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Spatial Analysis using Remote Sensing - A Case Study of Nethravathi River Basin, Dakshina Kannada, Karnataka.

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Introduction:

Land form studies may be purely descriptive or genetic (Smith, 1935; Kesseli, 1946; Russell, 1949; Hammond, 1964; Weaver,1965). In the analysis of land forms isolation of geomorphic variables is essential to dismantle the land forms and to reassemble the land forms for descriptive and genetic purpose. Spatial analysis is a technique to derive the quantitative data of a variable from a topographic sheet or aerial photos/satellite imageries and to prepare univariable maps to understand the spatial pattern. Such spatial maps form (Linton, 1959; Sharma, 1968; Ward, 1968; Gregory, 1976; Sharma et al., 1977, 1981; Rai, 1980; Saxsena and Prakash, 1981; Gujar, 1981; Singh, 1982; Sreedhara Murthy et al., 1989: Vijith. H. and Satheesh.R. 2006: Amee K. Thakkar and S.D. Dhiman, 2007: Bhatt, et. al. 2007: Manu, M.S and. Anirudhan, S. 2008) the base for terrain evaluation of a region. Attempts have been made to use the spatial analysis of geographic variables to analyse and interpret the land

The Study Area:

The Nethravathi river basin forms a part of western costal tract of peninsular India. The three major streams of the basin are Nethravathi, Kumaradhara and Gurupur. The basin is located in Dakshina Kannada district, (12^0 5' to 13^0 11' N and 74^0 46' to 75^0 44' E) Karnataka State, India. It is covered by Survey of India topographical map No's 48L/13, 48P/1,5,6,10,11 and 48 0/4,8,12 on the scale of 1:50,000, covering an area of 4256.80 Km^2 with a perimeter stretching over 380 km. The basin (Fig.1) is well demarked by the Arabian Sea to the west and Western Ghats in the east.

Physiography and Climate:

The physiography of the basin is broadly divisible into coastal tract, midland and Western Ghats. Based on the Murphy system of landform classification, the landform of Nethravathi basin may be symbolized as GMH (mountains in Gondwanas shield with humid land areas) and Gph (Plain area in Gondwanas shield region with humid areas). The Nethravathi basin lies between N 10^0 and 20^0 latitudinal zones and enjoys a tropical wet dry climate. The climate of the basin from coast to Western Ghats is marked by heavy rainfall, high humidity and small variations in temperature, whereas the parts above the Ghats are characterized by less rainfall, less humidity and marked variation in temperature at different seasons. The physiography of the basin (from coast to Western Ghats) profoundly influences the climate, particularly the distribution of rainfall. The Western Ghats hill ranges in the east act as a climatic divide between the coastal tract in the west and plateau region above the Ghats in the east. The average rainfall over a period of ten years(1990-2000) is 449.13cm. The annual precipitation increases from coast (437.6cm) to slopes of Western Ghats (518cm). According to Kop pens' Scheme of climatic groups and subgroups, the Nethravathi basin is a part of Wet Equatorial climate-tropical rainforest climate (AI), monsoon type (Am) characterized by moist tropical maritime (MT) and equatorial air masses.

Geology:

The Nethravathi basin, a part of the Indian Peninsula consists of geological units of Archean age, and alluvium deposits represents Recent age (Fig 2). The lithologic assemblage of basin includes the

