MORPHOLOGICAL REGIONALIZATION AND MORPHO-UNIT OF THE INTER-STREAM REGION OF DENWA-DUDHI AND NARMADA RIVERS OF MADHYA PRADESH, INDIA

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Abstract
Geo-morphology stems from three Greek words i,e. (ge) earth, (morphe) form and 'logos' a discourse. Geomorphology is defined as the science of description of various forms of the surface. The evolution of different suits of landforms in the region clearly express the several phases of sedimentation, faulting, intrusion of igneous material, climatic changes and several chapters of denudational cycles. Morphology means the scientific study of the form, structure, origin and development of organisms or of the external structure of rocks in relation to form. Thus, the morphological region is a distinctive unit of land form identified of the basis of form, rock structure, and evolutional history varying in scale or order.

Keywords: *Morphological Region, Morpho-Unit, Strucural Origin.*

Introduction

Inter-stream Region of Denwa-Dudhi and Narmada rivers is a part of 'Peninsular Foreland' having contrasting terrain of newer depositional surface as well as older residual surface. On the basis of drainage and the morphology, structure and geomorphological evolution of various suits of landforms, an attempt has been made here to the study the morphological regionalization, identification of morpho-unit, and the reconstruction of the past morphological history of Denwa, Dudhi and Narmada Rivers.

About the Region

The region taken for the study within the geographical ambit of 22º 30´ 59" N to 22º 58´ 50" N latitudinal and 78º 2´ 42" E to 78º 44´ 55" E Longitudinal extent forms a compact quadrangle shape having the longest dimension in east-west direction with a length of 71.5 kms, whereas its width in north-south direction increased from west to east which is only 24 kms in the former side and 44.5 kms in the later side (fig. 1). The northern boundary of the area under investigation having 1523.93km² areal extent, is characterized by almost a regular line of Narmada river which runs from south-west to, north-east direction with some meandering loops. The northern boundary thus begins from the confluence points of Maru kalan where Dudhi River terminates its courses into the Narmada. The western and eastern boundaries are again demarcated by the rivers Maru and Dudhi respectively which generally run from south to north with their tributary streams. The Maru follows north-west direction before meeting with the Narmada. The southern boundary of the area is also demarcated by the water divides. Thus the inter-stream region is drained mainly by the rivers Narmada Denwa Dudhi and Maru and their bank tributaries besides the head waters of the left bank tributaries especially of Dudhi and sua rivers.

Administratively, the inter-stream region chosen for the investigation under the head of hydro-geomorphology covers the parts of Hoshangabad and Chhindwara districts of Madhya Pradesh. Hoshangabad district is a long irregular strip. Country, stretching along the left bank of Narmada valley between the Vindhyan mountains and the Satpura hills,

and including part of the latter range within its borders, white the Chhindwara district may be described as consisting of three steps or sections of different elevations ascending from the south (Gazetteer of India, Hoshangabad and Chhindwara Districts, M.P., 1997). Geo-morphologically, the area is not homogeneous and thus, the region is not without interest and attraction. In general the northern part of the area is below to 300 metres while the eastern part of the area is above to 800 metres. The physiography of the region is distinguished as longitudinal hills and isolated inter-hill miniplains and is generally characterized with the subdued relief features viz. very gently sloping longitudinal low ridges along with the river courses, undulating valley-side slopes, nearly level to flat basinal plains, very gently sloping alluvial mid fans, undulating toe slopes, gullies and ravines, peripheral lands and some other minor topographic forms, the knolls, spurs and gorges etc. The southern hilly and plateau areas represent excessive relief features with strong to steep slopes having open mixed to dense mixed forest cover whereas the peripheral lands have more or less dissected topography with complex slopes ranging from 3% to 10% enjoying normal to excessive relief features. The northern plains and inter-montane valleys have very gentle slope gradient ranging from 0.5% to 3%.

