International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
www.chemijournal.com
IJCS 2021; 9(1): 2014-2018

Received: 14-10-2020
Accepted: 19-12-2020

Nagaraj
College of Agricultural Engineering, UAS, GKVK, Bengaluru, Karnataka, India

Rajashekarappa KS
Professor, Department of Agricultural Engineering. COA, UAS, GKVK, Bengaluru, Karnataka, India

Devaraja K
Senior Scientist, AICRP on Dry Land Agriculture Project. COA, UAS, GKVK, Bengaluru, Karnataka, India

Chikkaramappa T
Professor, Department of Soil Science and Agriculture chemistry. COA, UAS, GKVK, Bengaluru, Karnataka, India

Ashoka HG
Chief Scientific Officer, Directorate of Research, UAS, GKVK, Bengaluru, Karnataka, India

Corresponding Author:
Nagaraj
College of Agricultural Engineering, UAS, GKVK, Bengaluru, Karnataka, India

Morphometric analysis of Yarehalli micro-watershed, of Davanagere district, Karnataka using remote sensing and GIS techniques

Nagaraj, Rajashekarappa KS, Devaraja K, Chikkaramappa T and Ashoka HG

DOI: https://doi.org/10.22271/chemi.2021.v9.i1ab.11522

Abstract
Yarehalli micro-watershed lies between 750 51' 37.58" to 750 53' 29.93" East longitudes and 130 58' 59.95" to 140 1' 3.72" in Davanagere district of Karnataka. The drainage networks of micro-watershed were delineated from the Survey of India topographical map of 1:50,000 scale. ArcGIS software was used for evaluation of linear, areal and relief as pects of the micro- watershed. The present study reveals that, drainage pattern of the study area is dendritic with trunk order 4th. The watershed area, perimeter, maximum length and width of the watershed was 977 ha, 10.00 km, 4.40 km and 2.20 km respectively. The mean value of bifurcation ratio is 3.23, the micro-watershed have been suffered less structural disturbance and drainage pattern has not been distorted. The value of drainage density is 2.31 km km-2 which indicated that, the region is having permeable subsoil material and good vegetative cover. The value of form factor indicates micro-watershed is approaching towards elongated shape of watershed. The present study reveales that, GIS based approach in evaluation of geo-morphological characteristics is more appropriate than conventional techniques. Over all study suggests that the micro-watershed should be treated with soil and water conservation measures.

Keywords: Watershed, subsoil, water conservation, remote sensing, GIS and vegetative

Introduction
Watershed is a natural hydrological entity from which runoff resulting from precipitation flows past a single point into large stream, river, lake or ocean. Thus, a watershed is the surface area drained by a part or the totality of one or several given water courses and can be taken as a basic erosional landscape element where land and water resources interact in a perceptible manner. Morphometric analysis provides quantitative description of the basin geometry to understand initial slope or inequalities in the rock hardness, structural controls, recent diastrophism, geological and geomorphic history of drainage basin (Strahler, 1964) [18]. Morphometric analysis requires measurement of linear features, gradient of channel network and contributing ground slopes of the drainage basin. A major emphasis in geomorphology over the past several decades has been on the development of quantitative physiographic methods to describe the evolution and behavior of surface drainage networks (Horton, 1945) [5]. The influence of drainage morphometry is very significant in understanding the landform processes, soil physical properties and erosional characteristics. Drainage characteristics of many river basins and sub basins in different parts of the globe have been studied using conventional methods (Horton, 1945; Strahler, 1964) [5, 18]. Geographical Information System (GIS) techniques are now a days used for assessing various terrain and morphometric parameters of the drainage basins and watersheds, as they provide a flexible environment and a powerful tool for the manipulation and analysis of spatial information.

Material and Methods
The present study was taken up extensively in Yarehalli micro-watershed located in Channagiri taluk of Davanagere district, Karnataka state (Fig.1) and having total area of 977 ha which lies between 75^0 51' 37.585" to 75^0 53' 29.93" East longitudes and 13^0 58' 59.959" and140 1' 3.722" spread across Dongraghatta, Sunageri, Haronahalli and Yarehalli villages.

The average annual rainfall of study area is 612-1054 mm. The major soils are sandy clay & clay soil. The main cropping season is Kharif. Major crops in Davanagere district are paddy, ragi, jowar, maize, groundnut and sunflower. It is falling under the Survey of India top sheet of D43P13 (1:50,000).

