

MORPHOMETRIC ANALYSIS OF TERRAIN : A CASE STUDY OF SOUTH MIRZAPUR UPLAND

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ABSTRACT : The present paper attempts to classify South Mirzapur Upland into morpho-units of various hierarchical orders, based on diverse morphometric attributes, viz. absolute relief, relative relief, dissection index, drainage frequency, drainage density and slope. The delineation of morpho-units has been made by superimposing the distribution maps of these morphometric attributes obtained with the help of topographical sheets on the scale of 1:50,000. Thus it has been possible to identify 3 first order, 13 second order, 43 third order, and 66 fourth order morpho-units in the study-area. The first order morpho-units namely Sonpar Valley Tract, The Sonpar Upland, and Babhani Upland have been demarcated mainly on the basis of absolute relief and drainage frequency which covers 37.46, 53.49, and 9.05 percent area of the study region. These morpho-units would provide a broad framework for examining the possibilities for scientific management of soil, forestry, agriculture, settlements, and other related activities. The help of informations obtained in the course of field work has been also taken while delineating the boundaries of morpho-units.

INTRODUCTION

Morphometric analysis of terrain is a technique in the study of landforms. Geomorphologists, like Russell (1949), Kesseli (1954), Hammond (1965) and Smith (1935), have contributed significantly to the development of quantitative approach to the study of landforms. They have laid emphasis particularly on the surfacial expressions of landscape rather than on their genetic aspects. Russell (1949) in his paper entitled "Geographical Geomorphology" has pointed out the differences in the approaches to the geomorphology from geographer's and geologists point of view in the following words: "While the first is interested in studying the horizontal cross-section, the latter is concerned with the vertical cross-section of the

earth's surface". To explain in other words, geographers are mainly concerned with 'what', 'where' and 'how much', of the landscape while the geologists are more concerned with the structure, process and time. In the same paper, he has also mentioned that "when geomorphology really tells us what is present in a landscape and exactly where each form is to be found, it becomes geographical." Kesseli (1954) in his paper "A neglected field : Geomorphology" too, suggests that geographers should not concern too much with the origin of land. He formulated three concepts : (i) Concept of descriptive landform analysis, (ii) Concept of landform type, and (iii) Concept of landform type regions, and pointed out that a study of assemblages of geomorphic landscape is the

best means of establishing true geographer's geomorphology. Later Hammond (1965), following the ideas of Kesseli, devised a method for quantitative empirical description of landform type regions and also coined a new terminology 'land surface form' in order to avoid unnecessary dualism between the explanatory (genetic) and descriptive (surface form) approaches. Smith (1935) has also favoured non-genetic study of landform for geographers. Other geomorphologists, like Dury and Strahler, have laid greater emphasis on the quantitative analysis and mathematical symbolization of the characteristics of landforms, especially in the study of drainage network. In the context of the aforesaid development in the study of landforms attempts have been made to classify South Mirzapur Upland into morpho-units (morphological units) of various orders, based on various morphometric attributes such as absolute relief (AR), relative relief (RR), dissection index (DI), Slope (S), drainage density (DD), and drainage frequency (DF).

A morpho - or morphological unit may be defined as a unit area with similar or dissimilar topographical attributes, which sets it apart from the neighbouring areas. In fact, a morpho-unit is more or less a homogeneous unit. In other words, it may constitute an assemblage of landforms of similar levels having coherent form characteristics due to the homogeneous environmental processes actively taking part in the sculpturing of aforesaid congregation of landform unit in any particular region. Each morpho-unit is characterized by certain attributes, which may be applied to explain various resources of the region. Delineation of the morpho-units of the study-area would help in exploring the possibilities of soil development, settlements, agriculture, forestry, and other related activities in each unit.

AN OVERVIEW OF PREVIOUS WORKS

In the beginning of geomorphological studies, several geomorphologists divided the regional landforms into various units based on physiography and natural regions. A few others demarcated them on the basis of morphometry. In this regard, the contributions of Powell (1896), Joerge (1914), Fenneman (1914), Hammond (1954) and Savigear (1965) etc. are worth mentioning. In the later half of the present century, serious attempts were made not only to define morpho-units most precisely but also to provide the methodology for regionalization and delimitation of morpho-units/morphological regions/geomorphological regions, etc.

