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Morphometric Analysis of a Watershed of South India Using SRTM Data and GIS

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Abstract: An attempt has been made to study drainage morphometry and its influence on hydrology of Wailapalli watershed, South India. For detailed study we used Shuttle Radar Topographic Mission (SRTM) data for preparing Digital Elevation Model (DEM), aspect grid and slope maps, Geographical information system (GIS) was used in evaluation of linear, areal and relief aspects of morphometric parameters. The study reveals that the elongated shape of the basin is mainly due to the guiding effect of thrusting and faulting. The lower order streams are mostly dominating the basin. The development of stream segments in the basin area is more or less affected by rainfall. The mean Rb of the entire basin is 3.89 which indicate that the drainage pattern is not much influenced by geological structures. Relief ratio indicates that the discharge capability of these watersheds is very high and the groundwater potential is meager. These studies are very useful for planning rainwater harvesting and watershed management.

Keywords: Morphometric analysis, SRTM data, GIS, Wailapalli watershed, Andhra Pradesh.

INTRODUCTION

The drainage basin analysis is important in any hydrological investigation like assessment of groundwater potential, groundwater management, pedology and environmental assessment. Hydrologists and geomorphologists have recognized that certain relations are most important between runoff characteristics, and geographic and geomorphic characteristics of drainage basin systems. Various important hydrologic phenomena can be correlated with the physiographic characteristics of drainage basins such as size, shape, slope of drainage area, drainage density, size and length of the contributories etc. (Rastogi et al. 1976).

Geology, relief and climate are the primary determinants of running water ecosystems functioning at the basin scale (Mesa, 2006). Detailed morphometric analysis of a basin is a great help in understanding the influence of drainage morphometry on landforms and their characteristics.

The drainage characteristics of Wailapalli Basin and sub-basins were studied to describe and evaluate their hydrological characteristics by analyzing topographical map and SRTM data. The study area enjoys semi-arid conditions. The main occupation of the people in this area is agriculture. They depend on groundwater, because surface water resources are scarce. Due to erratic rainfall pattern and uncontrolled abstraction, groundwater levels have declined to deeper levels. Therefore watershed development schemes become important for developing the surface and groundwater resources in these areas. To prepare a comprehensive watershed development plan, it becomes necessary to understand the topography, erosion status and drainage pattern of the region. For the purpose of detailed morphometric analysis we used SRTM data for preparing DEM map slope and aspect maps. GIS was used in evaluation of Linear, Areal and Relief morphometric parameters.

Using SRTM data and GIS techniques (Map Maker) is a speed, precision, fast and inexpensive way for calculating morphometric analysis (Farr and Kobrick, 2000; Smith and Sandwell, 2003; Grohmann, 2004; Grohmann et al. 2007). An attempt has been made to utilize SRTM data and the interpretative techniques of GIS to find out the relationships between the morphometric parameters and hydrological parameters.

STUDY AREA

The Wailapalli watershed covers an area of 130 km^2 in Nalgonda district, Andhra Pradesh. It falls between east latitudes 17º3'30" and 17º 7', and north longitudes 78º 47'30" and 79º0' in the toposheet No. 56K/16 (Fig.1). The area forms a part of semi-arid zone and experiences tropical