Methodology

From Joerge (1914) to J.E. Gellert (1982a and 1982b), a number of scholars from various disciplines have made their attempts to delimit the morphological regional selecting different scales and attributes for their schemes. D.L. Linton, for morphological regionalization, postulated a hierarchy of increasing size and complexity from the smallest, the site, through stow, tract, section, province to continental sub-division. As a pioneer worker Joerge suggested inductive and deductive approaches for the delimitation of morphological regions to which he termed as 'natural regions' Fenneman (1914) determined the boundaries of morphological regions on the basis of chronology and homogeneous geological history and termed them as 'physiographic regions'. A two level scheme of characteristic site assemblage was introduced by Bourne (1931) wherein the regions of first level were demarcated on the basis of topographic features produced by the denudational processes and regions of the second level were determined by the environmental conditions affecting pedogenesis and vegetation growth. Though the two level scheme of Bourne for delimitation of morpho-regions was established on a solid base, yet it failed to gain currency for a long time due to quantitative revolution in geographical methodology when the qualitative techniques were replaced by the quantitative methods and the boundaries of morphological regions were determined by valid statistical methods. In this reference the approach of Hammond (1954 and 1964) is leading one. The attempt of Savigear (1965) was also outstanding wherein he superimposed the maps of various geomorphic elements for delimiting the morphological regions of different hierarchical orders naming them as natural regions. J.F. Gellert (1982a and 1982b) has presented a new scheme for morphological regionalization. In his scheme for the purpose he elaborated that the 'morphotops' or 'morphofacies' never occur as in isolated forms but they also form together regional units in the form of complexes and form groups with similar but heterogeneous geomorphological marks of orographical, morphological, morphometric, lithologic-sedimentological, morphogenetic, morpho-chronological and morpho-structural kinds.

Gellert presented five morpho-regions from smallest order to the largest orderviz. (i) MT- morphotops, (ii) MTG or MN Ch group of morphotops or morphonannocheres, (iii) M Mich morphomicrochores, (iv) M Mech morphomesochores, and (v) M Mach morphomacrochores.Some scientists and geomorphologists have also successfully divided

the entire globe into morphological regions on the basis of geo-environmental factors which successfully shape the landforms of the region concerned.

Morphological Regions

The inter-stream region of Denwa Dudhi and Narmada rivers falls under the Gellert's zone of sub-tropical heat, moist, semi humid region with developed dry season and precipitation with periodical rivers and dry perennial rivers. Study reveals that the Denwa Dudhi and Narmada rivers of the region are though perennial yet they are periodical and bear the character of dry perennial rivers. The seasonality of these dry perennial rivers is illustrated by the rainfall data of the catchment area of these rivers. The analysis of the rainfall data that mean monthly discharge of these rivers starts to decrease from October and continues to decrease up-to May every year. In between these months the catchment area of these rivers (Denwa, Dudhi and Narmada) either receives very very low rainfall or no rainfall. In the main channels of the rivers, the volume of water so enormously shrinks during three dry months (March, April and May) that channels are reduced to a line of water. Investigator has identified and classified the inter stream region of Denwa-Dudhi and Narmada rivers into three certain morphological regions viz. Morphological Unit of Fluvial Origin. Morphological Unit of Denudational Origin. Morphological Unit of Structural Origin.

The areal coverage and the percentage of all the three morphological regions is tabulated below as under-

Table 1. Areal Coverage and Percentage of the Morphological Regions

Sl.No.	Morphological Regions		Areal Coverage (Km^2)		Percentage	
1.	Morphological unit of Fluvial origin	A Infilled River Bed	793.87	223.62	52.47	14.78
		B. Older Hood Plain		570.25		37.69
2.	Morphological unit of Denudational Origin		295.34		19.52	
3.	Morphological unit of structural origin		423.79		28.01	
	Total:		113.00		100.00	

Morphological Unit Of Fluvial Origin

This unit of morphological features is of two different natures. The first one (A) is of food plain including infilled river bed and the second one (B) is of older food plain (Fig. 2). The flood plain of infilled river bed covers the 223.62 Km^2 area which is 14.78% of total surface area and extended north-east part of the study region covering the catchments of the both rivers. Locally this morphological unit is under the operation of agricultural activities. There is always a danger of floods in raining months. (July, August and September) and damages to the crops. The older flood plain of the Narmada River covers 570.25 Km^2 areas which 37.69% of the total surface area. This region gradually slopes from the foot-hill zone of Satpura range towards the Narmada river in which a number of rivers like Maru, Palakmati, Rain, Kubja and Anjan alongwith their tributaries like Periya (of Manu river), Langhan (of Palakmati river) Bawanganga, Korni, Sukhri (of Kubja river) etc. The large quantity of surface deposits of this morphological unit of fluvial origin away from the Narmada River appears to indicate a former distribution of the rivers throughout this older flood plain country different from that at present prevailing.