Powell (1896) has delineated the natural regions of North America on the basis of physiography. Joerge (1914), has suggested two approaches - inductive and deductive, for the determination of morpho-units of any given region. He, however, demarcated North America into morphological regions and called them natural regions. Fenneman (1914) divided United States of America into morphological regions, on the basis of chronology and uniformity of geological history of the physiographic regions. He categorised his divisions into three hierarchical orders, viz. major divisions, provinces and sections. After the quantitative revolution of 1950's and 1960's numerous quantitative methods and techniques have been proposed by many scholars for the determination of morpho-units of any given geomorphic region. Hammand, in 1954, proposed a new technique for the regionalisation and mapping of any geomorphic region on the basis of terrain characteristics of landscape components. Later, Savigear (1965), advocated the concept of morpho-units and classified these into different orders through the superimposition of maps of different geomorphic variables within the framework of natural region. He named his

morpho-units on the basis of natural regions. Following the above mentioned studies a few Indian geomorphologists, namely Asthana (1968), Kharkwal (1968), Singh (1968), Prasad (1980), Jha (1983), have also tried to identify the morpho-units for the areas of their study. In the present paper, an attempt has been made to delineate the morpho-units of various orders, on the basis of diverse morphometric attributes, and to examining the possibilities for scientific management of soil, settlements, agriculture, forestry, and other related activities according to the terrain characteristics of each unit.

PHYSICAL SETTING OF THE STUDY-AREA

South Mirzapur Upland (23°52'55" N-24° 37' N and 82° 42'E- 83° 27'29"E) has an area 417.5 km² (including 324.5 km² area under G.B.Pant Sagar); it includes the whole of Sonpar Vindhyan Upland and a small portion of the north-eastern Baghelkhand that constitute the district of Sonbhadra in Eastern Uttar Pradesh. Its northern boundary is formed by the W-E flowing Son River. The elevation of the area varies from 165 m to 525m. However, a few isolated hills, such as Ranikothi Pahar (651m), have elevations of over 550 m. Its relief is largely guided by geological structures associated with metamorphic rocks. Topographically, the study-area is characterized by the existence of a series of stream valleys and inter-stream divides, besides a few saucer-shaped basins. On the basis of topographic and terrain homogeneity, the study-area can be divided into two major physiographic units : (1) The Southern Son Valley, and (2) The Sonpar Upland. The Sonpar Upland can be further sub-divided into a series of smaller valleys and divides. The composite drainage of the area flows into the river Son, which ultimately joins the Ganga river system. The main tributaries of the Son are the Kanhar, the

Rihand the Bijul and the Pandu, which cut across the rocky outcrops and flow northwards to join the river Son. Physiographically, the area, excepting its southern most part, forms a constituent part of the Central Foreland of the Deccan Shield. Geologically, it is characterized by four major groups of rocks, namely the Archenans or Basement Rock Supergroup, Bijawar Group, Vindhyan Supergroup (Lower Vindhyan) and Gondwana Supergroup (Lower Gondwanas). These rocks show very little structural variations, except some folding contortion and local warping. The soils are loam to sandy loam in texture but, sometimes, may vary from coarse sand to various proportions of silt and clay. It enjoys tropical monsoon type of climate and has a mean annual rainfall of 109 cm and mean annual temperature of 27.76°C.

DELIMITATION OF MORPHO-UNITS

The delineation of the morpho-units of South Mirzapur Upland has been made on the basis of quantitative analysis of its various morphometric attributes so as to obtain more or less homogeneous units of various hierarchical orders. For this purpose, the spatial distribution of each morphometric attribute has been obtained from topographical maps on the scale of 1:50,000, published by Survey of India, Dehradun. These distributional maps of various morphometric attributes have been superimposed one upon another so as to obtain some standard isopleths for the delineation of morpho-units. In fact, the boundaries of the morpho-units of various orders have been fixed by the most coinciding isopleths of these attributes. Some of the standard isopleths used in the demarcation of morpho-units are 300 m and 400 m isopleths of absolute relief, 50m and 100 m of relative relief, 0.2 m and 0.3 m of dissection index, 3km/km² and 4 km/km² of drainage density 6° and 10° of average slope

and 3 streams/km² and 4 stream/km² of drainage frequency. Thus the entire study-area has been divided into 3 first order, 13 second order, 43 third order and 66 fourth order morpho-units has been made mainly on the basis of absolute relief and drainage frequency, those of second order units after relative relief and dissection index, and third order and fourth order units primarily on consideration of drainage density and slope respectively. It is noted that out of a total of 43 third order morpho-units, only 21 could be further sub-divided into 44 fourth order morpho-units, the remaining 22 morpho-units could not be sub-divided because of small variations in slope.

