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A Study on Morphometric Characteristics of Sonitpur District, Assam

DR. PRASENJIT DAS
Assistant Professor
Department of Geography
Bajali College, Pathsala, Assam
India

Abstract:

An attempt has been made for morphometric study on Sonitpur District of Assam. Absolute Relief (AR), Relative Relief (RR), Dissection Index (DI), Average Slope (AS) and Stream Frequency (Fu) are the different geomorphic parameters which have been analysed in the study area for morphometric analysis and to prepare the various thematic maps. These parameters have been analysed from SOI toposheets. The entire study area has been divided into 1331 grids of four sq. km each and all parameters are calculated for each grid. From the morphometric study of the study area, it is found that northern part is hilly (highest elevation 456 meters); middle and southern part is almost plain although three isolated hillocks are present in the southern parts which are made up of archean gneisses with a height varying from 80 to 172m above the mean sea level.

Key words: Morphometric study, Absolute relief, Average slope, Dissection index, Stream Frequency

Introduction

Landforms are the result of geologic and geo-morphologic processes that occur on the earth's surface (Crevenna et al, 2005). The term "landform" denotes a portion of the earth that

unites the qualities of homogeneous and continuous relief due to the action of common geological and geomorphological processes. Analysis of morphometric characteristics is a fundamental requirement of landform study of any area. Morphometry is defined as the measurement and mathematical analysis of the configuration of the earth's surface and of the shape and dimension of its landforms (Clarke, 1966). Morphometric methods though simple, have been applied for the analysis of area-height relationships, determination of erosion surfaces, slopes, relative relief and terrain characteristics as a whole. The morphometric analysis of different regions had been done by various scientists using conventional methods (Horton, 1945; Smith, 1950; Strahler, 1956). In the present study morphometric analyses of Sonitpur District have been carried out with a view to understand the geomorphic characteristics of the study area.

The Study Area

Sonitpur district is situated in the north-bank plain of the state of Assam. The district is sandwiched by the Brahmaputra River to the south and the Himalayan foothills of Arunachal Pradesh to its north. The area is characterized by lowlands with elevation varying between 10-80 meters, 80-100 and 100-200 meters (Saikia et al, 2008). A small strip of low hills on its northern limits with elevation ranging from 200 to 456 meter exists on its north western margin. Several rivers flowing parallel to one another in a north-south trend dissect the district as they flow down the foothills to the Brahmaputra River. The total area of the Sonitpur District is 5324 km^2 and is extends between 26˚28' N and 27˚02́ N latitudes and 92˚17́ E and 93˚47́E longitudes. The Sonitpur District of Assam lies in the regime of monsoon climate of the sub-tropical belt. Here, summers are hot and humid, with an average temperature of 29° C. As far as spatial distribution of rainfall is concerned,

there is a marked variation within the district. Rainfall is quite high at 1384 mm (GoA, 2004). According to Champion and Seth (1968), the forests in the study area are comprised primarily of subtropical evergreen, tropical semi-evergreen, tropical moist deciduous and riverain forest/grasslands.

Database and Methodology

For the preparation of base map and for morphometric analysis of the study area, topographical sheets of 1:50,000 scale of the Survey of India are used.

Absolute Relief (AR), Relative Relief (RR), Dissection Index (DI), Average Slope (AS) and Stream Frequency (Fu) are the different geomorphic parameters which have been analysed in the study area to differentiate physiographic characteristics and to prepare the various thematic maps. The entire study area has been divided into 1331 grids of four sq. km each and all parameters were derived and calculated for each grid.

Absolute relief gives the elevation of any area above the sea-level Absolute elevation in each grid has been computed from spot heights, triangulation points wherever available and from the maximum contour value passing through the grids (with contour interval 20m).

Relative relief represents the difference in elevation between the highest and lowest points falling in a unit area. For the purpose of relative relief analysis, the height difference between the highest and lowest elevation within each grid is computed with a contour interval of 20m.

