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Remote Sensing and GIS-Based Geomorphological Mapping: A Case Study of Achanakmar- Amarkantak Biosphere Reserve, Central India

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Abstract-Geomorphological maps report the erosion and depositional relief landforms, including submarine ones, highlighting the morphographic and morphometric characters and interpreting the endogenous and exogenous morphological processes, both past or present, that produce and shape the topographic relief. In this paper a comprehensive and flexible new geomorphological combination legend that expands the possibilities of current geomorphological mapping concepts. This results in a scientific map that is rich in data and which is more informative than most previous maps but is based on a simple legend. The system is developed to also be used as a basis for applications in GIS. The symbol-based information in the geomorphological maps can be digitally stored as a powerful database with thematic layers and attribute tables. This paper demonstrates a systematic approach for the identification of landforms and structures in Achanakmar Amarkantak Biosphere Reserve where conventional field based methods are difficult to adopt due to terrain inaccessibility. The geomorphological parameters of the study area using Multispectral Satellite Data (Landsat TM) and interpretation techniques were used by means of ARC-GIS 9.3 and ERDAS IMAGINE 9.1 Software which aided a better option for visualizing the terrain and mapping.

Index Terms- Geomorphological mapping, Remote sensing, GIS, Biosphere reserve.

1. INTRODUCTION

Geomorphological mapping is a preliminary tool for land management and geomorphological risk management, also providing baseline data for other sectors of environmental research such as landscape ecology, forestry or soil science. The science that deals with surface features of the earth, their forms, nature, their origin and development is termed as geomorphology. DAVIS (1912) first projected the concept of geomorphic cycle. According to bauling (1950), the role of factors that are important the geomorphology are lithology, stratigraphy, climatic variation and the regional basis for the development of land forms. Roy and Jugran (1986) have reported the mapping of geology and geomorphology using Landsat TM and MSS analog data in Kanha National Park, Madhya Pradesh. The IRS-1B LISS II & LISS III data haas been used for geomorphological mapping by Tripathi, et al(1996) and Karwariya, et al (2013).

Geomorphology has long been treated as a subject with landform identification by field investigation. Each of these investigations was focused on landform characterization leading to the process understanding. After more than a hundred years as a recognized discipline, landform characterization through field investigation remains central to many geomorphological studies until recent. Now, new trends have emerged that integrate field work with modern technologies such as GIS, GPS, remote sensing and elevation models, which further strengthens the study of relationship between the land-forms and the processes that created them. Over the years, scientists have conducted research and shown the usefulness of spatial technologies, remote sensing and field studies in landform mapping and understanding of geomorphic processes. Satellite imageries have been used for geomorphological mapping of large and remote areas along with field study and aerial photographs. However, while aerial photographs are of restricted nature in many countries, field investigations are labour intensive.

In this paper the geomorphological map of the Achanakmar-Amarkanatak Biosphere Reserve, (Central India) is presented. The map is the result of the interaction of different datasets, both traditional and innovative in geomorphology. Aerial photos and field survey are enhanced by DEMs and satellite images to achieve a digital final product that is not only a simple thematic map, but also an interactive

and upgradable Geographical Database. The geomorphological processes producing the present landscape are therefore better visible and understandable through the use of new tools.

2. STUDY AREA

The Achanakmar Amarkantak biosphere reserve lies between lat. 22° 15' N to 22° 58' N and long. 81° 25' E to 82° 5' E, having an area 3835.51 sq. km, partly falling in Madhya Pradesh and partly in Chhattisgarh state. The area falls in almost northern part of Biogeographic zone of 6 and Biogeographic province 6a (Deccan peninsula, central highlands). Out of the total area, (68.10%) lies in Bilaspur district followed by Anuppur (16.20%) and Dindori (15.70%).The protected area, Achanakmar Sanctuary (AWLS) is located in Bilaspur district, within the area of the Biosphere Reserve. The sanctuary has a total geographical area of 551.15 sq. km.

Presently the Achanakmar-Amarkantak biosphere reserve has been divided into core and buffer zones area only. The entire area of 551.15 sq. km of Achanakmar sanctuary has been designated as core zone and remaining area of 3284.36 sq. km serves as buffer zone. Out of this an area of 1224.98 sq. km. falls in Madhya Pradesh and the rest of the area of 2059.38 sq. km. fall in Chhattisgarh state. Fig - 1shown the details of the study area.