Morphological Unit Of Denudation Origin

This morphological unit covers an area of 295.34 Km^2 which is 19.52% of the total surface area of the study region. Geomorphologically, the unit is the result of sediment deposits rolled down from the Satpura hills' sides through running water action. Soils are moderately deep depending upon the category sequence. The fringes of the upper back slopes are highly dissected and mostly under moderate thick forest cover.

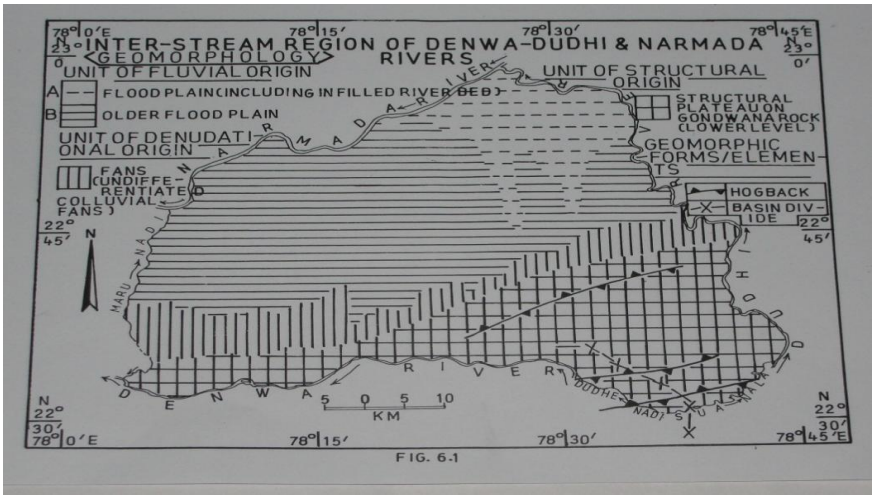

Figure 1. Inter stream region.

Morphological Unit Of Structural Origin

This morphological region of structural origin is spread over an area of 423.79 Km^2 which is 28.01% of the total surface area of the study region. This unit is exposed in the area in the form of structural plateau on Gondwana rocks having hills, ridges and valleys. In fact, this unit is distinguished as hill-valley complex of extremely sloping topography. Morphologically, the unit exposes the dip slopes of sandstone and shale belonging Talchir and Barker, formation coarse white sandstone and pebble beds of Denwa Formation, coarse conglomerate and varigated shale of Bagra Formation and sandstone, clay, silt stone and conglomerate of Jabalpur formation. All these formations are associated to the Gondwana super Group ranging from carboniferous to cretaceous age. In this structural unit, there is a deep narrow valley gorge of Dudhi River over Navalgarh hills (644 metres). The southern peripheral zone of this unit (along the Denwa river side) is under rapid erosion.

Table 2. Correlation Matrix of Six Variables.

	V1	V2	V3	V4	V5	V6
V1	X	0.10	0.87	0.52	0.58	0.42
V2		X	0.31	0.21	0.22	0.15
V3			X	0.50	0.51	0.35
V4				X	0.42	0.34
V5					X	0.64
V6						X

Note: An underline denotes minus correlation.
V1 = Relative Relief (R_R)
V2 = Average Slope (S)
V3 = Dissection Index (DI)
V4 = Drainage Density (Dd)
V5 = Stream Frequency (Sf)
V6 = Drainage Texture (Dt)

Table 3. Stratigraphic Principle for Determination of Morpho-Units.

Geomorphic Variables	Categories for the Analysis of Spatial Organization of Morpho-Units				
	Very Low (VL)	Low (L)	Moderate (M)	High (H)	Very High (VH)
Relative Relief (R_R) (in Metres)	EL+ML 0-15+15-30	L 30-60	M 60-120	MH 120-240	H >240
Slope (S) (in Degrees)	L 0^0-2^0	G 2^0-5^0	M 5^0-10^0	MS 10^0-15^0	S 15^0-20^0
Dissection Index (DI)	EL 0.0-0.1	L 0.1-0.2	M 0.2-0.3	MH 0.3-0.4	H + VH 0.4-0.5+>0.5
Drainage Density (Dd)	EL 0-1	L 1-2	M 2-4	H 4-6	VH >6
Stream Frequency (sf)	VP 0-2	P 2-5	M 5-10	H 10-20	VH >20
Drainage Texture (Dt)	VC 0.8-1.0	C 0.6-0.8	M 0.4-0.6	F 0.2-0.4	VF 0.0-0.2

