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ESTIMATION OF MORPHOMETRIC STUDY ON SHETRUNJI RIVER USING REMOTE SENSING AND GIS

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ABSTRACT

This research is focused on study the morphological characteristics of Shetrunji river which is located in the district of Bhavnagar, Amreli and Junagadh, Gujarat, India. The co-ordinates of the Shetrunji basin is 21°00'N to 21°47'N Latitude and 70°50'E to 72°10'E Longitude. In this watershed, maximum stream length of this river is 122-kilometer, relative perimeter is 9.53-meter, whole catchment area is 4582.83 square kilometer and it is divided into 9 watersheds. Downloaded remotely sensed SRTM (Shuttle Radar Topography Mission) satellite images from earth explorer, USGS to prepared drainage map, slope map, drainage density map, and digital elevation model map using ArcGIS 10.2 software. The Shetrunji is found as a 5th order river and stream frequency is 0.08 per square kilometer. The mean bifurcation ratio is found as 3.32. The drainage density and drainage texture of the basin are found as 4.36 km/square km and 0.77 per meter respectively. The elongation ratio and circulatory ratio of the watersheds varied from 0.626 and 0.249 respectively. Similarly, the form factor and shape factor for the basin are 0.253 and 3.247 respectively. The relief, relative relief, and relief ratios are 558-meter, 1.16 kilometer and 4.57 respectively. Each morphometric characteristic is considered as a single parameter and knowledge-based weight has been assigned by considering its role in soil erosion. The other morphometric properties determined for this basin as a whole and for each watershed will be useful for the efficient planning of water harvesting and groundwater recharge projects on watershed base.

Keywords: *Remote sensing, SRTM, ArcGIS, morphometric properties*.

1. INTRODUCTION

Land and water are the two most valuable and vital resource essentially required not only for sustenance of life but also the economic and social progress of a region. Population pressure is increasing over the years which resulted in the scarcity of availability of land and water resources. Industrial expansion is also a need of the time, which requires infrastructural facilities; which intern forms a feedback resulting in further pressure on finite land and water resources. The watersheds or hydrological units are considered more efficient and appropriate for necessary survey and investigation for the assessment of these resources and subsequent planning and implementation of various development programs like soil and water conservation, command area development, erosion control in Catchment River, dry land rain fed farming, reclamation of lands etc. The hydrologic units are equally important for the development of water resources through major, medium and minor storage projects as well as farm level water harvesting structures. So, the watershed approach is more rational because land and water resources have optimum interaction and effect when developed on the watershed. Climate, geography and physical properties of watershed changes region to region and accordingly basin response to the rainfall event changes. To overcome the water related problems extensive care should be given to the operation and management of reservoirs and watersheds. surface, shape and dimensions of its landforms (Clarke, 1966). The morphometric analysis of a drainage

basin/watershed is of great importance in understanding the hydrologic behavior as well as hydrogeology and groundwater conditions of the area. This analysis can be achieved through measurement of linear, aerial and relief aspects of basin and slope contributions. The description of drainage basins and channel networks, based on the contributions made by Horton (1932, 1945) and supplemented by Langbein (1947), Melton (1958), Miller (1953), Schumn (1956), Smith (1950) and Strahler (1957, 1964) were transformed from a purely qualitative and deductive study to a rigorous quantitative science providing hydrologists with numerical data of practical values. Morphometric analysis using geo-spatial techniques have been done by some researchers in different watersheds which help to understand the nature of the watershed before adopting any management practices. Considering the above facts in view this study is undertaken to derive different drainage characteristics with the specific objectives- to derive geomorphological parameters of shetrunji watersheds using ArcGIS 10.2 Software.

