.13 sq. kms. They are also useful for plantation, forestation and for fodder. Pediments

occupy 210.93 sq. km. area, this is important for plantation, industrialization, built-up, forestation and

S.N.	Origin	Geomorphic Feature	Area (in sq. km.)	Area (in %)	Total Area
1	Denudational Landforms	BUTE	0.12	0.01	524.93 sq. km.
2		MESA	0.83	0.09	
3		PEDIMENT	210.93	23.82	
4		PEDIPLAIN	313.05	35.35	
5	Structural Landforms	PLATUE LESS DISECTED	11.93	1.35	345.94 sq. km.
6		PLATUE MODERATELY DISECTED	334.02	37.77	
9		WATER BODY	14.13	1.60	14.13 sq. km.
Total Area			885.00	100.00	885.00 sq. km.

fodder. Pediplains cover 313.05 sq. km. area. It is useful for agriculture, horticulture any type of built-ups, lakes, ponds, canal, railway lines, roads and forestation. Because it is covered with thick soil. It is also useful for natural hazard assessment.

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