The boundaries of the morpho-units, delineated on the map have been subsequently in field. The naming of the morpho-units has been made after topographical designation like river valley or upland, with objectives like 'Western/Central/Eastern/or flat topped or dissected, etc. prefixed. The area of each morpho-unit has been measured by planimeter (Table 1). Standard symbols have been used to represent the form characteristics of various morpho-units. For example, absolute relief has been represented by capital letter ('A', with categories as A1 (Low : below 200m), Aml (Moderately low: 200m-300m), Am (Moderate : 300m-400m), Amh (Moderately high:400m-500m) and Ah (High : over 500m). Relative relief has been represented by 'R' with categories as Rel (Extremely low : below 25m), R1 (Low : 25m-50m), Rm (Moderate : 50m-100m), Rmh (Moderately high : 100m-200m), Rh (High : over 200m), and dissection index by 'D' with categories as Dvl (Very Low : below 0.1), D1 (Low : 0.1-0.2), Dm (Moderate: 0.2-0.3), Dmh (Moderately high: 0.3-0.4), Dh (High :over 0.4). The letters 'Dd', 'F' and 'S' have been used to represent drainage density, drainage frequency and slope respectively. These attributes have been further classed as Ddec

(Extremely coarse : below 1 km/km²), Ddmc (Moderately coarse :1-2km/km²), Ddc (Coarse :2-3km/km²), Ddm (Moderate : 3-4 km/km²), Ddmf (Moderately fine : 4-5 km/km²), Ddf (Fine : over 5 km/km²), Fvp (Very poor : 1 stream/km²), Fp (Poor : 1-2 streams/km²), Fm (Poor : 1-2 streams/km²) Fm (Moderate : 2-3 streams/km²), Fmh (Moderately high : 3-4 streams/km²), Fh (High : 4-5 streams/km²), Fvh (Very high : over 5 streams/km²) and Sl (Level : below 2°), Sg (Gentle : 2°-6°), Sm (Moderate : 6°-10°) and Smg (Moderately steep : over 10°).

Analysis has revealed that there is dominance of a few morphometric attributes such as low relative relief (Rl), low dissection index (DI), moderate slope (Sm), moderate absolute relief (Am), moderately fine drainage density (Ddmf), and moderate drainage frequency (Fm) which (over 51.24%, 47.08%, 46.80%, 55.23%, 55.76% and 49.38% of the study -area respectively.

A brief description of the morpho-units alongwith sub-divisions in hierarchical order (macro and meso units only) is given as follows:

I. THE SONPAR VALLEY TRACT

The Sonpar Valley tract with an area of 1437.9 km² (37.46%), covers the east-central and the north -western parts of the study-area. It is mainly drained by the river Son and its four important rightbank tributaries, namely the Bijul, the Rihand, the Kanhar and the Pandu. Its terrain is composed of sandstone, limestone, dolomite, porcellinite, shale, phyllite, slate, granite, pegmatite, magmatite, and alluvium. In general, the valley is flat-bottomed with a narrow flood plain, which separates the Son valley from the steeply sloping uplands both to the north and with south. The areal coverage of the different categories of morphometric attributes in this region is as follows :

Absolute relief : Al - 12.20%, Aml-64.88%, Am-21.30%, Amh-1.25%, and Ah-0.28%;
Drainage frequency : Fvp - 1.66%, Fp-19.16%, Fm-61.90%, Fmh-14.32% and Fh-2.96%;
Relative relief Rel - 4.96%, Ri-53.11%, Rm-37.71%, Rmh-3.94% and Rh-0.28%;
Dissection index : Dvl - 17.60, D1, Dm-25.90%, Dmh-4.40%, And Dh-0.90%,
Drainage Density, Ddec-0.58%, Ddmc-4.85%, Ddc-35.45%, Ddm-51.05%, Ddmf-7.51%, and Ddf -0.56 and slopes : Sl-3.0%, Sg- 67.8%, Sm-29.2% and Sms-1.0%. The region is characterized by dominance of moderately low absolute relief, low relative relief, low dissection index, moderate drainage frequency and drainage density and gentle slope. This morpho-unit seems to be in early mature stage of its development. It has been sub-divided into five second order morpho-units, namely (A) Western Sonpar Goreg, (B) The Bijul-Rihand Valley Tract, (C) The Son-Kanhar Valley Tract, (D) The Eastern Sonpar Gorge, and (E) The Pandu-Malia Valley Tract, mainly on consideration of relative relief and dissection index (Table 1 and Fig. 1).

