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Research Article

MORPHOMETRIC PROPERTIES OF ALLAGADDA AREA, KURNOOL DISTRICT, ANDHRA PRADESH, INDIA. USING CARTOSAT-1 DEM WITH GIS

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ABSTRACT

Remote sensing and GIS has effective tools used for analyse the Morphometric properties of the drainage basin in Allagadda region. It is located in latitudes 780.40' E and 780.70'E longitudes -150.40'N and 140.90'N. The Morphometric parameters like linear, aerial and relief aspects of the river basin were determined and computed. Stream network, flow direction, flow accumulation, slope, aspects and contour have been prepared using Arc GIS 9.3 with Cartosat-1 DEM. The catchment area has 6th order of basin and drainage pattern mainly sub dendritic and parallel type. Subdendritic drainage pattern has represented less structural control and parallel drainage pattern suggest that gentle slope and less resistant bed rock. The area is occupied by Kurnool super group of rocks (Quartzites, limestone and sandstone). The results indicated that drainage density (2.5), Stream Frequency (7.67), Form Factor (0.46), Elongated ratio (0.76) and Circularity ratio (0.53).Bifurcation ratio (2.25). Which are suggested that the circulation ratio value indicate that the watershed is elongated in shape and highly permeable. Bifurcation ratio value represented very hard surface and terrain, and different in geological composition which might increase the hazard of floods. The study reveals that the highly vulnerable Drought area.

Keywords: GIS, Cartosat-1 DEM, Morphometric analysis and Allagadda watershed area.

INTRODUCTION

Hydrological and geomorphological analysis using Geographical information system (GIS) had worked over 1960s onwards; it had developed many stages [1]. In 1960-1975 was the "hydrological modeling" era in which mathematical description of fluvial process were developed and incorporated into hydrological models. During from 1975-1985 was a "transport models" Era for predict water pollution, mid 1980s had a led to the Era of "spatial modeling". Digital terrain data and remote sensing catchment charactering are considered as hydrological and water quality models. Miadment (1993) [2] has well explained about Modern hydrological process using GIS. The comparison between topological based hydrological data and geomorphological models has excelling review watershed analysis.

They are many changes in geomorphological analysis over last decades for the development of physiographic methods to describe the evolution and behavior of drainage networks on the surface [3]. Morphometric analysis of basin incorporates a quantitative description of drainage network which is important for prioritization of watershed [4]. Idenfication of Morphometric properties in various regions using Gis techniques with Dem data done by many workers [5-9].

Geographical information System has a powerful tool for analysis of watershed, various terrain conditions and manipulation of morphometric parameters of catchment area. GIS data has perfect accuracy, fast and provide a flexible environment.

Study area

The Allagadda region drainage basin covers 1564 Km^2 in Kurnool district, Andhra Pradesh, India. The study area has situated in between latitudes78^0.40'E and 78^0.70'E, longitudes -15^0.40' N and 14^0.90'N (Fig 1). Northeast side Nallamalla Hills occupied by Allagadda Reserve forest and Nandyal Reserve forest.Cartosat-1 DEM, ISO Toposheet 1:50000 scale (57I/5, 57I/6, 57I/7, 57I/11, 57I/14 and 57J/1), Satellite images and ARC GIS 9.3 were used for Geomorphological analysis. Arc GIS 9.3 was used to digitizing the DEM image data and manipulated, measuring and drawing the spatial data of the different analysis. Fill, Flow direction, Hill shade, Flow Accumulation, Basin, Aspects, Slope (Fig 2) and a stream network have been prepared using GIS.

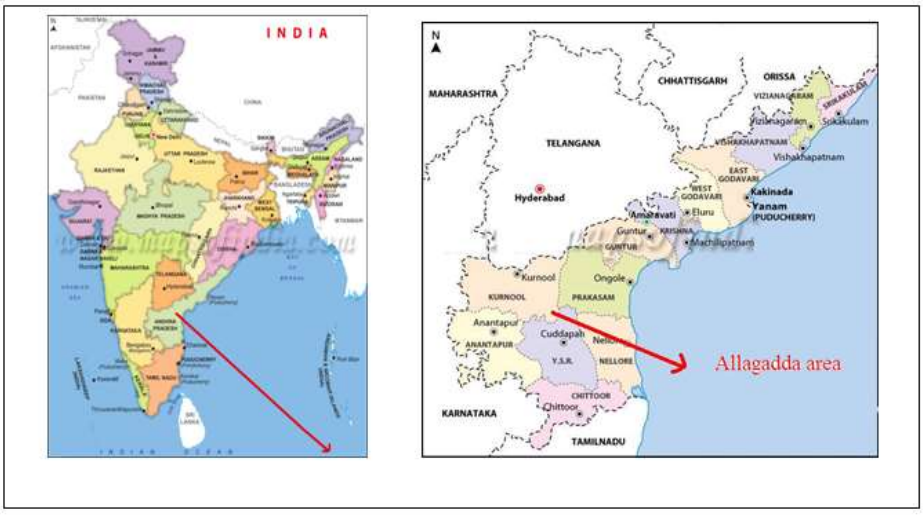


Fig 1: Location of the Study area.