The dissection index, which is the ratio between relative relief and absolute relief, gives a better understanding of the landscape. Nir (1957) computed 'Dissection Index" as the ratio of two morphometric variables i.e., relative relief and absolute relief within a specific areal unit. He measured vertical distance from the erosion base to express the dynamic potential

and relief energy of the area. It has been calculated by the following methodology:

$$\text{Dissection Index (D.I.)} = \frac{\text{Relative Relief (R.R.)}}{\text{Absolute Relief (A.R.)}}$$

The term 'slope' in its broadest sense means an element of earth's solid surface, including both terrestrial and submarine surfaces; it is, therefore, simply an element of the interface between the lithosphere or atmosphere (Strahler, 1956). Slope refers to the angle which any part of the earth's surface makes with horizontal. It is an element of the interface between lithosphere and either hydrosphere or atmosphere (Fairbridge 1968).

Computation of slope angles from topographical maps or through field measurement involves tedious and time-consuming procedures. Several techniques of the derivation and computation of average slopes from topographical maps have been suggested from time to time e.g. Smith (1935), but the technique of Wentworth, being easier and involving lesser measurement and calculation and more rapid procedure than other schemes, has been adopted for the slope analysis in the area.

The formula devised by Wentworth is given below:

$$\text{Average Slope} = \tan \theta = N \times CI/3361$$

Where, N = Average no. of contour crossing in an area per sq. mile.

CI = Contour interval in feet

3,361 = A constant figure

The stream frequency is defined as the total number of stream segments per unit area. In general, the occurrence of stream segments depends on the nature and structure of rocks, vegetation cover, nature and amount of rainfall and infiltration

capacity of the soil. It is an index of the various stages in landscape evolution.

Horton (1932, 1945) introduced stream frequency as the number of stream segments per unit area.

Numerically, it is defined by the relation

$Fu = (N)\ u/Au$

Where

Fu = Stream frequency in no/km^2

(N) u = Sum of total number of stream segments of all orders

Au = Total area of the drainage basin in sq. km

The expression Fu gives the average frequency of streams in the basin.

The various geomorphic attributes of the study area are discussed below.

Absolute Relief (AR)

The elevation within the study area varies from 50m in the south to 460m in the north-west, the grid wise computed absolute heights, have been classified into 8 categories with a class interval of 20m ranging from less than 60m to over 180m above mean sea level (Table- 1). The highest elevation of 456 m. above m.s.l. is located on Charduar Reserved Forest near Sonai Rupai River.

Table-1 Distribution of Absolute Relief

Absolute Relief Categories(m)	Grid Frequency	Grid Frequency (%)	Area (sq. km)	Cumulative Area	Area (%)	Cumulative Area (%)	Major Absolute Relief Groups
Above 180	61	4.58	244	4.58	4.58	4.58	Above 160m – Very High 312 sq. km (5.86%)
160-180	17	1.28	68	312	1.28	5.85	
140-160	31	2.33	124	436	2.33	8.18	120-160m High 412 sq. km (7.74%)
120-140	72	5.41	288	724	5.41	13.59	
100-120	158	11.87	632	1356	11.87	25.46	80-120m High Moderate 1980 sq. km (37.19%)
80-100	337	25.32	1348	2704	25.32	50.78	
60-80	424	31.84	1696	4400	31.84	82.63	Below 80m Low 2620 sq. km (49.21%)
Below 60	231	17.37	924	5324	17.37	100.00	
	1331	100	5324	5324	100	100	

Distributional Pattern of Absolute Relief

The different Absolute Relief categories reveal a peaked grid frequency distribution between below 80m and 80-100m categories.

Table-1 Reveals that very high and high relief categories have insignificant spatial distribution (5.86%, and 7.74% respectively). On the other hand large part of the study area has moderate to low absolute relief groups (37.19% and 49.21% respectively). The distribution of these groups is discussed below.

Very High Absolute Relief (Above 160m)

The terrain representing this group is confined to the north-eastern and northern part of the study area. This part is located in the foothills of Arunachal Himalaya and it is composed of Sedimentary Rocks. This area is densely forested and Charduar and Balipara reserved forest is located here.

High Absolute Relief (120 To 160m)

The terrain representing the high absolute relief is located to the south of the very high absolute relief. This part is also densely forested but recently lot of deforestation has taken place and the forest area is taken over by human settlements.

