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Analysing Geological Characteristics using GeospatialTechnique:AcasestudyofVishwamitri Watershed, Gujarat

Dr. paulomi.b.vyas
Professor civil engineering
spce Bakrol anand gujarat bakrol anand

ABSTRACT

Increasing population, faulty irrigation practices, urbanization, and industrialization have pressurized water demand, especially, in developing countries. The problem gets aggravated by erratic patterns of rainfall which leads to dropping levels of the groundwater table. A watershed, therefore, actsas water supplyfor irrigationand water management. The management ofsuchareas becomes mand ore important for developing the groundwater reserve. Hence, watershed management is taken into account considering an important part of sustainable development.

1. Introduction

In current situation when there is high demand and limited accessibility, it becomes more imperative to manage water resources. Also, changes in land uses have effect on rivers and its processes.(Bhatt.B, Joshi.J 2018).Quantitative Morphometric analysis of a watershed describeswatershed geometry andalso plays important role in evaluationof groundwaterpotential,management,riverbasin and environment.The analysis is based on systematic study of R. E. Horton in 1930s, followed by Miller (1953), Schuman (1956), Strahler (1964) and Clarke (1966).

Drainagebasinmorphometry makesanattempt toelucidate andpredictthe semipermanentaspectsofbasindynamics leading tomorphological changesamongthe basin (Thompson et al. 2001).It is additionallyused in varied fields ofnatural science associated engineeringapplicationsasanindirecttoolforestimationofsoil,landslideconditionmapping,predictingthemovementofgroundwater and analyzing topography (Pike 2000).

Basinmorphometryexplainsand calculatesthelong-termcharacteristic ofbasindynamics (Thompsonet al. 2001).Itisadditionallyalso used in various fields of earth science and engineering applications as an indirect tool for estimation of soil, landslide vulnerability mapping, calculate the movement of groundwater and analyzing topography (Pike 2000).

Atpresentgeo-spatialtechnologiesarepreferredoverconventional manualbasindelineationas lesstimeconsumingand moreaccurate. Hence, muchofthe traditional topographic map informationcannowbe collected and processed digitallybyusingGIS-based data.The technique has been increasingly used to delineate river basins and to automatically extract morphometric parameters employed in hydrologic model(Rao etal, 2010).Thesetoolshave beenefficiently used for water resources assessment vulnerabilityto pollution and mapping of ground water quality (Bhatt.B, Joshi.J,2019). Geospatial technique have been integrated extensively byresearchers for different drainage basin analysis viz., Nag(1998) Chopra et. al. (2005), Nookaratram et. al. (2005), Thakkar, et al(2007)Sreedevi et. al. (2009) ,. Magesh et al (2013), Gajbhiye, S. (2015), Dayal et al(2015) Dahiphale et.al (2016) Rai, et. al (2018),Sahoo et.al(2019)

Thepresentstudyintendsto quantifyarangeof morphometricfactor viz.,linear, areaandreliefofVishwamitri watershed withthehelp of Geospatial techniques.

2. Studyarea

Vishwamitri watershed located in the Gujarat is a tributary of the Dhadhar River. It originates from Pavagadh hill at about at elevation of more than 600 meters and extends between 73° 7‟ E to 73° 33‟ E longitudesand 23° 2‟ N to23° 33‟ N latitudes.The study is carried out for area between Pavagadh (origin and upper catchment) to Jambuva (where it leaves Vadodara city) covering length of 91km and area of about 601 sq.km.

3. Methodology

ThedrainagenetworkhasbeenextractedusingSRTMwith90m resolutionandtopographicalmaps(SOIsheets)(1:50,000).Watershed is demarcated using Arc GIS. Geometric characteristics of drainage basin viz., area and perimeter, length and number ofstreams are derived using GIS. Other parameters are derived based on the methods suggested by Horton, 1945, Strahler, 1964, Hardly 1961, Schumn 1956, Nookaratanm et. al. 2005 and Miller 1953. Spatial analyst tool is used to analyze drainage density and frequencydistribution of the watershed