Geomorphology

The Allagadda region one third areas covered by moderately dissected hills and reserved forest. Nallamala hills have N-S trending mostly occupied in Eastern Part. The geomorphological areas of Allagadda have classified different units: moderate dissected hills (200-904 m msl). Lacustrine area (187 msl) and Pediment and pediplain complex elevation is 160-137 m, above mean sea level. Kunderu river form pediplain are in Northwestern. They are many tributaries such as Bavanasi, Tundlavagu and Vakkileru flows and connected with Kunderu River. The drainage pattern of the Allagadda area is parallel and subdendritic- dendritic in nature.

Geology

The geology of the study area is mostly occupied by Kurnool super group. Rock types are shale with Phyllite of Nanadyal formation (Upper proterozoic age), Limestone as Koilkuntla formation (Middle Proterozoic age) and Cuddapah Group of Nallamala formation rocks are Quartzite-Slate (Middle proterozoic age) Dolomite, red ochre rocks also occurs [10].

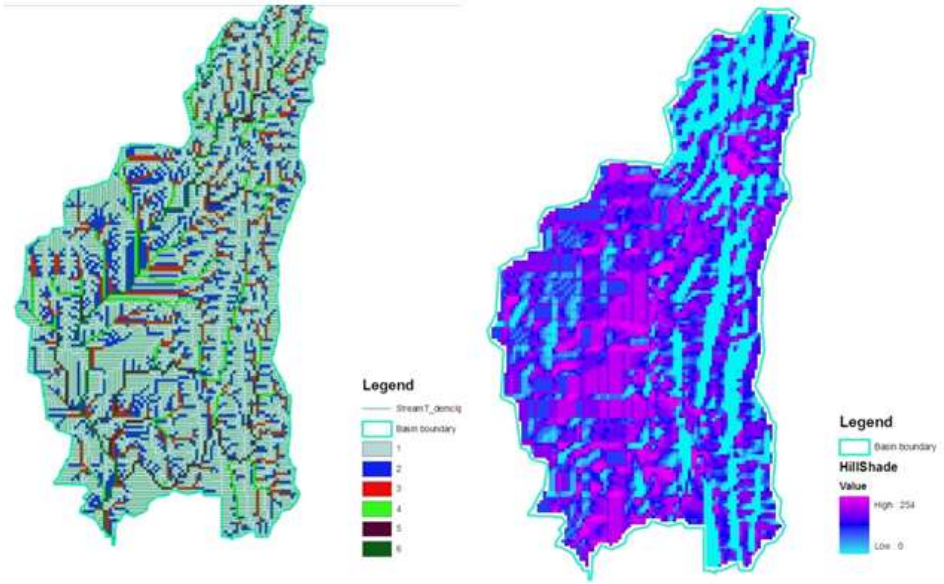


Fig 2 a: Stream network of the Study area b: Hill shade of the study area

METHODS AND MATERIALS

The following materials we were used for analysis of catchment area of Allagadda region.

Cartosat-1 DEM

Cartosat-1 DEM has a good accuracy while comparison other DEMs like ASTER and SRTM [11]. It has a Pair of Panchromatic cameras for acquire stereo image data with a base-to-height (0.63 ratio). The Spatial Resolution is 2.5 m in the horizontal plane. CartoDEM (30m, 90m) data was freely to download from BHUVAN, isro. Gov. in, ISRO (Indian Space Research Organization) has developed CartoDEM for Idenfication of terrain conditions, delineation of watershed and various scientific works.

Survey of India Topo sheet (1: 50,000)

Morphometric Properties of the Allagadda region Toposheets (57I/5, 57I/6, 57I/7, 57I/11 and 57J/1, 57i/14) were scanned and digitized in Arc Gis Software.