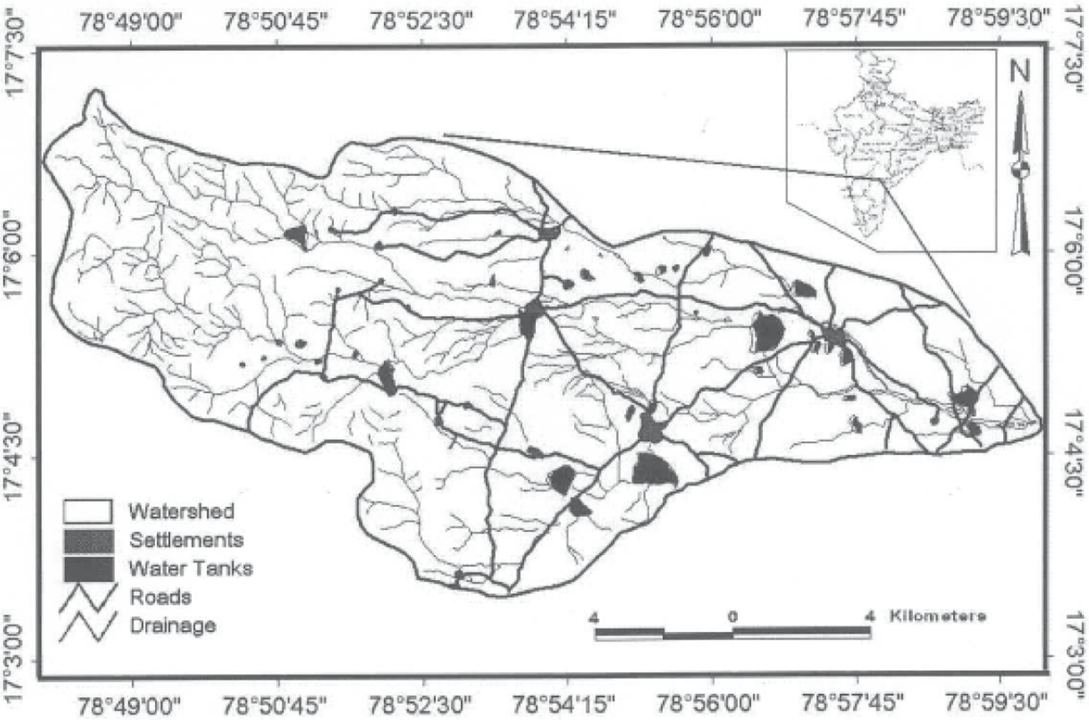

Fig.1. Location map of Wailapalli Basin.

climate. The average annual rainfall is 655 mm, most of which falls during southwest monsoon from June to September. The temperature reaches its high in April and May, and low in January, with the mean maximum of 42°C in May, a mean minimum of 11°C in January.

Drainage

The type of drainage is dendritic, which is characterized by irregular branching of tributary streams in many directions joining the main channel at considerably less than a right angle (Fig. 2). Based on the drainage pattern the basin was divided in to 5 sub-basins. The total area of the basin is 130 km^2, and of the total 282 streams recognized in the area, 74.11 percent area is of 1st order, 20.57 percent 2nd order, 3.90 percent area 3rd order, 1.06 percent area 4th order and 0.35 percent area 5th order. In the watershed most dominant streams are 1st order streams, followed by 2nd order and then 3rd, 4th and 5th order streams. 1st and 2nd order streams are located in high elevation areas. In these areas runoff is more. It means there is less recharge taking place in these areas.

Geomorphology

One-third of the area is covered by hillocks and forest. Major part of the area is undulating plain country with isolated hills, while N-S trending hill ranges mostly occupy the western part. The topography slopes towards SE. The entire area can be classified into three important geomorphological units viz. denudational hills (700-730 m amsl), dissected pediment and pediplain. The general topographic elevation in the east is 280 m above mean sea level (amsl), and 400 m in the west. The area forms a part of the Krishna River basin and is drained by Wailapalli vagu stream, a tributary of the Halia River, running from west to east, almost through the middle of the basin. The drainage pattern is sub-dendritic to dendritic in nature.

Hydrogeology

Groundwater occurs both under water Table and semi-confined conditions in the weathered and fractured horizons. The thickness of the weathered zone varies from 5 to 20 m increasing occasionally up to 40 m. The fractured zone occurs beneath the weathered zone down to the depth of 25 to 70 m. The water table ranges in elevation from 275 m amsl in the east to 325 m amsl in the west. The hydraulic gradient is 5 m/km in the plain. The water levels are deep and generally ranging from 5 to 25 m below ground level (bgl).

Geology and Structure

The area is underlain by Archaean group of rocks represented by older group of rocks and peninsular

