Drainage Morphology Approach for Water Resources Development of Sub Watershed in Doodhganga Basin

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***Abstract-* Using Arc GIS software, the research area's morphometric analysis was completed. The study area is 3035 square km. On a scale of 1:50,000, the drainage network was defined using SOI. To determine the drainage line's utility for surface development, its morphological characteristics, including shape, size, number, order, length, Dd, Sf, Rb, Fs, T, and Rc, are derived. The current study uses a Geographic Information System (GIS) analysis technique to assess and compare the Doodhganga watershed's linear relief and aerial morphometry. Doodhganga watershed is primarily dendritic to subdendritic and is a 6th order drainage system. The drainage basin's drainage density and texture are 1.32 km/km2 and 6.81, respectively. Doodhganga watershed have a drainage frequency of 1.63, although the bifurcation ratio ranges from 2.79 to 5.65. Thus, it can be inferred from the study that GIS technology is a reliable tool for morphometric analysis.**

Keywords: **Morphometric analysis, Drainage frequency, Drainage density.**

Introduction

Due to fast urbanisation and rising population, the surface and ground water supplies are insufficient to fulfil the expanding water demands. The need to evaluate the quantity and quality of water for its best use has arisen as a result of the rising demand for water throughout time.Different ground elements, such as geological formations, geomorphic features, and their hydraulic characteristics, can be identified and highlighted in order to provide direct or indirect indications of the existence of ground and surface water. Understanding the water carrying properties of hard rocks requires an understanding of the geomorphic circumstances. By examining the kind and type of drainage pattern and doing a quantitative morphometric analysis, it is possible to better understand the function of rock types and geologic structure in the evolution of stream networks. A watershed's morphometric characteristics can be used to summarise its hydrological behaviour because they are largely reflective of its hydrological response.The most effective method for the proper planning of watershed management is considered to be a quantitative morphometric characterization of a drainage basin because it allows us to compare and contrast different drainage basins that have evolved under various geological and climatic conditions and understand the relationships between various aspects of the drainage pattern of the basin.Doodhganga stream is a sizeable river located between the latitudes 330 43’ N and 340 8’N and longitudes 740 29’E and 740 42’E in the district Budgam of the Kashmir valley and is a left bank tributary of river Jhelum.It has a total cactchment of about 663 sq kms and a course of about 58 kms .Morphometry, according to Clark (1966), is the measurement and mathematical analysis of the configuration of the earth's surface and the size, shape, and dimensions of its landforms. Geographic information system methodology has been employed in the current study to evaluate several topographical and morphometric drainage basin and watershed parameters. Planning for development of the Doodhganga watershed involves evaluating linear, relief, and aerial morphometric factors. Stream order (u), stream length (Lu), mean stream length (Lsm), and bifurcation ratio (Rb) are among the linear parameters that were examined.Basin Relief (Bh) and Ruggedness number (Rn) are two of the relief parameters that are examined. In computing, subsurface and surface water flow, permeability, the development of landforms, drainage density (Dd), stream frequency (Fs), texture ratio (T), form factor (Rf), circulatory ratio (Rc), and constant channel maintenance (C), which aids in the development of drainage, the reliability of watersheds is crucial. One of the key markers of the landform feature is drainage density. It offers a quantitative assessment of the runoff potential and dissection of the landscape. Due to variations in geological structure, land form layout, slope, vegetation, and rainfall distribution, the drainage pattern varies greatly in linear, relief, and areal morphometric parameters.

Study area

Doodhganga stream is a sizeable river located between the latitudes 33^o 43’ N and 34^o 8’N and longitudes 74^o 29’E and 74^o 42’E in the district Budgam of the Kashmir valley and is a left bank tributary of river Jhelum.It has a total cactchment of about 663 sq kms and a course of about 58 kms .It originates from Tattakuti glacier and flows from the great slopes of pir panjal .Frothing and crashing on its way over the rocks ,the river makes a little milky white foam which gives it this name (doodh meaning milk in urdu).River Doodhganga has number of streams forming a well developed dendritic pattern in the upper portion of catchment and more less parallel drainage pattern in the lower portion.

The study area has a diverse rock types ranging in age from Archean to recent. In the study area the oldest formation comprises the Salkhala series which are found in the upper reaches in which dynamic high grade metamorphism is evident. The Salkhala group consists of slates, phyllite and schist with interbedded crystalline limestone and flaggy quartzite. Salkhala group are followed by andesitic and basaltic traps of and Panjal volcanics which are extensively found in the study area. The Panjal volcanic are of Carboniferous age in which the agglomeratic slate series is overlain often intermixed with a thick succession of andesitic and basaltic traps.