Morpho-Units And Their Spatial Analysis

The region of such nature falls naturally into three parts, the valley, plateau and the hills. The landscape of Denwa-Dudhi and Narmada inter-stream zone consists of a bottom story of Narmada Dudhi alluvial plain in the north above which rises the middle story of Denwa plateau having the lower hills on its top the heights of which range between 426 metres (Magaria hill) to 557 metres (Kursi-Khapa hill). The general absolute height of this story dwindles between 340 metres to 360 metres. A top storey of higher Satpura range and dissected hills rises above the middle storey of Denwa plateau. The heights of this top story range between 415 metres (near Tekapar) and 889m (Najarpur hill). This three storied landform mosaic of the inter-stream region of Denwa-Dudhi and Narmada rivers appears as a solid base for identifying the morpho-units of the inter-stream region under compass of the study. The concept of 'general relief groups arranged in three storied manner' six landform (geomorphic) variables viz. relative relief (R_R), average slope (S) dissection index (DI), drainage density (Dd), stream frequency (Sf) and drainage texture (Dt) have also been used for the identification of the morpho-units.

The obtained results after superimposition of the six geomorphic variables and physiographic regions have been arranged into the following categories on the basis of 'Z' score limits (from-3.00 to + 3.00) for the analysis of spatial organization of the morpho-units of the inter-stream region of Denwa-Dudhi and Narmada rivers.

Class Limits	Description
More than + 1.5	Very High
0.5to+1.5	High
+0.5 to -0.5	Moderate
-0.5 to -1.5	Low
Less than -1.5	Very Low

Obtained results, on the basis of 'Z' score limits have been tabulated in the table4.

Table 4. Area and Percentage of the Morpho-units according to Z Score Limits

Morpho-Units of First and Second orders	Very High Above 1.5		High 0.5 to 1.5		Moderate 05 to -0.5		Low -0.5 to -1.5		Very Low Below-1.5		Total	
	Km^2 Area	%	Km^2 Area	%	Km^2 Area	%	Km^2 Area	%	Km^2 Area	%	Km^2 Area	%
1. Narmada-Dudhi Plain Unit	08	0.53	23	1.52	150	9.91	318	21.02	373	24.65	872	57.63
1.1 Alluvial Plain Terrain Unit	02	0.13	16	1.06	140	6.37	285	18.84	314	20.75	721	47.65
1.2 Gullied Plain Terrain unit	06	0.40	07	0.46	46	3.04	33	2.18	59	3.90	151	9.98
2. North Denwa Plateau Unit	06	0.40	53	3.50	65	4.30	38	2.51	95	6.28	257	16.99
2.1Dissected Denwa Plateau Unit	04	0.27	36	2.38	452	2.78	23	1.52	62	4.10	167	11.04
2.2 Narrow Denwa Plateau Unit	02	0.13	17	1.12	23	1.52	15	0.99	33	2.18	90	5.95
3. Najarpura Unit of Higher Hilly, Upland	32	2.11	98	6.48	41	2.71	32	2.12	92	6.08	295	19.50
3.1 Anjan-Korni Upland Unit of Lower Heights	10	0.66	37	2.45	19	1.26	15	0.99	26	1.72	107	7.07
3.2 Najarpura-Kurangarh upland unit of Higher Heights	22	1.45	61	4.03	22	1.45	17	1.13	66	4.36	188	12.43
4. Intermontane Titoriya Valley Unit	06	0.40	30	1.98	08	0.53	07	0.46	38	2.51	89	5.88
4.1 Titoriya Valley Dissected Terrain Unit	04	0.27	16	1.06	03	0.20	04	0.26	24	1.59	51	3.37
4.2 Titoriya Valley Dissected Terrain Unit	02	0.13	14	0.92	05	0.33	03	0.20	14	0.92	38	2.51
ENTIRE REGION	52	3.44	204	13.48	264	17.45	395	26.11	598	39.52	1513	100.00