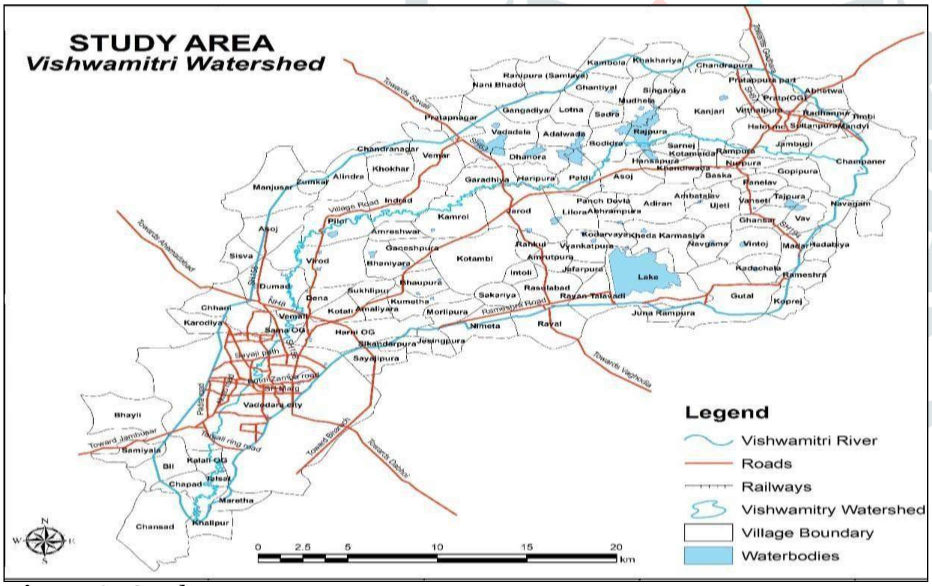


Figure1: Study area

1. Resultsanddiscussion

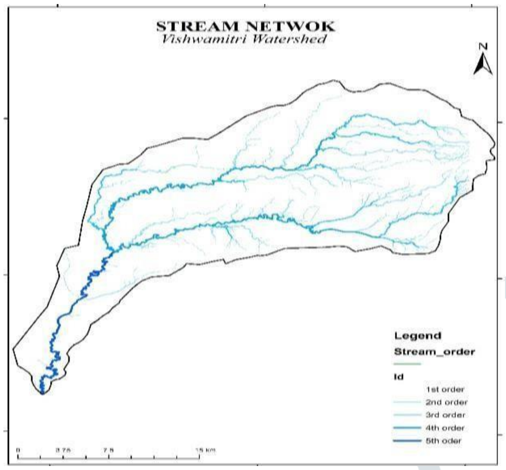
EstimationoflinearAspects

Stream Order	**Number ofstrea m**	**Total numbe r of Stream**	**Lengt h of the Stream**	**Total Length**	**Mean Stream Length**	**Strea m Lengt h Ratio**	**Bifurcation ratio**	**Mean Bifurcation Ratio(Rbm)**	**BasinLength (Lb)**
1	175	238	222.553	558.13	1.27	-	3.72	3.17	49.70
2	47		119.858		2.55	2.01	3.62		
3	13		77.7815		5.98	2.35	6.50		
4	2		81.5898		40.79	6.82	2.00		
5	1		56.35		56.35	1.38	-		

Table1linear Aspects

1 **Stream order (Su).** The study of drainage basin starts the stream ordering. In the present study, streams are rankedaccording toStrahler‟s stream ordering method.It has observed that the first order streams are maximum and as the stream order is increasingthere here is a decrease.(Table 1). The lower orderstreams are dominant in the study area.

Figure2: Streamarrangement andStreamOrderinWatershed



2 **Stream Length(Lu):**Totallengthofthestreamsis558.13km.includes83.160Km in1order,222Km in2ndorder,119.858Kmin3rd order, 77.7815 in 4th order and 81.5898 Km in 5th order respectively shown in Table1.