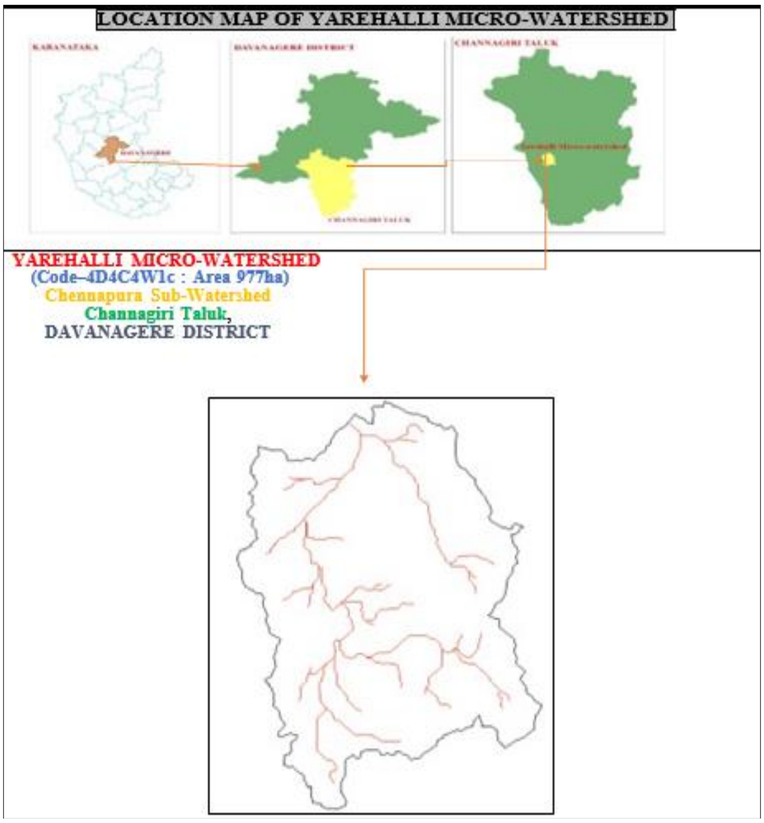

Fig 1: Location Map of the study area

DEM data is used to calculate the flow direction a staple for determining many important hydrologic parameters stream network is determined by using Arc GIS tools. Quantitative morphometric analysis was carried out for micro watersheds for linear aspects, areal aspects and relief aspects. The analysis was carried out using Arc GIS 10.4. The detailed list of various morphological characteristics derived for Table 1 is used for calculating the morphometric parameters of the micro watersheds.