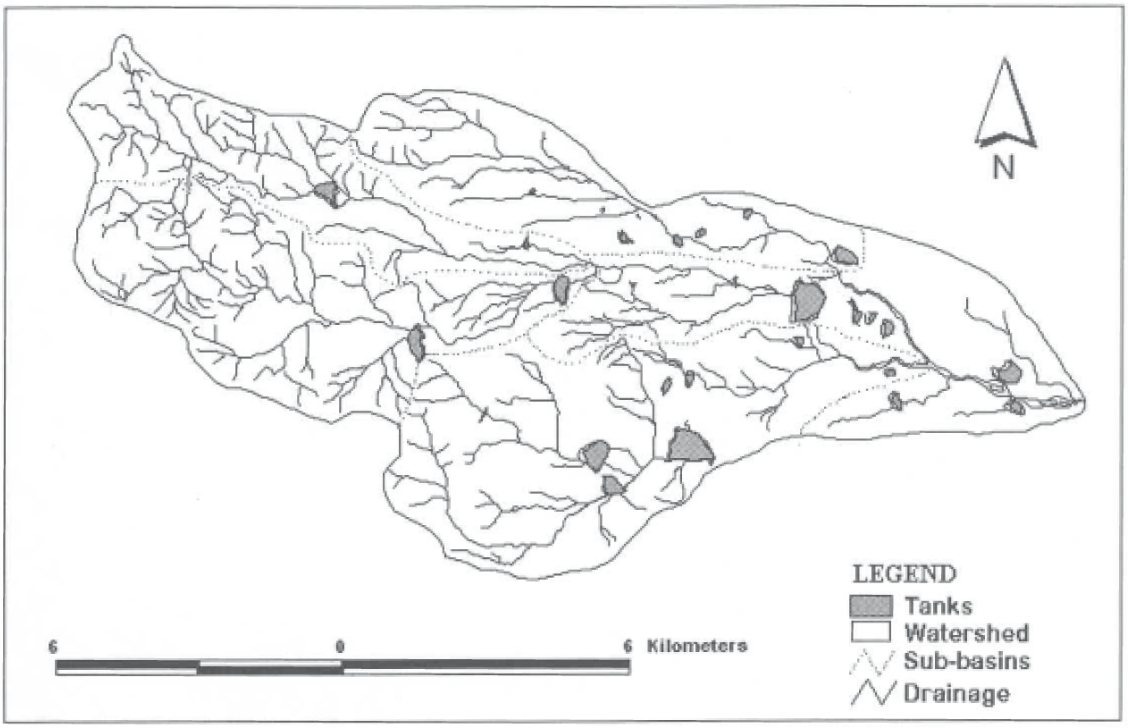

Fig.2. Drainage with sub-basins map of Wailapalli Basin.

gneissic complex. The older rocks consist of hornblende schist, biotite schist and amphibolites, while peninsular gneissic complex is represented by pink and porphyritic granite gneisses, pink granites with quartz, pegmatites and epidote veins. Dolerites mark the last phase of igneous activity and cut across all the above rock. The area experienced substantial structural disturbances resulting in development of well marked jointing and fracturing. The major sets of joint trend in N10ºW - S10ºE and N75ºE – S75ºW and are vertical in nature. The main fractures are along NW-SE, NNE-SSW and WNW-ESE directions.

METHODOLOGY

The morphometric analysis of the Wailapalli watershed was prepared based on published topographic maps on a 1:50,000 scale and also on SRTM data. The SRTM was an 11 day space shuttle mission in February 2000. SRTM has created an unparalleled data set of global elevations that is freely available for modelling and environmental applications. The version 3 processed (SRTM) 90 m digital elevation model (DEM) for the entire globe was compiled by Consultative Group for International Agriculture Research Consortium for Spatial Information (CGIAR-CSI) and made available to the public at http://137.73.24.202/array1/portal/srtm3/srtm_data_geotiff/srtm_52_09.zip. Spatial Resolution data is 90/90 m, or one pixel represents a terrain cell 90/90 m in size.

The SRTM DEM is a fast and inexpensive way for regional geomorphological analysis. The data were taken from the http://srtm.usgs.gov/data/obtaining.html and then imported to the Arcview. Based on the data we prepared the slope and topographic elevation maps with contours for the watershed. Stream network and micro watersheds were also prepared using Arcview.

The drainage network of the basin was scanned and digitized as available on toposheets (1:50,000). The basin was divided into 5 sub basins and morphometric analysis was carried out at sub basin level in Arcview (ESRI, 2000). Based on the drainage order, the drainage channels were classified into different orders (Strahler, 1964). Basin parameters viz area, perimeter, length, stream length, stream order were also calculated which were later used to calculate other parameters like bifurcation ratio, stream length ratio, RHO coefficient, stream frequency, drainage density. Drainage texture, basin relief, relief ratio, elongation ratio, circularity index, and form factor were evaluated with the help of established mathematical equations (Strahler, 1964). The morphometric parameters were divided into three categories: linear, areal and relief aspects of the basin.

RESULTS AND DISCUSSION

The DEM has been obtained with a pixel size of 90 m and has an area of 130 km^2 (Fig.3). Furthermore, it has been used to calculate slope and aspect maps. The total drainage area of Wailapalli Basin is 130 km^2 and it is divided into 5 sub-basins for the analysis (Fig.2). The development of drainage networks depends on geology, precipitation apart from exogenic and endogenic forces of the area. The drainage pattern of the basin ranges from dentritic to sub-dentritic at higher elevations and parallel to sub- parallel in the lower elevations. Based on the drainage orders, the Wailapalli Basin has been classified as fifth order basin to analyse linear, relief and areal morphometric parameters as shown in Table 1 (Horton, 1932, 1945; Smith, 1950; Schumm, 1956, 1963; Hadley and Schumm, 1961; Strahler, 1964; Sreedevi et al. 2005; Mesa, 2006).

Linear Aspects

Computation of the linear aspects such as stream order, stream number for various orders, bifurcation ratio, stream lengths for various stream orders and length ratio are described below.

Stream Number (Nu)

It is obvious that the total number of streams gradually decreases as the stream order increases with the application of GIS, the number of streams of each order and the total number of streams were computed (Table 2a).

Stream Order (U)

The streams of the Wailapalli Basin have been ranked according to the Strahler's (1964) stream ordering system and the number of streams of each segment (Nu) of the order (U) is presented in Table 2a. The details of stream characteristics confirm Horton's first law (1945) "Law of stream numbers" which states that the number of streams of different orders in a given drainage basin tends closely to approximate an inverse geometric ratio. It also confirms to Horton's (1932) "Law of stream length" which states that the average length of streams of each of the different orders in a drainage basin tends closely to approximate a direct geometric ratio. The variation in order and size of the tributary basins are largely due to physiographic and structural conditions of the region. Application of this ordering procedure through GIS shows that the drainage network of the study area is of a fifth order basin. One sub-basin (3) was under third order, three sub-basins (1, 2 and 5) were identified under fourth order, and one sub-basin (4) was under fifth order. 1st and 2nd order streams are dominate in 1, 2 and 5 sub-basins. However these sub-basins are occupied by hillocks (Fig. 2).