I. A. WESTERN SONPAR GORGE

This second order morpho-unit lies in the north-western part of the Son valley. It is flanked by steeply sloping plateaus and hill ranges both in the north and the south, which rise abruptly from the valley bottom to elevations of about 300 m end, in some cases to even 450 m.

The area of this morpho-unit is 108.3 km² or 2.82% of the study-area. It is mostly composed of moderately resistant rocks - sandstone, dolomite, shale, and phyllite, and is characterized by moderate relative relief, low dissection index, moderate drainage frequency, gentle slope, moderately low absolute relief and moderate drainage frequency (Table 1). Climatologically, settlements can be developed here on the upland above the gorge. It has been

sub-divided into two third order units, namely; (1) The North-Western Sonpar Gorge, and (2) Bargawan Upland. The North-Western Sonpar Gorge may be further divided into two fourth order units, namely (a) Newari Plain Tract, and (b) Srathwa Upland.

I. B. THE BIJUL- RIHAND VALLEY TRACT

It covers 194.7 km² or 5.07% of area, and includes the lower portions of the Bijul and Rihand Valleys. A major part (93.30%) of this unit has elevations of less than 300 m. The upper courses of these streams are characterized by gorges. The absolute relief of this unit ranges from 180 m to 400 m. This second order morpho-unit is characterized by moderately low absolute relief (71.65%), moderate drainage frequency (66.92%), moderate relative relief (51.90%), low dissection index (68.30%), moderate density (75.59%) and gentle slope (59.30%). It has been sub-divided into 3 third order morpho-units, namely: (1) The Lower-Bijul Valle, (2) The Lower Rihand Valley, and (3) The Gurmua Upland.

I. C. THE SON-KANHAR VALLEY TRACT

This morpho-unit lies in the north-central part and the eastern margin of the study-area, adjoining the state of Bihar. It measures 742.4 km² or 19.34% of the study-area. Its elevation varies from below 200 m to 500 m. Many villages located in this area, get their supply of water from artificial reservoirs, formed by construction of small dams across various streams. The region is drained by sub-tributaries of Kanhar like the Gothan, the Malia, the Danmarwa, and the Lauwa. It is characterized by following proportions of various terrain attributes : A1 - 16.91% , Amh - 66.45%, Am - 25.08%, Amh - 1.01% and Ah - 0.01%, Fvp - 1.25%, Fp - 22.14%, Fm -