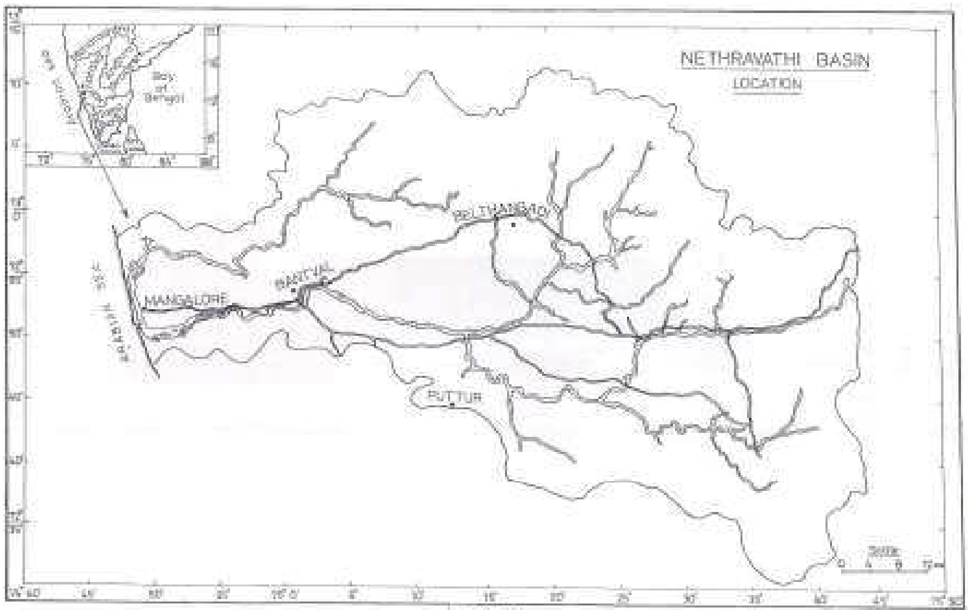

Fig. 1

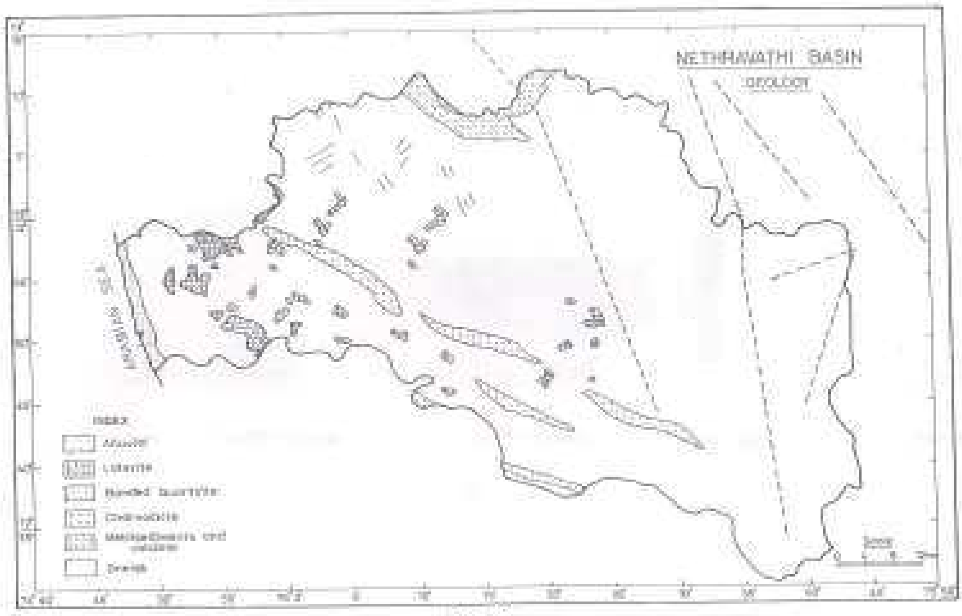

Fig. 2

migmatite gneisses, charnockites, metavolcanics and meta-sediments, laterite, sand and pebble deposits. The gneissic rocks occur as ridges, isolated hillocks in undulatory terrain. At places they are covered by laterite, sand and soil. Metavolcanics and metasediments essentially found in the eastern part of the basin (Western Ghats) and form conspicuous landforms with rugged mountains forming watersheds for all the rivers originating in the basin. The occurrence of laterite is confined to west and central parts of the basin. The laterite occurs as capping material on flat topped mountains and hillocks of gneissic rocks. In the southern part of the basin charnockites occur as linear patches. The occurrence of pebble, alluvial, sand and gravel deposits of Sub-Recent to Recent age is confined to river course, beach and land adjacent to the coast.