Table 1. Linear relief and areal morphometric parameters

Parameters	Formulae	References
Linear Aspects		
Stream Order (U)	The smallest permanent streams are called "first order". Two first order streams join to form a larger, second order stream; two second order streams join to form a third order, and so on. Smaller streams entering a higher-ordered stream do not change its order number.	Strahler (1964)
Stream Length (Lu)	The average length of streams of each of the different orders in a drainage basin tends closely to approximate a direct geometric ratio.	Horton (1945)
Stream Length Ratio (RL)	$RL = \frac{Lu}{Lu - 1}$	Sreedevi et al (2005)
Bifurcation Ratio (Rb)	$Rb = \frac{Nu}{Nu + 1}$	Horton (1932)
Areal Aspects		
Drainage density (Dd)	$Dd = \frac{Lu}{A}$	Horton (1945)
Drainage texture (T)	$T = Dd\,x\ Fs$	Smith (1950)
Stream Frequency (Fs)	$Fs = \frac{\Sigma Nu}{A}$	Horton (1945)
Elongation ratio (Re)	$\mathrm{Re} = \frac{D}{L} = 1.128\frac{\sqrt{A}}{L}$	Schumm (1956)
Circularity ratio (Rc)	$Rc = 4\pi A / P^2$	Strahler 1964
Form factor (Ff)	$Ff = A / L^2$	Horton (1945)
Relief Aspects		
Relief	$R = H - h$	Hadley and Schumm (1961)
Relief Ratio	$Rr = \frac{R}{L}$	Schumm (1963)
Slope	$Sb = \frac{H - h}{L'}$	Mesa (2006)
Gradient Ratio	$Gr = \frac{H - h}{L}$	Sreedevi et al (2005)

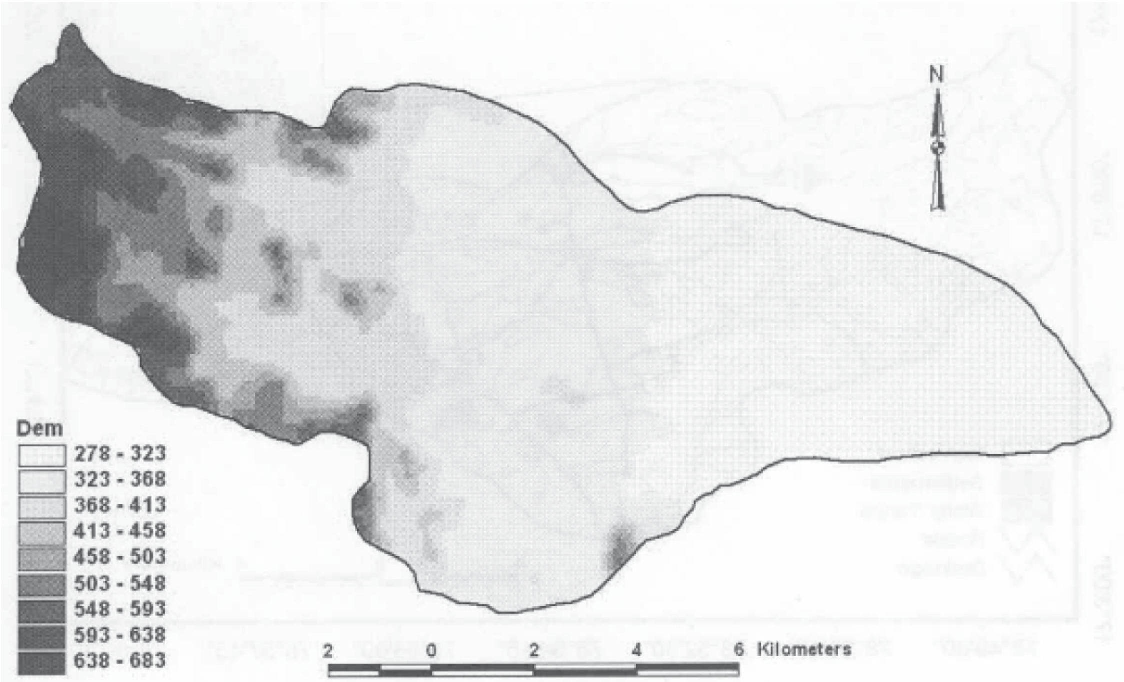

Fig.3. Digital Elevation Model map of Wailapalli Basin.

