International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-8 Issue-12, October 2019

Morphometric Analysis and Prioritization of Microwatershed of Bisalpur Reservoir using Geospatial Techniques

G.Sangeetha, A.Srinadh, B.Chethan, K.Vishal, Y.Nithin

***Abstract:** Limited natural resources and their wide utilization with increasing population is a major concern. Conservation of natural resources is of prime importance for sustainable development and to mitigate the demand and supply gap between resources. Rivers are major source of water, Morphometric analysis of watershed covers the drainage networks and parameters such as drainage area, gradient and relief. Morphometric analysis is significant for prediction of floods, soil erosion and sediment yields. Present study covers linear aspects of Morphometric analysis in Bisalpur Reservoir by using Geospatial techniques. Watershed delineation, flow accumulation, flow direction, Flow length followed by Stream ordering have been accomplished by using Hydrology tool in ArcGIS 10.2.2 Software. Advanced space-borne Thermal Emission and Reflection Radiometer (ASTER) and Shuttle Radar Topographic Mission (SRTM) Digital Elevation model (DEM) have been used for preparation of linear aspects of Morphometric parameters. Drainage characteristic have been calculated such as stream length, mean stream length and Bifurcation Ratio for basin evolution studies, such studies are extremely useful for planning rainwater harvesting and Watershed Management.*

***Keywords:** SRTM, ASTER data, Morphometric Analysis, Flow, linear aspects, GIS, ERDAS IMAGINE.*

I. INTRODUCTION

Watershed denotes any area or land that drains some streams and rainfall towards a common outlet that may be a reservoir, bay mouth, or even to a point over a stream channel. It is also termed otherwise as a drainage basin or catchment area. Watershed is main source for water with reference to received precipitation. In this work a watershed is analyzed to arrive its characters related to water storage.

Revised Manuscript Received on October 30, 2019.
* Correspondence Author
G.Sangeetha*, Assistant Professor, Department of Civil Engineering, S R Engineering College, Warangal, India.
A.Srinadh, UG Student, Department of Civil Engineering, S R Engineering College, Warangal, India.
B.Chethan, UG Student, Department of Civil Engineering, S R Engineering College, Warangal, India.
K.Vishal ,UG Student, Department of Civil Engineering, S R Engineering College, Warangal, India.
Y.Nithin,UG Student, Department of Civil Engineering, SR Engineering College, Warangal, India.