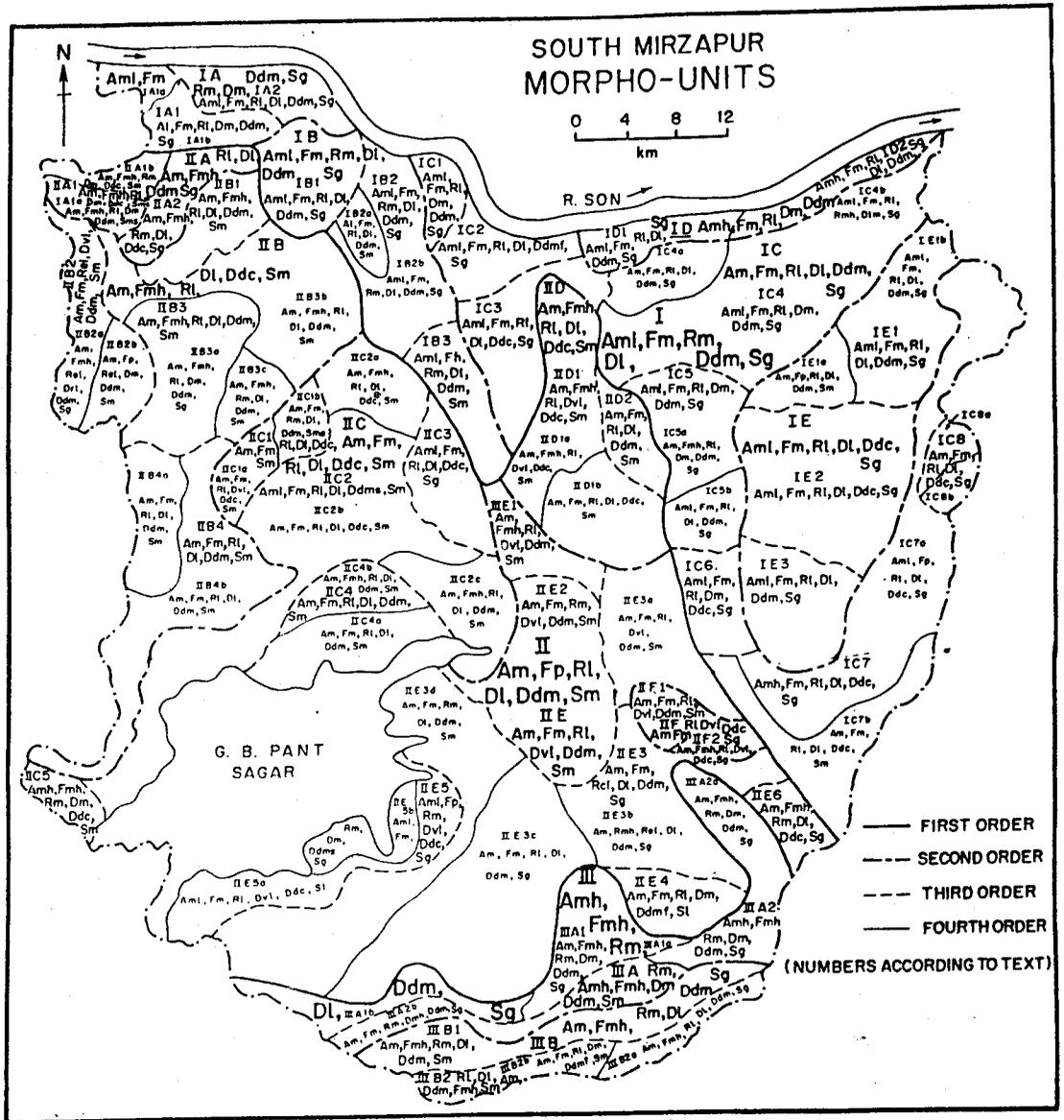


FIG. 1

Fig.No.1: South Mirzapur : Morpho- Units

58.43%, Fmh - 15.75%, and Fh - 2.43%; Rel - 7.30%, Rl - 55.40%, Rm - 35.0%, Rmh - 1.80%, and Rh - 0.50%; Dvl - 17.7%, Dl - 54.70%, Dm - 24.4%, and Dmh - 3.20%, Ddec - 0.44%, Ddmc - 3.91%, Ddc - 42.48%, Ddm - 45.08%, Ddmf - 7.00% and Ddf - 1.08%, and Sl - 3.10%, Sg - 67.40%, Sm - 27.8%, and Sms - 1.70%.

The area is composed of Bijawar supergroup of rocks and exhibits gentle slope. It has been sub-divided into 8 third-order morpho-units, namely : (1) The Central Saucer-Shaped Depression, (2) The Kajrahat Gently sloping zone, (3) Paraspani Gently sloping zone, (4) The Kanhar-Pandu Divide, (5) The Central Kanhar-Lauwa Valley Tract, (6) The Middle Lauwa Valley Tract, (7) Rannu-Mahwaria Plain Tract, and (8) The Harnakachar Upland. Three of the above mentioned third order units have been further sub-divided as follows : The Kanhar-pandu Divide (a) The Kanhar Gorge, (b) The Kanhar-Pandu Divide. The Kanhar-Lauwa Valley Tract (a) The Lower Lauwa Valley, (b) The Central Kanhar Valley. The Rannu-Mahwaria Plan Tract, (a) The Sundari-Bagsoti Plain, (b) The Nagwa-Mahwaria Plain.

I. D. THE EASTERN SONPAR GORGE

The Eastern Sonpar Gorge lies in the north-eastern part of Son valley. It is quite narrow and has an area of 56.7 km² only. A major part of this area is under forest. The absolute relief of this region varies from 200 m to 500 m. It is composed mainly of sandstone and shale. The areal coverage of various categories of morphometric attributes in this unit are : Aml - 47.09%, Am - 50.26%, Amh - 2.65%, Fp - 28.22%, Fm - 52.56%, and Fmh - 19.22%, Rel - 13.9%, Rl - 42.3% and Rm - 43.8%, Dvl - 17.5%, Dl - 34.9%, Dm - 31.7%, and Dmh - 15.9%, Ddc - 31.22%, Ddm - 68.78%, Sg - 61.64% and Sm - 38.6%.

This second order morpho-unit can be divided into two third order morpho-units : (1) The Hardi Plain, and (2) The Majhagawan Upland.