Methodology:

The basin, demarcated based on topographical maps of 1:50,000 was divided into grids of 4 Km^2, each for drainage frequency (number of streams/area), drainage density (total length of streams/area), relative relief (difference between maximum and minimum altitude) and dissection index (relative relief/maximum height) for the calculation and construction of isopleths maps, for absolute relief the contour map extracted from the topographical maps have been used. For slope analysis, the basin was divided into grids of 2 km^2 and by using went worth's (Wentworth, 1930) formula the slope value was calculated and isopleths map was drawn. The isopleths maps have been used to understand the regional variation of morphometric variables.

Drainage Frequency and Density:

The drainage frequency of the basin (Fig. 3) has been classified into low (0-5 streams), medium (5-10 streams) and high (>10) categories. The area having low frequency amounts to 3114 Km^2, about 1102.80 Km^2 has medium frequency, where as the high frequency is confined to 40 Km^2. More than 75% of the area of the basin has low to medium frequency. The drainage frequency increases from west to east, with high frequency in the mountainous tract of the Western Ghats. The area bordering the west is characterized by a very low frequency (<10), followed by narrow strip having 5 to 10 streams. In the extreme east (above the Ghats) the frequency is low to medium. In the central parts of the basin the frequency varies from low to high. The hilly tract of Western Ghats is characterized by high frequency with pockets of very high frequency. The drainage density of the basin (Fig. 4) is classified as low (0-2), medium (2-4) and high (4-6). Major portion of the basin (94.50%) has low to medium density. The area covered by low drainage density amounts to 1767.80 Km^2 where as the area covered by medium density is 2239.60 Km^2 and about 249.40 Km^2 of the basin is having high density. The area with high density is negligible amount. The coastal tract is tropical with extremely low density values. The area adjoining the coastal tract, the eastern parts and isolated patches in the central parts are of low density. A major portion of the central part of the basin has density in the range of 2 to 4. The eastern parts have density high values in the range of 4 to 6.

Relief Properties:

The total relief of the basin is 1884 m. The relief increases from mean sea level in the west and reaches to a maximum on the crest of Western Ghats in the east. The intensity of absolute relief is categorized as extremely low (<100 m), medium (100-500 m), moderately high (500-1000 m), high (1000-1500 m), and very high (>1500 m) relief. The extremely low relief dominates the area and occupies 37% of the basin, whereas 23% of the basin exhibits low relief. The high relief is characteristic of 28% of the basin. The remaining part of the basin exhibits moderate-moderately high to very high relief. The western part of the basin is of extremely low and low relief whereas the slopes and crests of Western Ghats exhibit moderately high to very high relief. The area between the slopes of Western Ghats and the zone of low relief in the west is having moderately high relief. A part of the basin above the Ghats in the east is again a zone