Spatial Analysis Of Morpho-Units

The entire inter-stream region of Denwa-Dudhi and Narmada rivers is divided into four morpho-units. 1. Narmada - Dudhi Plain Unit. 1.1. Alluvial Plain Terrain Unit. 1.2 Gullied Plain Terrain Unit. 2. North Denwa Plateau Unit. 2.1. Dissected Denwa Plateau Unit. 2.2 Narrow Denwa Valley Unit. 3.Najarpura Unit of Higher Hilly Upland. 3.1 Anjan-Korni Upland Unit of Lower Heights. 3.2. Najarpura-Kurangarh Upland Unit of Higher Heights. 4.Inter-montane Titoriya Valley Unit. 4.1. Titoriya Valley Plain Terrain Unit. 4.2 Titoriya Valley Dissected Terrain Unit.

Narmada-Dudhi Plain Unit

This flat plain unit of Narmada-Dudhi river system is spread over an area of 872 Km^2 which is 57.63% of the total surface area of the study region. This region generally overlooks the peneplain surface of extensive Denwa plateau on the South. This plain (21.02%) categories of morpho-component scores and is poorly represented by moderate (9.91%), high (1.52) and very high (0.53%) categories of morpho-component scores. This infilled plain unit of low relief is divided into two morpho-units of second order viz. (i) alluvial plain terrain unit, and (ii)

gullied plain terrain unit. This unit of second order is also represented rather dominated by very low (20.75%) to low (18.84%) categories of morpho-component scores.

North Denwa Plateau Unit

This morpho-unit of first order covers an area of 257 km^2 which is 16.99% of the total surface area of the study region. the entire morpho-unit presents a classic view of peneplain characterized with dissected, sloping, undulating surface of 5% to 10% slope gradient and moderate to deep erosional features. Very low to moderate dimension of morpho-component scores presents the fact that at present also, this morpho unit is characterized with moderate to high potential kinetic energy of streams draining over the land. This morpho-unit is divided into two morpho-units of second order viz. (i) dissected Denwa plateau unit, and (ii) narrow Denwa Valley unit. Dissected Denwa plateau unit covers an area of 167 $Km^{2.}$ The narrow Denwa plateau unit is also dissected in the riverine zones and is characterized with the hills of lower heights. The region is characterized with high potential energy which is transferred into high kinetic energy of the streams draining and eroding the tract continuously.

Najarpura Unit Of Higher Hilly Upland

This morpho-unit is spread over an area of 295 Km^2 which is 19.50% of the total surface area of the study region. This morpho-unit is characterized with moderate to steep (at some places very steep more than 50% slope gradient) slopes is dotted with highly dissected Najarpura hills (of Satpura range). In fact, the hills of the morpho-unit are the source region of the number of tributaries which exhibit topographic sinuosity with marked gradient. , the hills of this morpho-unit are the source region of the number of tributaries which exhibit topographic sinuosity with marked gradient. The drainage patterns are parallel to sub-parallel, at some places trellised in the hilly ranges, Centripetal at a lake and radial in the area of high hills. The entire morpho-unit is dominated by very high to high relative relief which is expressed by the complex topographic features like steep scraps, rectilinear and basal concavity of slopes, rapids, narrow and deep gorges, steep valley side slopes and waterfalls etc.

Intermontane Titoriya Valley Cinit

The unit is dominated by very low (38 Km^2) and high (30 Km^2) categories of morpho-component scores followed by the categories of moderate (8 Km^2), low (7 Km^2) and very high (6 Km^2) component scores. Like other morpho-units of the study region, this morpho-unit has been also divided into two morpho-units of second order viz. (i) Titoriya valley plain terrain unit, and (ii) Titoriya valley dissected terrain unit. Dissections of the river banks, sliding and slumping are the main denudational processes which are active over the different zones of this morpho-unit. This morpho-unit of second order is dotted with rocky wastes, vertical cut-banks and erosional remnants covered with red graveled forest soils of less productivity.

In essence, it may be concluded that the main objects of the corrective measures are to preserve and improve the existing forest cover and to conserve the soil and water (moisture) and land. We can reclaim all the degraded land. Here it is necessary to keep in mind that every effective program of action needs to locate its priorities. Keeping in view all these things, a management plan has been suggested for the future development of the study region the suggested plan is associated with the land development, irrigation, drinking water,

approach roads, energy plantation, grass planting green fodder forms, pasture land development improved breed cattle's, fruit bearing plants, habitat improvement, soil, forest and water conservation etc.

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