2. STUDY AREA: -

The shetrunji is one of the major rivers of Saurashtra. The shetrunji basin is the eastern most basin of saurashtra and is situated in between 21°00'N to 21°47'N latitude and 70°50 E to 72°10 E longitude. The river shetrunji originates at chchai hills in Gir forest of Junagadh district at RL 380m above mean sea level a flow towards east direction till its confluence with gulk of Khambhat near Santrampur port. The river shetrunji is fertile the area of Amreli and Bhavnagar district and some part of Junagadh district of saurashtra. The shetrunji drains an area of 4582.83km out of which more than 50% in Amreli district. Also, the shetrunji receives several tributes on both banks. There are 9 tributaries having length more than 15 km. The stali, thebi and gagadia are important tributaries feeding from left bank of shetrunji and drain nearly 34% of total catchment area of the river shetrunji.

3. CRITICAL APPRIASAL: -

A. Shetrunji watershed is a large catchment in Bhavnagar district, Gujarat, but all the previous works had been done only few parts of Shetrunji basin (but still now no work has been done in Shetrunji watershed reason)
B. The major limitations of Shetrunji watershed area are soil erosion, irregular rainfall, undulated land and poor water holding capacity which affects adversely the crop production and productivity.
C. In this watershed due to improper water harvesting and poor soil and water conservation structures, there is a significant decrease in the groundwater status.

4. SIGNIFICANCE AND OBJECTIVES FOR THE RESEARCH: -

The objectives of the present study are as follows-

A. To derive geo-morphological parameters of Shetrunji river using ArcGIS.
B. To Estimate necessary driving factors for adopting watershed technology.