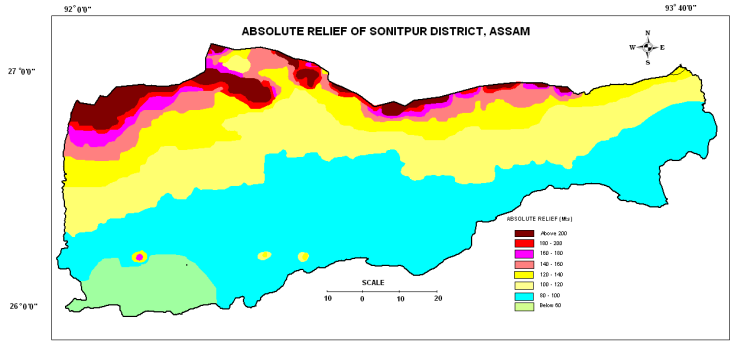

Fig- 1 Absolute Relief of Sonitpur District, Assam

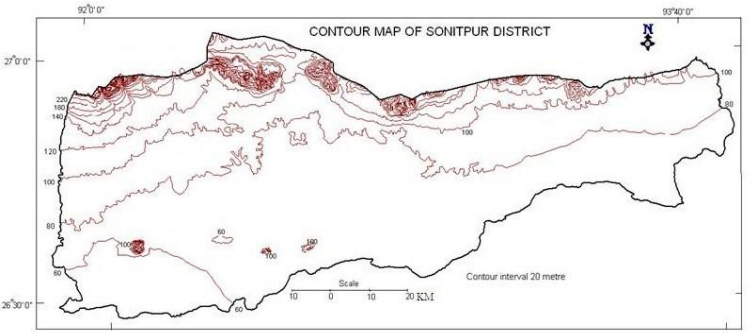

Fig. 2 Contour Map of Sonitpur District

Moderate Absolute Relief (80 To 120m)

The terrain representing the moderate absolute is located to the south of the high absolute relief. Here both forest and human settlements are found with the dominance of the later.

Low Absolute Relief (Below 80m)

The terrain representing low absolute relief is located to the south of moderate relief. This part is almost plain and is dominated by human settlement. This portion of the study area

is prone to flood which often creates havoc damaging both life and property of the people.

Relative Relief (RR)

For the purpose of relative relief analysis, the height difference between the highest and lowest elevation within each grid is computed with a contour interval of 20 m. The relative relief varies from 0m in the south to 150m in the north and northeast. The grid values are classified into eight categories (Table- 2). With a class interval of 20m, ranging from less than 20m to more than 140m above mean sea level. The spatial distribution of these categories is shown in fig-3.The different relative relief categories reveal a decrease above 20-40m category which indicates an almost plain relief of the study area. For qualitative assessment these categories have been classed into four major groups (Table-2) and discussed below.

Table 2 Distribution of Relative Relief in Sonitpur District

Relative Relief Category	Grid Frequency	Grid Frequency (%)	Area (Sq. Km)	Cumulative Area (Sq. km)	Area (%)	Cumulative Area(%) (%)	Major Relief Groups
Above 140	3	0.22	12	12	0.22	0.22	Above 120m Very High 32 sq. km (0.60%)
120-140	5	0.38	20	32	0.38	0.60	
100-120	6	0.45	24	56	0.45	1.05	80-120m High 68 sq. km (1.27%)
80-100	11	0.83	44	100	0.83	1.88	
60-80	14	1.05	56	156	1.05	2.93	40-80m Moderate 128sq. km (2.40%)
40-60	18	1.35	72	228	1.35	4.28	
20-40	32	2.40	128	356	2.40	6.68	0-40m Low 5096 sq. km (95.72 %)
0-20	1242	93.32	4968	5324	93.32	100	
	1331	100	5324	5324	100	100	

Distributional Pattern of Relative Relief

A perusal of Table-2 reveals that low relief (95.72%) dominates the entire study area, moderate relief (2.40%) comes in distant second. High and very high reliefs (1.27% and 0.60%) occupy only a very insignificant portion of the study area.

Very High Relative Relief (Above 120m)

It covers a negligible area (0.60% or 32 sq. km) in the study area and is found over north and northwestern side of the study area. In these areas river valleys and hills exist together resulting in such high relative relief.

High Relative Relief (80-120m)

It covers an insignificant area (1.27% or 68sq. km) and is spread over as clusters in the northeastern, northern and northwestern side of the study area. The upper reaches of Jia Bharali and Gabharu River have high relative relief.