Lower part of the study area consists of Plio-Pleistocene deposits and recent alluvium.Theplio-pleistocene deposits of Kashmir comprises the karewa formation that contains lacustrine and fluvial sediments intercalated with glacial tills. Karewas are followed by large amount of material brought about by water and deposited in lower parts of the area .Lithologically ,the alluvium consists of blue grey sand,silts and varved clays ,shales and sands of various hues,textures and structures.Grain size ranges from fine,medium to coarse .The colour of alluvium varies from dark brown ,reddish to flesh red.

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Methodology

Entire study area is delineated from rectified, mosaiced SOI topographic map on the scale 1:50,000 on polyconic projection system with the help of Arc-GIS software.Drainage network was digitized (Figure No. 2) and stream order was calculated using method proposed by Stahler (1964). Arc-GIS 9.3 software was used for computing all morphometric parameter (Table - 1)

Hypothesis

Different segments of Doodhganga watershed exhibit different morphometric and hydrologic characteristics and relationship. These will analyses by ordering scheme. This scheme is applied to prepare different morphometric tables and it helps for deriving idea for suggesting drainage capacity and discharge form the segment which helps to develops Decision Support System (DSS) for water conservation.

Results and Discussion

The most prevalent attribute of a drainage basin that is linear is its stream order, stream length, and length of overland flow.The total number of segments (Nu) in each order (u) was calculated based on the Horton (1945) approach as modified by Strahler A.N. This drainage basin's stream order is numbered up to sixth order (Figure No. 2).

For all three watersheds, stream length (Lu) has been calculated based on Horton's (1945) law. The majority of the first and second order streams occur at high elevations with a moderate slope, whereas the higher order streams generally occur at low elevations with deep dissects. In nature, stream length is typically noticed higher up the order.Longer streams have advantages over shorter ones because they may gather water from a wider region and have more room for bund construction. It can be shown from Table 4 that Lsm is 0.83.

Using Horton's law (1945) of stream length as a guide, the logarithm of stream length (ordinate) as a function of stream order (abscissa) is shown in Figure No. 4. This results in a group of points that virtually lie along the straight line. The straight line fit suggests that geometrical similarity is maintained in basins of increasing order and that the ratio of Lu to u is consistent throughout successive orders of basins. Water flows over land for a certain amount of time before becoming concentrated into a certain stream channel (Horton, 1945).

One of the key factors influencing the drainage basin's topography evolution is the duration of the overland flow. The length of overland flow (Lg) is about equal to one-half of the Constant Channel Maintenance (Horton, 1945), or half the reciprocal of drainage density (Figure No. 3). In the current study, the length of the overland flow is 0.29, and the shorter it is, the quicker surface runoff will enter the stream.

Ruggedness number (Rn) and Basin Relief (Bh) are two examples of relief parameters. In terms of drainage development, surface and subsurface water flow, permeability, landform development, and associated terrain features, the relief element of the watershed is crucial.

Doodhganga watershed has more than 550 metres of basin relief, which denotes low infiltration and high runoff. In relation to relief and drainage density, the bifurcation ratio (Rb) and ruggedness (Rn) reveal the structural complexity of the terrain (Table 4).The basin's form can be determined using the bifurcation ratio. Circular basins have a high Rb value compared to elongated basins' low Rb value (Morisawa, 1985). The Doodhganga watershed's Rb value is 4.95. It varies depending on the order. Due to the mountainous terrain and steep slope, the greatest Rb value of 11 indicates the matching highest overland flow and discharge.

Analysed values for the aerial parameter were Dd, Df, T, Rf, Rc, Rb, Re, and C. One key determinant of land form is drainage density (Dd). It offers a quantitative assessment of the runoff potential and dissection of the landscape. Additionally, it shows how closely spaced the streams are. In the current study, the drainage density (Dd) for the Doodhganga watershed is 6.89, and the drainage frequency (Df) is 2.73. High Df value denotes high relief and low bed rock infiltration capacity. The underlying lithology, infiltration potential, and relief characteristics of the terrain all affect texture ratio (T).

