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EVALUATION OF DIFFERENT LANDFORM UNITS AND NEOTECTONIC IMPLICATIONS FOR A PART OF THE LOWER CHAMBAL VALLEY, USING SATELLITE IMAGES – A COMPUTER AIDED GEOMORPHIC APPROACH

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ABSTRACT

The rampant gully erosion and spectacular ravinous badlands have made the Chambal Valley as one of the worst eroded areas in India. The extensive belts of deep ravines along the Chambal River have considerably incised the regional upland plateau surface. An attempt has been made to delineate various landform units of a part of Lower Chambal Valley using the satellite data. A geomorphological map of the study area has been prepared from the visual analysis of LISS II data and followed by digital enhancements of LISS III and PAN data. The criteria adopted for identification and grouping of landforms of specific genetic types are: morphography, morphometry, underlying geology, relief forming processes and association of forms. Digital image processing output has been found useful in identifying certain geomorphic landforms. The integration of the traditional geomorphic study and computer aided analytical technique has given an account of Quarternary geology and geomorphology of the study area. All the landform units have been grouped under three genetic types, viz. fluvial, denudational and structural origin. In all, twelve different landform units have been delineated under the three genetic types as (i). Landform units of Fluvial origin: Alluvial Plain, Flood Plain, River Terrace, Sand Bars, Ravinous Zone, Valley Fills (ii) Landform units of Denudational origin: Residual Hills, Pediment, Burried Pediment (iii) Landform units of structural origin: Plateau, Plateau Top and Dissected High Land. This alluvial plain and ravinous zone together covers almost fifty percent of the study area. The most striking geomorphic unit in the area is ravinous zone, which is an extremely dissected landscape difficult to cross and agriculturally unfit. Since the large part of the study area is inaccessible, remote sensing data have played an important role in detailed geomorphic mapping. The implications of the neotectonic activity are also discussed. The rapid advances of badlands at present are the sign continuing neotectonic activity, and that the region has significant vertical incision with little lateral migration. It further reveals that the drainage network and the neotectonic activity appears to be responsible for the topographic rejuvenation on a regional scale.

Key words: Landforms, Neotectonics, Lower Chambal Valley, Satellite images.

INTRODUCTION

The word 'ravine' denotes gullied land containing systems of gullies running more or less parallel to each other and entering a nearby river flowing much lower than the surrounding table lands. It is associated with an isolated gully. The Lower Chambal Valley of Madhya Pradesh is highly affected by gully erosion. The rampant gully erosion and spectacular ravinous badlands have made the Chambal Valley as one of the worst eroded areas in India. The extensive

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belts of deep ravines along the Chambal River have considerably incised the regional upland plateau surface. Attempts have already been made by a number of workers in mapping the ravinous lands using available remote sensor data as well as in studying their geomorphological aspects (Karale *et al.*, 1988; Dhir,1990). The availability of IRS 1C /1D and PAN data having much higher resolution than the earlier satellites has improved the quality of mapping of different landforms. Saini *et al.* (1999), and Singh *et al.* (1999) have tried to evaluate the utility of IRS – 1C PAN data for monitoring gullied and ravinous lands in western Uttar Pradesh.

The present investigation has been carried out with an integrated Remote Sensing approach along with the conventional methods. The traditional geomorphic studies, and the computer aided analytical techniques have been integrated in the present study to discuss the regional implications of neotectonic activities.

MATERIALS AND METHODS

The selected study area is a part of Lower Chambal Valley which lies near Sabalgarh town, in both M.P. and Rajasthan states. The area covering about 690 sq km, is located between $26^0$15' to 26^0 30' N latitude, and 77° 15' to 77° 30' E longitude, which falls in the Survey of India topographic sheet No. 54 F/7. Physiographically, a major part of the area is covered by thick alluvium deposited by the Chambal River and its tributaries. The area to the north of the Chambal River is characterized by deeply dissected plateau resulting in on undulating topography. To the extreme south, the presence of residual hills gives a locally uneven physiography. In the central part i.e., on both sides of the Chambal River, ravine lands exhibit the overall badland topography. The satellite data products used for the detailed image processing of the area around Sabalgarh are:

I. IRS-1B LISS-II georeferenced standard FCC hardcopy, path 28 and row 49, of March, 1996

II. IRS-1C LISS-III, path 97 and row 53, of November, 1998

IRS-1C PAN, path 97 and row 53, of November, 1998

The ILWIS 2.2 software is used in the preparation and analysis of present investigation. It is a Geographic Information System (GIS) with image processing capabilities.