Stream Number (Nu)

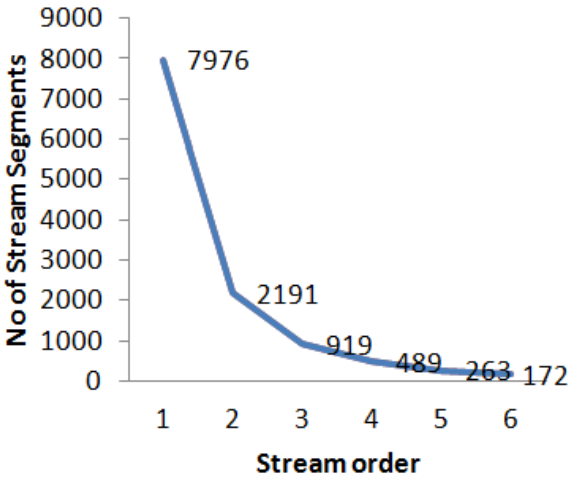
The catchment area has number of streams, the order wise total number of streams is known as stream number the study area have 6 order of streams for DEM analysis were 1st order stream 7976, 2nd order stream 2191,3rd order stream 919,4th order stream 489, 5th order stream 263 and 6th order stream172. The relationship between stream order and a drainage basin. The important results were as stream order increases the number of stream decreases in an inverse geometric ratio (Fig 2).

Stream Order

Horton (1945) [3], Strahler (1952) [12] has proposed stream ordering is the first step of analysis of watershed. Stream order determines the hierarchical position of a stream within drainage Basin. The primary rivers are order rivers, contact with two primary rivers and form the second order river, two second order river contact each other and form a third order river like that all 6 order rivers will form and it covers the size of the network of the river. The result is decreasing of stream frequency as the stream order increases.

Table 1: Linear Aspects of study area.

S.No	Stream Order	Stream Number	Bifurcation Ratio (Rb)	Stream Length (km)	Length /order	Length Ratio	No.ofStream length used in Ratio
1	1	7976	-	2662.26	2662.26		
2	2	2191	3.64	716.02	358.01	7.4	3378.28
3.	3	919	2.38	304.69	101.56	3.5	1020.71
4.	4	489	1.87	164.99	41.2	2.4	469.68
5.	5	263	1.85	89.97	17.9	2.3	254.96
6.	6	172	1.52	59.49	9.9	1.8	149.46
Total	=	3997.42					
Mean			2.25				3.46



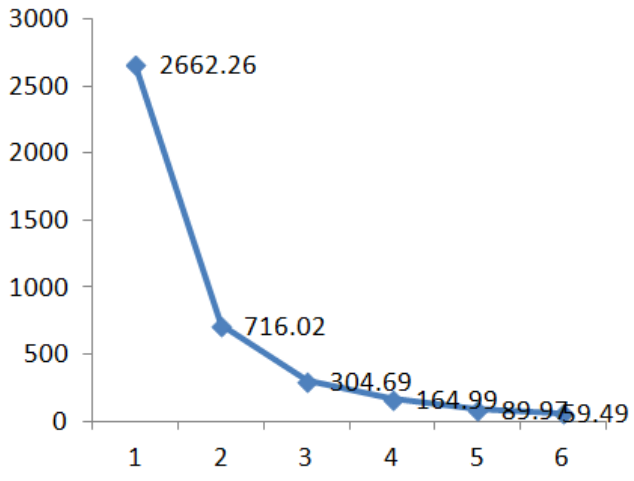


Figure 2: line graph for Stream Order verses no of Stream Segments. Figure 3: line graph for Stream order verses no of Stream Length

Stream Length (Lu)

The total stream lengths of the study area have various orders which have computed with the help of ArcGIS Hydro tool (Table: 1). Plot on the graph stream order verses stream length (Fig: 3) showed stream lengths decreases in watershed of increasing order [4]. The linear pattern which indicates the homogenous rock material subjected to weathering-erosion characteristics of the basin. Deviation from its general behavior indicates that the terrain is characterized by variation in lithology and topography [13].

Bifurcation Ratio (Rb)

The bifurcation ratio is representing the ratio of the number of the stream segments of given order to the number of streams in the next higher order [14]. Rb is not have same values in all stream order. It is depends on the Topological, climatic conditions and lithology of the catchment area [12]. Generally Rb value is indicate from 3.0-5.0 The lower values of Rb are characteristics of the watersheds, which have suffered less structural disturbances [4] then the present catchment area have less Rb value 2.25 (Table 1). That means it is very hard surface and terrine, and different in geological composition which might increase the hazard of floods.