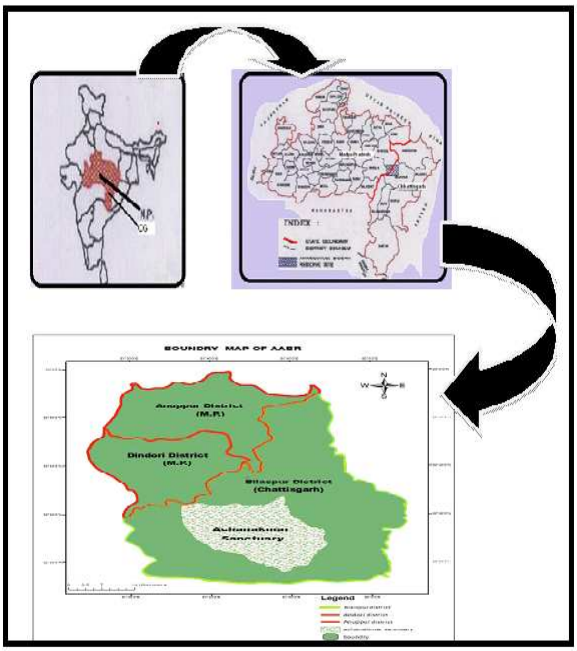


Figure 1. Location Map of study area.

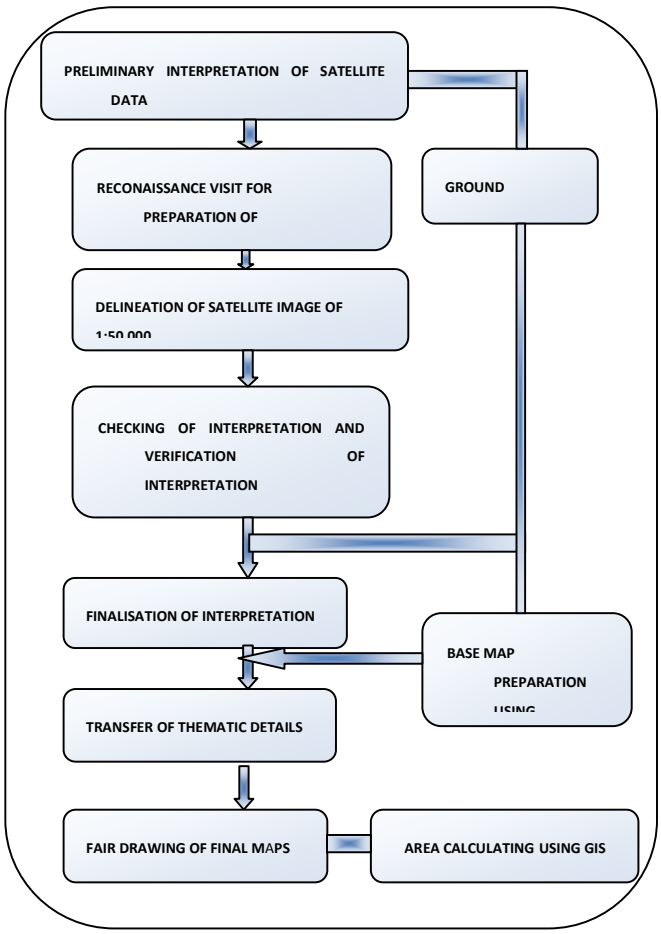
3. MATERIALS AND METHODS

Landsat TM satellite data has been downloaded from the website www.glovis.usgs.gov, which have swath width 185*185 sq. km. with a ground resolution of 30 .The satellite data of study area has been imported into ERDAS IMAGINE 9.1 in (img.) format for geometric correction. Images have been co-registered with already rectified Landsat TM satellite data to accuracy below root mean square error (RMSE) 0.2 precision. Apart from the space-based data, ancillary data such as Topographic map on 1:50,000 scale with a 20 m contour interval and District Resource Map (GSI) on 1:250,000 were also used in this study. Contours were also generated from Topographic sheets 64F/5, 64F/6, 64F/7, 64F/9, 64F/10, 64F/11, 64F/13, 64F/14, 64F/15, 64J/1, 64J/2, and 64J/3.

4. METHODOLOGY

The study work will be carried out systematically in the following

- Satellite data interpretation.
- Ground trusting for mapping and other detail.
- Base map preparation through topographic map.
- Incorporation of other thematic detail through topographic map for final map preparation
- Information transfer to base map.
- Field investigation and correction.
- Preparation of land use map/land cover map.
- Preparation of vegetation map through satellite image.
- Preparation of geomorphology map on 1:50,000 scales through satellite image and some other detail incorporate through SOI toposheet.
- Analysis using GIS. The details of methodology are given in Flow chart 1.