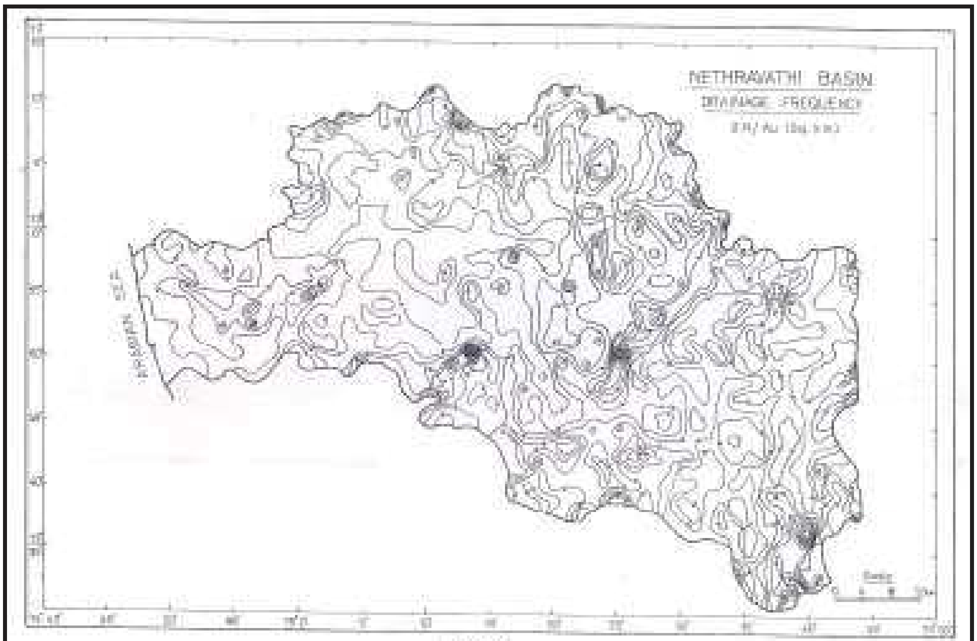

Fig. 3

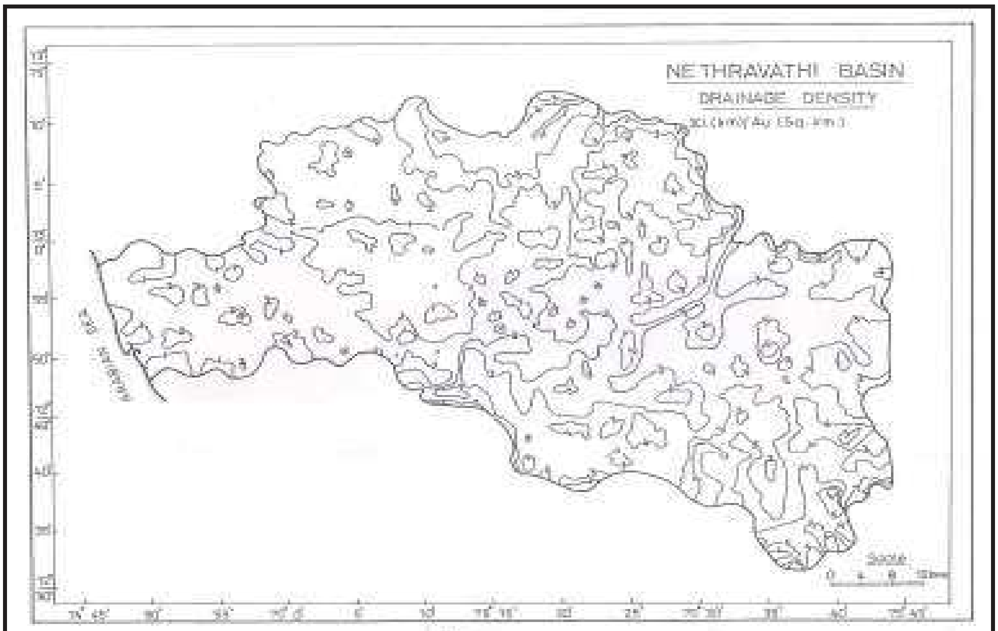

Fig. 4

of moderately high relief. The relative relief (Fig. 5) which represent the variation of altitude in a unit area with respect to its base level, has been categorized into low (0-100 m), medium (100-200 m), high (200-500 m). The western part of the basin is characterised by low relative relief, covers an area about 2196.40 Km^2. The part covered by the Western Ghats in the east is an area of high relative relief and covers 1347.50 Km^2. The central part of the basin is characterised by medium relative relief occupies an area of 712.90 Km^2. The dissection index (Fig. 6) increases from east and west towards centre of the basin and attains high to very high values. Based on the intensity of dissection, the basin is divided into low (0.0-0.3), medium (0.3-