Stream Length (Lu)

The stream lengths for all sub-basins of various orders have been measured on digitized map with the help of Map Maker gratis of GIS. Length of each stream is stored in a Table. Then after adding each stream for a given order, the total stream length of each order (Lu) is computed. The maximum length of the total watershed is 276.3 km and that of the five sub-basins are 144.8, 54.38, 35.65, 29.77 and 11.68 km respectively (Table 2a).

Stream Length Ratio (RL)

The length ratio (RL) is defined as the ratio of mean stream length (Lu) of segment of order u, to mean stream segment length (Lu-1) of the next lower order u-1.

Table 2a. Linear aspects of Wailapalli Basin

Basin/sub-basin	Area	Length	Stream numbers in different orders						Order wise total stream lengths (km)					
	(km^2)	(km)	1	2	3	4	5	Total	1	2	3	4	5	Total
Sub-basin -I	29.69	11.67	79	22	4	1		106	45.1	18.49	6.67	10.95		81.23
Sub-basin -II	19.79	12.13	44	13	3	1		61	26.04	7.68	4.01	11.23		48.95
Sub-basin -III	19.72	11.16	21	4	1			26	19.01	7.79	10.22			37.02
Sub-basin -IV	23.94	10.68	18	4	1		1	24	18.99	3.69	5.27		11.68	39.63
Sub-basin -V	36.86	11.82	47	15	2	1		65	35.29	16.55	9.40	7.59		68.83
Wailapalli Basin	130.00	22.45	209	58	11	3	1	282	144.82	54.38	35.65	29.77	11.68	276.30

Table 2b. Linear aspects of Wailapalli Basin

Basin/sub-basin	Average Stream length (km)						Stream length ratio (Rl)					Bifurcation ratios				
	1	2	3	4	5	Total	2/1	3/2	4/3	5/4	Rl	Rb1	Rb2	Rb3	Rb4	Mean Rb
Sub-basin-I	0.57	0.84	1.67	10.95		14.03	1.47	1.98	6.56		2.63	3.59	5.5	4		3.29
Sub-basin-II	0.59	0.59	1.34	11.23		13.75	0.99	2.26	8.40		2.92	3.38	4.33	3		2.68
Sub-basin-III	0.91	1.95	10.22			13.08	2.15	5.24			1.85	5.25	4			2.31
Sub-basin-IV	1.06	0.92	5.27		11.68	18.93	0.87	5.71			1.65	4.5	4			2.13
Sub-basin-V	0.75	1.10	4.70	7.59		14.14	1.47	4.26	1.61		1.84	3.13	7.5	2		3.16
Wailapalli Basin	0.69	0.94	3.24	9.92	11.68	26.47	1.35	3.46	3.06	1.18	2.62	3.6	5.27	3.67	3	3.89

The stream length ratios (RL) are changing haphazardly at the basin and sub-basin levels. The values of the RL vary from 0.87 to 8.4 for sub-basins, while it ranges from 1.65 to 2.92 for the whole basin. It is noticed that the RL between successive stream orders of the basin vary due to differences in slope and topographic conditions (Rakes Kumar et al. 2001; Sreedevi et al. 2005). The RL has an important relationship with the surface flow discharge and erosional stage of the basin (Table 2b).

Bifurcation Ratio (Rb)

The term 'bifurcation ratio' (Rb) was introduced by Horton (1932) to express the ratio of the number of streams of any given order to the number in the next lower order. According to Strahler (1964), the ratio of number of streams of a given order (Nu) to the number of segments of the higher order (Nu+1) is termed as the Rb.

In the study area mean Rb varies from 2.13 to 3.3; the mean Rb of the entire basin is 3.89 (Table 2b). Usually these values are common in the areas where geologic structures do not exercise a dominant influence on the drainage pattern.

Chow (1964) stated that an Rb range '3 to 5' for watersheds of a geologic structure does not exercise a dominant influence on the drainage pattern. Sub-basins Rb values range from 2 to 7.5. The higher Rb for sub-basins is the result of large variation in frequencies between successive orders and indicates the mature topography.

Areal Aspects

The area of the basin was computed by converting the map of the basin into polygon form. The total area of the basin is found to be 130 km^2 (Table 3).

Drainage Density (Dd)

The relationship between various environmental variables and Dd has been extensively analysed and the main findings are reported below.

Several studies indicate the influence of climate on drainage density. According to Gregory and Gardiner (1975) and Gregory (1976) showed that drainage density broadly increases with precipitation intensity index defined as the ratio between the maximum reported 24h rainfall and the average annual rainfall.

Generally it is a positive correlation between Dd and rainfall parameters (Montgomery and Dietrich, 1989; Tucker and Bras, 1998). Abrahams (1984) showed that several climatic factors simultaneously affect drainage density in a complex way.

Field observations generally show that high drainage density is favoured in arid regions with sparse vegetation cover as also in temperate and tropical regions subjected to frequent heavy rains (Melton, 1957; Strahler, 1964; Toy, 1977; Morisawa, 1985).

