MORPHOMETRIC ANALYSIS OF DRAINAGE BASIN OF SAGAR LAKE, DISTRICT SAGAR M.P. & SURROUNDING AREA USING GIS AND RS TECHNIQUES

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Abstract

This analysis was done using survey of India toposheet no. 55 I/9 & 55 I/13, Geographical Information system (GIS) software & remote sensing techniques. The study shows that the terrain exhibits dendritic drainage pattern. The present study deals with the evaluation of morphometric parameters such as stream order (u), stream length (Lu), bifurcation ratio (Rb), drainage density (D), stream frequency (Fs), elongation ratio (Re), circularity ratio (Rc), Form Factor (Rf), etc.

Keywords: *Geographical Information system, remote sensing techniques, morphometric parameters, dendritic drainage.*

Introduction

Morphometric analysis is referred as the quantitative evaluation of form characteristics of the earth surface and any landform unit. This is the most common technique in basin analysis, as morphometry form an ideal areal unit for interpretation and analysis of fluvially originated landforms where they exhibit and example of open systems of operation. The composition of the stream system of a drainage basin is expressed quantitatively with stream order, drainage density, bifurcation ration and stream length ratio (Horton, 1945). Morphometric analysis is an important technique to evaluate and understand the behavior of hydrological system. Drainage morphometry helps in understanding the stages of development of the erosional work through the controlling factor such as geology, structural, climate, topographic relief and the altitude of the area controls the development of the drainage of the area.

Study Area: Sagar district is located in the north central part of the state of Madhya Pradesh and occupies as area of 10252 sq. km. The district extends between the latitude of $23^0$10’ and 24^0 27’ north, longitude of 78^0 04’ and 79^0 21’east (fig.1.). Sagar Lake is situated in the heart of Sagar city (23^0 50’ N: 78^0 45’ E and 517 MSL), which falls on the toposheets no. 55 I/9 and 55 I/13.

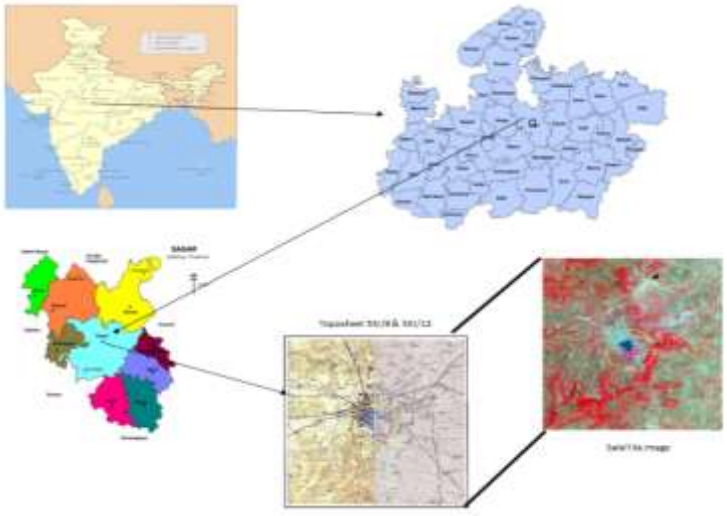

Fig. 1. Showing the Location Map

Methodology

The drainage map (Fig.2) of the study area is prepared using SOI toposheets no. 55 I/9 & 55 I/13 on 1: 50,000 scale with sufficient ground truth. The ArcGIS 9.3 software has been used for digitizing purpose, morphometric analysis and also for calculation.

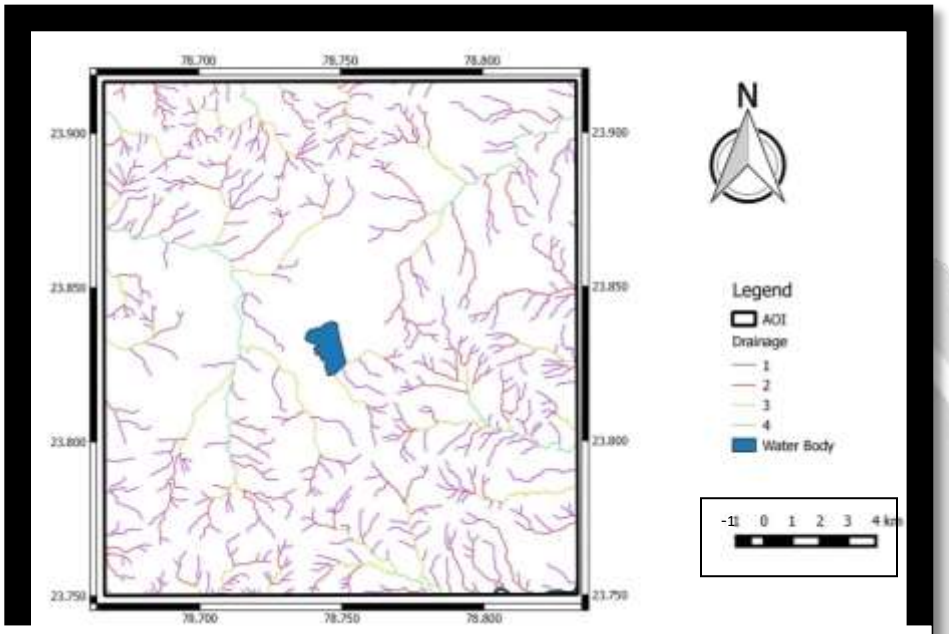

Fig. 2 showing drainage map of the study area with orders

Result & Discussion

Morphometric analysis refers as the quantitative evaluation of form characteristics of the earth surface and any landform unit. This is the most common technique in basin analysis, as morphometry form an ideal areal unit for interpretation and analysis of fluvially originated landforms where they exhibit and example of open systems of operation. The composition of the stream system of a drainage basin in expressed quantitatively with stream order, drainage density, bifurcation ration and stream length ratio (Horton, 1945).

