MORPHOMETRIC ANALYSIS OF A MICRO WATERSHED OF GIRI RIVER BASIN IN HIMACHAL PRADESH, INDIA USING GEOSPATIAL TECHNOLOGY

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Abstract

Quantitative and morphometric analysis help us to understand the structure process and evolution of landscape. The Giri river micro watershed is located in Sirmaur and Shimla District of Himachal Pradesh India. In the present study the quantitative and morphometric analysis of the watershed is done by using Survey of India Topographical map and a Land Sat satellite imagery with the help of GIS software QGIS. The linear and areal aspects of morphometry such as stream order, stream length, stream length ratio, bifurcation ratio and drainage density were calculated for the river basin. The basin was found to be a third order basin with a mean bifurcation ratio of 2.88 and drainage density of 0.27 km/sq.km. The study has strengthened in understanding the hydrological, geological and geomorphological characteristics of the basin.

Keywords : Quantitative, Morphometric analysis, GIS, River basin

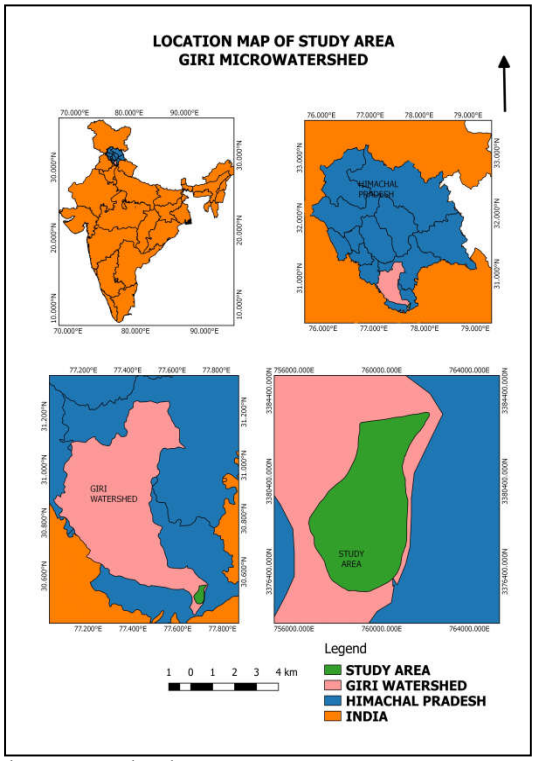
INTRODUCTION

An area that drains into a common water body is called a watershed or drainage basin or catchment area. It is a geographical unit in which we can analyze all the components of hydrological cycle. The study of the watershed is done along the stream cross section. It is an ideal unit for planning and management as all the components such as physical, biological, social, economic and political are integrated in it. Remote sensing and GIS techniques are used to study the morphometric characteristics of the drainage basin. With the help of these techniques we can access the required information without conducting a land survey GIS help us to analyze the spatial data very efficiently.

R.K.Somashekar and P.Ravikumar(2011) used remote sensing and GIS to evaluate the morphometric parameters to estimate the aerial, linear and relief aspect of Hesaraghatta and the four watershed, Banglore. Agarwal(1998) used remote sensing and GIS techniques to stud the drainage pattern of Navgarh area of Varanasi and concludes that these techniques are very useful to study the drainage basin and can be used for planning and management of watershed.

In the present study various morphometric parameters are used to measure the drainage basin. These parameters are used to study the earth surface. They are stream order, stream length, stream length ratio, mean stream length, bifurcation ratio and drainage density etc. Investigation of these morphometric parameters of watershed help us to understand the various aspects of the characterization of watershed.

STUDY AREA



The locale of the study is Giri river micro watershed, located in Sirmaur and Shimla District, Himachal Pradesh India ,which extends from 33° 78’ 57’’ N to 33° 83’ 40’’ N latitude and from75° 90’ 24’’ E to 76° 20’ 94’’ E longitude. The area of Giri watershed is 289 sq km. The climate in this region is mostly temperate. Temperatures vary from a minimum of 7 degree in winter to about 41 degree Celsius in summer. Annual rainfall is a quite uniform between 550 and 500 mm on the North West and 500 mm up to 1200 mm on East- West which has a significant effect in the watersheds.

OBJECTIVE OF THE STUDY

The present study is carried out to achieve the following objective

- To study the quantitative analysis of linear aspects of a micro watershed of Giri river basin.
- To evaluate the natural resources of Giri river basin by using geospatial technology.

DATA BASE

- Survey of India Toposheet
- Satellite Image
- Software Used-QGIS 2.16.3

METHODOLOGY

The study area is analyzed for the quantitative morphological analysis of the watershed by using Survey of India Topographical map on the scale 1: 50,000 which is used for reference, in addition to this a geocoded FCC of Landsat ETM satellite imagery taken during 2017 was used. The Topographical map and digital satellite imagery were geometrically rectified and geo-referenced using digital image processing software QGIS. To extract the drainage layer from the satellite imagery, edge detection and linear enhancement filters were used for enhancing visual interpretation ability of the stream order on satellite image. Morphometric analysis is implemented to interpret the watershed characteristics such as linear aspects of the drainage network, stream order, bifurcation ratio, stream length, stream frequency and drainage density of the basin. The whole process adopted to study the morphometric analysis of the linear aspect of basin is as follows.

