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The Studies on Analysis of Geomorphometric Characterization of Himayat Sagar and Osman Sagar Catchment Using Remote Sensing and Geographical Information System

Gangadhar N.[1*], Manojkumar G.[2], Gajanan R.[3] and Siva Lakshmi Y.[4]

[1,2]Department of Soil and Water Engineering, [4]Department of Agronomy,

College of Agricultural Engineering Kandi, Sangareddy Professor Jayashankar Telangana State Agricultural University (PJTSAU), Rajendranagar. Hyderabad

[3]Department of water resource division TRAC, Hyderabad

*Corresponding Author E-mail: gangadharagrieng93@gmail.com

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ABSTRACT

In the present study, analysis of geomorphometric characteristics of osman sagar and Himayat sagar catchment was carried out using remote sensing and GIS and the drainage networks of the both the catchment were generated using SRTM DEM (90m resolutions). Two adjacent catchments, Himayath sagar and Osman sagar, located Rangareddy district of Telangana state, India were selected for study. Morphometric features and drainage network of Himayath sagar and Osman sagar catchments were extracted from DEM using ArcGIS software. Such as relief parameters viz, Total Basin relief, relief ratio, relative relief and ruggedness number for both catchments were determined using ArcGIS.

Keywords: *Total Basin relief, Relief ratio, Relative relief and Ruggedness number*

INTRODUCTION

Water is known as the liquid for sustenance of life. All living beings are depending on water, without which no life exists on the earth. Earth has plentiful water due to the presence of hydrological cycle on it, but most of it is unfit for living beings use and consumption. The study of the watershed morphometric analysis provides the beneficial parameters for the assessment of the groundwater potential zones, identification of sites for water harvesting structures, water resource management, runoff and geographic characteristics of the drainage system (Singh et al., 2014). Morphometry is the measurement and mathematical analysis of the configuration of the earth's surface, shape, dimension of its landforms (Clarke, 1996). Morphometry represents the topographical expression of land by way of area, slope, shape, length, etc.

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These parameters affect catchment stream flow pattern through their influence on concentration time. River characteristics are reasonably understood by the morphometric analysis of that particular river basin. Morphometric analysis requires measurement of linear features, gradient of channel network and contributory ground slopes of the drainage basin. The morphometric parameters are divided into three categories: linear, areal and relief aspects (Sreedevi et al., 2009). The parameters namely area, perimeter, stream order and stream length are extracted from the geo-database and other parameters such as bifurcation ratio, stream length ratio, Rho coefficient, drainage density, stream frequency, drainage texture, length of overland flow, constant of channel maintenance, basin relief, relief ratio, relative relief, ruggedness number, gradient ratio, Melton ruggedness ratio, basin slope, laminscate ratio, form factor, circulatory ratio, elongation ratio and shape index are calculated by means of various mathematical equations (Thomas et al., 2010).Remote sensing techniques using satellite images are convenient tools for morphometric analysis. The satellite remote sensing has the ability to provide synoptic view of large area and is very useful in analyzing drainage morphometry. The image interpretation techniques are less time consuming than the ground surveys which coupled with limited field checks yield valuable results. Geographical Informational System (GIS) is a computer-assisted system designed to capture, store, edit, display and plot geographically referenced data.

MATERIALS AND METHODS

This chapter briefly describes the details of the study area and the material and methods used including input parameters to achieve the selected research objectives. The delineation of watersheds from Digital Elevation Models (DEM), determination of morphometric parameters.

Study Area

The study area for the present work consists of catchment of Himayath sagar and Osman sagar reservoirs (Fig.1). Himayath sagar reservoir was constructed on Esa River in 1925 and is situated 9.6 km in southwest direction from Hyderabad, located at 17º02'00" N to 17º21'15" N latitude and 77º53'49" E to 78º26'48" E longitude. Osman sagar reservoir was constructed on Musi river in 1922 and is situated 9.6 km from Hyderabad in western direction located at 17º14'31" N to 17º29'50" N latitude and 77º50'30" E to 78º20'4" E longitude. The catchment area of Himayath sagar is 1358.53 km^2 with elevation range of 516 m to 730 m. Where the Osman sagar catchment area consists of 746.73 km^2 with elevation varies between 522 m to 722 m. Both reservoirs supply drinking water to Hyderabad city. The study area is pertaining to K6Dm4 Agro-Ecological sub region. It is part of North Telangana Plateau, hot moist semi-arid eco sub-region with deep loamy and clayey mixed red and black soils having very high available water content and 120-150 days growing period.