0.6), and high (0.6-0.9) categories. The terrain with low dissection value occupies an area of 471Km^2. The moderately and highly dissected terrain occupies an area of 2432.6 Km^2 and 1352.3 Km^2 respectively. In general the Nethravathi basin is moderate to highly dissected. The western part and western ghat mountain area in the east of the basin are highly dissected, whereas, the terrain in the central part and in the extreme east (above the ghats) is less dissected. Areas with low dissection index represent the dune sands, flood-plain material, soil cover and occasionally low lying laterite in the western parts and plateau like surface above the ghats in the east having granulites with occasional mounds and hillocks. The area with moderate and high .dissection is represented by laterite, river valleys and residual hills. The Western Ghat mountains are deeply dissected by broken ridges, peaks and deep valleys. The average slope (Wentworth, 1930) in the basin (Fig. 7) varies from 20° to 60^0. The slope is classified into low (0-20^0), Moderate (20^0-40^0) and high (40^0-60°). The western part of the basin characterised by low slope values, covers an area of about 2643.80 Km^2.The terrain categorized by moderate slope, occupies an area of 970.30 Km^2.The parts covered by Western Ghats in the east is an area of high slope and covers an area of 642.70 Km^2.

Discussion:

Attempts have been made by several geomorphologies to relate drainage frequency and density with factors like climate (Chorley, 1957: 1975; Peltier, 1962; Stoddart, 1968; Gregory, 1976) bed rock nature (Horton, 1932), infiltration, intensity of rainfall and vegetative cover (Strahler, 1957; 1964; 1969). Broadly the climate (Gregory, K. J. and walling D.E.1973) rock type, relief, slope infiltration capacity and vegetative cover (Gardiner, V. and Park. C. C. 1978) could be considered as important factors in (Narendra, K. and Nageswara Rao, K. 2006) controlling the stream frequency and density of a basin. As stated earlier, the drainage frequency and density in the basin increase from west to east, with maximum values in the hilly tract of Western Ghats. The variation of these two parameters may be explained by varying intensity of precipitation, lithological variation, varying slope values and uneven distribution of vegetative cover. In the western part of the basin, the intensity of rainfall is minimum. The average slope is less than five degrees, because of unconsolidated material, absence of vegetative cover and very low slope of the tract, the rate of infiltration is higher than run-off, thus inhibiting the development and integration of streams. As a result, frequency of this part is low and extremely low. The slopes of Western Ghats are crowded with streams accounting for higher frequency and density. Because of heavy precipitation and moderate to steep slopes, slope initiated streams are numerous. The surface run-off exceeds infiltration because of slope and hard rocks. Though vegetative cover is dense in this area, parts of the ghats with steep slopes are barren. The slope between the unconsolidated material in the west and slopes of Western Ghats in the east are undulating at parts. Isolated (Fig. 8) hillocks, the terrain and laterite occur as discontinuous patches capping granitoids. The intensity of weathering and thickness of soil cover vary from place to place. The slope is moderate and gradually increases towards the ghats. The joints are numerous and some of them are structurally controlled. The vegetation is

