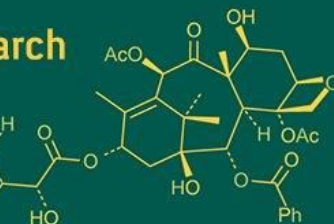
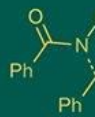


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Nainsi Naya
Scientist, Department of Soil
Science, IGKV, Raipur,
Chhattisgarh, India

Dr. Gaya Prasad Ayam
Scientist, Department of Soil
Science, IGKV, Raipur,
Chhattisgarh, India

Dr. Rakesh Banwasi
Senior Scientist, Department
of Soil Science, IGKV, Raipur,
Chhattisgarh, India

Ashish Kumar Chandrakar
Assistant Director Agriculture,
Balod, Chhattisgarh, India

Dr. Vedhika Sahu
Assistant Professor,
Department of Soil Science,
Saja, Bemetara, Chhattisgarh,
India

Parmanand Verma
Ph.D. Scholar, Department of
Soil Science, IGKV, Raipur,
Chhattisgarh, India

Geospatial characterization of Chhattisgarh plains landforms using ALOS-DEM data

Nainsi Naya, Dr. Gaya Prasad Ayam, Dr. Rakesh Banwasi, Ashish Kumar Chandrakar, Dr. Vedhika Sahu and Parmanand Verma

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Abstract

The characterization of landforms is crucial for understanding geological processes, environmental management, and regional planning. This study uses high-resolution Advanced Land Observing Satellite Digital Elevation Model (ALOS-DEM) data to analyze and characterize the landforms NGWDP-1 watershed in Balod district of Chhattisgarh". To achieve the objectives of the study, free available open source high resolution satellite data viz. 12.5 m ALOS-DEM were utilized. The terrain variables considered in this study were elevation (Meters above mean sea level), slope (Percentage), hill shade/relief, and contour lines at 15-meter intervals. To develop the landform map, contour lines generated at various elevation levels were overlaid on the image, identifying four major landform units namely upper plains, lower plains, alluvial plains, and flood plains. The results reveal the spatial distribution of landforms and highlight the utility of ALOS-DEM data in regional landform analysis.

Keywords: Chhattisgarh plains, ALOS-DEM, landform characterization, GIS, remote sensing, NGWDP-1

Introduction

Landforms play a crucial role in influencing various natural and human factors, including hydrology, soil distribution, vegetation patterns, and human settlement. The Chhattisgarh Plains, located in central India, are a significant geographical area exhibiting diverse landforms created by complex geological and geomorphological processes. Characterizing these landforms is vital for sustainable development and resource management in the region.

The advent of remote sensing technology and digital elevation models (DEMs) has significantly advanced the study of landforms by providing high-resolution, three-dimensional representations of the Earth's surface. The Advanced Land Observing Satellite (ALOS) provides high-resolution DEM data that is invaluable for detailed geomorphological studies. This study aims to characterize the landforms of the Chhattisgarh Plains using high-resolution ALOS-DEM data. New generation watershed development programme aims at improving the ground water status of the project area and development of the project area as a whole. By employing advanced geomorphometric techniques and Geographic Information System (GIS) tools, this research seeks to map and analyze the spatial distribution of various landform features and providing valuable information for land-use planning, agricultural development, and environmental conservation.

Material and Methods

Study area

Study area covers a new generation watershed development project designated as "NGWDP-1" is situated between 20°44'19.19" to 20°50'23.89" N latitude to 81°27'53.58" to 81°32'21.18" E longitude with an altitude range of 334 m to 341 m above MSL in Gurur block of Balod district and some part of the study area falls in the Dhamtari district of Chhattisgarh state. The study area of selected watershed has an area about 3856.04 ha. The study area covers villages namely Devkot, Sangali, Sanaud, Bohara, Palari in Balod district and some part of Parastarai and Potiyadih villages in Dhamtari district. Rice is the major crop of the study area. Other important crops are wheat, gram, sugarcane and lathyrus.

Corresponding Author:
Nainsi Naya
Scientist, Department of Soil
Science, IGKV, Raipur,
Chhattisgarh, India

In some areas, double cropping is also practiced where most of them are small farmers with fragmented land holdings (Figure 1).

Data and Methodology

Data Collection

The primary data source for this study is the ALOS-DEM, which provides high-resolution elevation data with a spatial

resolution of 12.5 meters. The ALOS-DEM data was obtained from the Copernicus Open Access Hub-<https://scihub.copernicus.eu/dhus/#/home>, and an open source 3-D view ALOS-DEM downloaded from USGS earth explorer (<https://earthexplorer.usgs.gov/>) and pre-processed using ArcGIS 10.4.1 software to ensure accuracy and consistency (Figure 2).