LINEAR ASPECTS

The drainage network transport water and the sediments of a basin through a single outlet, which is marked as the maximum order of the basin and conventionally the highest order stream available in the basin considered as the order of the basin.

Stream Order (U)

The ordering of streams is the first stage of basin analysis shown in Fig. 2. There are four different system of ordering streams that are available Gravelius (1914), Horton (1945), Strahler (1952) and Schideggar (1970). Strahler's system, which is a slightly modified of Horton's system, has been followed because of its simplicity. Where the smallest, unbranched fingertip streams are designated as 1st order, the confluence of two 1st order channels give a channel segments of 2nd order, two 2nd order streams join to form a segment of 3rd order and so on. When two channel of different order join then the higher order is maintained. The trunk stream is the stream segment of highest order, which is 4th stream order.

Stream Number (Nu)

The total number of stream segments present in each order is the stream number (Nu).

Nu is number of streams of order (U).

Stream Order (U)	I	II	III	IV
Stream Number (Nu)	471	135	37	6

Stream Length (Lu)

The total length of individual stream segments of each order is the stream length (Lu) of that order. Stream length measures the average (or mean) length of a stream in each order, and is calculated by dividing the total length of all streams in a particular order by the number of streams in that order.

(U)	I	II	III	IV
(Lu)	289.147	126.324	73.857	34.307

Mean Stream Length (Lū)

Mean stream length of a stream channel segment of order 'u' is a dimensional property revealing the characteristic size of components of a drainage network and its contributing basin surface (Strahler, 1964).

(U)	I	II	III	IV
(Lū)	0.614	0.936	1.996	5.718

Bifurcation Ratio (Rb)

The bifurcation ratio is the ratio between the number of streams in one order and in the next higher order. It is calculated by dividing the number of streams in the lower by the number in the higher of the two orders. The bifurcation ratio of large basins is generally the average of the bifurcation ration of the stream orders within it.

I/II	II/III	III/IV	Mean Bifurcation Ratio
3.489	3.649	6.167	4.435

AERIAL ASPETS

Drainage Density (D)

It is defined as the total stream length of all order divided by the area of the basin.

D = 1.668 km/sq. km

The area having the low density indicates that the most rainfall infiltrates the ground and few channels are required to carry the runoff.

Drainage (Stream) Frequency (Fs)

Drainage frequency may be directly related to the lithological characteristics. The number of stream segments per unit area is termed as Stream Frequency.

$F_s = 2.075$

The basins of the structural hills have higher stream frequency while the basins of alluvial has minimum.

Drainage Texture (Dt)

Drainage texture is defined as the product of the drainage density and drainage frequency. It is important to geomorphology which means that the relative spacing of drainage lines. Drainage texture is on the underlying lithology, infiltration capacity and relief aspect of the terrain. Smith (1950) has classified drainage texture into 5 different textures i.e., very coarse (<2), coarse (2 to 4), moderate (4 to 6), fine (6 to 8) and very fine (>8).

Dt = 3.461

Course drainage texture means the porosity and permeability of the terrain or study area is good.

Form Factor (Rf)

Form factor is the numerical index (Horton, 1932) commonly used to represent different basin shapes.

Rf = 0.2496

Smaller the value of form factor, more elongated will be the basin, elongated drainage basin with low form factors has lower peak flow of longer duration.

Elongation Ratio (Re)

Schumm's 1956 used an elongation ratio (Re) defined as the ratio of diameter of a circle of the same area as the basin to the maximum basin length.

Re = 0.282

Elongation ratio	Shape of basin
<0.7	Elongated
0.8-0.7	Less elongated
0.9-0.8	Oval
>0.9	Circular

0.282 represent the elongated basin with low relief.

Circularity Ratio (Rc)

The circularity ratio is a similar measure as elongation ratio, originally defined by

Miller (1953), as the ratio of the area of the basin to the area of the circle having same circumference as the basin perimeter.

Rc = 0.784

The value represents more circularity in the shape of the basin.

Length of Overland Flow (Lg)

The term length of overland is used to describe the length of flow of water over the ground before it becomes concentrated in definite stream channels. Horton (1945) expressed it as equal to half of the reciprocal of Drainage Density (D).

Lg = 0.2998

0.2998 value represents long time of flow in the basin.

Constant of Channel Maintenance (C)

Schumn (1956) has used the inverse of the drainage density having the dimension of length as a property termed constant of channel maintenance. The drainage basins having higher values of this parameter, there will be lower value of drainage density.

C = 0.5995

Higher value of constant channel Maintenance reveals strong control of lithology with a surface of high permeability.

Conclusion

GIS and Remote sensing techniques have proved to be accurate and efficient tool in drainage delineation and their updation. Bifurcation ratio, length ratio and stream order of basin indicates that the basin is fourth order basin with dendritic type of drainage pattern with homogeneous nature and there is no structural or tectonic control.

The area having the low density indicates that the most rainfall infiltrates the ground and only few channels are required to carry runoff. The basins of the structural hills have higher stream frequency while the basins of alluvium have minimum. Course drainage texture means the porosity and permeability of the terrain or study area is good. Smaller the value of form factor, more elongated will be the basin, elongated drainage basin with low form factors has lower peak

flow of longer duration. The shape of the basin is circular. The length of the overland flow represents the longtime of flow in the basin.

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