- In the first step geo-referencing of the toposheet/map is done to by using Quantum GIS.
- The physical position of the real world features are measured, computed, recorded and analyzed.
- Digitization of stream is done with stream order attributes, length, coding etc. to create different set of layers for river and its tributaries.

- Calculation of Morphometric parameters is done by using accredited formula and tools provided in the following attribute tables

MORPHOMETRIC PARAMETERS TO STUDY LINEAR ASPECTS

PARAMETERS	FORMULA	Refrence
Stream order	Hierarchical rank	Strahler(1964)
Stream Length (Ls)	Length of stream	Horton (1945)
Mean Stream Length	Lsm = Lu/Nu	Horton (1945)
Mean Bifurcation Ratio (Rbm)	Rbm = Average of bifurcation ratio of all orders	Schumm(1956)
Drainage Density (Dd)	Dd = Lu/A	Horton (1945)
Bifurcation ratio (Rb)	Rb=Nu/Nu+1	Schumm(1956)

RESULT AND DISCUSSION

The linear aspects such as stream order, stream length, stream length ratio, mean stream length, bifurcation ratio and drainage density are measured with the help of morphometric parameters. They are described as below.

Stream order

The streams of the Giri 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 Table1. The stream characteristics are in accordance with the Horton's first law (1945) "Law of stream numbers" .The law states that the number of streams of different orders in a given drainage basin tends closely to approximate an inverse geometric ratio. The physiographic and structural conditions of the region is responsible for the variation in order and size of the tributary basins .Stream order is done through GIS and it was found that in the study area the drainage network is of third order.

Stream Order of the Basin

Sr. No	Stream Order	No. Of streams
1	1	49
2	2	16
3	3	6
4	Canals	12
5	Main River Chanel	2
	Total	85

(Table 1).

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 shown in table no. 2. The total stream length of each order (Lu) is computed by adding each stream for a given order. Mean stream length of each order of stream is also computed.

Stream Length of the Basin

Sr. No	Stream Order	No. Of streams	Total Stream Length(In Metres)	Mean Stream Length(in Metres)
1	1	49	33213	678
2	2	16	18199	1137
3	3	6	6602	1100
4	Canals	12	15564	1297
5	Main River Chanel	2	4118	2059
	Total	85	77696	

(Table 2)

Stream Length Ratio (RL)

The stream 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. In the Giri micro basin the stream length is changing haphazardly at the basin levels. The values of the RL vary from 0.97 to 1.68 for the-basins. The variation in the RL at the basin and sub-basin level is caused by the slope of the area and the topographic

conditions. The stream length ratio helps us to understand the relationship between surface flow discharge and erosion stage of the basin.

Mean Stream Length (Lum)

Mean Stream Length is a dimensional property revealing the characterstics size of components of a drainage network and its contributing watershed surfaces (Strahler, 1964).It is obtained by dividing the total length of stream of an order by total number of segments in the order (Table 2).Mean stream length is directly related with the stream order i.e.it increase with the increase in stream order.

Bifurcation Ratio (Rb)

The term 'bifurcation ratio' (Rb) was introduced to express the ratio of the number of streams of any given order to the number in the next higher order(Schumn 1956).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 Rb.In the study area mean Rb varies from 2.67 to 3.06. The mean Rb of the entire basin is 2.86. The value of bifurcation ratio indicates that in the study area the geological structure do not have a dominant effect on drainage pattern.

Drainage density

Drainage density is the other element of drainage analysis which provides a better quantitative expression for analysis of land forms. Drainage density (Dd) is defined as the total stream length of all stream order to the total area of watershed. The drainage density is a quantitative measure that helps us to measure the average length of stream channel area of the watershed. The drainage density of the basin is 0.27 km/sqkm.The value of drainage density indicates that the region is having highly resistant permeable sub soil material with dense vegetation cover.

CONCLUSION

In the present study, morphometric features of drainage are identified and mapped by satellite remote sensing data with the help of QGIS software. QGIS techniques used to study the river basin proves to be competent tools in morphometric analysis and provide very high accuracy of mapping & measurement. The stream frequency and the drainage density are very important factors for the morphometric classification of the basins. All the hydrological parameters like runoff pattern, sediment yield of the drainage basins

are controlled by the drainage density. The value of drainage density indicates that the region is having highly resistant permeable sub soil material with dense vegetation cover. The value of bifurcation ratio indicates that in the study area the geological structure do not have a dominant effect on drainage pattern. As the steam order increases the stream length decreases. The variation in the value of RL at the basin and sub-basin level is caused by the slope of the area and the topographic conditions.

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