Aerial Aspects

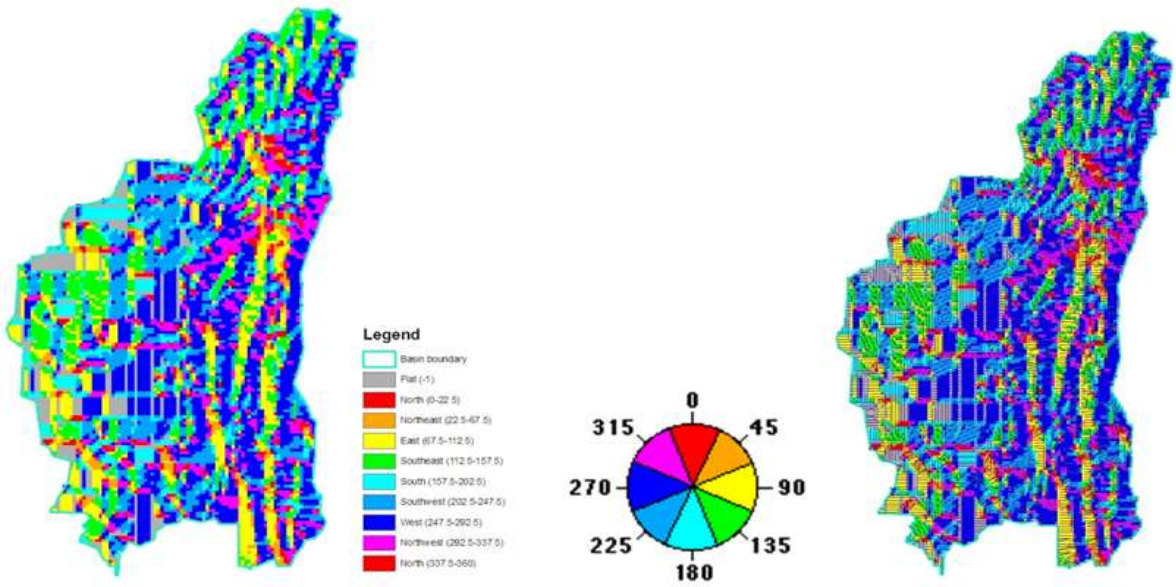


Fig 4 a: Aspect image of the study area b: Aspect directions

Aspect ratio represents the direction of the hill slope faces. The values of the study area will be the compass direction of the aspect [15]. The Aspect ratio image created from the Cartosat-1 DEM data is represented in eight directions (Fig 4). The flat surface identified in south west direction (Gray shade is a flat area).

Form Factor (Rf)

Form Factor is Represent the different basing shapes. Which is defined the basin area divided by square of the basin length [16]. The ratio of the values indicates 0.1-0.8. Elongated basins have the small form factor values. The basins which have high values of form factor it indicates a high peak flows of shorter duration, whereas elongated drainage basin with low form factors have to flow of longer duration. The basin have form factor value is 0.3 which indicate elongated in shape and flow for long duration.

Elongated Ratio (Re)

Schumm (1956) [14] represents the elongation ratio (Re) as the ratio of diameter of a circle of the same area as the basin to the maximum basin length. The value of Re varies from 0 (highly elongated shape) to unity (circular shape). Thus the higher the value of elongation ratio the more circular shape of the basin and vice-versa. Where as those of (0.6 to 0.8) are usually associated with high relief and steep ground slope [17]. The elongation ratio of Watershed is 0.76 which is defined as a less elongated and low relief of the terrain (Table: 2).

Circulation ratio (Rc)

Miller (1953) [18] defined it as the ratio of the area of the basin to the area of the circle having same circumference as the basin perimeter. Miller has described circulation ratio values from 0.4-0.7 indicates strongly elongated and highly permeable homogeneous materials. The circulation ratio values 0.53 which indicate that the watershed is elongated in shape and highly permeably stara.

Drainage Density (Dd)

Drainage Density is the ratio of total length of all streams to the total area of the basin. Dd of any basin reveals the terrain configuration that a property of the rock of the area [19]. It is indirectly help to the Idenfication of groundwater potential of an area due to its relation with surface runoff and permeability [16]. The area Allagadda characterized according to the value to the obtained it's an area with a low density (2.5). It is suggested that sub soil, thick vegetation cover and low relief Low drainage density leads to coarse drainage texture while high drainage density leads to fine drainage texture.