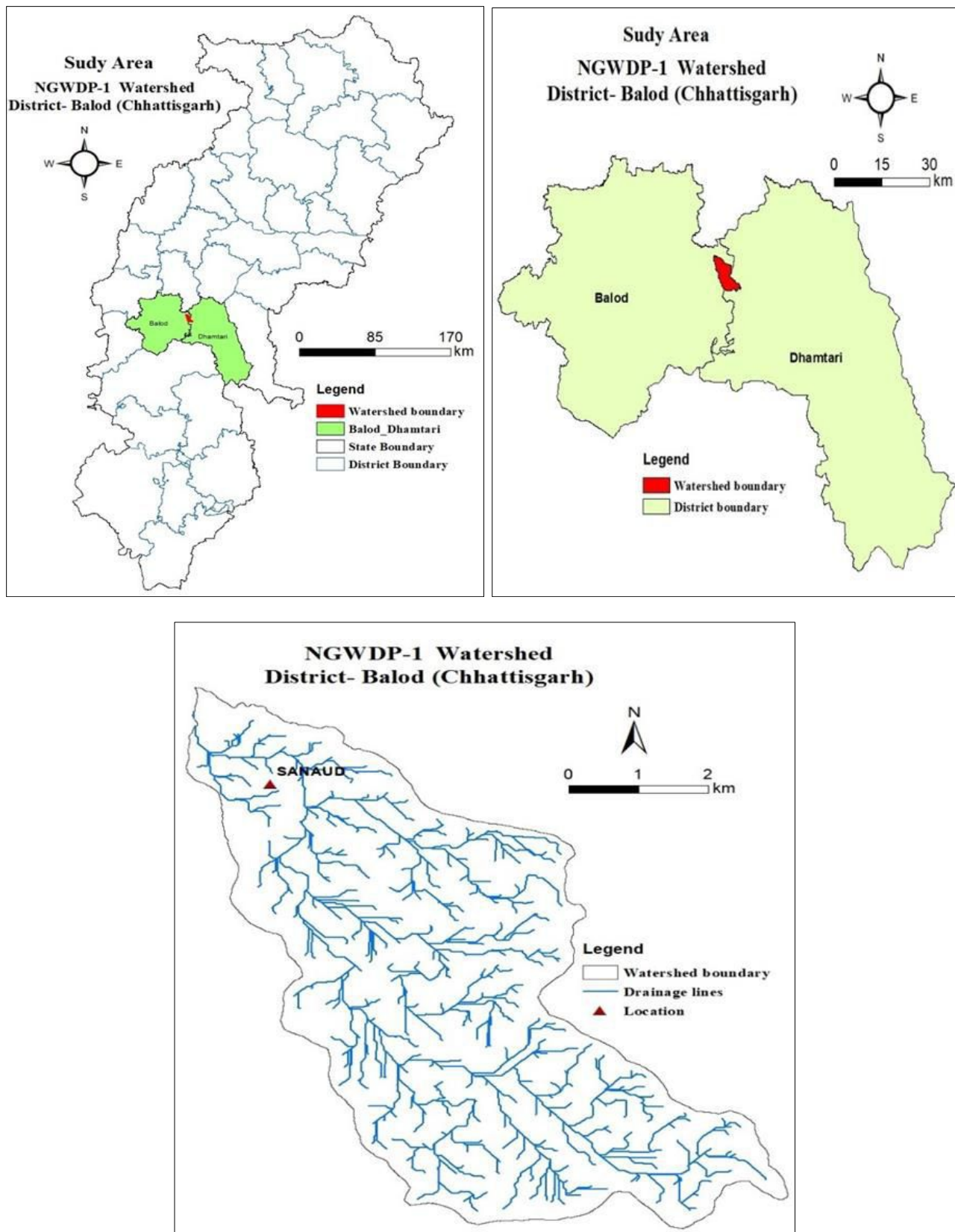


Fig 1: Location of study area NGWDP-1 Watershed

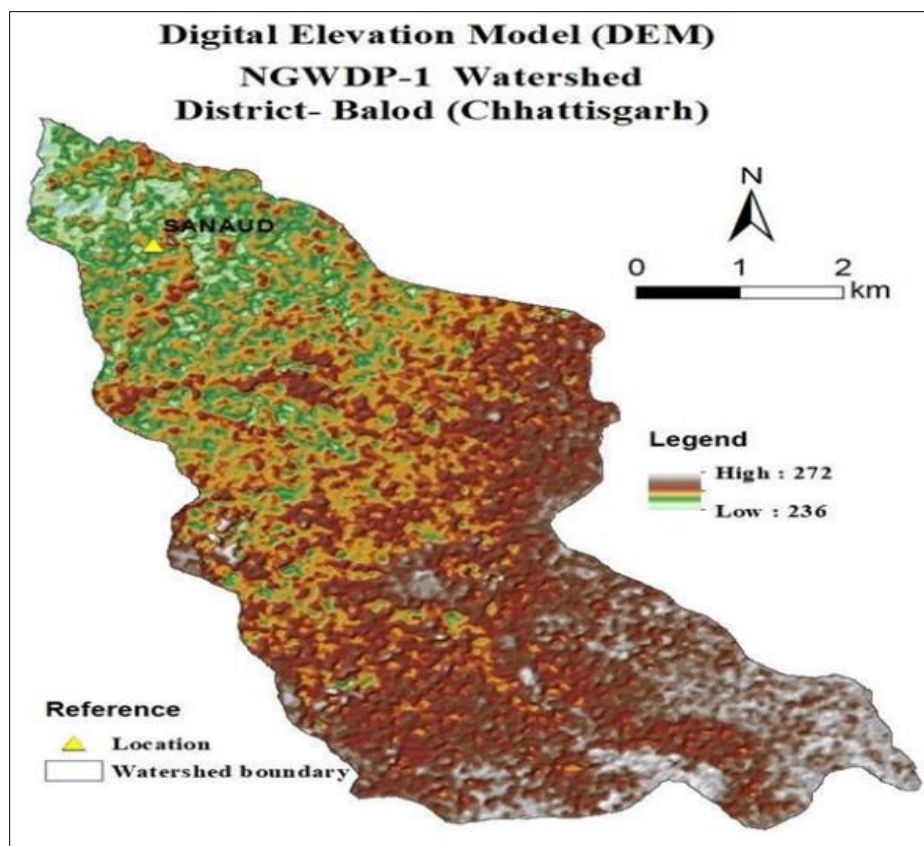


Fig 2: Digital elevation model (DEM) of the watershed

Methodology

The methodology for characterizing landforms involved several steps.

Slope and Aspect Analysis

Slope and aspect are fundamental geomorphometric parameters that describe the inclination and orientation of the land surface. These parameters were calculated using GIS tools, providing insights into the topographic variability of the watershed areas.

- 1. Slope Calculation:** The slope was derived using the first derivative of elevation, highlighting areas of steep and gentle terrain.
- 2. Aspect Calculation:** The aspect was determined to understand the directional exposure of slopes, influencing microclimates and vegetation patterns.

Terrain Classification

The terrain was classified into different landform categories based on slope, elevation.

Drainage Network Extraction ^[12]

The drainage network was extracted using hydrological analysis techniques to understand the flow of water and its impact on landform development.

Results and Discussions

Slope

The different slope categories were derived using ALOS-DEM within the study area, covering a total geographical area (TGA) of 3,856.04 hectares (Table 1). The largest portion, comprising 2,993.29 hectares or 77.6% of the TGA, falls under the Very Gently Sloping (1-3%) class, characterized by mostly flat terrain that is ideal for

agriculture and other land uses requiring minimal elevation change. The Gently Sloping (3-5%) class occupies 279.38 hectares, accounting for 7.2% of the TGA, and offers better drainage but requires careful management to prevent erosion. Water bodies, such as lakes and rivers, cover 52.62 hectares or 1.4% of the TGA, playing a vital role in local biodiversity and the hydrological cycle, while also supporting irrigation and other water-dependent activities. Habitation areas, encompassing 530.75 hectares or 13.8% of the TGA, include residential, commercial, and industrial zones, highlighting areas of urban development and population concentration. This comprehensive analysis of slope classes aids in understanding the geomorphological characteristics of the region, which is crucial for effective land use planning and resource management (Figure 3).

