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Morphometric Analysis of Chamundi Hills, Mysuru, India Using Geographical Information System

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ABSTRACT

The article attempts to determine and understand the morphometric form of Chamundi Hills which are in the south-eastern part of Mysuru city. The study was based on the Mysore City Guide map (part of Toposheet No. 57 D/11) published by the Survey of India in 1976 and it was prepared within the geospatial software ArcGIS 10.3. The study was made with the grid method followed by interpolation method in determining relative relief, dissection index, and ruggedness index. Slope analysis was one of the extensions of relief morphometry which was developed and designed using Arc GIS. The slope analysis tools covered slope in degree, slope in percent, slope aspect and slope curvature. The study revealed that the Chamundi Hills had a hexagonal shape with steep slopes and were highly dissected in the northern and in the western sides. The study indicated that the hills were in the mature stage as per the geographical cycle of erosion. Maturity in the cycle of erosion, steep slope, high dissection, high slope in degree and in percent and high concavity might hinder the developmental programme, with exception on the eastern and on the southern parts of the Chamundi Hills.

Keywords— Morphometric analysis, relief, GIS, Chamundi Hills.

I. INTRODUCTION

Morphometry is defined as the "measurement of the shape, length, height, or geometry, of any form - be it plant, animal or relief features"[1]. Morphometric analysis incorporates quantitative study of the area, altitude, volume, profiles, slope, and relief of the land or drainage basin characteristics of the concerned area. The study of morphometry has two different branches - relief and fluvial morphology. This study is aimed at understanding the relief morphometry of the Chamundi Hills. Morphometric analyses are important in investigating topography of the earth surface and environmental assessment. It helps in investigating relief, dissection, ruggedness, degree and percent of the slope, slope aspect and the curvature of the surface which will be discussed in the later paragraphs.

Mysore City, the old capital and the second largest city in Karnataka state, is beautified by a granite hills called the Chamundi Hills. Geographically, Chamundi hills is situated between 76° 39' 35" E to 76° 42' 6" E longitude and 12° 15' 25" N to 12° 17' 13" N latitude with an area of 8.64 km^2. It is 4 km towards south-east of Mysore city. Geologically, Chamundi Hills is composed of igneous rock called granite rock - grey and pink granite. The age of Mysore Chamundi granite presents an anomaly as the granite is dated at 800 million years[2]. The Chamundi granite exhibits the structure like platy or planar; flow lines; fractures; faults and joints; and developments of gneissic borders as well as small intrusions is well exhibited in the rocks of Chamundi hills[3].

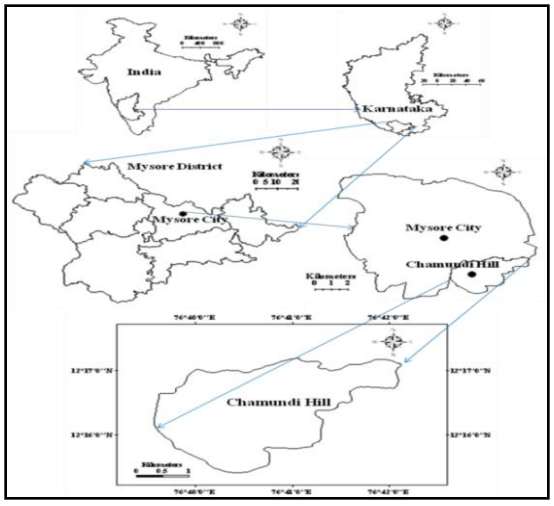

Fig. 1: Location of Study area

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II. METHODOLOGY

The topographic information was extracted from the analogue map i.e. Mysore City Guide Map (part of Toposheet No. 57 D/11) published by the Survey of India. Various relief morphometric techniques in ArcGIS 10.3 were used to determine the relief morphometry of the study area. A method to integrate GIS and statistics in morphometric analysis was presented for most usual morphometric parameters viz. areal (area, shape, etc.) and relief (profile, relative relief, dissection, ruggedness, etc.). The statistical methods used in the morphometric analysis of the Chamundi Hills is shown in Table 1 and 2.