IRS-1C PAN and LISS-III data were geometrically corrected by collecting ground control points (GCPs) with respect to Survey of India topographic base map. Survey of India topographic base map of 1985 has been georeferenced collecting 14 GCPs using affine transformation with an RMS error of 0.468 pixel. IRS 1C PAN data have been geometrically corrected taking 14 uniformly distributed GCP's from SOI Toposheet (scale 1:50,000) with an RMS error of 1.2. IRS 1C LISS III data have been geometrically corrected with respect to PAN data collecting 14 ground control points, with RMS error of 0.86.

Nearest neighbourhood method has been used in georeferencing the PAN image whereas convolution method has been used in georeferencing LISS-III image. The standard FCC and hybrid FCC 543 have been generated from LISS-III data assigning red, green and blue to band 4, band 3, and band 2 and band 5, band 4 and band 3 respectively. Principal component transformation has been performed on all the four bands of LISS III data. In this work, an FCC has been generated assigning red, green and blue to PC1, PC2 and PC3 respectively.

Subsequent to digital image processing of IRS-1C LISS III data to standard FCC, hybrid FCC 543 and FCC generated from first three principal components of LISS III data, the ravine outline map obtained from LISS II data was duly modified and validated during field investigation. Principal Component Analysis (PCA) method has been employed for merging IRS-1C LISS III and PAN data.

GEOLOGICAL SET-UP

Geologically, the area under investigation is covered by the Proterozoic sedimentary rocks and Pleistocene and Recent river deposits. The region is largely occupied by the Vindhyan Supergroup, which strikes approximately north to south, except in its northern portion, where the direction gradually changes initially to northeast and later becomes parallel to the Chambal River (Sharma, 1979). There are four principal ranges cropped up with massive sandstone beds, which taken in order from east to west, belong to Lower Rewa, Upper Rewa and Lower Bhander Formations. The predominant geological formations exposed in the region are Rewa and Bhander of Upper Vindhyan age. To the north, near the Chambal River, alluvium comprises of clay, silt and gravel having varying thicknesses, the maximum thickness being 200 m. Recent and Sub-Recent deposits cover the largest part of the area. From visual analysis of LISS II data and subsequently through digital enhancements of LISS III and PAN data, a detailed lithological map of the area has been prepared. Later, the prepared lithological map has been validated through selective field investigations and finally a map showing the detailed lithology of the area has been prepared. (fig. 1)

GEOMORPHIC UNITS

In the present study, geomorphological map for the part of Lower Chambal Valley has been prepared using the satellite data. Since the large part of the study area is inaccessible, remote sensing data have played an important role in detailed mapping. An attempt has been