Table: 2 Aerial Aspects of Study area

S.No	Morphometric parameter	Results
1	Basin Area (A)	1564 m^2
2	Perimeter (P)	191.2 km
3	Length of basin (L_b)	58
4	Width of basin(W_b)	32.7
5	Circularity ratio (Rc)	0.53
6	Elongated ratio(Re)	0.76
7	Form Factor (Rf)	0.46
8	Drainage Density (Dd)	2.5
9	Stream Frequency (Fs)	7.67

Stream Frequency (Fs)

Horton (1945) [3] suggested the stream frequency of the basin is the ration of total number of streams (Nu) of all orders to the Basin Area (A).It is a good indicator of drainage basin. It mainly depends on the lithology of the basin and reflects the texture of the drainage network. The stream frequency of the Kunderu river in Allagadda region is 7.67

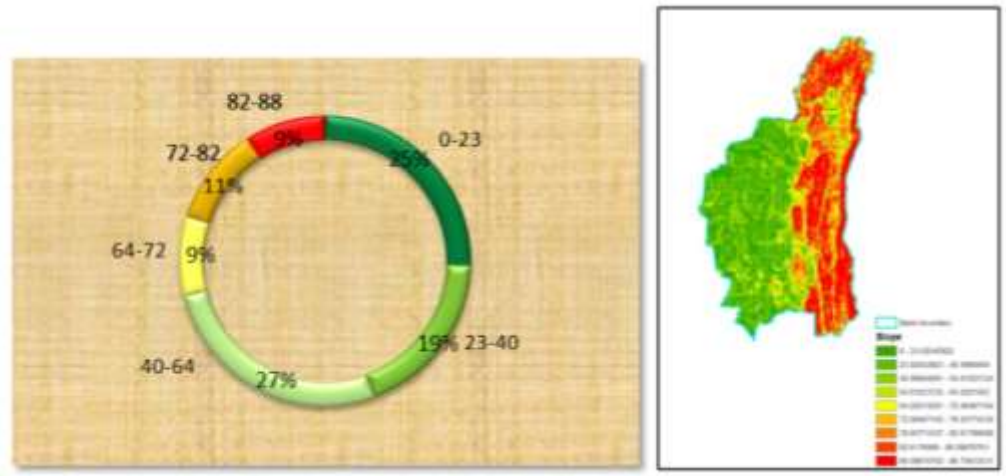


Fig: 5. (a) Graphical represent of Slope of the area b) Slope map of the study area

Slope of the Area

Slope map prepared from CartoSat-1 DEM image in Arc GIS 9.3 software [20]. Gradient of the area broadly divided 6 types such as (Fig: 5). Flat or leveling area (25%), Very gently slope (19%), gently slope (27%), moderately sloping (9%), steeply sloping (11%), Very steeply sloping (9%). A Lower slope value is 25% which indicate flat terrain in South west side, near mouth of the Kunderu River. Higher values indicate very steep sloping (9%) in northeastern side. The drainage of Allagadda region 44% of the area occupied by Nallamala Hills Hence the slope map can be used to identify areas with high runoff and high erosion rates.

RELIEF ASPECTS

Basin Area (A)

Area (A) and Perimeter (P) both are important parameter for Quantitative morphology of watershed. Basin area is the important aspect of hydrology which concern directly size of the storm hydrograph and mean runoff. The basin area computed using ARC GIS software which is 1564 Sq kms.

Basin Relief (H)

Relief is the vertical distance between point of maximum elevation and minimum elevation. The maximum elevation of the basin is 904m and minimum elevation is 136m. Relief ratio of the basin is 768m.

Relief Ratio (Rr)

The relief ratio is defined as the Ratio between the total relief of a basin (H) and the maximum measured length of the drainage basin (Lb)".

There is direct relationship between the relief and channel gradient and also a correlation between hydrological characteristics and the relief ratio of a drainage basin. The value of the Relief ratio is 0.013 which indicate that the relief ratio is moderate and steep and moderate gentle slope, generally the low relief ratio indicates less resistant rocks of the area [21].

CONCLUSION

The study of Morphometric analysis is more useful for rainwater harvesting, watershed management plans. The catchment area of Allagadda region has 6th order drainage basin. The drainage pattern is parallel and dendritic pattern. Subdendritic drainage pattern has less structural control and parallel drainage pattern suggest that gentle slope and less resistant bed rock. While increase the stream order, number of stream segments decrease in the study area, 1st, 2nd order of streams situated in Nallamala hills and flows eastern to western direction due to slope. The circulation ratio value (0.53) indicates that the watershed is elongated in shape and highly permeable. Bifurcation ratio value (2.25) represented very hard surface and terrain, and different in geological composition which might increase the hazard of floods. The Relief ratio is 0.013 which indicate that the relief ratio is moderate and steep and moderate gentle slope the study reveals that this area is not suitable for construction dam and check dams because in rainy season more water comes from 1st order and 2nd order of streams. So this area is a highly vulnerable Drought area.

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