I. E. THE PANDU-MALIA VALLEY TRACT

This tract is located in the north eastern part of the study-area. It covers about 335.8 km² or 8.75% of the study-area and is drained mainly by Pandu, Malia and Thema rivers and their smaller tributaries. The region is composed of the rocks of Parsoi formation (Bijawar). Its terrain is gently sloping. The absolute relief of the region varies from below 200 m to 400 m. A large part of its area (61.13%) has moderately low absolute relief. Climatologically its valley tract and the adjoining divide are quite suitable for the development of settlements.

This second order morpho-unit is characterized by moderate drainage frequency low relative relief, low dissection index, coarse drainage density and gentle slope (Table 1). It has been further divided into three third order morpho-units, namely (1) The Upper Pandu Valley, (2) The Malia Valley, and (3) The Lower Thema Valley. Similarly, two fourth order morpho-units of the Upper Pandu Valley are : (a) The Gulpathan Table land (Am, Fp, Al, Dl, Ddm, Sm), and (b) The Gently sloping Kachnarwa Tract (Aml, Fm, Rl, Dl, Ddm, and Sg).

II. THE SONPAR UPLAND

The Sonpar Upland with an area of about 2053 km² accounts for 53.49% of the study-area. It lies in the western part. With north-south alignment. This area is drained by the rivers Bijul, Rihand and Kanhar and their tributaries. It is mainly composed of the Archeasns, the Bijawars and the Lower Gandwana Supergroup rocks, including granite, pegmatite, phyllite, slate, sandstone, coal, magmtite, granite-quartz and schist. Its terrain is made up river valleys,

basins, divides and symmetrical ridges that extend in east west direction. Large part of its area is under protected forest. Its altitude varies from about 200 m to 600 m, but 83% of its area lies in the height category of 300 m to 400 m. It has the following proportions of various morpho-metric attributes: Absolute relief : Al - 1.59%, Aml - 9.26%, Am - 83.40%, Amh - 5.26% and Ah - 4.82%; Drainage frequency : Fvp - 0.19%, Fp - 5.13%, Fm - 45.55%, Fmh - 39.15%, Fh - 7.77% and Fvh - 2.19%; Relative relief : Rel - 18.30%, RI - 53.40%, Rm - 23.40%, and Rmh - 4.90 %; Dissection index : Dvl - 29.11%, Dl - 53.18%, Dm - 16.39% and Dmh - 1.32 %; Drainage density : Dde - 35.08%, Ddm - 53.53%, Ddmf - 7.76%, Ddf - 7.76% and Ddf - 0.74%, and slope : Sl - 2.10 %, Sg - 29.29 %, Sm - 61.80 %, and Sms - 6.90%. This morpho-unit has been further dismantled into six second order morpho-units : (A) The Siari-Bijul Divide, (B) The Bijul-Rihand Divide, (C) The Barhar-Singrauli Upland, (D) The Northern Kanhar-Rihand Divide, (E) The Southern Rihand Kanhar Divide, and (F) The Central Thema Valley Tract (Fig. 1).

II. A. THE SIARI - BIJUL DIVIDE

It is located in the western part and measures 78.5 km² or 2.84% of the study-area. Its absolute relief varies from 280 m to 400 m. This morpho-unit is drained by the Siari and Bijul rivers and its terrain is largely composed of phyllites and slates. The region, as a whole, is dominated by moderate absolute relief, moderately high drainage frequency, moderate drainage density, moderate relative relief, low dissection index and moderate slope (Table1).

The second order morpho-unit has been divided into two third order morpho-units, namely (1) The Upper Siari Valley, and (2) The Middle Siari Valley. The third order morpho-unit of Upper Siari Valley can be further sub-divided

into two fourth order morpho-units, namely (a) Turra Upland and (b) Bharahi Upland.

II. B. THE BIJUL - RIHAND DIVIDE

The Bijul - Rihand divide extends from west of Dudhichuan in the south to Mahilpur and Kansar in the north. It is drained by the headwaters of Bijul and Rihand rivers. This unit is characterized by moderate absolute relief, moderately high drainage frequency, low relative relief, low dissection index, moderate drainage density and moderate slope (Table 1). A major part of the its area is covered by forests.