Moderate Relative Relief (40-80m)

This group covers 2.40% or 128sq.km of the study area. This group is found throughout the northern side of the study area as well as in some scattered patches in southern side (Agnigarh and Bhomuraguri hills)

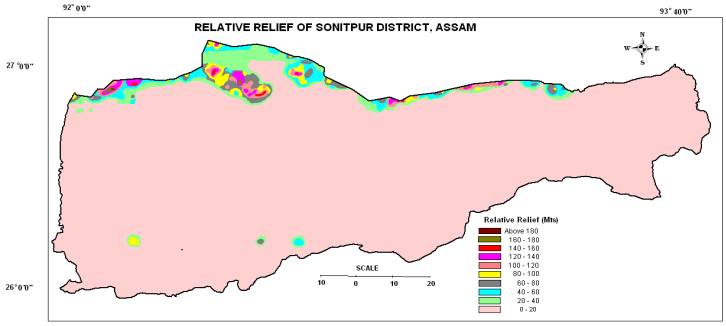

Fig 3 Relative Relief of Sonitpur District

Low Relative Relief (0-40m)

This group dominated the whole study area as it covers 95.72% or 5096 sq. km of the total area. Sonitpur district is primarily a

plain area and that is why more than 95 percent of the study area has low relative relief.

Dissection Index

In the study area, dissection index is computed for 1331 grids. The value varies from 0.0 to 0.64 and it has been classified into seven categories (Table-3) with a class interval of 0.10, ranging from less than 0.10 to above 0.60. The spatial distribution of these categories is shown in Fig.-4. For qualitative assessment, these seven categories have been classed into three groups.

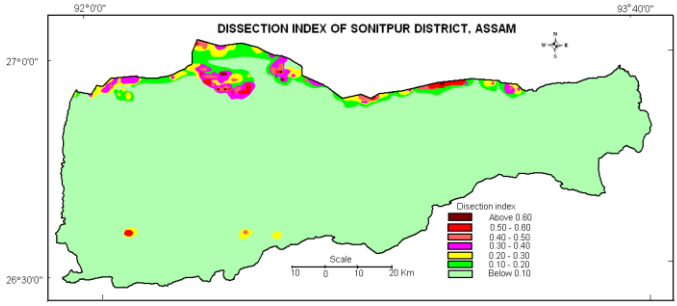

Fig. 4 Dissection Index of Sonitpur District

Distributional Pattern of Dissection Index

A perusal of Table 3 reveals that maximum grid frequency lies under the low groups covering 96.02% of the total frequency. It indicates plain nature of the topography in the study region. The different dissection index groups are discussed below.

Very High (Above 0.50)

It covers negligible area (0.68%), mainly confined to the northern part of the study area.

Table 3 Distribution of Dissection Index in Sonitpur district

Dissection Index Category	Grid Frequency	Grid Frequency (%)	Area (sq. km)	Cumulative Area (sq. km)	Area (%)	Cumulative Area (%)	Major Dissection Index Group
Above 0.60	3	0.23	12	12	0.23	0.23	Above 0.50 High
0.50-0.60	6	0.45	24	36	0.45	0.68	36 sq. km (0.68%)
0.40-0.50	8	0.60	32	68	0.60	1.28	0.20-0.50 Medium
0.30-0.40	14	1.05	56	124	1.05	2.33	176 sq. km (3.30%)
0.20-0.30	22	1.65	88	212	1.65	3.98	
0.10-0.20	29	2.18	116	328	2.18	3.98	0-0.20 Low
0.0-0.10	1249	93.84	4996	5324	93.84	100	5112 sq. km (96.02%)
	1331	100	5324		100		

Moderate (0.20-0.50)

This group is also found in the northern part of the study area and it also covers a negligible area (3.30%). Three patches of moderate dissection are also found in the southern part of the study area where some small hillocks are found.

Low (0.0-0.20)

This group dominates the entire study area as it occupies 96.02% of the total area.

Average Slope (As)

The term 'slope' in its broadest sense means an element of earth's solid surface, including both terrestrial and submarine surfaces; it is, therefore, simply an element of the interface between the lithosphere or atmosphere (Strahler, 1956).