Slope gradient and relative relief are the main morphological factors controlling drainage density. Strahler (1964) noted that low Dd is favoured where basin relief is low, while high Dd is favoured where basin relief is high.

The combined role of relief and climate on Dd has also been investigated by Kirkby (1987), suggesting that the relationship between Dd and relief depends on the dominant hill slope processes. He predicts a positive relationship for semi-arid environments and an inverse one for humid climate. Gardiner (1995) showed that greater drainage densities are generally associated with impermeable rocks.

Dd is generally inversely related to hydraulic conductivity of the underlying soil. For steep slopes, an inverse correlation has been modeled by Montgomery and Dietrich (1992). Generally, Dd increases with decreasing infiltration capacity of the underlying rocks and/or decreasing transmissivity of the soil.

Horton (1945) defined Dd as the total length of channels (Lu) in a catchment divided by the area (A) of the catchment.

The Dd for the whole basin is 2.1 km/km^2, while those of the five sub-basins are shown in Table 3. Dd gives an idea about the physical properties of the underlying rocks in the study area. Low Dd occurs in the regions of highly resistant and permeable sub soil materials with dense vegetated cover and low relief; whereas high Dd is prevalent in the region of weak impermeable sub surface materials

Table 3. Areal aspects of Wailapalli Basin

Basin/sub-basin	Drainage density (km^{-1})	Drainage Texture (km^{-1})	Stream Frequency (km^{-2})	Elongation ratio	Circularity ratio	Form factor
Sub-basin-I	2.73	9.81	3.59	0.53	0.42	0.22
Sub-basin-II	2.47	7.62	3.08	0.41	0.64	0.13
Sub-basin-III	1.91	2.57	1.34	0.45	0.65	0.16
Sub-basin-IV	1.66	1.59	0.96	0.52	0.24	0.21
Sub-basin-V	1.87	3.29	1.76	0.58	0.54	0.26
Wailapalli Basin	2.13	4.64	2.18	0.57	0.50	0.26

which are sparsely vegetated and show high relief in the study area.

Drainage Texture (T)

The drainage texture (T) depends upon a number of natural factors such as climate, rainfall, vegetation, rock and soil type, infiltration capacity, relief and stage of development (Smith, 1950). The soft or weak rocks unprotected by vegetation produce a fine texture, whereas massive and resistant rocks cause coarse texture. Sparse vegetation of arid climate causes finer textures than those developed on similar rocks in a humid climate. The texture of a rock is commonly dependent upon vegetation type and climate (Darnkamp and King, 1971). In simple terms T is the product of Dd and Fs.

The T of the whole basin is 4.64, while those of the 5 sub-basins are shown in Table 3. According to Smith classification T of the whole basin comes under coarse texture, as the values are less than 4.0.

Stream Frequency (Fs)

The stream frequency (Fs) of a basin may be defined as the number of streams per unit area (Horton, 1945).

The Fs of the whole basin is 2.18 km/km^2, while the Fs for 5 sub-basins are shown in Table 3. It mainly depends on the lithology of the basin and reflects the texture of the drainage network.

Elongation Ratio (Re)

Elongation ratio (Re) is defined as the ratio between the diameter of a circle with the same area as that of the basin (A) and the maximum length (L) of the basin.

Elongation ratio for the basin is estimated as 0.572, and the 5 sub-basins are shown in Table 3. The variation of the elongated shapes of the basins is due to the guiding effect of thrusting and faulting in the basin. High Re values indicate that the areas are having high infiltration capacity and low runoff. The sub-basins nos. 1, 4 and 5 are characterized by high Re, and sub-basins nos. 2 and 3 have low Re respectively. The sub-basins having low Re values are susceptible to high erosion and sedimentation load.

Circularity Ratio (Rc)

The circularity ratio (Rc) has been used as an areal aspect and is expressed as the ratio of basin area (Au) to the area of a circle (Ac) having the same perimeter as the basin (Strahler, 1964). It is affected by the lithological character of the basin.

Rc values approaching 1 indicates that the basin shapes are like circular and as a result, it gets scope for uniform infiltration and takes long time to reach excess water at basin outlet, which further depends on the prevalent geology, slope and land cover. The ratio is more influenced by length, frequency (Fs) and gradient of various orders rather than slope conditions and drainage pattern of the basin. The Rc of the whole basin is 0.502, while those of the 5 sub-basins are shown in Table 3. It is a significant ratio, which indicates the dentritic stage of a basin.

Form Factor (Ff)

Form Factor (Ff) is defined as the ratio of the basin area to the square of the basin length.

Horton (1945) proposed this parameter to predict the flow intensity of a basin of a defined area. The Ff of the whole basin is 0.26, while the Ff of 5 sub-basins is shown in Table 3. The index of Ff shows the inverse relationship with the squre of the axial length and a direct relationship with peck discharge.