This region has been sub-divided into three third order morpho - units, namely (1) The Majhauri Moderately sloping zone, (2) Kanhari - Paraspani Upland, (3) The Barhar Upland, and (4) Western Flank of Singrauli, Upland (Fig. 1). Further, the third order morpho-unit of Kanhari - Paraspani Upland has been sub-divided into two fourth order morpho-units, namely (a) The Kansar Upland, and (b) The Kubri Upland. Similarly, the Barhar Upland has been sub-divided into three fourth order morpho-units, namely : (a) Charka Upland, (b) Parsoi Upland, and Upland has been again dismantled into two fourth order morpho-units, namely (a) Randhor-Upland and (b) Lojhara Upland.

II. C. THE BARHAR - SINGRAULI UPLAND

The Barhar - Singrauli Upland is situated in the western part of the Rihand Valley and covers 452.8 km² or 11.08% of the study-area. It is mainly composed of phyllite, slate and granite (Bijawars), and sandstone and limestone with coal beds of Lower Gondwana age. Its absolute relief varies from about 200 m to 500 m. It is drained by small tributaries of the Rihand. The central part of this unit is comparatively higher than its surrounding area.

This second order region, as a whole, is dominated by Am - 78.86%, Fm - 47.72%, Rl - 64.2%, Dl - 53.2%, Ddm - 49.09%, and Sm - 77.2%, Categories of morphometric attributes, and has been sub-divided into five third order units, namely (1) The Lower Basiniya Upland, (2) The western Rihand Divide, (3) The Middle Rihand Valley Tract, (4) Sohvani Upland, and (5) Kota Upland (Fig.1).

The third order morpho-unit of Lower Basiniya Upland has been further divided into two fourth order morpho-units namely (a) Jogendra Upland and (b) Kharhwa Upland. The Western Rihand Divide has been again divided into three fourth order units : (a) Karmasar Upland, (b) Renusagar-Amarsota Upland, and (c) Upper Rihand Upland. Also, the Sohvani Upland can be sub-divided into the following fourth order morpho-units : (a) Lower Sohvani Upland, and (b) Upper Sohvani Upland (Table 1).

II. D. THE NORTHERN RIHAND-KANHAR DIVIDE

The northern Rihand-Kanhar divide is located in the north-central part of Sonpar Upland. This morpho-unit has an area of 186.8 km² or 4.87% of the study-area. It is composed of rocks of Paraol formation and is drained by the Rihand, the Kanhar and the Hathinala and their smaller tributaries. Its altitude varies from 320 m to 400 m. A large part of this is covered by forest. This divide area, as a whole, is dominated by moderate absolute relief (84.37%), moderate drainage frequency (53.0%), low relative relief (73.6%), low dissection index (55.1%), coarse drainage density (59.15%) and moderate slope (63.7%).

It has been sub-divided into two third order morpho-units; namely (1) The Hathwani-Bagherdol Upland, and (2) The Lower Kanhar-Pandu Divide. The Hathwani - Baheradol Upland can be sub-divided into two fourth

order morpho-units, namely (a) The Basudha Upland, and (b) The Rajkhar Upland.

II.E. THE SOUTHERN RIHAND - KANHAR DIVIDE

The Southern Rihand - Kanhar divide lies in the south central part of the study-area. It is drained by Kanhar and its tributaries - Thema, Lauwa and Pangon, and the Rihand River. The slope of this divide zone is directed towards the tributaries of the Rihand and Kanhar rivers. Its altitude, in the southern, varies from 260 m to 600 m. The isolated hill of Gora Pahar in Pangon fork has an elevation of 565 m. The area is mainly composed of shale and Archeon Supergroup rocks. It is dominated by moderate absolute relief (88.61%), moderate drainage frequency (53.22%), low relative relief (41.2%), very low dissection index (37.4%), moderate density (62.08%), and moderate slope (51.1%).

This second order unit has been sub-divided into six third order morpho-units; namely (1) The Belguri Upland, (2) The Manbasa Upland, (3) The Upper Lauwa-Thema and Ajir Valley Tracts, (4) The lower Pangan Basin, (5) Pindari-Sirsoti Gently sloping zone and (6) The Gora Upland. The Upper Lauwa-Thema and Ajir Valley Tracts have been sub-divided into four fourth order morpho-units; namely (a) The Upper Lauwa Valley, (b) The Upper Thema Valley, (c) Mahmar-Bichchi Divide, and (d) Darinara-chapki Upland. Similarly Pindari-Sirsoti Gently sloping Tracts can be again sub-divided into two fourth order morpho-units; namely (a) Sirsoti-Pindari Level Tract, and (b) Harhori Gently sloping Tract.