The study area has been divided into 1331 grids of four sq. km each and the number of contours crossing per four sq.

km. i.e. per grid is counted (contour crossing per side of the grid divided by four = contour crossing per grid). With the Wentworth's formula, average slope per grid is computed (the value obtained by the formula is converted into degrees). These average slope values obtained have been classified into 6 categories (Table-4) with an interval of 2.5. For qualitative assessment, these six categories have been classed into three groups. The spatial distribution of these categories is shown in Fig-5. The slope within the study area varies from 0° in the south to 14° as isolated patch in the northwestern part of the study area.

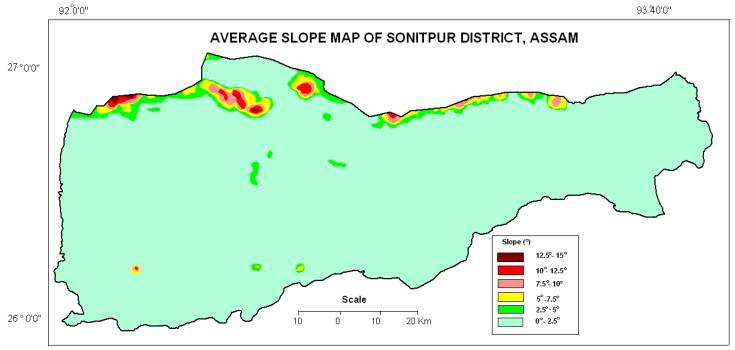

Fig. 5 Average Slope Map of Sonitpur District

Table 4 Distribution of Average Slope in Sonitpur District

Slope Category (°)	Grid Frequency	Grid Frequency (%)	Area (sq. km)	Cumulative Area (sq. km)	Area (%)	Cumulative area (%)	Major Slope Group (°)
12.5 - 15	2	0.15	8	8	0.15	0.15	Above 10° Steep 36 sq. km (0.68%)
10 – 12.	7	0.53	28	36	0.53	0.68	
7.5 – 10	9	0.68	36	72	0.68	1.36	5° - 10° Moderate 108 sq. km (2.03%)
5 – 7.5	18	1.35	72	144	1.35	2.71	

2.5 – 5	31	2.33	124	268	2.33	5.04	0° - 5° Gentle 5180 sq. km (97.29%)
0 – 2.5	1264	94.96	5056	5324	94.96	100	
	1331	100	5324	5324	100		

Distributional Pattern of Slope

The different slope categories show that maximum portion of the study area has gentle slope (97.29%). Since the study area is essentially a part of Brahmaputra valley, which is almost totally a plain area except some monadnock like features here and there, maximum portion of the study area has gentle slope. A perusal of table-4 reveals that steep slope group has negligible areal extent (0.68%). Similarly moderate slope group only occupies 2.03% of the total study area. The distribution of various slope categories is discussed below.

Steep Slope (Above 10°)

Steep slope covers about 36 sq. km or 0.68 per cent of the study area. This category occurs in the northern side of the study area which is hilly in character. This category is also found in the southern part of the study area where it occurs as isolated patches where monadnocks like features are found.

Moderate Slope (5°-10°)

This category covers 108 sq. km or 2.03% of the study area. This category is also mainly found in the northern part which is hilly in character.

Gentle Slope (0°- 5°)

This is the predominant slope category of the study region. As the whole study area is almost plain, so this category is dominant all over except some isolated patches here and there. This category covers 5180 sq. km or 97.29 percent of the total study area.

Stream Frequency (Fu)

The stream frequency within the study area varies from 0 nos. in the southernmost part to 10nos. scattered towards the northern and eastern part of the study area. The grid wise computed drainage frequencies are classified into five categories (Table-5) with a class interval of 2, ranging from below 2 nos. per sq. km to above 8 nos. per sq. km. The spatial distribution of these categories is shown in Fig.-6. These categories have been classed into three major stream frequency groups and discussed in table-5.