TABLE I

AREAL MORPHOMETRIC PARAMETER

S.N	Parameters	Formulae	References
1	Hill Shape Index (HSI)	HIS = 1.27 ×A/L^2	Hagget and Chorley (1954)

TABLE II

RELIEF MORPHOMETRIC PARAMETERS

S.N	Parameters	Formulae
1	Relief (R)	$R = H - h$
2	Dissection Index (DI)	$DI = \frac{H-h}{H}$
3	TRI	$TRI = \frac{TC \times TF}{TC + TF}$
4	Degree of slope (DS)	$DS = \theta\ (Rise/Run)$
5	Percent of Slope (PS)	$PS = \theta \times 100$
6	Slope Aspect	$SA = 57.29578 \times atan2\left[\left(\frac{dz}{dy}\right) - \left(\frac{dz}{dx}\right)\right]$
7	Curvature	$Curvature = .2(D + E) \times 100$

III. RESULTS AND DISCUSSION

The quantitative measures have been developed to describe perimeter, area, shape, terrain altitude and surface – relative relief, dissection, and terrain ruggedness. The development of geospatial technology has enhanced in the field of morphometric analyses like slope in degree, slope in percent, slope aspects and curvature which are incorporated in the following paragraph.

Perimeter and areal aspects

The length and breadth has been measured by taking the farthest point of Chamundi Hills; from south-west to north-east directions and from north-west to south-east directions. The length of Chamundi Hills is 2.49 kilometers and the breadth is 1.57 kilometers covering an area of 8.64 square kilometers. Hagget and Chorley's (1954) drainage basin shape concept has been employed to understand the shape of the Chamundi Hills. As per Hagget and Chorley's concept, the Chamundi Hills with 0.80 hill shape index indicates that it resembles a hexagonal shape.

Relief aspects

Profile

The profile is a cross-section showing outline where the plane of a section cuts vertically the surface of the terrain. The profiles have been crossed in two sections as south-west to north-east (length) and north-west to south-east (breadth) of the Chamundi Hills. The profile-line running from south-west to north-east direction indicates that the western and south-western side is steeper than the north-eastern side (Fig 2). On the other hand, north-western side is steeper than the south-eastern side of the Chamundi Hills (Fig 3).

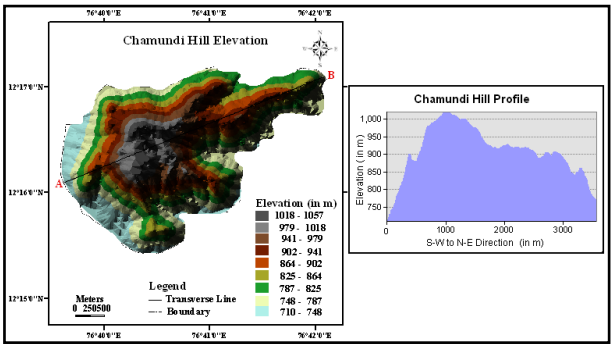

Fig 2: Chamundi Hills profile (South-west to North-east direction)

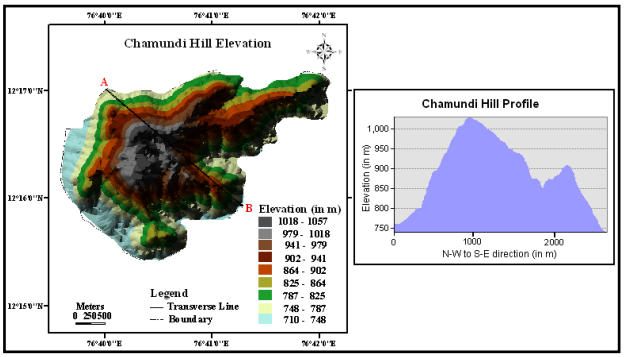

Fig 3: Chamundi Hills profile (North-west to south-east direction)

Relative Relief

Relative relief is also called amplitude of 'available relief' or 'local relief'. It is the ratio of highest contour and the lowest contour. The hills experienced very high relative relief ranging from 139 to 200 m covering the top of the Chamundi Hills in the south-western side in a hook shape (Fig 4). Most of the areas of the hills have 117 to 139 m as a relative relief. While the middle portion and the outlying areas in the east,

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north, north-west and south-west parts have low relative relief ranging from 20 m to 102 m.

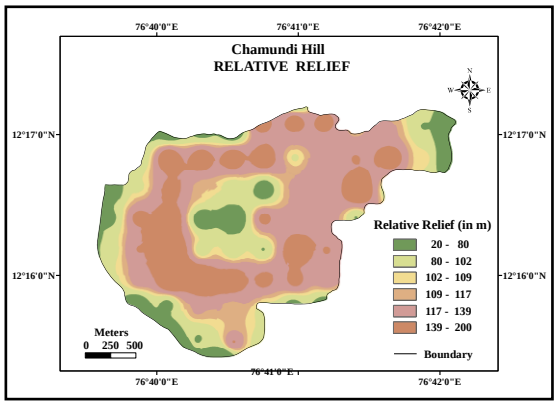

Fig 4: Relative Relief of Chamundi Hills

Dissection Index

DovNir (1957) dissection index methods have been adopted to analyse the dissection of the study area. It is the ratio of the relative relief and the highest relief. It is one of the important morphometric indicator of the nature and magnitude of dissection of terrain. Spatially, the western part near the highest point of the Chamundi Hills is highly dissected (Fig 5). On the other hand, it is less dissected in the middle part and in the eastern part of the Chamundi Hills ranging from 0.03 to 0.11 dissection index. The average dissection index with 0.12 indicates the mature stage in the cycle of erosion.