Table 1: Extent and distribution of slope classes

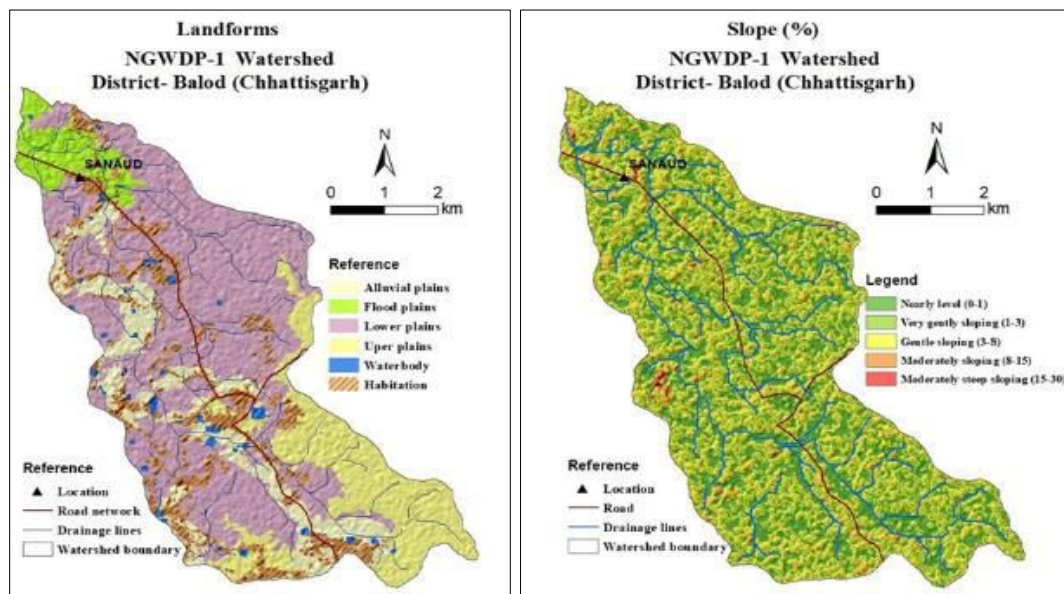
S. No.	Slope classes	Area (ha)	% TGA
1	Very gently sloping (1-3%)	2993.29	77.6
2	Gently sloping (3-5%)	279.38	7.2
3	Water body	52.62	1.4
4	Habitation	530.75	13.8
	Total	3856.04	100.0

Landform delineation and characterization

In Table 2 Based on the contour lines at different elevations provides an insightful analysis of the geographical layout within the study area and representing different landform units of upper plains, lower plains, alluvial plains and flood plains which encompasses a total of 3,856.04 hectares. The largest portion of the land is classified as lower plains, covering 1,891.55 hectares and constituting 49.1% of the total geographical area (TGA).

Table 2: Extent and distribution of various landform units

S. No.	Landform unit	Area (in ha)	% TGA
1	Upper Plains	675.65	17.5
2	Lower Plains	1891.55	49.1
3	Alluvial Plains	486.30	12.6
4	Flood plains	219.17	5.7
5	Water body	52.62	1.4
6	Habitation	530.75	13.8
	Total	3856.04	100.0

**Fig 3:** Landforms and slope maps of the watershed

This extensive region is characterized by its relatively flat terrain, making it suitable for agriculture and settlements due to its accessibility and fertility. The upper plains are the second largest landform unit, occupying 675.65 hectares or 17.5% of the TGA, known for slightly elevated terrains that might offer moderate agricultural benefits and drainage. The alluvial plains which cover 486.30 hectares and account for 12.6% of the TGA, are significant for their fertile soils deposited by river systems, making them ideal for agriculture and supporting a variety of crops. The Flood Plains making up 219.17 hectares or 5.7% of the TGA, are areas that are periodically inundated by nearby water bodies, playing a crucial role in replenishing soil nutrients but also posing challenges due to flood risks. This distribution highlights the spatial dynamics of urbanization and land use planning. The analysis of these landform units is vital for understanding the geomorphological and ecological characteristics of the region, thereby facilitating informed decisions in land use planning and sustainable development.

Conclusion

This study successfully characterized the landforms of the NGWDP-1 watershed using high-resolution ALOS-DEM data. Four landform units *viz.* upper plains, lower plains, alluvial plains and flood plains representing 17.5, 49.1, 12.6 and 5.7 per cent of (3856.04 ha) of the watershed, respectively were delineated using ALOS-DEM (digital elevation model) on 1:10000 scale. The DEM were further used to delineate two slope classes namely very gently sloping (1-3%) and gently sloping (3-5%) occupying an area of about 2993.29 and 279.38 ha, respectively. The analysis revealed diverse geomorphological features and highlighted the utility of remote sensing data in regional landform

studies. The findings provide a foundation for further research and practical applications in environmental management and regional planning.

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