The Doodhganga watershed in the current study region has a texture ratio (T) of 18.60, which is considered to be of moderate to fine texture in nature. The Form factor (Rf) value and the shape of the watershed are directly related. Watershed in Doodhganga has a high Rf value. This demonstrates that drainage basins have a somewhat lengthy shape, with low side flow during shorter periods and high main flow over longer periods. The length and frequency of the stream, the geological structure, the use and cover of the land, the climate, the relief, and the slope of the basin all have an impact on the circulatory ratio (Rc).

If the Rc value is 0.37, the watershed is said to be elongated in shape. For this watershed, Constant Channel Maintenance (C) is 0.44, which suggests a high degree of structural disruption, a steep to extremely steep slope, and a high level of surface runoff (Figure No. 4).

The research area's drainage frequency (Df) is 2.73, which reflects the high relief, creation of a new channel, or lengthening of an existing stream.There is only one high order stream segment in total. There are no high order, or seventh order, streams in the study area's major rivers.

Conclusion

GIS software is proven to be of enormous value in drainage basin, elevation, watershed prioritisation for soil and water conservation, flood prediction, and natural resource management when used for the quantitative analysis of morphometric parameters. Using a morphometric technique, it was discovered that the catchment's 660 km2 area contains 1074 streams that are grooved with one another in sequence from first to seventh. A thorough analysis of the Dhoohganga watershed aids in the development of natural resources and provides important guidance for surface runoff. The drainage has been covered by an impermeable subsurface and high mountainous topography, according to the bifurcation ratio. Circulatory ratio and elongation ratio demonstrate strong peak flow and high slope in the watershed. The infiltration rate and relief of the landscape are shown by the texture ratio.

The study area demonstrates that the topography is primarily composed of mixture of sedimentary, igneous, and metamorphic rocks having a dendritic to subdendritic drainage pattern, and is categorised as having a high runoff zone and a strongly sloped terrain that results in significant drainage discharge.

Thus, the study demonstrates that the use of GIS for morphometric analysis aids in understanding all terrain factors, which ultimately leads to the completion of watershed development planning and management with regard to water conservation.