A drainage basin is an area that collects precipitated water and delivers into a large streams and lakes. Drainage basins are also called as catchment area of a river it is a bowl which catches the rain. We are dealing with the water within watershed the main source of water concern with respect precipitation **[1].** Morphometry is a mathematical analysis of earth surface consists of shape, size, dimension, landform. Drainage basin analysis by Morphometric parameters that are classified into Linear aspects (one dimensional), Aerial aspects (two dimensional), Relief aspects (three dimensional). Drainage basin is important to find the characteristics like soil conditions, surface water potential, topography, slope and runoff characteristics. The morphometric parameters are divided into three types and they are basic parameters, derived parameters, shape parameters. Morphometric is the science that deals with quantitative measurement like shape, geometry of any natural landforms. It denotes the measurement of 3dimensional geometrical properties of land surface. Catchment area or drainage basin is an area drained by river system which includes all areas of land that collect precipitation of water and drain off into stream, lake, body of water. Watershed Management is a method to protect and improve the quality of water and also control erosion in the catchment area in a broad manner. Watersheds are classify into Mini watershed (1 to 100 ha), micro watershed (100 to 1000 ha), Milli watershed (1000 to 10000 ha), Sub watershed (10000 to 50000 ha) and Macro watershed (> 50000 ha)**[2].**Watershed Prioritization is the scientific process of watershed delineation and monitoring **[3].** Morphometric analysis is an satisfactory method for analysis for river basin also because it gives relationship between various aspects like stream order, stream length within drainage basin. A comparative elevation observed in different drainage basins develops in geomorphology and topographical situations the quantitative analysis of drainage system is in a important aspect characterization of watershed**[4].** Prioritizing the watersheds of appropriate scale has been mostly based on the morphometric characteristics and quantitative measurements. Attention has also been focused on the natural resources (such as soil and water) based conservation of watersheds**[5]**.Watershed prioritization is the ranking of different sub-watersheds of watershed according to the order it is used treatment through water and soil conservation measures and water prioritization based on morphomeric analysis universal soil equation, land cover geomorphology and sediment yield index through remote sensing techniques ,GIS techniques **[6].**The concept of prioritization plays an important role between soil and water to development of watershed and planning a watershed a watershed is an ideal unit for management like natural resources like land and water for mitigation of impact of natural disaster for achieving sustainable development **[7]** A watershed is normally a collector zone for the precipitation occurring in that area or within the stream flow region. It is proved by several researcher's that not all precipitation flows into a particular watershed, some amount of water is also lost owing to several phenomena such as evaporation, runoff, transpiration etc. If we take a swimming pool, watershed is its sides where water can flow in.watershed is a naturally available hydrological unit, Its development is not confined to irrigation ands but covers full catchment area, its sub parts are basic units that are required for management of land and water supply. It is proved that focus on implementing agricultural water management programs over appropriate spatial levers or extends may have good positive effects on water availability and soil erosion control. Also growth of population and increasing resource demand requires effective utilization of reducing natural resources such as agricultural water resource and its demand is on rise to support ever increasing agricultural and industrial water demand. Normally watershed management is an integrated multi-teamed, multi-disciplinary approach focusing on arriving a solution to suggest possible measures to avoid over exploitation of resources and to keep them within tolerance level. Some of the attributes used in RS based watershed analysis size, shape, drainage, geology, land use soil, Physiography, slope, groundwater with various attribute parameters.

Remote sensing is the gathering information of an object without any physical contact with an object. GIS is designed to analyze, capture, store, manage, manipulate and present all types of spatial data in the geographical formats in the computer itself. It as a tool for analyzing the spatially distributed information's Arc GIS and ERADAS IMAGINE powerful software's. The inherent coincidence of data sets of various river basin characteristics, since they are depend on the same satellite images, has provided the most economical inventories. Dynamic phenomena, such as changes of land use, can be better captured using multi temporal satellite data to arrive at the most accurate estimates. The GIS has proven to be a useful tool in the creation of spatial databases, to make the data compatible from one format to another and the recovery of data according to the requirements. Since the input data is geographic in nature, GIS proved to be a potential tool when conducting spatial analyzes based on criteria for the optimal management of natural resources. It is found that natural phenomena such as the hydrological response of the selected area of the river basin to precipitation and its propensity to water erosion can be better simulated through the GIS. From downloading the required satellite images for website USGS with 30M resolutions and that image should be analysis Arc GIS software the spatial analytic tools that are to hydrology and consider watershed parameters like fill, flow direction, flow accumulation, Basin In the present paper an challenge has been made to describe various physical features of drainage basin and accepting the relationship between them and ASTER and SRTM. Digital Elevation Model (DEM) have been used for preparation of Linear, Areal and Relief Morphometric parameters helpful to know about lithology and geologic structures in development of drainage pattern . Watershed prioritization has also been performed for a no of watersheds using parameters such as linear and shape components of the basin and slope contribution, modeling of herbal phenomena such as hydrologic response of watershed to precipitation and phenomenon to erosion hazard due to runoff can be best simulated by using GIS. Effective use of area based totally RS facts suitably built-in with collateral, hydrological and meteorological statistics using GIS options with cloud services can help to evolve alternate prescriptions to obtain sustainable improvement of natural resources.