3. **MeanStream Length(Lsm):**Themeanstream lengthofstream increaseswithincreasingorder.It wasobservedthat Lsmwasless for1st order stream andgraduallyincreasedforthe5th orderstream.This may beduetodifferencein slopeandtopography

4. **BifurcationRatio(Rb):**

Itistheratioofthenumberofthestreamsegmentsofgivenorder‟Nu‟tothenumberofstreamsinthenexthigherorder(Nu+1).Itis calculated asRb = Nu/Nu+1(Nu: total number of stream segment of order „u‟,Nu+1:number of segment of next higher order. The bifurcation ratio for **Vishwamitri**basin ranges from 2 to 6.5 and mean bifurcation is 3.17, suggesting a very lower degree of drainage integration. Lower value of bifurcation ratio indicates plain land, permeable and soft bed rock which can act as ground water potential zone. Mean Bifurcation Ratio is arithmetic mean of bifurcation ratios of all orders. In the present study the mean bifurcation ratio of 3.17 reveals that the water shed falls within normal basin category as suggested by Strahler.

5 Basin Length (Lb): The basin length is the longest part of the basin parallel to the principal drainage line defined bySchumm(1956). The equation Schumm (1956) used for calculationLb=1.312 X A0.568(A: area of the basin) Streamlengththatis49.70km.(Table1)

2. EstimationofAreal Aspects: Theparameterscalculatedunderthisare ofstreamfrequency, drainagedensity,drainagetexture,form factor, circularity ratio, elongation ratio and length of overland flow.

Table2:ArealCharacteristicsoftheWatershed

Area of Watershed sq.km	Perimeterkm	Stream Frequency	Drainage Density	Length of overlandflow	Elongation Ratio	Circularity Ratio	Compactness Constant
601.11	128.19	0.40	0.93	0.54	0.56	0.46	1.47

StreamFrequency (Fs): Itisthetotalnumberofstreamsegmentsofallordersperunitarea. AccordingtoHortonFs=N/A. (Horton, 1945). Stream frequency of watershed is 0.40.

2 **Drainage density (Dd):** Drainage density (Dd) is an important indicator of the linear scale of land form elements in stream eroded topography. It is the ratio of total channel segment length cumulated for all order within a basin to the basin area, which is expressed in terms of Km/Km2. It is calculated as Dd=L/A, where L isthe total length (km) of all stream segments, A is basin area (km2).This value for watershed was found to be 0.9 km/sq.km. In the study drainage density observed very low with highly permeable sub soil materials, under dense vegetation cover and where relief is low.

3 **Lengthofoverlandflow(Lof**) : Itisthelengthof water over theground beforeitgets concentrated intodefi

4. **Elongation Ratio (Re):**It is defined as the ratio of diameter of a circle having the same area as of the basin and maximumbasin length (Schumm 1956).

Re=2√(A/π)/Lb;where,A=Areaofwatershed,π=3.14,Lb=Basinlength.

It signifies the shape of the river basin which is result of the climate and geology of the area.A circular basin is more capable in surplus discharge compared to an elongated basin (Singh and Singh, 1997). The value of elongated ratio varies between 0.6 and 1.0 typically in theregions of very low relief, whereas value between 0.6 and 0.8 are associated with high relief and steep ground slope (Strahler, 1964). The elongation ratio of Vishwamitri basin is. 0.56. The elongation value can be grouped into three categories, namely circular basin when Re>0.9, Oval basin if Re is between 0.9-0.8, and less elongated basin when Re<0.7. In the Vishwamitri watershed the Re value is less than 0.7 and hence the watershed is less elongated in shape.

5. **Circularity Ratio (Rc):** Circularity ratio is the ratio between the areas of watershed to the area of circle having the same circumference as the perimeter of the watershed (Miller, 1953). Rc=4πA/P2;where,A=Areaofwatershed,π=3.14,P=Perimeterofwatershed.

The value ranges from 0.4 to 0.5, greater the value more is the circularity ratio. The value low, medium and high are associated with youth, mature and old stage of the cycle.The value of 0.46 indicates an elongated basin, with a dendritic drainage pattern.

6. **Compactness Constant (Cc):**It can be represented as basin perimeter divided by the circumference of a circle to the same area of the basin. This factor is indirectly related with the elongation of the basin area. Cc=0.2841P/$A^{0.5[}$P:perimeterofbasin,A:areaofthebasin

Lower values indicate more elongationofthe basinand less erosion, while higher values indicate lesselongationand higherosion. The value of 1.47 indicates elongated shape of watershed.