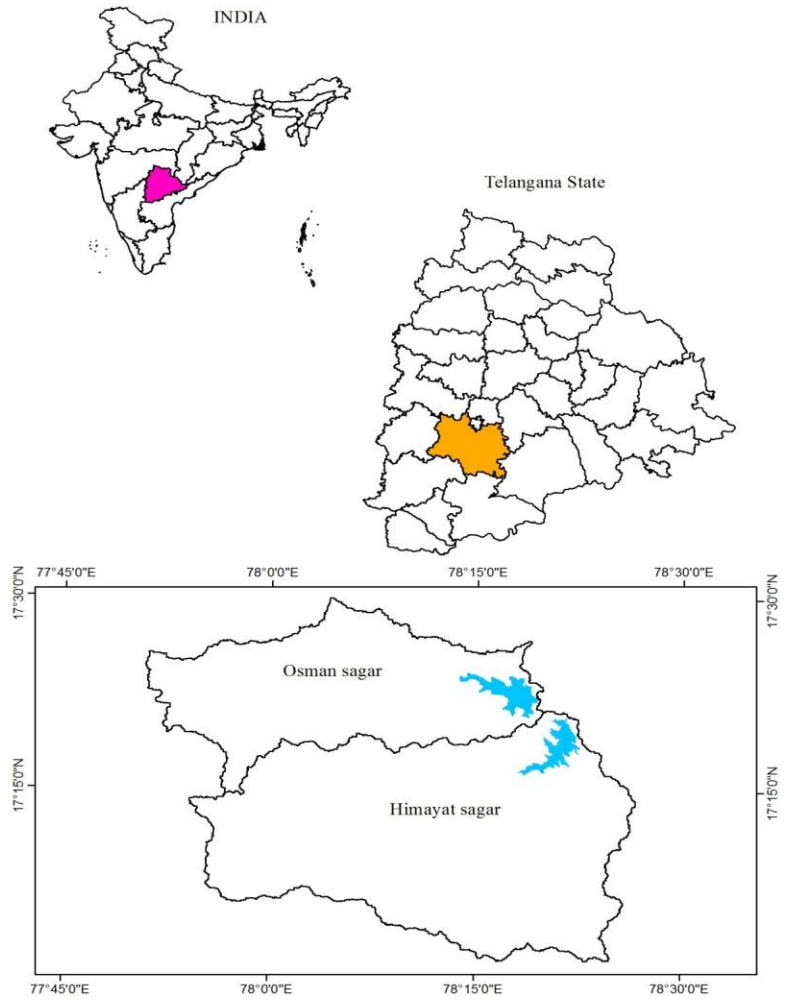

Fig. 1: Location of study area

Remote sensing data

Topographic data: Shuttle Radar Topography Mission Digital Elevation Model (SRTM DEM) version 4.1 with a 90 m resolution was downloaded from http://srtm.csi.cgiar.org. DEM of study area is depicted in Fig.2