1.1 Study Area:

Bisalpur Reservoir is located in between the longitudes and latitudes of 75°45′56″E and 25°55′28″N respectively and which is situated on the river Banas in Tonk district of Rajasthan state where the place is mostly having experienced with an average rainfall of 578 mm in the last 30 years and with a maximum temperature of 43°C. The main purpose of this reservoir is to supply potable water to nearby cities and irrigation facilities to the agricultural lands which are facing the downstream side of the site.

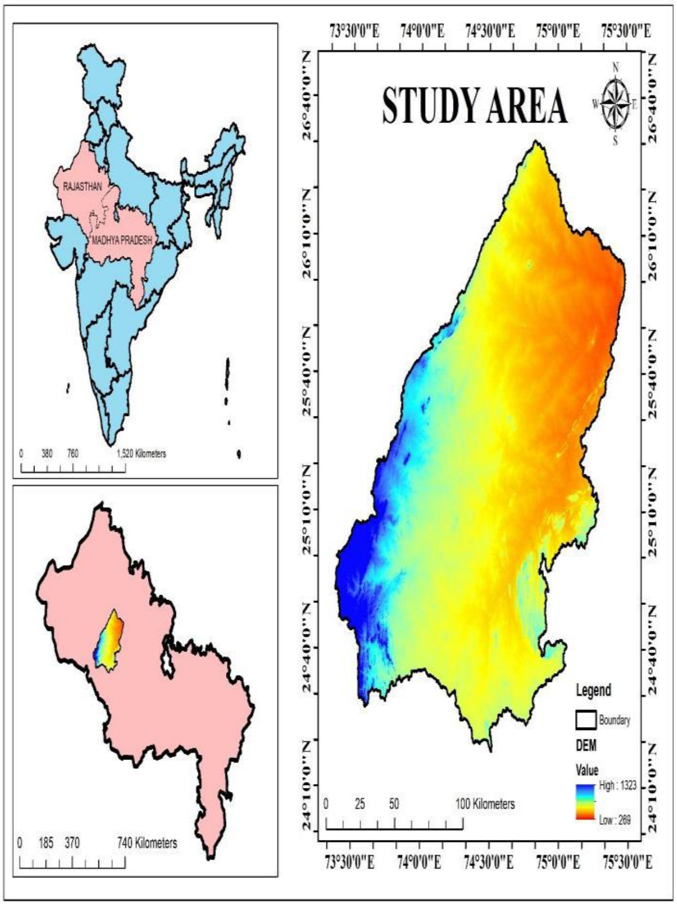

Fig.1. Study Area Map of Bisalpur Reservoir (DEM Analysis)

II. MATERIALS AND METHODOLOGY

2.1 Data processing and collection

In this research we had utilized the satellite dataset was SRTM DEM (30m & 90m) and ASTER DEM (30m). Details of the datasets are given in the following table which depicts the detailed study of the datasets. Data sets used in this research are SRTM and ASTER DEM data which are having the resolutions of 30m and 90 m respectively with different bands of high resolution, where the high resolution images like ASTER DEM is used to create detailed maps of surface temperature, elevation, reflection and emissivity of the land deformations. These data sets are georeferenced into the datum of WGS84 and then it is referenced into the datum of EGM96 geoid.

Table-I: Satellite dataset used for this study was SRTM DEM (30m & 90m) and ASTER DEM (30m).

Satellite	Sensor	Spatial Resolution	Spectral Brands
DEM	SRTM	30 m and 90 m	1
DEM	ASTER	30 m	1

2.1.1 Methodology

The Prime aim of this research is to perform Morphometric analysis of Bisalpur reservoir of Rajasthan state which is done as per the methodology mentioned in Figure 2.
In the preliminary work of the research is collecting the datasets of SRTM DEM 30meters & 90meters and ASTER DEM 30meters which are used to derive various linear aspect parameters of watershed. In order to create a drainage network of the basin and giving the stream orders for drainage network is the predominant step process for the process of creating a depression less DEM in delineation of the morphometric parameters. In this the first step is to find the hydrologic model and to fill in the empty cells in the elevation grid.
We had used two data sets in this work SRTM and ASTER DEM which is having resolution of 30 m and 90 m respectively. The methodology adopted is given in fig 2
The process involved processing of DEM data by fill, flow direction marking, flow accumulation marking and arriving stream order and stream length. Finally, identification of the catchment area will be done by using stream to feature tool in Arc GIS software. By using linear morphometric analysis watershed and sub watershed are categorised used upon stream length and catchment area.