Flow Chart 1. Details of Methodology

5. DIGITAL ELEVATION MODEL (DEM)

A DEM is a digital model or 3D representation of a terrain's surface represent as a raster. DEMs are commonly built using data collected using remote sensing techniques, but they may also be built from land surveying. DEMs are used often in geographic information systems, and are the most common basis for digitally-produced relief maps. To generate a DEM, a 20 m interval was used .In ARCMap, and ERDAS, GIS domain using top grid module a hydrolgically correct grid of elevation from line and polygon coverage was generated. In this, contour data was used to generate a generalized morphology of the surface based on the curvature of the contours and also used as a source of elevation information. They are powerful ways of adding additional topographic information. The interpolated lower to higher values is shown in fig 2 and table 1 shown the areal estimation of Dem.

Table 1. Areal estimation of dem in the study area

Contour (meter)	Area in sq. km	Percentage (%)
288-400	827.75	21.56
400-600	1133.64	29.56
600-800	870.34	22.69
800-1000	785.05	20.47
1000-1140	219.38	5.72
Total	**3835.51**	**100**

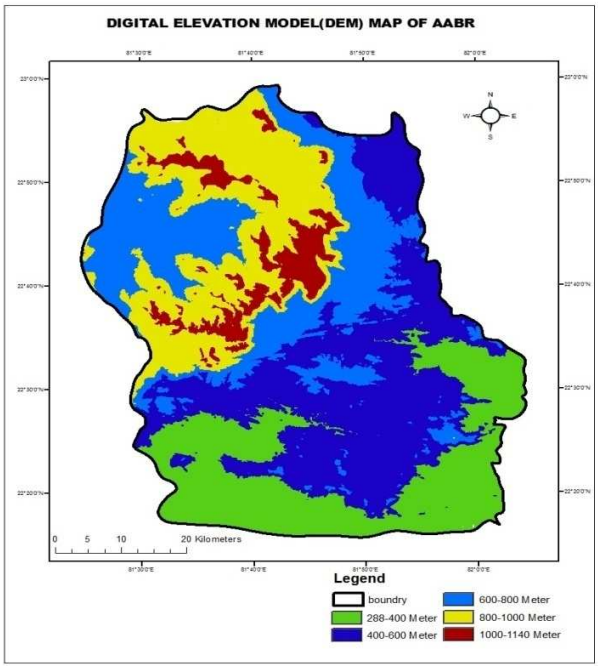


Fig 2. Shown topography variation in Biosphere Reserve

6. RESULT AND DISCUSSION

Geomorphology was an important aspect which guides immensely in urban planning. Mapping of geomorphology not only gives an idea about the variations in landscape but also indirectly facilitates in evaluating the resources of an area. Present study shows the capability of satellite data in delineating major geomorphological units in Biosphere Reserve. It has also been observed that geomorphological maps along with other relevant terrain-related information. Geomorphic units are given.

I- HIGH LEVEL PLATEAU

The high level plateau is identified over high land above 900m elevation from mean sea level. The plateau is un dissected in nature and covered with forest. This geomorphic unit covers 425 sq km or 11.08 % of the total area of the study region. The main high relief features of the area are the Maikal Range and Maikal Plateau (Amarkantak Plateau) in south-east part of the M.P. district covered with Deccan Trap Basalts. Some denudational hills/ hillocks are at foot hills of Rajendragram plateau. Linear ridges of intrusive (Dolerites) at northern and north-eastern part.

II- MIDDLE LEVEL PLATEAU

The middle level plateau is characterized as 500m to 900m elevation above mean sea level. The central alluvial plain comes under middle level plateau is fluvial deposition covers a total area of 870 sq km which is 22.68 % of the total area of the study region. This depositional plain is formed by the alluvium brought down by the Narmada and its tributaries that rise over the Maikal hills and flow down the steep slopes of these highlands. Some of the highland is chemically weathered into laterite. The basaltic lava flow is converted into iron rich laterite cover due to prolonged weathering, shows reddish to brown colour shed.

III- DENUDATIONAL HILLS ON DECCAN TRAPS

The denudational hills on Deccan traps comprise of the Maikal highlands in south, south-western and eastern part of the study region. The dominant processes operating within this region are fluvial as well as tectonic in origin. The geomorphic unit covers 251.1 sq km or 6.55 % of the total area of the study region. It is formed due to differential erosion and weathering, so that a more resistant formation or intrusion stand as mountains/ hills. It is associated with fractures/joints and lineaments.