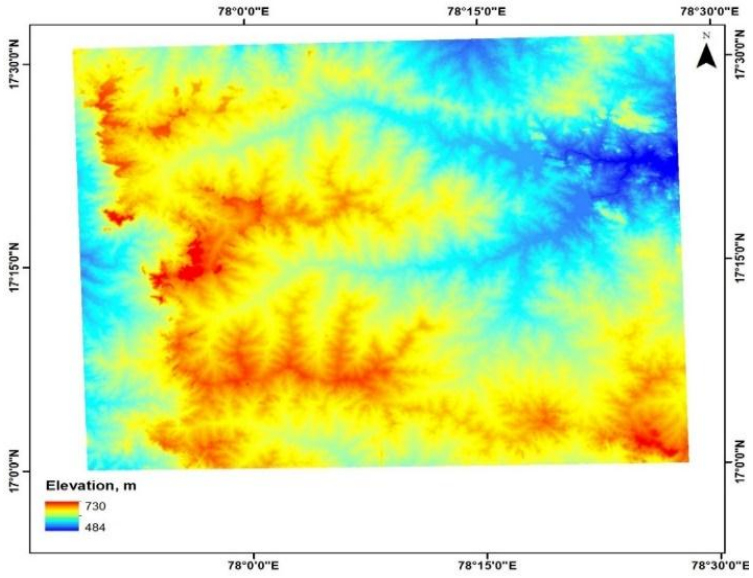

Fig. 2: Digital elevation model representation of study area

Catchment delineation

Catchment area is delineated from a DEM by computing the flow direction. To determine the contributing area, a raster representing the direction of flow is created. Once the direction of flow out of each cell is known, it is possible to determine which and how many cells flow into any given cell. This information is used to define catchment boundaries. A series of steps are preceded to delineate catchment and to define stream network. A process flowchart of catchment delineation is depicted in Fig.3