2.2 Dem Acquestion:

The Digital elevation model is the first input given for morphometric analysis. Digital Elevation Models are a type of raster Geographical information system layer. In a Digital elevation model, each cell of raster GIS layer has a value according to its elevation (z-values are spaced at regular intervals).

2.3 Fill:

Fill is the shifting of improper data in raster surface, values of higher elevation of the cell which is neighbored by depression. An elevation raster is a depression of a cell surrounded by high value of elevations, which symbolize the area of drainage interval

2.4 Sink:

Sink is an operation where every cell and edges of the grid of the drainage network is filled by the tool sink, it is cell which is surrounded by the higher elevation cell around it which operates the particular cell where the water gets trapped and cannot flow in the order. It may also lead to an endless processing loop, if the cell fails to drain off in the edge of the grid it results in drain into each other **[8].**

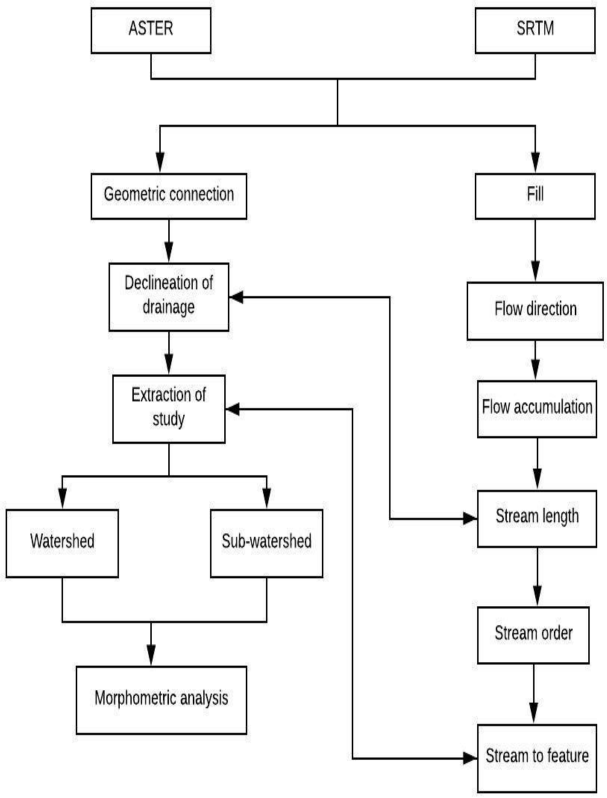

Fig.2. Flow chart of methodology adopted for morphometric analysis

2.5 Flow Direction:

A flow direction shows the direction of the water which will flow out of each cell. In which the prediction starts from the flow of water where if it flows in the direction of east it is given a value of 1 and if it is flowing in the direction of west it is given with a value of 16 and the remaining all the adjacent directions are described with the model of eight-direction pour point model where Surface input is taken and output raster is shown as flow direction resulting in the values ranging from 1, 2, 4, 8, 16, 32, 64 and 128.