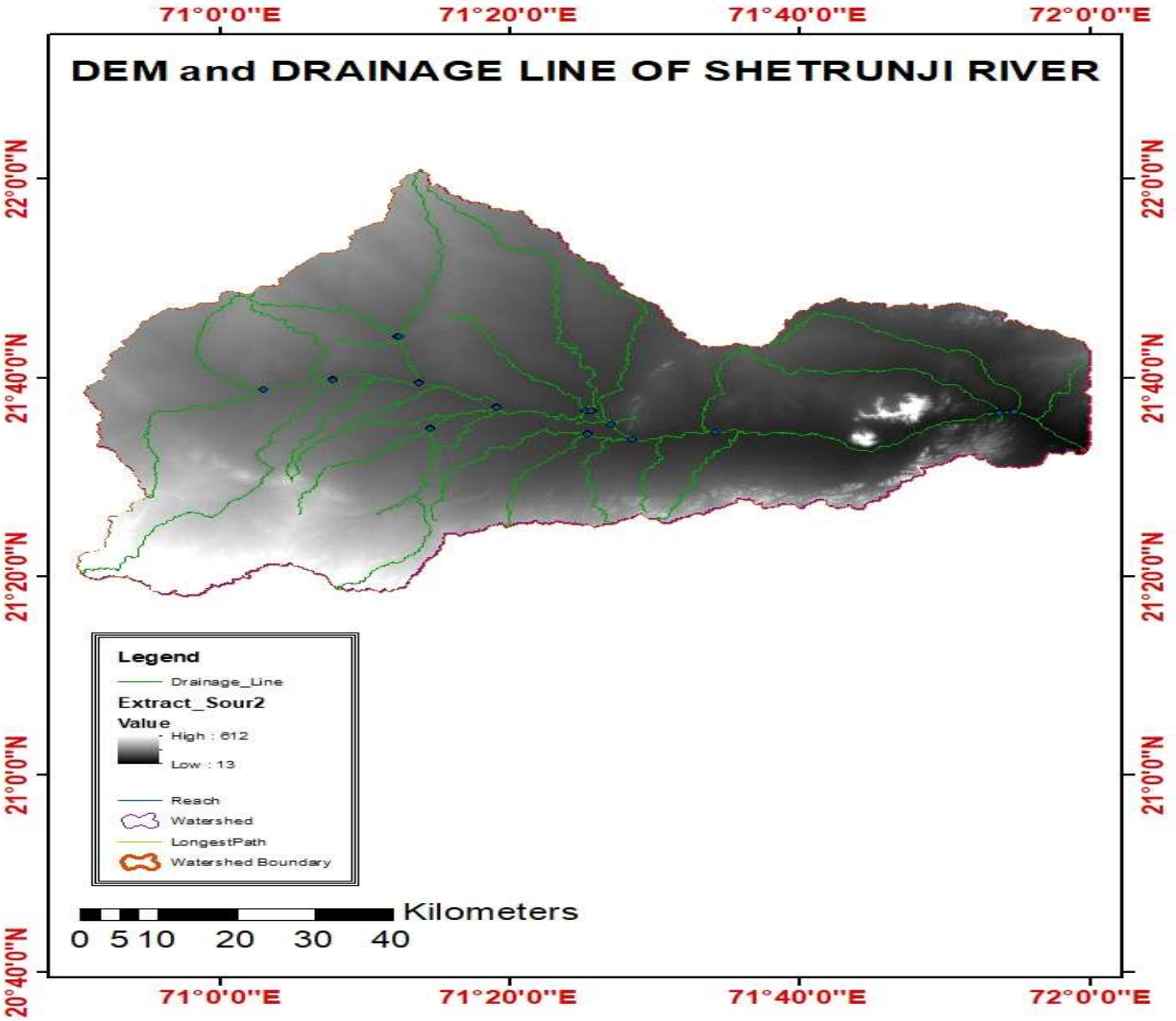

Fig-1: Drainage Line of Shetrunji River (Extracted from arc map 10.2)

5. MATERIAL AND METHOD

The linear aspect of the drainage network morphometry includes stream order, stream length, drainage density, drainage frequency and bifurcation ratio. Various morphometric parameters including. Relative perimeter (Pr), elongation ratio (Re), Circularity Ratio (Rc), drainage texture (Dt), drainage density (Dd), relative ratio (Rr), stream length (Lu), bifurcation ratio (Rb), relief ratio (Rh) etc. are calculated for the Shetrunji River and described in below.

5.1. Stream length (Lu)

Stream length is the length of all the streams having a given stream order. It is indicative of the contributing area of the basin of that given stream order.

5.2. Drainage density (Dd)

Drainage density is defined as the ratio of total length of the streams of all orders of basin to the area of basin. The drainage density, expressed in km/km^2, indicates closeness of spacing of channels, thus providing a quantitative measure of the average length of stream channel for the whole basin. Further, it also gives an idea of the physical properties of the underlying rocks. Low drainage density occurs in regions of highly resistant and permeable sub soil materials with dense vegetation and low relief, whereas high drainage density is prevalent in regions of weak, impermeable sub surface materials which are sparsely vegetated and have high relief (Strahler, 1964)

5.3. Relative perimeter of basin area (Pr)

The perimeter of a drainage basin is defined as the horizontal projection of its water divide It delimit the area of the drainage basin on the Watershed.

5.4. Drainage Texture (Dt)

Drainage texture is the total number of stream segments of all order in a river basin to the perimeter of the basin.

Dt $= Nu/\mathrm{P}$

Where Nu=Total stream number of all order, P = Perimeter of basin area

5.5. Circulatory ratio (Rc)

It is the ratio of area of the basin to the area of circle having the same circumference as the perimeter (*P*) of the basin. It is influenced more by the length, frequency and gradient of streams of various orders than slope condition and drainage pattern of the basin. In the present study, the *Rc* value is found to be 0.294 (which is less than 1) showing the nature of the watershed as elongated.

$$\mathrm{Rc}=4\pi A^2 / \mathrm{P},$$

Where A=Area of basin, π=3.14, P=Perimeter of basin

5.6. Shape Factor Ratio (Rs)

Basin shape factor (Rs) is the ratio of square of basin area to basin length (Lb).

$\mathrm{Rs}=Lb^2/\mathrm{A},$ Where Lb=Basin Length

5.7. Elongation ratio (Re)

The elongation ratio (Re) is the ratio between the diameter of the circle of the same area as the drainage basin and the maximum basin length. A circular basin is more efficient in the discharge of runoff than an elongated basin. $\mathrm{Re}= 2\sqrt{A/\pi}/\mathrm{Lb}$

Where A=Area of basin, π=3.14, Lb=Length of basin

5.8. Relative Ratio (Rr)

The term relative relief means the actual variation of height i.e. different between maximum height and minimum height in per grid. Relative relief is one of the techniques which is effectively capable of presenting the relief characteristics without considering sea level.