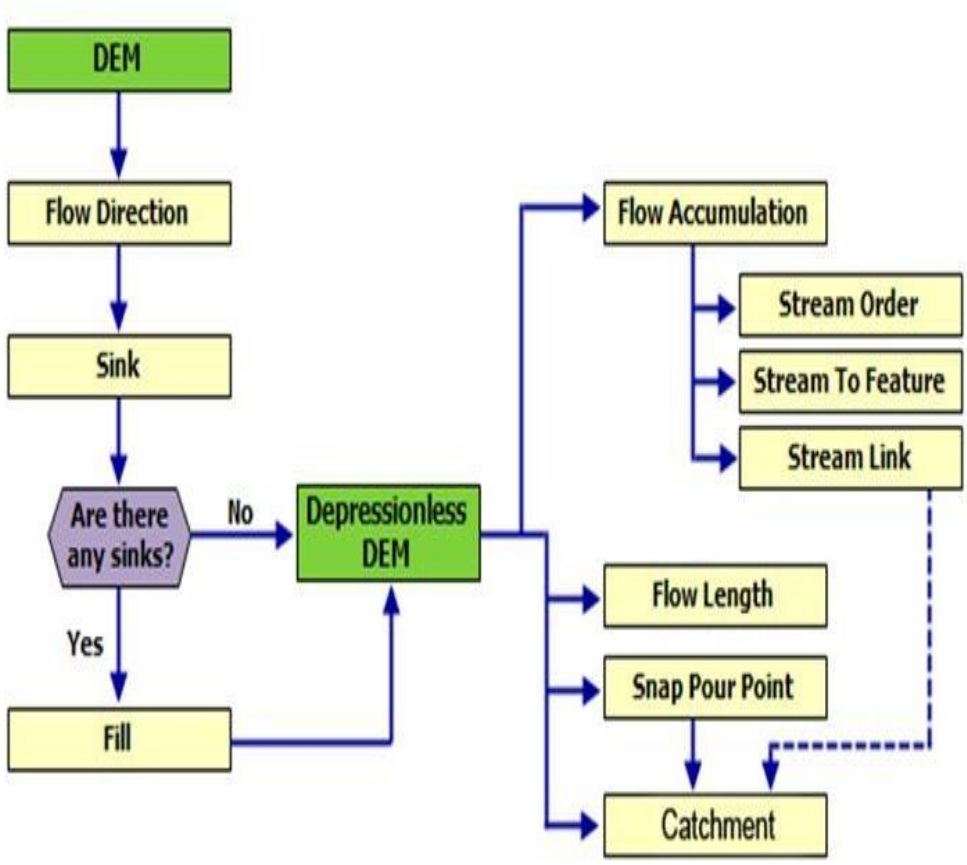

Fig. 3: A process flowchart of catchment delineation

Morphometric Parameters Estimation

Morphometric analysis is the measurement of the three dimensional geometry of landforms and has traditionally been applied to watershed, drainages, hill slopes and other group of terrain features (Babar, 2005). Drainage basin or basins should be the study area for better understanding of the hydrologic system. Basin morphometry is a means of numerically analyzing or mathematically quantifying aspects of drainage channels. Spatial arrangement of streams has given rise to a particular design which is called the drainage pattern. Morphometric analysis requires measurement of linear features, gradient of channel network and contributory ground slopes of the drainage basin. Geographic information system and remote sensing satellite images are convenient tools for morphometric analysis. To estimate the morphometric features of catchments of Himayath sagar and Osman sagar reservoirs, the drainage network was extracted from digital elevation model in ArcGIS software. Catchment areas of Himayath sagar and Osman sagar were extracted from SRTM DEM version 4.1, with a 90 m resolution using hydrology tool of ArcGIS. Geomorphometric characteristics such as linear, areal and relief aspect parameters for both catchments were determined using ArcGIS.

1. Total basin relief

It is the maximum vertical distance between the lowest and highest point of the watershed. It is also known as maximum watershed relief.

$$R = Z_m - Z_0 \quad \cdots(i)$$

where, R is the total basin relief; Z_m is the maximum elevation on the watershed; Z_0 is the elevation of the outlet.

2. Relief Ratio

Relief ratio means difference between highest and lowest point of elevation of the watershed. The relief ratio may be defined as the ratio between the total relief of a basin and the longest dimension of the basin parallel to the main drainage line (Schumm, 1956).

$$R_h = \frac{R}{L_b} \quad \cdots(ii)$$

where, R_h is the Relief ratio; R is the maximum basin relief; $L_b$is the horizontal distance along the longest dimension of the basin parallel to the principle drainage line.

3. Relative relief

It is the ratio of the maximum basin relief to the perimeter of the basin.

$$R_{hp} = \frac{R}{P} \quad \cdots(iii)$$

where, R_{hp} is the relative relief; R is the maximum basin relief; P is the perimeter of the basin.

4. Ruggedness number

This is the product of drainage density and catchment relief.

$$R_n = Dd \times R \quad \cdots(iv)$$

Where, R_n is ruggedness number; R is relief; D_d is the drainage density

RESULTS AND DISCUSSION

Morphometric Parameters Estimation

In morphometric analysis, configuration of the earth's surface and dimensions of the landforms is measured. This analysis was carried out for quantitative evaluation of drainage basin. Three major aspects: Linear, Areal and Relief have been described for analysis. Linear aspect in morphometry is characterized by basin length, stream order, stream number, stream length and bifurcation ratio. Areal aspect represents the characteristics of catchment area and describes how catchment area controls and regulates the hydrological behavior. Relief aspect defines terrain setup of the catchment and terrain characteristics. The geomorphometric parameters of the Himayath sagar and Osman sagar catchments were carried out using SRTM DEM with 90 m spatial resolution. Examined parameters are presented in detailed in following sections.

Total basin relief is the maximum vertical distance between the lowest (outlet) and the highest (ridge) points in the watershed. Total basin relief of Himayath sagar and Osman sagar catchment is determined as 214 m and 200 m, respectively. It is an indicative of the potential energy of a given watershed above a specified datum available to move water and sediment down slope. Fig. 4 shows relief map of Himayath sagar and Osman sagar catchment.