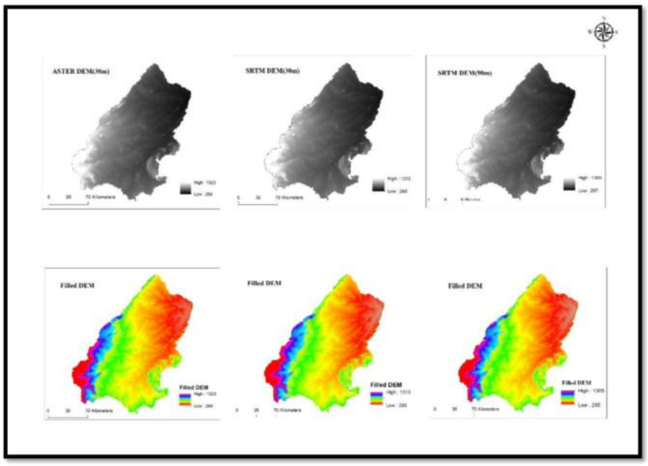

Fig.3. Automatic extraction of Streams through ASTER (30), SRTM (30) & (90) data

2.6 Flow Accumulation:

A flow accumulation which transfers the raster data to each cell. The number of cells that will flow through it. The transfer of flow accumulation is based on direction of flow of water in the raster. Cells which are having accumulation values correspond to stream channels. If cells are having flow accumulation the value of zero corresponds to ridgeline. Flow accumulation is multiplied by the cell size, so the flow accumulation value equals to drainage area.

The flow accumulation which is used to generate drainage network based upon the flow direction which is extracted by considering the pixels greater than a threshold of 100 by trial and error approach within each cell of the basin. **[9].** Flow accumulation is normally used for generation of drainage network which is based upon the direction of flow. This is extracted further by considering the number of pixels which are more than the threshold value of 100 by using trial and error approach. It is the horizontal projection of its water divide which delimits area of drainage basin. Always it is smaller than true length of water divide and used for topographical aspects.

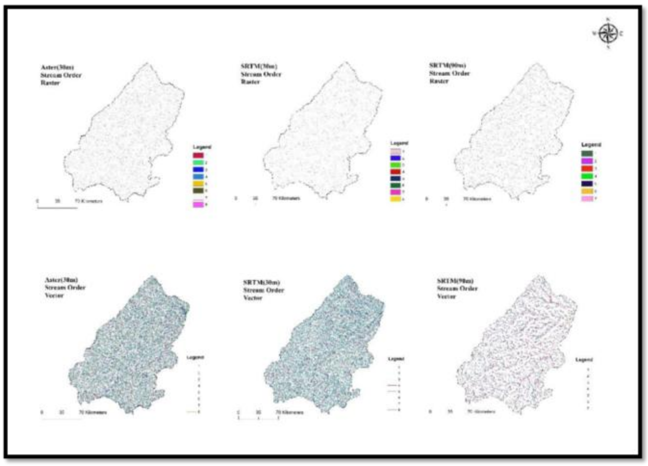

Fig. 4. Automatic extraction of Streams through ASTER (30), SRTM (30) & (90) data

2.7 Basin:

Basin is widely recognized in the scientific study of the hydrological process as the natural unit of water management. Basin is defined through the process of water draining at a proportion of land which geographically appears to be the cross section of the stream network.

2.8 Basin Perimeter:

Basin perimeter is defined as the length of the watershed, which is divided into surrounding basin, it is measured along the rigid lines which separate the watersheds from each other **[10].**

2.9 Basin Length:

Basin length is defined as the length of the stream from starting point of the basin to the optimum point on the drainage area, where it is calculated by the straight line. It is calculated using the formula mentioned below. Where area is given in m^2 [**11].**

Basin length = 1.312 X $Area^{0.568}$

2.10 Stream Length:

The total length of the stream is Sum of the lengths of each stream order.

Lu = L1+L2 ……Ln (1)

Where, Lu is stream length,

L1 is length of the first order stream,

L2 is length of the second order stream and Ln is n number of the stream length.

Stream length is evaluated by diving the total length of all streams in a particular order to the number of streams in the same order, where it is measured by considering the average length of the stream in each order. Stream length and stream order are directly proportional to each other which indicates that the increase in the stream length results in the increase of stream order.