5.9. Relief Ratio (Rh)

It is the total relief of watershed divided by the maximum length of the watershed. It is an indicator of the potential energy available to move water and sediment down the slope.

$$Rh=Bh/Lb$$

Where Bh=Basin Relief, Lb=Basin length

5.10. Bifurcation ratio (Rb)

The bifurcation ratio is the ratio of the number of the streams of given order to the number of streams in the next higher order (Horton, 1945). It is a dimensionless property.

$$Rb=Nu/\ Nu+1$$

Where Nu= Number of stream segment present in the given order, Nu+1=Number of segments of the next higher order.

Table.1: Linear morphometric parameter of Shetrunji watershed

Sl.No.	Morphometric parameters	Method/Formula	Reference	Result
1.	Relative Perimeter (Pr)	Pr = A / P	Schumm (1956)	9.53m
2.	Elongation Ratio (Re)	Re = 2 / Lb * (A / π) 0.5		0.626
3.	Stream length (Lu)			122kilometer
4.	Circularity Ratio (Rc)	Rc = 4πA/P^2	Miller (1953)	0.294
5.	Drainage Texture (Dt)	Dt = Nu / P	Horton (1945)	0.77/m
6.	Drainage Density (Dd)	Dd = Lu / A	Horton (1932)	4.36km/km^2
7.	Bifurcation Ratio (Rb)	Nu/Nu+1		3.32
8.	Form factor			0.253
9.	Shape factor	Rs=Lb^2/A		3.247
10.	Relief			558meter
11.	Relative relief			1.16kilometer

6. RESULTS AND DISCUSSIONS

6.1Watershed analysis

The morphometric parameters of Shetrunji watershed have been studied in detail and found that the total drainage area is 4582.83 square km. The drainage pattern is dendritic in nature due to topography of the area. The drainage pattern shows the influence of slope and lithology. Dendritic pattern is most common pattern found in a drainage basin composed of fairly homogeneous rock with no control of the underlying geologic structure. The altitude of the watershed ranges from 361 to 570m above mean sea level. The quantity and quality of ground water is fast deteriorating in this area. The major constraints of the watershed area are soil erosion, erratic rainfall, undulated land and poor water holding capacity which affects adversely the crop production and productivity. Due to improper water harvesting and various soil and water conservation structures, there is a significant decrease in the groundwater status.

7. CONCLUSIONS

The morphometric analysis works as a powerful tool in river basin management and planning, watershed prioritization, soil and water conservation, and management of natural resources at different levels. The morphometric parameters analyzed using remotely sensed SRTM (Shuttle Radar Topography Mission) satellite images from earth explorer, USGS helped to understand various parameter. morphometric analysis carried out in Shetrunji watershed shows that the value of stream length is 122-kilometer, Relative Perimeter is 9.53, drainage texture is 0.77/m, shape factor is 3.247 and bifurcation ratio is 3.32, which is an indication of the negligible influence of geology on the drainage network and this is a 5th order watershed. The value of form factor is 0.253 which shows the watershed to be elongated in nature. The values of circulatory and elongated ratios are found to be 0.249 and0.626, The relief and relative relief is 558-meter and1.16 kilometer respectively showing the nature of the watershed as elongated. The value of drainage density is 4.36 km/km^{2}which show the high drainage density nature of watershed. Drainage network of the basin shows dendritic pattern which indicates the homogeneity in the rock, structure. Slope and topography play the important role for the variation in stream length ratio. This study will help the decision makers to devise better water use mechanism for watershed management.

8. FUTURE SCOPES

A. To estimate the monthly stream flow by SCS-CN method in Shetrunji watershed using Remote sensing and GIS approach.
B. Effects of LULC changes on surface runoff in Shetrunji watershed.

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