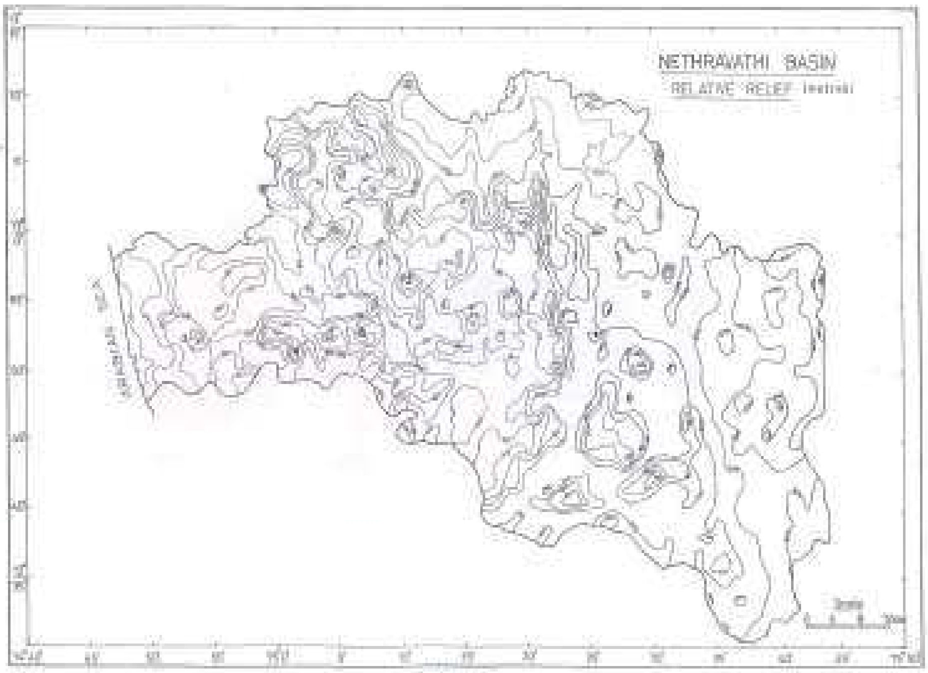
NETHRAVATHI BASIN
RELATIVE RELIEF (metres)