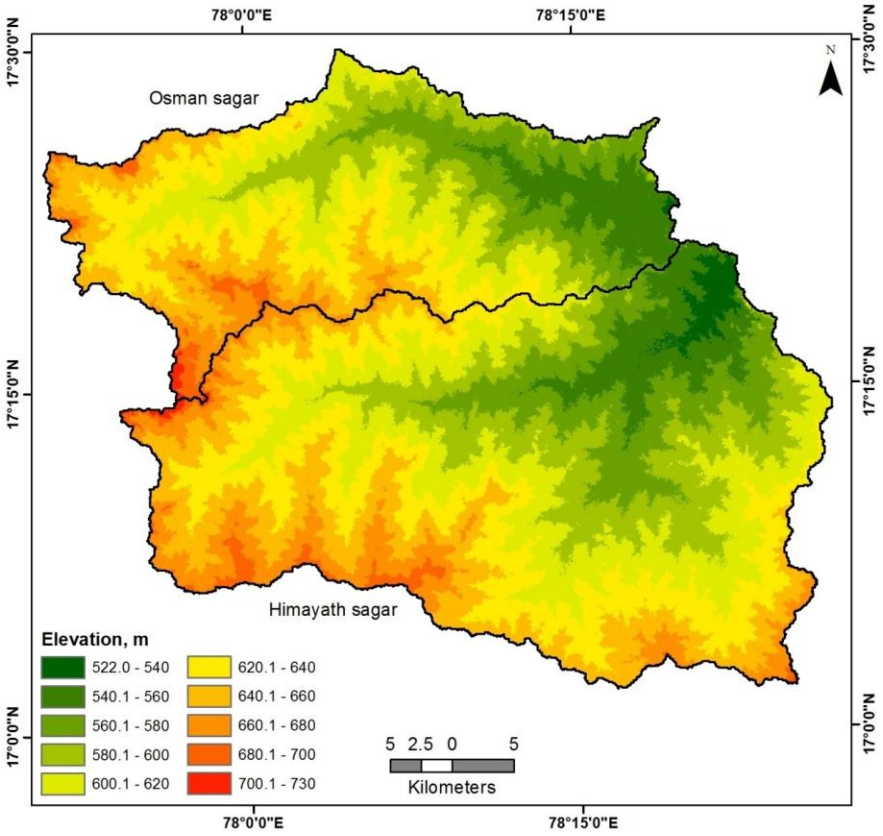

Fig. 4: Relief map of Himayath sagar and Osman sagar catchment

Relief ratio measures the overall steepness of the watershed and can be related to its hydrologic characteristics. It is an indicator of erosion process operating on the slopes of the basin. Relief ratio of Himayath sagar and Osman sagar catchment is determined as 3.949 and 3.902, respectively. The values of relief ratio in the basin are indicating moderate relief and moderate slope. Relative relief of Himayath sagar and Osman sagar catchment is found to be 0.081 and 0.088, respectively. It is an indicator of general steepness of the basin from summit to mouth. Ruggedness number of Himayath sagar and Osman sagar catchment is 0.398 and 0.399, respectively. The areas of low relief but high drainage density are regarded as ruggedly textured as areas of higher relief having less dissection (Strahler, 1958). The moderate ruggedness value of both catchments implies that area is moderately prone to soil erosion and have intrinsic structural complexity in association with relief and drainage density.

SUMMARY AND CONCLUSIONS

Water plays principal role in the sustainability of livelihoods, agriculture and regional economy. Water management is the primary safeguard against drought and plays a fundamental role in achieving food security at the watershed, sub basin and basin from local to global planes. The study of the watershed morphometric analysis provides the beneficial parameters for the assessment of the groundwater potential zones, identification of sites for water harvesting structures, water resource management, runoff and geographic characteristics of the drainage system. Morphometry represents the topographical expression of land by way of area, slope, shape, length, etc. These parameters affect catchment stream flow pattern through their influence on concentration time. River characteristics are reasonably understood by the morphometric analysis of that particular river basin. Morphometric analysis requires measurement of linear features, gradient of

channel network and contributory ground slopes of the drainage basin. Considering the above facts, the present study focuses on the analysis of geomorphometric characteristics in the two adjacent catchments. The specific objectives of the study are as follows to analyse geomorphometric characteristics of Himayath sagar and Osman sagar catchment using RS and GIS. Particular to the present study, the following salient conclusions are drawn. A GIS technique characterized by very high accuracy of mapping and measurement proves a competent tool in geomorphometric analysis. Relief aspect shows moderate relief, moderate slope and moderately prone to soil erosion.

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