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Figure No. 1 Location Map

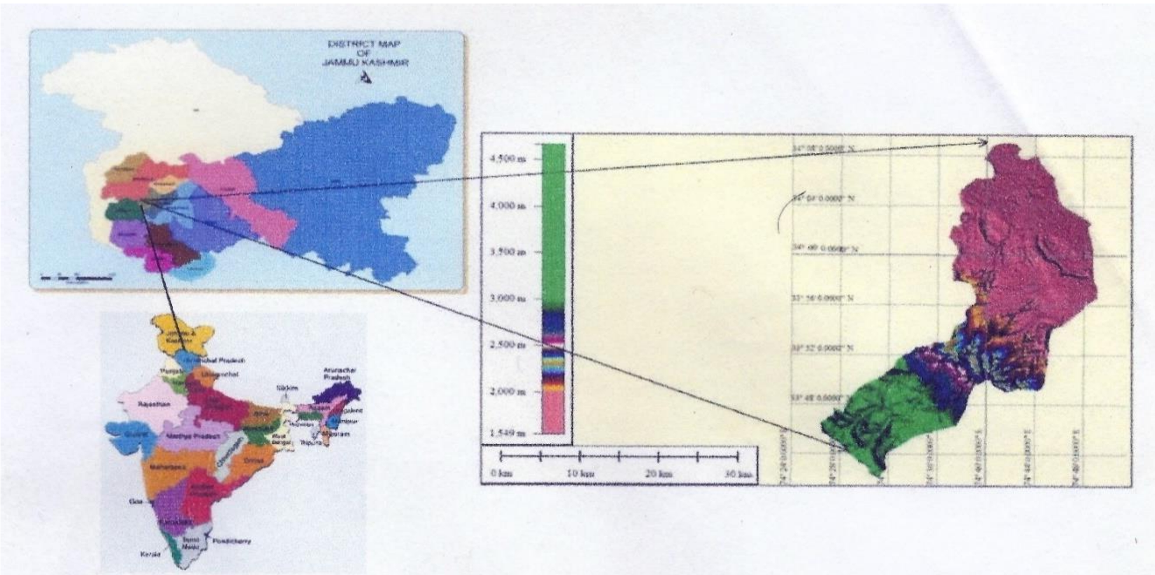


Figure No. 2 Drainage Network

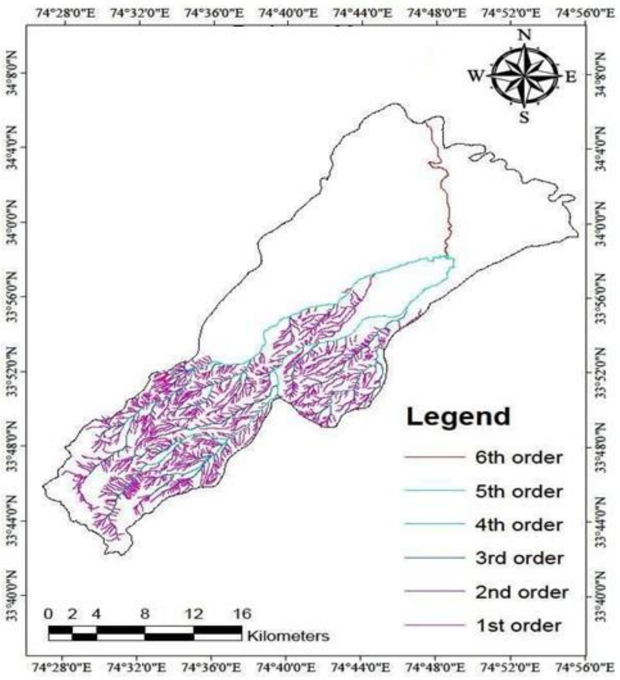


Figure No. 3 Drainage Density Map

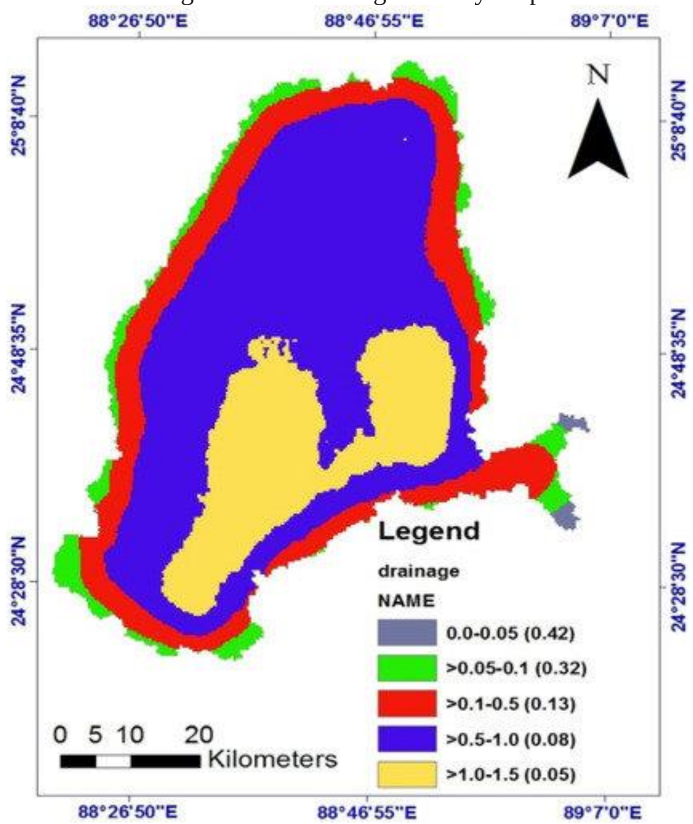
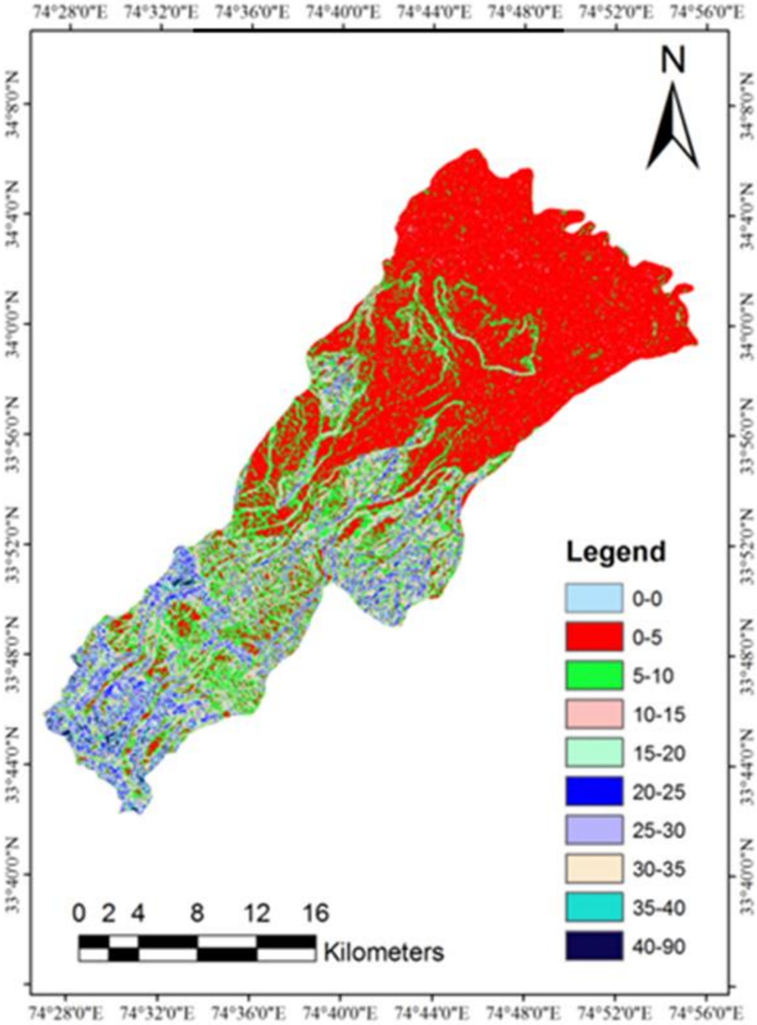