2.11 Stream Order and Stream Number

In the drainage map of the basin, the network is divided into channel segments and has been assigned a sequence of numbers to the orders according to the hierarchy of orders of magnitude. According to Strahlers **[12]** system of the ordering, each fingertip channel is assigned as a segment of the first order and the number increases by one when two different order streams meet together, the order remains as that of the higher order stream.

By the use of Arc GIS 10.2.2 software the tools are helpful for the morphometric analysis in order to give the count of total number of segments of each number, where the operation is not useful for the count of all the segments, the joining the segments manually and will be counted individually to obtain relevant stream number which is the total number of streams that are accumulated together with particular order. Hence stream number will be a positive whole number denoted and used in hydrology for indicating the level at which a river system branches is the total number of streams which are accumulated together with a particular order

III. RESULTS AND DISCUSSION

Morphometry is termed as a measurement analysis by using the land the lands surface, dimensions and shape and landform where the drainage basin and channel network are serves the basins geo hydrological behavior. It shows the available geo hydrological and climate, geomorphology, climate condition and structural antecedents of catchment area the parameters used are listed in table 2

Morphometry is defined as the measurement analysis by using the configuration of earth's surface, shape and dimensions of the landforms where the morphometric analysis of the drainage basin and the channel network area acts as the geo-hydrological behavior of the basin which also expresses the prevailing climate, geology, geomorphology and structural antecedents of the catchment area. The relationship between the parameters is tabulated in table 2**[13]**

Most of Sub watersheds are ranked on the basis of watershed prioritization order is taken according to their treatment and soil conservation measures. Morphometric analysis could be used for prioritization of sub watersheds by studying different parameters like linear, aerial and relief aspects of the basin and slope contribution. This analysis can be achieved through measurement of linear and areal parameters of the watershed even without the availability of soil maps.

3.1 Linear morphometric parameters

Linear aspects of morphometric analysis include stream order, stream number, stream length which are very close to the channel outlines of the drainage network which considers only the topological characteristics of the stream segments where the terms of open links of the drainage networks are analysed.

3.1.1Stream order

Stream order terms to be the first and prior step in the drainage basin analysis, as per the standard scheme of orders the study area is depicted with the 8^{th} order drainage basin with respect to the data used of ASTER DEM (30m) & SRTM DEM (30m), whereas it is observed to be the 7^{th} order by the data SRTM DEM (90m). The orders of 7^{th} and 8^{th} are usually termed as the higher stream order because it is associated with the greater discharge in the bisalpur reservoir. [**14**]

3.1.2 Stream number

Stream number depends upon the terms like permeability and infiltration, which in results indicates that the higher stream order will have lesser permeability and lesser infiltration rate. Whereas stream frequency and stream order are noted as inversely proportional to each other which clearly indicates that where the stream order increases automatically it results in the decrease of stream frequency. Because of the dissimilarities in the structures of the rock, these variations are responsible for the variations and changes in stream frequency of each order where the streams regularly decrease in the geometric progression with an increase in the stream order, gradually which shows a negative correlation between the stream orders and the stream numbers.

3.1.3 Stream length

In the study area it is observed clearly from table 2 i.e. the total stream length is decreasing gradually as per the increase in stream order in the drainage basin, where it is observed in the case of 5^{th} order the length of stream is recorded more and the length is decreased automatically with the increase in stream order.

From the table.2, it is observed that the stream length for SRTM and ASTER DEM (30m) recorded a high stream length when compared to the SRTM (90 m). This discrepancy is because of change in resolution and the differences in the relief and tectonic forces.

3.1.4 Mean Stream Length (Lsm)

Mean stream length is related with the watershed in terms of surface flow, discharge and erosion. Because of the change in slope and topographic changes the values of mainstream length vary randomly, where it results in the change of main stream length from one order to another order.

Lsm=Lu/Nu.