Fig. 5

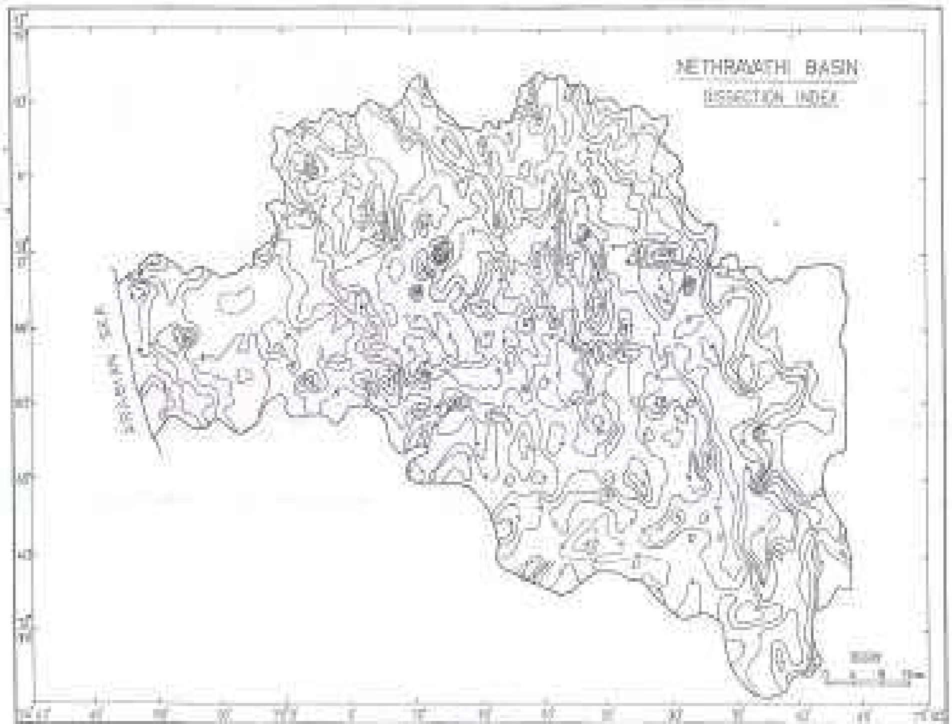
NETHRAVATHI BASIN
DISSECTION INDEX

Fig. 6

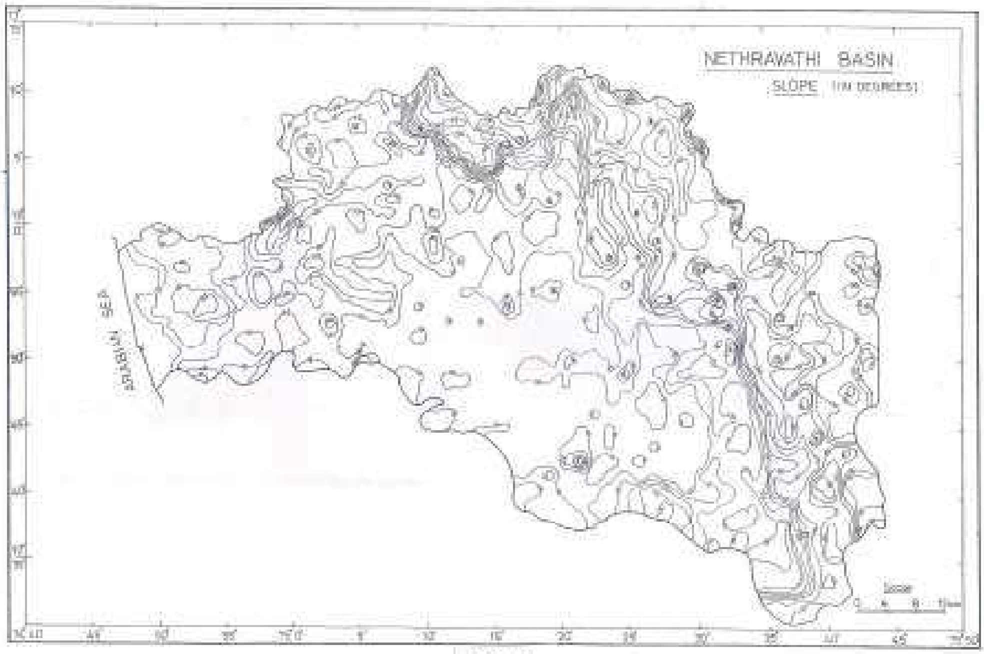

Fig. 7

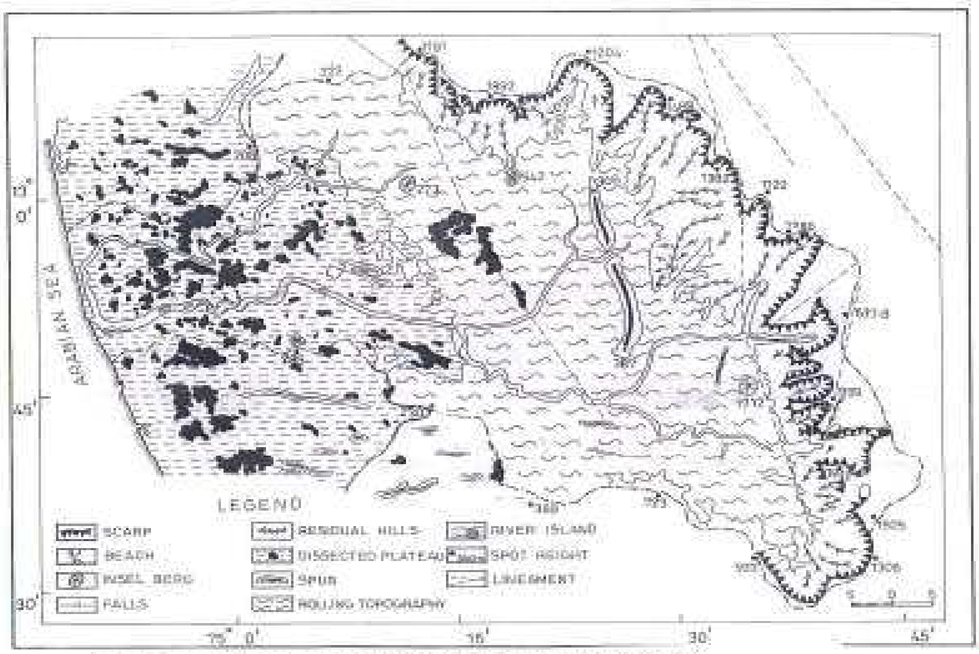

Fig. 8 Geomorphological map of the Nethravathi river basin on IRS Imagery

scanty. Because of the above factors the frequency and density is low to medium. The drainage is controlled by lithology, slope and structure in this part of the basin. Above the ghats in the east, the tract consists of granitoids which are highly altered and the slope is moderate, with low to medium drainage frequency and density. The western margin of the basin is a terrain of beach, estuary, marsh and creek. The rivers are braided and Nethravathi River is meandering. The lateritic terrain close to the coast is plateau like and extends east ward as an undulating terrain. The rivers that drain this part are in aggradational stage as indicated by braiding and terraces. Further, the area to the north and south of the basin under study has evidences of sea level changes accounting for marine erosion and depositional processes; thus, the western margin is a terrain of degradational (low level granitoid mounds and laterite) arid aggradational processes, producing flat to undulating topography with extremely low relief (less than 100 m), and moderate relative relief (less than 200m), low to high dissection index (less than 0.9) and low slope (less than 20°) values. The terrain north of the estuary is more dissected than that of the terrain lying to the south of the estuary. The terrain above the ghats in the east is a terrain of granitoids (part of Mysore Plateau); the rugged mountains of Western Ghats give way to uneven topography with mounds and hillocks of granitoids. This terrain is an erosional surface; the intensity of relief is generally low (in comparison to Western Ghat terrain). The relative relief is 20 m to 100 m in southern half and 20 to 400 m in northern half of this terrain. The increase in the relative relief of the northern portion of the area is middle to the presence of residual hills. The dissection index varies from 0.1 to 0.5 and the major part of the area is low to moderately dissected (0.1 to 0.6). The slope values vary from 20° to 40° and major part of the terrain has low to moderate slope values(<20). The Western Ghats are a mountainous tract with meta sediments and metavolcanics. The physiography of this tract is distinctly different (Sreedhara Murthy, et. al. 1989) from that of coastal tract and the tract above the ghats. The arcuate belt of mountains has several