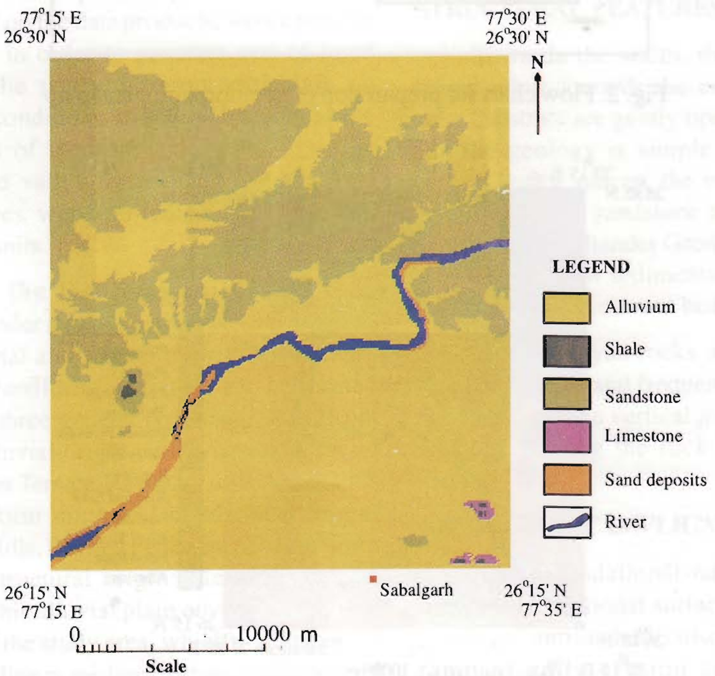

Fig. 1. Lithological map of the study area

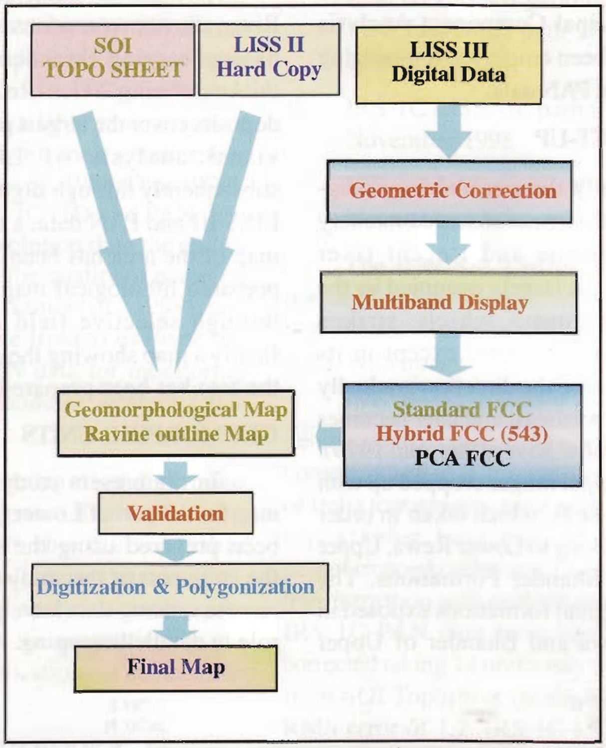

Fig. 2. Flow chart for preparation of geomorphological map

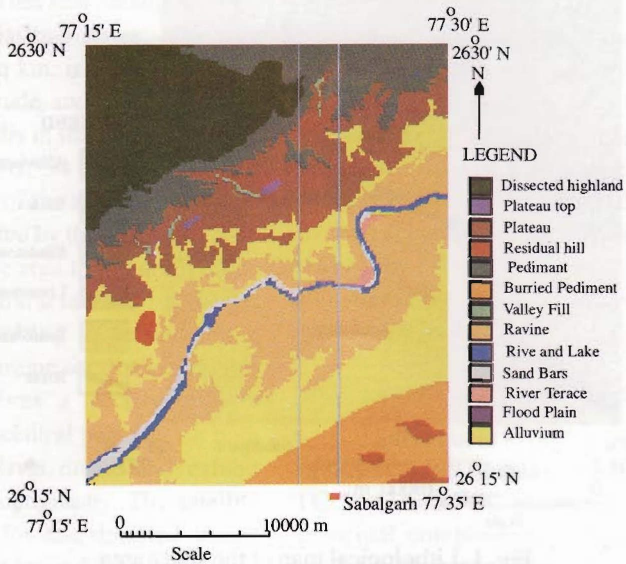

Fig. 3. Geomorphological map of the study area.

made to delineate various geomorphic features of the study area from the visual analysis of LISS II data and subsequently digital enhancements of LISS III and PAN data. A Flow Chart showing the steps for the preparation of geomorphological map has been shown (fig. 2). Later, the prepared geomorphological map is validated through selective field investigation and finally a map showing the geomorphological units of the study area is prepared. (fig. 3)

The criteria adopted for identification and grouping of landforms of specific genetic types are: morphography, morphometry, underlying geology, relief-forming processes and association of Landforms. The pertinent geomorphic information in this case was critically derived through scanning and visual interpretation of all available remotely sensed data products. The various landforms/ landscape units, present processes, etc., as recognized on the data products, were carefully delineated in order to generate sets of input data for the study. Ground truth data on lithologic conditions, structural features, shape and extent of landforms/elements, drainage system and valley forms, land use and land cover types were collected to verify the landform units.