Figure No. 4 slope map



Slope category	Slope percentage	Area	
		Km2	%
Gentle	0-5	334.4	50.6
Moderate	5-10	132.94	20.14
Moderately Steep	10-20	129.46	11.57
Steep	20-30	25.5	3.86
Very Steep	30-40	15.74	2.38
Escape Steep	40-90	2.95	0.45

Figure 4.1 Slope categories of the catchment

Table - 1 Formulae adopted for computation of Morphometric parameters

Sr. No.	Mophometric Parameters	Formula	Reference
1	Stream order	Hierarchial rank	Strahler (1964)
2	Stream length (Lu)	Length of the stream	Horton (1945)

3	Mean stream length (Lsm)	Lsm = Lu / Nu Where, Lsm = Mean stream length Lu = Total stream length of order 'u' Nu = Total no. of stream segments of order 'u'	Strahler (1964)
4	Stream length ratio (RL)	RL = Lu / Lu – 1 Where, RL = Stream length ratio Lu = The total stream length of the order 'u' Lu – 1 = The total stream length of its next lower order	Horton (1945)
5	Bifurcation ratio (Rb)	Rb = Nu / Nu + 1 Where, Rb = Bifurcation ratio Nu = Total no. of stream segments of order 'u' Nu+1 = Number of segments of the next higher order	Schumn (1956)
6	Mean bifurcation ratio (Rbm)	Rbm = Average of bifurcation ratios of all orders	Strahler (1957)
7	Relief ratio (Rh)	Rh = H / Lb Where, Rh = Relief ratio H = Total relief (Relative relief) of the basin (km) Lb = Basin length	Schumm (1956)
8	Drainage density (D)	D = Lu / A Where, D = Drainage density Lu = Total stream length of all orders A = Area of the basin (km2)	Horton (1932)

Table - 2 Stream Analysis of Doodhganga Watershed

Stream Order	Stream NumberNu	StreamLength (Km)	Length Ratio	Mean Stream Length	BifurcationRatio	Mean Bifurc ation Ratio	Mean Length Ratio
1	866	528.61	0.26	0.61	5.65	5.65	1.95
2	160	141.15	0.54	0.88	3.89		
3	37	76.97	0.60	2.08	4.04		
4	8	46.3	0.34	5.78	4.40		

5	2	62.14	0.27	31.07	2.79		
6	1	17.07	-	17.07	4.07		
Total	1074	872.24					

Table - 3 Linear aspect of drainage network of Doodhganga watershed

Watershed	**Streamorder**	**Number of stream (Nu)**	**Total length of stream in km(Lu)**	**Log Nu**	**Log Lu**
Doodhganga	1	866	528.61	3.77	3.60
	2	160	141.15	3.22	3.15
	3	37	76.97	2.69	2.88
	4	8	46.3	2.14	2.58
	5	2	62.14	1.34	2.14
	6	1	17.07	0	1.80

Table - 4 Morphometric Analyses

Watershed	**Morphometric Parameters**	
Doodhganga	A (Km^2)	660 km^2
	P (Km)	58km
	Lu	872.24 km
	Lsm	0.81
	Rb	5.65
	Bh	0.031
	Rn	0.040
	Dd	1.32
	Rf	0.17
	Rt	6.81
	Rc	0.33