peaks, rapids and deep 'v' shaped valleys. The western face of the mountain is characterized by abundant channels. The Western Ghats exhibit moderately high and extremely high relief. The relative relief increases from 100-120 m to 600 m (from lateritic terrain to the west of the ghats to the crest of the Western Ghats). The area with relative relief in the range of 200 - 400 m is prominent in the terrain. The zone of relief in the range of 400 m to 600 m occurs in patches. The dissection index is high to very high (0.3-0.8) with a domination of very high values. The terrain is characterized by slope values varying between 50-40° (moderate to very high slope values) from west to east. The western ghat mountains, initially a depositional basin with extrusive are believed to have been formed by folding and faulting, and modified later by scarp retreat and other processes. Thus the tectonic forces and erosional processes resulted in the morphology of this tract being characterised by high relative relief, and high slope values and the terrain is moderate to highly dissected by fluvial action. The terrain in between the coastal tract and the Western Ghats comprises of granitoids capped by laterite at several places. The laterite form plateau or uneven terrain. At places the granitoids stand out prominently as isolated hillocks and hill ranges. The intensity of weathering and lateritisation of the granites is significant and varies from place to place. Majority of the channels are controlled by joint/lineament. Because of intense weathering and lineament controlled channels the terrain is highly dissected. Further, the terrain has low to moderate relief, low to moderately high relative relief and slope values less than 20^0. Thus, the lithology, structure, and varying intensity of weathering, have produced the terrain as observed in between the coastal tract and the Western Ghat.

Conclusion:

The drainage frequency and density increase from west to east, with high values on the slopes of the Western Ghat mountains. The intensity of relief (absolute), relative relief and slope also increases from west to east. Above the ghats in the extreme east, the frequency and density is poor to medium and extremely low to low respectively. The depth of dissection increases from east and west and west with maximum in the centre of the basin. The frequency and density of the basin is controlled mainly by lithology in the western part, slope in the hilly tract and lithology, slope and structure in the central parts.

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