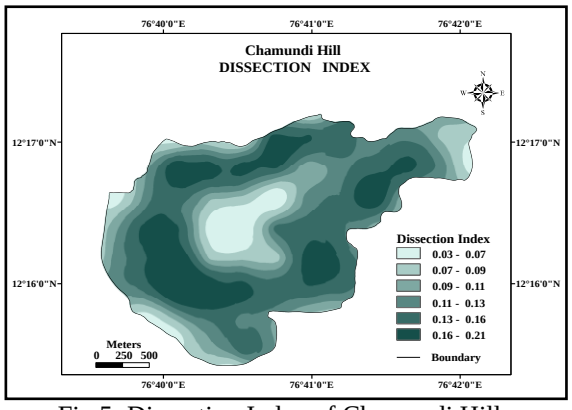

Fig 5: Dissection Index of Chamundi Hills

Terrain Ruggedness

Terrain ruggedness is the roughness of the surface of the earth. The terrain ruggedness index developed by Nellemann and Thomsen (1994) has been employed to determine the terrain ruggedness of the Chamundi Hills. It is expressed as the ratio of the total number of contour multiplying total number of fluctuation of contour and total number of contour adding total number of fluctuation of contour[4].The terrain roughness ranges from 0.5 to 9.98 with 4.95 as the average ruggedness index on the Chamundi Hills (Fig 6). The north, north-east, and south-east sides are highly rugged ranging between 6.3 to 9.9 ruggedness index on the Chamundi Hills. On the other hand, terrain ruggedness is low in the eastern edges, middle areas and in the western sides of the study area.

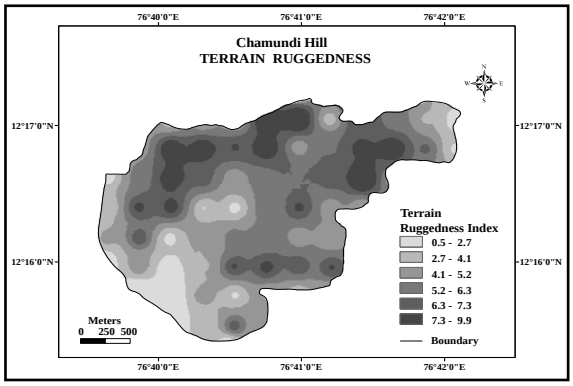

Fig 6: Terrain Ruggedness Index of Chamundi Hills

Slope aspect

Slope aspect identifies the downslope direction showing the four cardinal directions and four sub-cardinal directions. In the northern part of the Chamundi Hills, direction of the slope is in north, in north-east and in north-west (Fig 7). In the eastern part, the down-slope direction is in south and south-west. The western side faces north-west, west and south-west directions. The southern side of the Chamundi Hills faces south, south-east, east, and west directions. There is not much downslope which faces south directions. The slope facing eastern directions are scattered around on the south-eastern side.

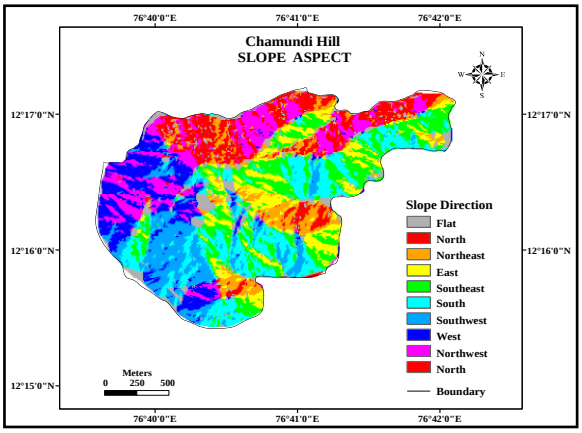

Fig 7: Slope aspect of Chamundi Hills

Slope analysis in degree and percent

Slope is the rate of maximum change in z-value which can be studied in two ways; slope in degree and slope in percent. The former is the inclination of slope which is calculated in degrees and the later is the rising of slope which is calculated in percent. The later is also referred as percent slope.

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The slope analysis depicts that there is gradual increase of slope degree in the north-eastern and southern part on the Chamundi Hills (Fig 8 and 9). The slope above 45 degree hooked around twice just above the foothill and just below on the top of the hills. The highest point and its vicinities range from 10 to 23 slope degree.