3. EstimationofReliefAspects

1 Form Factor (Rf): Horton defines the form factor as Rf dimensionless ratio of watershed area (A) to the square of the length of the watershed (L). The value of form factor would be less than 0.7854 for a perfect circular shaped watershed. For the watershed formfactor is 0.24 which indicates the elongated shape of the basin.

Table3:ReliefCharacteristicsoftheWatershed

FormFactor(Rf)	TextureRatio	BasinRelief (H)	ReliefRatio(Rhl)	RelativeRelief	Ruggedness Number(Rn)
0.24	1.37	756	15.21	0.59	0.70

2. **Texture Ratio (T):** Texture ratio is an important parameter in the drainage morphometric analysis which is depends on the original rock system, infiltration capacity and relief aspect of the terrain. The texture ratio is expressed as the ratio between the first order streams and perimeter of the basin. T = N1/P where,N1=Total number of first order streams; P=Perimeter of watershed

Inpresentstudy, thetexture ratiois1.37. Thelowervaluesofspecifiesthatthebasinisplainwithlesserdegreeofslope.

3. **Infiltration Number (If):** Infiltration number of a drainage basinis the product ofdrainage density(Dd) and stream frequency(Fs) suggesting the infiltration character of the basin. The higher the infiltration number, the lower will be the infiltration and higher will be the run-off (Rao Liaqat et.al. 2011). The value obtained in the study is 0.37.

4 Basin Relief (H): Basin Relief is the vertical distance between the lowest and highest points of watershed.The elevation varies from 24 to 780 mt. The computed values for Vishwamitri river watershed indicate high basin relief 756 mt.

5ReliefRatio(Rh): Totalreliefofthebasinrepresentsthedifferenceintheelevationofthehighestpointandthelowestpointonthevalley flooroftheriverbasin.The„Rh"istheratiobetweenthetotalreliefandthelengthiestmeasurementofthebasinparallelto the main drainage line (Schumm1956) Rh=Bh/Lb; Where, Bh=Basin relief;Lb=Basin length In the study area, the relief ratio valueis 15.21.

6. RelativeRelief (Rhp) Themaximumbasinrelief wasobtained fromthehighestpointonthe watershed perimeter to the mouthofthe stream.

Rh= (H*100)/p

The value 0.59 m indicates that basin is plane with mild slope. Therefore, the area can be mainly used for agricultural activities around stream as it is plane and has accessibility to water.

7 Ruggedness Number (Rn) :. An extreme high value of ruggedness number occurs when both variables are large, and slope is steep (Strahler, 1956).

Rn=Bh×DdWhere,Bh=Basinrelief;Dd=Drainagedensity

Thelowruggednessvalueofwatershed meansthatareaislessvulnerabletosoilerosionandhavestructuralcomplexitywithreliefand drainage density. Calculated accordingly, the watershed has a ruggedness number 0.70 which shows that watershed less suscpteible erosion

5. Conclusion

The quantitative morphometric characteristic of basin in the study area shows that the basin is elongated, with low relief and gentle slope.

The analysis drainage basin result shows that the basin has a dendritic pattern with fifth order stream. The maximum stream order frequency is of first-order streams and followed by other order streams. Hence, there is decrease in stream frequency and the stream order. High bifurcation ratio in study area indicates a strong control of geological structure.. The result of relief aspect shows the study area is characterized by low relief and high stream density. The mean bifurcation ratio reflectsthat the watershed is in normal basin category. The watershed is elongated in shape as circulatoryratio of 0.56 and elongation ratio is 0.46.

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1. Water shild management govrment guide line of india
2. Water management guide line government of Gujarat
3. Water resources by d.cpunimea
4. Watershild guide line by tamil naadu
5. Highdrawlogy by p.k. sharama
6. Guide line by Indian water commision

observed that an area has moderaterelief and slope. Low values of relief ratios suggest theresistant basement rocks of the basin andlow degree of slope.

Overall the basin falls under normal category having low to moderate relief, gentle slope, high stream density, and dendritic pattern, resistant basement rocks, less erosion, high infiltration, and low runoff.

The quantitative analysis of morphometric parameters in river basin evaluation can be very valuable in water resource management. GeographicalInformationSystem(GIS) isa competent tool to delineate drainage basinand water resourcesplanning.The present study is valuable contributing to planning and optimal sustainable management of watershed.

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