All the landform units have been grouped under three genetic types, viz. fluvial, denudational and structural origin. In all, ten different landform units that are delineated under the three genetic types as (i) Landform units of Fluvial origin : Alluvial Plain, Flood Plain , River Terrace, Ravinous zone, Valley Fills (ii) Landform units of Denudational origin: Residual Hills, Burried Pediment (iii) Landform units of structural origin: Mesa, Butte, and Plateau. This alluvial plain covers almost fifty percent of the study area, which gives medium grey tone, fine to medium texture, characterized by external drainage, gullying phenomenon and low drainage density. In LISS –II and LISS-III standard FCC's, it is found to have yellowish red tone. The ravinous zone is characterized by a very fine drainage network and short steep slopes with narrow interfluves. Ravines develop generally along the face or front of retreating scarps. Three main slope elements have been found to develop in this zone. These are - pediment at the base followed by steep cohesion slope and finally the dissected upland area. The most striking geomorphic unit in the area is ravinous zone which is an extremely dissected landscape difficult to cross and agriculturally unfit .The whole country between Bhind and Morena districts of M.P. is mostly dissected, irregular and is made up of steep ridges, low sloping hills, deep trenches and broad-cut incised meanders. The gullies vary in depth from 10 m in the upper reaches to 50 m adjacent to the Chambal River. Limestone and sandstone constitute the residual hills having moderate relief of the order of 240 m to 260 m.

STRUCTURAL FEATURES

Towards the south, the Vindhyans are folded while towards the eastern side of the area, the strata are gently open and undulating and the geology is simple. Along the road cutting at few places, the micro folds in the Lower Bhander sandstone and limestone are observed. The Bhander Group of rocks are fine grained and show sedimentary structures viz., ripple marks and current bedding at places.

The Vindhyan rocks are highly jointed, more prominent and frequent joints parallel to beddings, and the vertical joints are normal to bedding, making the rock highly blocky in nature.

NEOTECTONIC IMPLICATIONS

The degradational nature of the river, presence of erosional surfaces, deeply incised drainage, entrenched cut-off meanders and rampant gully erosion are suggestive of evidences which indicate neotectonic movements in the area. The area is traversed by four sets of lineaments trending NE-SW, NNE-SSW, NW-SE, and NNW-SSE. These lineaments exert profound control on the drainage of the region and cause the river to follow its courses with sharp kinks and abrupt bends. The ephemeral gullies also depict strong lineament controls with trellis, rectangular and parallel drainage patterns that can be visible everywhere in the ravinous tract. The entrenched meanders are commonly cut-off at their narrow necks through normal erosional processes. Such cut-off meanders have come into existence due to the tectonic movements along lineaments passing through the neck of the meanders.

RESULTS AND DISCUSSIONS

The ravinous tract forms the most striking geomorphic unit in the area, which is an extremely dissected landscape difficult to cross. The depth of ravines and gullies ranging from few metres to more than 50 metres have been observed in the area. Head-ward erosion is also responsible for the evolution of many of the deepest and widest ravines in the Lower Chambal Valley. Since the large part of the study area is inaccessible, remote sensing data play an important role in detailed geomorphic mapping. The rapid advances of badlands at present are the sign of continuing neotectonic activity. The catchment of the Chambal River is very narrow and is solely represented by the width of the ravinous tract and exhibit significant vertical incision with little lateral migration. These features are indicative of a large, sudden and rapid lowering of erosional base level (Yoxall, 1969; Schumm, 1993). The accelerated erosion along the rivers to attain the local base level of the Chambal led to prominent incision of the drainage and initiated the formation of badland topography.

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