The maximum rate of change in slope above 73 to 122 percent is witnessed in the north, north-west, west, south-west and south-east parts on the study area. On the top of the Chamundi Hills and its neighbouring areas, the eastern side, south-western, and north-western witnessed from 0 to 73 percent of slope.

Curvature

Curvature is the second derivative of the surface of the slope. The Chamundi Hill's curvature map depicts mainly two types of output; a positive curvature indicating the surface is upwardly convex represented by grey colour on the map, and a negative curvature indicating the surface is upwardly concave shown by black colour on the map (Fig 10).

Chamundi Hills comes under rugged hill with extreme high relief based on curvature index varying from -31 to 24. The concavity ranges from 0 to -31 curvature index whereas convexity ranges from 0 to 24 curvature index. As per the curvature index, the concavity is more as compared to convexity on the Chamundi Hills. It indicates that where there are streams, concavities are more on the Chamundi Hills.

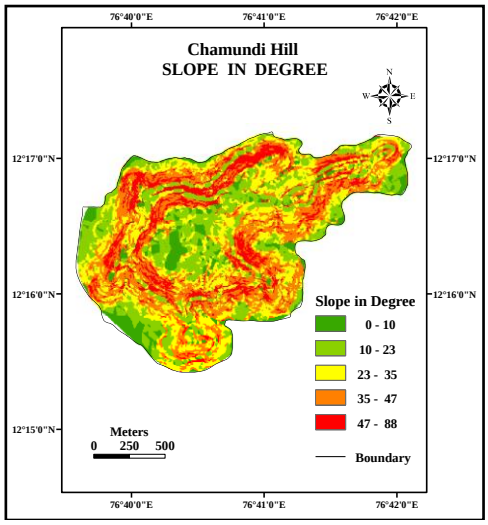

Fig 8: Slope analysis in degree

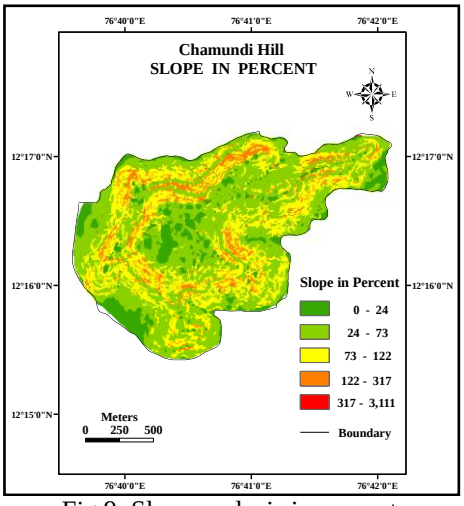

Fig 9: Slope analysis in percent

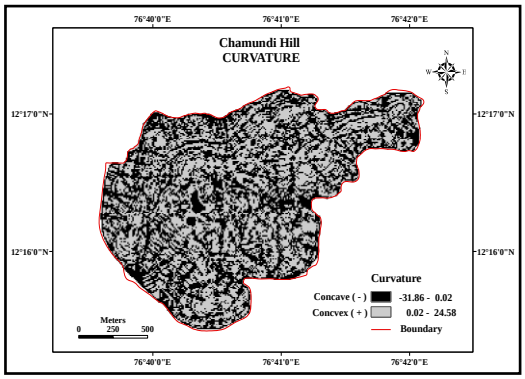

Fig 10: Curvature of Chamundi Hills

V. CONCLUSION

Various morphometric analysis techniques have been employed to determine and understand the perimeters and relief characteristics of Chamundi Hills. The study indicated that the Chamundi Hills is oriented in the direction of north-east to south-west. The length and breadth of Chamundi Hills is 2.49 km and 1.57 km. It covered an area of 8.64 square km resembling a hexagonal shape. The study of Chamundi Hills reveals that western and northern sides are steeper and broader than eastern and southern sides. The western side of the Chamundi Hills has very high relief and highly dissected. As per DovNir dissection index method, Chamundi Hills is in the mature stage in the cycle of erosion. On the other hand, terrain ruggedness is high in the north, north-east, and south-east part of the Chamundi Hills. Slope in degree and in percent are high in middle portion almost around the Chamundi Hills. As per the slope aspect analysis, it identified that there is not much downslope which faces east and south. Categorising, the study area has extreme high rugged hill based on curvature index. The surface of Chamundi Hills is upwardly concave as compared to upwardly convex

surface. As per the results, the eastern side and the southern part with less relief, dissection, ruggedness, and slope (in degree and in percent) have the advantages for the developmental programme like afforestation than the northern and western part of the Chamundi Hills.

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