Relief Aspects

Evaluation of some of the relief aspects of the basin is discussed below

Relief

Relief is the maximum vertical distance between the lowest and the highest points of a basin. Basin relief is an important factor in understanding the denudational characteristics of the basin. The maximum height of the whole basin is 703 m and the lowest is 280 m. Therefore, the relief of the basin is 423 m.

Table 4. Relief aspects of Wailapalli Basin

Basin/sub-basin	Elevation in 'm'		Relative relief (H-h) (m)	Relative relief (H-h) (km)	Longest axis 'L' (km)	Relief ratio (H-h/L)
	Max 'H'	Min 'h'				
Sub-basin-I	703	340	363	0.363	11.32	0.032
Sub-basin-II	654	342	312	0.312	11.85	0.026
Sub-basin-III	603	303	300	0.3	10.53	0.028
Sub-basin-IV	340	280	60	0.06	11.11	0.005
Sub-basin-V	623	290	333	0.333	11.11	0.030
Wailapalli Basin	703	280	423	0.423	22.22	0.019

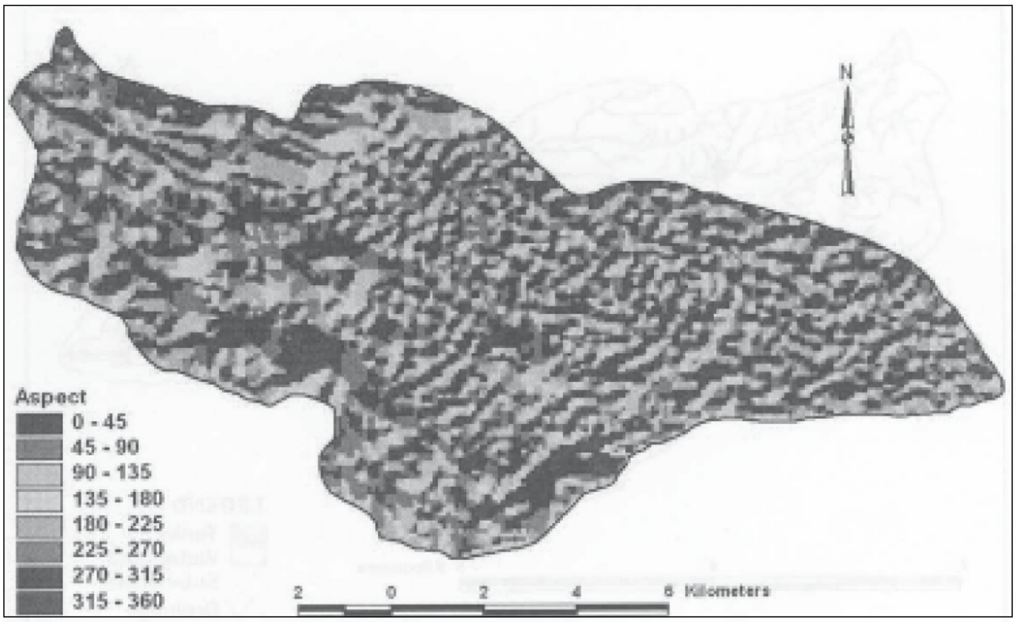

Fig.4. Aspect grid map of Wailapalli Basin.

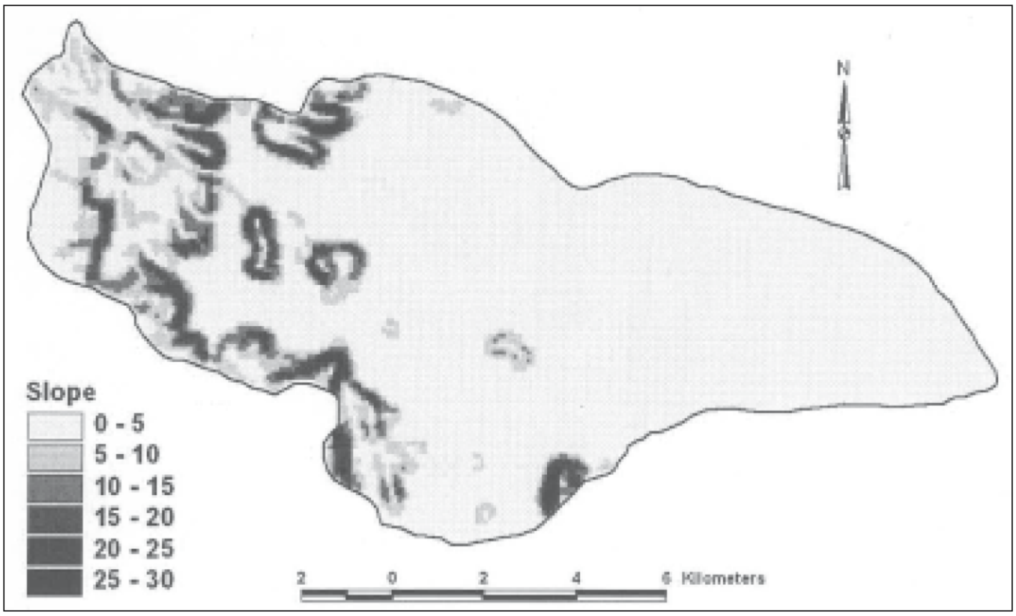

Fig.5. Slope map of Wailapalli Basin.