IV- METAMORPHIC ROCK

Metamorphic rocks are recycled rocks that have been subjected to varying degrees of pressure and temperature. As a result of all this extreme heating and pressure, old minerals become unstable and new ones begin to form. Mostly Achanakmar sanctuary covers the metamorphic rocks in AABR. These were occupying an area of approximately 911 sq km or 23.75 % of the total area. Metamorphic rocks also weather slowly because of their hardness.

V- PEDIPLAIN / PEDIMENT

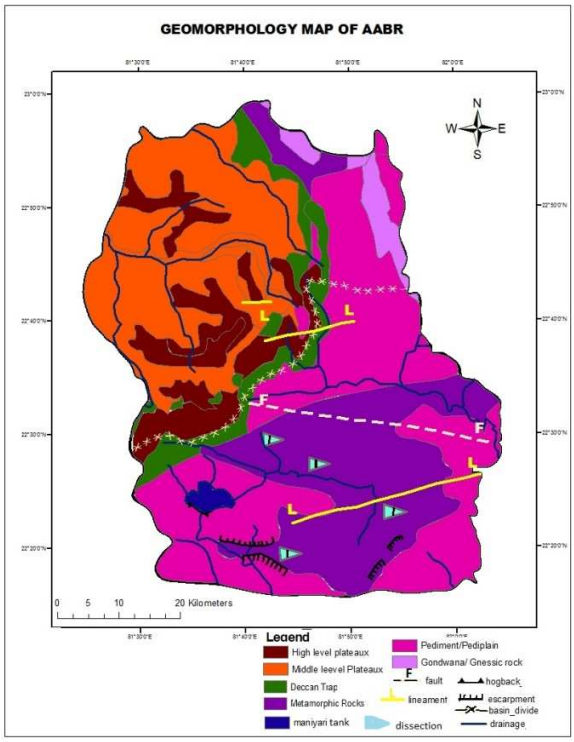
The Pediplain comprises in Amarkantak which is the origin place of the Narmada. It covers 1290 sq km or 33.63 % of the total area in extremely eastern portion of the study area. Pediplain / Pediment area also covering north and central part of the Bilaspur district in AABR (covering Lormi, Kota, Gaurela, and Pendra Blocks). It is resultant product of polycyclic erosional and depositional processes. It is concealed and covered under thin soil cover. Basically the hill ranges on northern part are due to structural activities and the area on Southern part (Chhattisgarh plain) can be categorized as Pediplain. The portion of a plain adjacent to mountain slopes is known as a piedmont.

VI- GONDWANAS ROCK

The Talchir formation of lower Gondwanas group, comprising of well sorted sandstone, olive green shales and basal conglomerates are forming poor aquifer in the area. These formations are occurring southwards of Anuppur town and a big belt found in a Pendra road to venketnagar along with rail line in Bilaspur district In AABR. A total area comprises approximately 91.50 sq km or 2.39 % of the total area of biosphere.

Table 2 . Geomorphic unit area in biosphere reserve.

Geomorphic Units	**Area(sq.km)**	**Percentage (%)**
High level plateau	425.00	11.08
Middle level Plateau	870.00	22.68
Denudational Hills on Deccan Traps	251.10	6.55
Metamorphic Rock	911.00	23.75
Pediplain / Pediment	1290.00	33.63
Gondwanas Rock	91.50	2.39
Total	**3835.51**	**100**



7. CONCLUSION

The Geomorphological map has been basically used for Geobotanical trend analysis. The mapping of major units was done by the Landsat TM image and topographic data. Six categories have been delineated taking. Area under different geomorphic unit's categories has been determined-The high level plateau is identified over high land above 900m elevation from mean sea level. This geomorphic unit covers 425 sq km or 11.08 % of the total area of the study region. The middle level plateau is characterized as 500m to 900m elevation above mean sea level. The central alluvial plain comes under middle level plateau is fluvial deposition covers a total area of 870 sq km which is 22.68 % of the total area of the study region. The denudational hills on Deccan traps comprise of the Maikal highlands in south, south-western and eastern part of the study region. It is formed due to differential erosion and weathering. Metamorphic rocks are recycled rocks that have been subjected to varying degrees of pressure and temperature. Mostly Achanakmar sanctuary covers the metamorphic rocks in AABR. These were occupying an area of approximately 911 sq km or 23.75 % of the total area. The Pediplain comprises in Amarkantak which is the origin place of the Narmada. It covers 1290 sq km or 33.63 % of the total area. Gondwanas formations are occurring southwards of Anuppur town and a big belt found in a Pendra road to venketnagar along with rail line in Bilaspur district In AABR. A total area comprises approximately 91.50 sq km or 2.39 % of the total area of biosphere.

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