Table 5 Distribution of Stream Frequency in Sonitpur District

Stream Frequency Category (nos/sq. km)	Grid Frequency	Grid Frequency (%)	Area (sq.km)	Cumulative Area (sq. km)	Area (%)	Cumulative Area (%)	Major Stream Frequency Group
Above 8	8	0.60	32	32	0.60	0.60	Above 6 nos./ km² - High 120 sq. km (2.25%)
6 - 8	22	1.65	88	120	1.65	2.25	
4 - 6	75	5.64	300	420	5.64	7.89	2 – 6 nos./ km² - Medium 1624 sq. km (30.50%)
2 - 4	331	24.87	1324	1744	24.87	32.76	
0 - 2	895	67.24	3580	5324	67.24	100	0 - 2 nos./ km² - Low 3580 sq. km (67.24%)
	1331	100	5324		100		

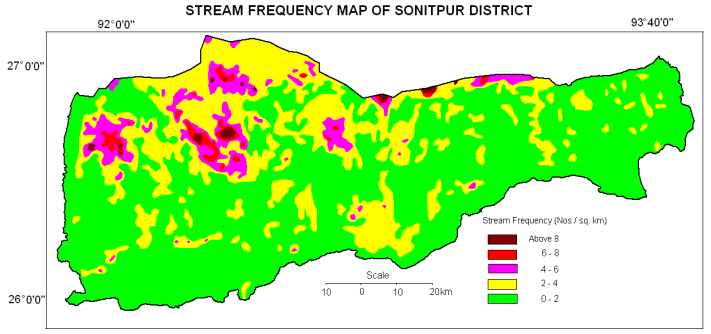

Fig.6 Distribution of Stream Frequency of Sonitpur District

Distribution of Stream Frequency in Sonitpur District

The different drainage frequency categories reveal a peaked grid frequency distribution between 0-2 nos. per sq. km and 2-4 nos. per sq. km stream frequencies. A perusal of (Table-5) indicates that high stream frequency group has insignificant distribution of 2.25% in the study area. The distribution of various stream frequency groups are discussed below.

High Stream Frequency (Above 6 Nos/ Km²)

It is scattered mainly in the northern and eastern part of the study area in discrete patches.

Moderate Stream Frequency (2- 6 Nos/ Km²)

This group occurs as large patches all over the region especially in the northern and eastern part. The spatial distribution of this group does not indicate any influence of lithology or structure.

Low Stream Frequency (Below 2 Nos/ Km²)

This is the dominant stream frequency group in the study region as it covers 67.24 % of the study area. Except the northernmost part, where it is almost absent, this group dominates everywhere in the study area.

Conclusion

From the terrain evaluation of the study area; it is found that Sonitpur District is almost plain with the exception of its northern part. Northern part is hilly (highest elevation 456m); middle and southern part is almost plain although three isolated hillocks are present in the southern parts which are made up of Archean gneisses with a height varying from 80 to 172m above the mean sea level. The highest elevation of 456m. above m .s. l. is located on Charduar Reserved Forest near Sonai Rupai River. From the study of Absolute Relief, it is

found that that very high and high relief categories have insignificant spatial distribution (5.86%, and 7.74% respectively). On the other hand large part of the study area has moderate to low Absolute Relief groups (37.19% and 49.21% respectively). From the study of Relative Relief, it is found that the relative relief varies from 0 m in the south to 150m in the north and northeast. Low relief (95.72%) dominates the entire study area; moderate relief (2.40%) comes in distant second. High and very high relief (1.27% and 0.60%) occupies only a very insignificant portion of the study area. From the study of Dissection Index, it is found that dissection index value varies from 0.0 to 0.64. and maximum grid frequency lie under the low groups covering 96.02% of the total frequency which indicates plain nature of the topography in the study region. From the study of Average Slope, it is found that the slope within the study area varies from 0° in the south to 14° as isolated patch in the northwestern part of the study area. The different slope categories show that maximum portion of the study area has gentle slope (97.29%). Since the study area is essentially a part of Brahmaputra valley, which is almost totally a plain area except some monadnock like features here and there, maximum portion of the study area has gentle slope. From the study of stream frequency, it is found that the stream frequency within the study area varies from 0 nos. in the southernmost part to 10nos. scattered towards the northern and eastern part of the study area. The different stream frequency categories reveal a peaked grid frequency distribution between 0-2 nos. per sq. km and 2-4 nos. per sq. km stream frequencies. Further it is found that high stream frequency group has insignificant distribution of 2.25% in the study area.

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