3.1.5 Stream length Ratio:

Stream length ratio is defined as length of successive segments of the streams and it is the ratio of mean length of the order of the stream, stream length ratio is to estimate geometric sequence of stream length and average length of segments

RL=Lsmu/(Lsmu-1)

3.1.6 Bifurcation Ratio:

Bifurcation ratio is narrowly linked to the branching pattern of a drainage network. The bifurcation ratio values for the Watershed vary because of likelihood of variations in watershed geometry and lithology.

The highest bifurcation ratio (5.34) is found between3rd and 4th order that shows maximum overland flow and discharge because of hilly less permeable rock formation related with high slope configuration. The comparatively high bifurcation ratio shows early hydrograph peak with a possible flash flooding throughout the storm in the areas where these stream orders rule.

Rb=Nu/ (Nu+1)

IV. CONCLUSION

Rapid Urbanization create a complex Eco system and puts thrust on policy makers concerned with resource allocation for the Cities, Recent research works have provided many decision-making tools for the policy makers through which proper decisions for managing the urban cities can be taken. So Prioritization of watershed analysis is the necessity analysis for determining the watersheds and the sub watersheds.

Prioritization of watershed analysis is the based on the quantitative analysis which is required for the sustainable development. The quantitative analysis of the morph metric parameters is to utilize in the river basin evolution, watershed prioritization for the soil and also water conservation at micro watershed levels. Geology, relief and climate are the key determinants of running water through ecosystems and also about functioning at the basin scale. Morphometric descriptors represent the relatively simple approaches to describe the drainage basin processes and used to compare basin characteristics and enable an enhanced understanding the geological and geomorphic history of the drainage basin. Using Remote Sensing and GIS the information analysis is upgraded, morphometric analysis is analyzed by remote sensing because digital elevation models are generated according to the streams. The representation of remote sensing data in coexistence with enough real ground information which makes it to get possible and also to identify outline of various ground features such as geological structures, geomorphic features and their hydraulic characters. Watershed prioritization has also been conducted for various sub watersheds using parameters such as linear and shape aspects of the basin and slope contribution.

Table- II: Linear aspects of bisalpur reservoir

Area	Source	Stream Order(u)	Total No. of Streams per order Σ(Nu)	Total Nos. of Streams Σ(Nu)	Stream Length in Km (Lu)	Total Stream Length in Km Σ(Lu)	Mean Stream Length	Stream Length Ratio	Bifurcation Ratio (Rb)	Mean Bifurcation Ratio (Rbm)
BISALPUR RESERVOIR	ASTER DEM(30)	1	14233.00	18336.00	17793.41	35017.00	1.25		4.48	4.00
		2	3180.00		8785.49		2.76	0.45	4.50	
		3	706.00		4368.86		6.19	0.45	4.13	
		4	171.00		2126.90		12.44	0.50	5.34	
		5	32.00		997.65		31.18	0.40	3.20	
		6	10.00		618.23		61.82	0.50	3.33	
		7	3.00		322.92		107.64	0.57	3.00	
		8	1.00		3.98		3.98	27.06		
	SRTM DEM(30)	1	14319.00	18459.00	17795.46	34417.82	1.24		4.48	3.98
		2	3196.00		8458.11		2.65	0.47	4.32	
		3	739.00		4214.95		5.70	0.46	4.71	
		4	157.00		2075.22		13.22	0.43	4.49	
		5	35.00		957.70		27.36	0.48	3.89	
		6	9.00		588.87		65.43	0.42	3.00	
		7	3.00		223.11		74.37	0.88	3.00	
		8	1.00		104.40		104.40	0.71		
	SRTM DEM(90)	1	1550.00	1993.00	5686.17	11215.75	3.67		4.55	3.57
		2	341.00		2822.95		8.28	0.44	4.43	
		3	77.00		1429.85		18.57	0.45	4.53	
		4	17.00		667.43		39.26	0.47	3.40	
		5	5.00		478.60		95.72	0.41	2.50	
		6	2.00		114.04		57.02	1.68	2.00	
		7	1.00		16.71		16.71	3.41		