II. F. THE CENTRAL THEMA VALLEY

This unit extends from the source of the Thema to Dudhi and covers an area of 28.11 km² only. Settlements are found on both the sides of this river. It is mainly composed of Archean supergroup rocks. Its elevation varies from 360

m to 400m. The dominant morphometric attributes of this unit, with percent areal coverages are as follows : moderate drainage frequency (57.30%), low relative relief (64.4%), very low dissection index (64.0%), coarse drainage density (53.74%) and gentle slope (49.7%).

This second order morpho-unit has been sub-divided into two third order morpho-units, namely (1) Gently sloping Murta zone, and (2) Kharatia Lowland.

III. BABHANI UPLAND

The first order morpho-unit occurs in the southern part of the study-area. It measures about 347.6 km² and its altitudex varies from 360 m to 650m. Moderate slope characterizes the small isolated hillocks of this unit. The Ranikothi Pahar (651m) is located in the fork of Pangan River in the southern part. A large part of this unit is covered by protected forest. The Ajir and Pangan rivers and their small tributaries, which flow over migmatites, granite-gneiss, schist and Dudhi group of rocks of this area, have produced rugged terrain. More than 64% of the its area has elevations of 400 to 500 m. The proportions of various morphometric attributes characterizing this morpho-unit are : Am-30.76%, Amh - 64.58% and Ah - 4.66%, Fp- 1.47%, Fm - 21.58, Fmh - 72.47%, Fh- 3.45% and Rh - 4.30%, Dvl - 9.0%, Dl- 41.9%, Dm - 30.7%, Dmh - 13.2% and Dd - 5.20%, Ddc - 18.81%, Ddm- 68.07%, Ddmf - 12.0%, 12.0%, Ddf-1.12%, Sl-6.9%, Sg- 54.7%, Sm-36.4% and Sms-2.0%.

It has been sub-divided into two second order morpho-units, namely (A) Ajir-Pangan Divide, and (B) Bajia-Sistola Upland (Fig. 1).

III.A. AJIR-PANGAN DIVIDE

It occurs in the southern part of the study-area and occupies an area of 208.8km²(5.43%).It

elevation ranges from 380 m to 500m. The area is mainly composed of migmatites and granite-gneiss and is drained by the Pangan and Ajir rivers. It is characterized by gentle slope. This morpho-unit is dominated by moderate absolute relief (51.20%), moderately high drainage frequency (74.18%), moderate relative relief (47.1%), low dissection index (32.4%), moderate drainage density (65.61%) and gentle slope (50.9%).

The second order morpho-unit has been divided into two third order morpho-units, namely (1). Lower Ajir -Pangan Divide, and (2) Jiganhwa-Machbandhawa Upland. The Lower Ajir-Pangan Divide can be further subdivided into two fourth order morpho-units, namely (a) Ghari Upland, and (b) Bichchiari Upland. The Jignahawa-Machbandhanwa Upland has been also sub-divided into two fourth order morpho-units, namely (a) Ranikothi Pahar, and (b) Barwatola Upland.

III. B. BAJIA - SISTOLA UPLAND

Lying between 380 m to 500 m, this second order morpho-units covers an area of 138.8 km² or 3.60% of the study-area. It is drained by the Pangan Badi and its small tributaries. Its terrain is composed of migmatites, granite-gneiss, and schist rocks. A major part of this unit is covered by protected forest. Moderate absolute relief (88.33%), moderate relative relief (37.6%), low dissection index (54.5%), moderately high drainage frequency (69.88%), moderate drainage density (71.76%) and moderate slope (60.5%) characterize this unit.

This morpho-unit has been sub-divided into two third order morpho-units, namely : (1) Nawatola-Barawadih Uplands, and (2) Sistola-Ekdari Upland. The Sistola-Ekdari Upland has been further sub-divided into two fourth order morpho-units, namely (a) Ekdari Upland, and (b) Sistola Upland.

CONCLUSION

Classification of terrain of South Mirzapur Upland into morpho-units of various hierarchical orders, based on diverse morphometric attributes, has been made with a view to resource appraisal and its scientific management. Consequently, this upland region, lying to the south of Son River, has been divided into 3 first order, 13 second order, 43

third order and 66 fourth order morpho-units. The three first order morpho units are : (i) Sonpar Valley Tract, (ii) Sonpar Upland and (iii) Bhabhani Upland comprising 37.46, 53.49 and 9.05 percent area. These morpho-units provide a broad framework for examining the possibilities for scientific management of soil forestry, agriculture, settlements and order related activities.

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