Relief Ratio

According to Schumm (1963) the relief ratio is the dimensionless height-length ratio equal to the tangent of the angle formed by two planes intersecting at the mouth of the basin, one representing the horizontal, the other passing through the highest point of the basin.

The relief ratio of the Wailapalli Basin is 0.019, while those of the 5 sub-basins are shown in Table 4. While high values are characteristic of hill regions low values are characteristic of pediplains and valley. In relation to stream slope, the inclinations of the ground surface are closely tied with its channel gradients and relief. In field it has been observed that there is a high degree of correlation between high relief and high drainage frequency, high stream frequency and high stream channel slopes which bring out high discharges in short duration (Gopalakrishna et al. 2004). These are characteristic of watersheds 1 and 2. These are indicating that the discharge capability of these water-

Table 5. Gradient aspects of Wailapalli Basin

Basin/sub-basin	Elevation at		Fall in height (a-b) (m)	Fall in height (a-b) (km)	Length of main stream 'L'	Gradient ratio (a-b/L)
	Source 'a'	Mouth'b'				
Sub-basin-I	660	332	328	0.328	11.32	0.029
Sub-basin-II	600	332	268	0.268	11.85	0.023
Sub-basin-III	603	300	303	0.303	10.53	0.029
Sub-basin-IV	340	273	67	0.067	11.11	0.006
Sub-basin-V	623	288	335	0.335	11.11	0.030
Wailapalli Basin	600	273	327	0.327	22.22	0.015

sheds is very high and the groundwater potential is meager.

Slope

Slope analysis is an important parameter in geomorphic studies. The slope elements, in turn are controlled by the climatomorphogenic processes in the area having the rock of varying resistance. An understanding of slope distribution is essential as a slope map provides data for planning, settlement, mechanization of agriculture, deforestation, planning of engineering structures, morphoconservation practices etc. (Sreedevi et al. 2005). In the study area slope map was prepared based on SRTM data were converted into slope and aspect grids using Arcview method (ESRI, 2000). Aspect grid is identified as "the down-slope direction of the maximum rate of change in value from each to its neighbours" (Gorokhovich, 2006) (Fig.4). Slope grid is identified as "the maximum rate of change in value from each cell to its neighbors, using methodology described in Burrough (1986). The Wailapalli watershed area slope varies from 0° to 32.95° with a mean slope of 3.74° and Slope Standard Deviation 5.58°. A high degree of slope is noticed in the western and northwestern parts of the basin (Fig.5).

Gradient Ratio

Gradient ratio is an indication of channel slope from which the runoff volume could be evaluated. The basin has a gradient ratio of 0.015, while those of the 5 sub-basins as shown in Table 5, varies from low to moderate.

IDENTIFICATION OF GROUNDWATER POTENTIAL ZONES USING MORPHOLOGICAL PARAMETERS

Drainage pattern of an area is very important in terms of its groundwater potentiality. It is the source of surface water and is affected by structural, lithological and geomorphological set up of an area (Schumm, 1956). The drainage pattern in the present study area is dendritic in nature. This may be due to more or less homogeneous lithology and structural controls. In the study area high drainage density is observed over the hilly terrain with impermeable hard rock substratum, and low drainage density over the highly permeable sub-soils and low relief areas. Low drainage density areas are favourable for identification of groundwater potential zones.

Slope plays a very significant role in determining infiltration vs. runoff relation. Infiltration is inversely related to slope i.e. gentler is the slope, higher is infiltration and less is runoff and vice-versa. In the study area gentle slope is towards Northwest–Southeast direction. Low drainage density areas are showing gentler slope in the study area.

CONCLUSION

Based on the drainage orders the Wailapalli Basin has been classified as fifth order basin. The Dd of Wailapalli watershed, as well as those of the sub-basins, reveal that the subsurface strata are permeable. This is a characteristic feature of coarse drainage as the density values are less than 5.0. The study reveals that the drainage areas of the basin are passing through an early mature stage of the fluvial geomorphic cycle. Lower order streams mostly dominate the basin. The development of stream segments in the basin area is more or less affected by rainfall. The elongated shape of the basin is mainly due to the guiding effect of thrusting and faulting. The erosional processes of fluvial origin are predominantly influenced by subsurface lithology of the basin. Relief ratio indicates that the discharge capability of these watersheds is very high and the groundwater potential are meager. These studies are very useful for rainwater harvesting and watershed management plans. 1^{st} and 2^{nd} order streams are not useful for constructing check dams in the study area because these streams are situated on hilly terrains.

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