REFERENCES

1. .shok S. Sangle, Pravin L. Yannawar, 2014, Morphometric Analysis of Watershed using GIS and RS: A Review, International journal of engineering research and technology (IJERT) Volume 03, ISSN: 2278-0181.
2. Sahil Sanjeev Salvi, S. Mukhopadhyay, Dr. S. D. Ranade, Anuja Rajagopalan.,2017 Morphometric Analysis of River Drainage Basin / Watershed using GIS and RS: A Review. International Journal for Research in Applied Science & Engineering Technology (IJRASET),ISSN: 2321-9653
3. Bera, K. and Bandyopadhyay, J., 2013. Prioritization of Watershed using Morphometric Analysis through Geoinformatics technology: A case study of Dungra sub-watershed, West Bengal, India. *International Journal of Advances in Remote Sensing and GIS*, *1*(3), pp.1-8.
4. Rahaman, S.A., Ajeez, S.A., Aruchamy, S. and Jegankumar, R., 2015. Prioritization of sub watershed based on morphometric characteristics using fuzzy analytical hierarchy process and geographical information system–A study of Kallar Watershed, Tamil Nadu. *Aquatic Procedia*,*4*, pp.1322-1330
5. Gumma, M., Birhanu, B., Mohammed, I., Tabo, R. and Whitbread, A., 2016. Prioritization of watersheds across Mali using remote sensing data and GIS techniques for agricultural development planning. *Water*, *8*(6), p.260.
6. Biswas, S., Sudhakar, S. and Desai, V.R., 1999. Prioritization of subwatersheds based on morphometric analysis of drainage basin: A remote sensing and GIS approach. *Journal of the Indian society of remote sensing*, *27*(3), p.155.
7. Ratnam, K.N., Srivastava, Y.K., Rao, V.V., Amminedu, E. and Murthy, K.S.R., 2005. Check dam positioning by prioritization of micro-watersheds using SYI model and morphometric analysis—remote sensing and GIS perspective. *Journal of the Indian society of remote sensing*, *33*(1), p.25
8. Maidment, D.R. and Morehouse, S., 2002. *Arc Hydro: GIS for water resources*. ESRI, Inc...
9. Macka Z (2001) Determination of texture of topography from large scale Contour maps. *GeografskiVestnik*73 (2):53-62

10. Schumm, S.A., 1956. Evolution of drainage systems and slopes in badlands at Perth Amboy, New Jersey. *Geological society of America bulletin*, *67*(5), pp.597-646.
11. Schumm SA (1956) Evolution of drainage systems and slopes in badlands at Perth Amboy, New Jersey.*Geol Soc Am Bull* 67:597–646
12. Strahler, A.N., 1964. Part II. Quantitative geomorpholog of drainage basins and channel networks. *Handbook of Applied Hydrology: McGraw-Hill, New York*, pp.4-39.
13. Horton RE (1945) Erosional development of streams and their drainage basins. Hydro physical approach to quantitative morphology. *Geol Soc Am Bull*56 (3):275-370
14. Strahler A.N., (1964) Quantitative geomorphology of drainage basin and channel networks. *In: Chow VT (ed) Handbook of Applied Hydrology*.McGrawHill Book Co., New York, pp. 4–76

AUTHORS PROFILE

G.Sangeetha, M.Tech Remote Sensing and GIS, working as Assistant Professor in S R Engineering college.

A.Srinadh, UG student, Department of Civil Engineering, SR Engineering College, Warangal, India.

B.Chethan, UG Student**,** Department of Civil Engineering, SR Engineering College, Warangal, India.

K.Vishal , UG Student, Department of Civil Engineering, S R Engineering College,India.

Y.Nithin, UG Student, Department of Civil Engineering,SR Engineering College, Warangal, India.