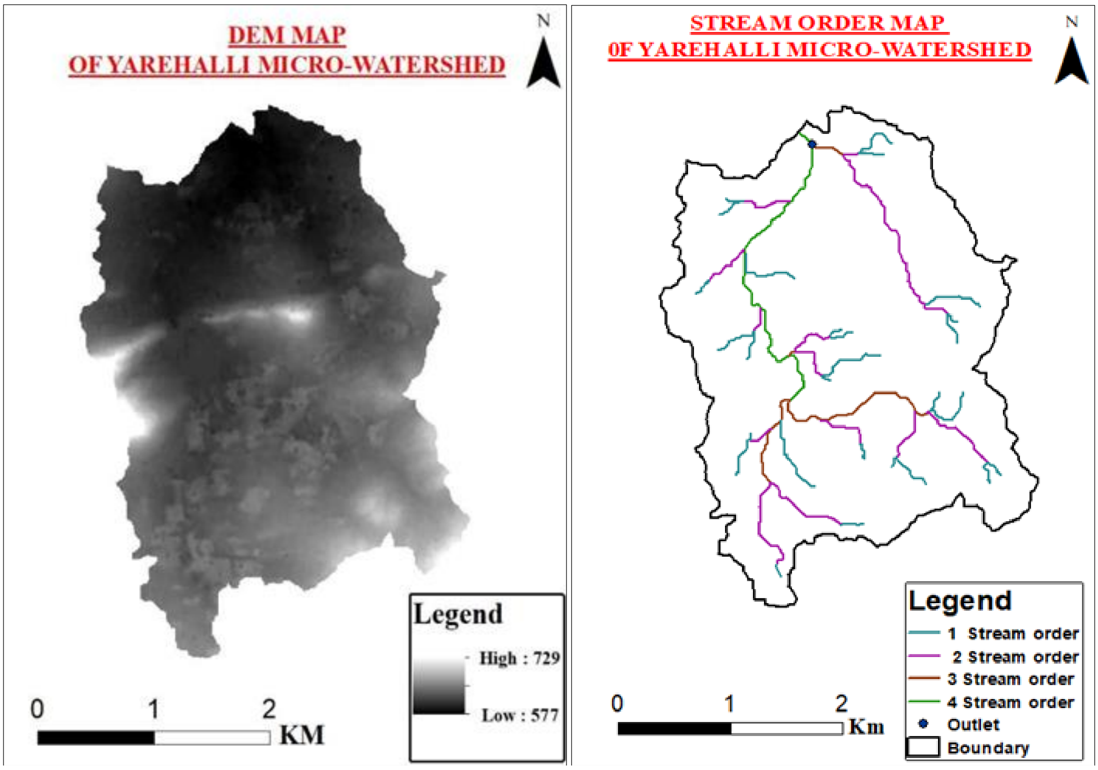

Fig 2: Show the DEM and Strean Irder map

Table 1: Formulae adopted for evaluation of geo-morphological characteristics

Sl. No.	Parameters	Formulae		References
Linear Aspects				
1	Stream order (U)	Hierachical rank	-	Strahler (1964)
2	Stream length (L_u), km	Length of the stream	-	Horton(1945)
3	Mean stream length ($\bar{L}_u$), km	$\bar{L}_u = \frac{\sum L_u}{N_u}$	L_u = Cumulative length of all streams of order u (km) N_u = Number of streams of the given order u	Strahler (1964)
4	Bifurcation ratio (R_b)	$R_b = \frac{N_u}{N_{u+1}}$	N_u = Number of stream segments of order u N_{u+1} = Number of stream segments of next higher order	Schum (1956)
5	Stream length ratio (R_L)	$R_L = \frac{\bar{L}_u}{\bar{L}_{u-1}}$	$\bar{L}$= Mean stream length (km) $\bar{L}_l$= Mean stream length of next lower order (km)	Horton (1945)
Areal Aspects				
6	Drainage density (D_d), km km^{-2}	$D_d = \frac{L}{A}$	L = Total length of streams of all order (km) A = Total area of watershed (km^2)	Horton (1932)
7	Drainage texture (D_t)	$D_t = \frac{N_t}{P}$	N_t = Total Number of stream segments of all orders P = Basin perimeter (km)	Smith (1950)
8	Stream frequency (F)	$F = \frac{N}{A}$	N = Total number of stream segments of all orders A = Basin area (km^2)	Horton(1945)
9	Form factor (R_f)	$R_f = \frac{A}{L_b^2}$	A = Area of watershed (km^2) L_b = Length of basin (km)	Horton (1945)
10	Elongation ratio (R_e)	$R_e = \frac{2}{L_b}\sqrt{\frac{A}{\pi}}$	L_b = Basin length (km) A = Basin area (km^2)	Strahler (1964)
11	Circulatory ratio (R_c)	$R_c = \frac{4\pi A}{(A_c)^2}$	A = Area of watershed, (km^2) A_c = Perimeter of the watershed (km)	Schum (1956)
12	Length of over land flow (L_g), km	$L_g = \frac{1}{2D_d}$	D_d = Drainage density (km km^{-2})	Horton (1945)
Relief Aspects				
13	Maximum watershed relief (H), m	$H = h_{max} - h_{min}$	h_{max} = Elevation of highest elevated point (m) h_{min}= Elevation of lowest elevated point (m)	Schum (1956)
14	Relief ratio (R_r)	$R_r = \frac{H}{L_b}$	H = Maximum watershed relief (m) L_b= Maximum watershed length (km)	Schum (1956)
15	Relative relief (R_R), %	$R_R = 100 \frac{H}{L_p}$	H = Watershed relief (m) L_p = Length of perimeter (m)	Schum (1956)
16	Rugdness number (R_n)	$H D_d$	H = Maximum watershed relief (m) D_d = Drainage density (km km^{-2})	Melton (1957)
17	Time of Concentration (T_c), min	$T = 0.0195 L^{0.77} S^{-0.38}$	L = Length of watershed from remote point to outlet (m) S = Slope of the catchment (m/m)	Kirpich (1940)

Results and Discussion

The geomorphological analysis and measurements were made from the digitized drainage pattern map of the Yarehalli micro-watershed. Digitized drainage pattern was shown in Fig.2.

Linear aspects of drainage network: In this chapter, stream order, stream number, basin length, average basin width, stream length, mean stream length, bifurcation ratio and stream length ratio were analysed. After analysis it was found that, the micro-watershed was of 4th order trunk stream and drainage pattern was dendritic which indicates the homogeneity in texture and lack of structural control. Maximum length and basin width of micro-watershed was found to be 4.40 km and 2.20 km respectively. The number of streams for 1st, 2nd, 3rd and 4th order streams were found to be 31, 14, 4 and 1 respectively. The values of cumulative stream length for 1st, 2nd, 3rd and 4th order streams were found to be 7.80, 8.60, 2.88 and 3.35 km respectively (Table 2). The stream length of different orders and respective mean stream lengths were found out by digitizing the stream networks using ArcGIS software.

Table 2: Stream order and its mean stream lengths of Yarehalli micro-watershed

Parameters	Stream order (U)				Total
	I	II	III	IV	
No. of streams	**31**	**14**	**4**	**1**	**50**
Cumulative stream length,(km)	7.80	8.60	2.88	3.35	22.63
Mean stream length, (km)	0.25	0.61	0.72	3.35	4.93

The other important properties of linear aspects of drainage network is bifurcation ratio (Rb), which reflects about geological and tectonic characteristics of the watershed. The bifurcation ratio (Rb) values of 1st to 2nd, 2nd to 3rdand 3nd to 4th stream was found to be 2.21, 3.50 and 4.00 respectively (Table 3). The mean value of bifurcation ratio was found to be 3.23. Thus, the bifurcation ratio value was low indicates that, micro-watershed had suffered less structural disturbance and drainage pattern had not been distorted by structural disturbance (Nag, 1998) [11]. The values of stream length ratio (RL) for 2nd to 1st, 3rd to 2ndand 4th to 3rd order streams were found to be 2.44, 1.17 and 4.65 respectively (Table 3). Change in stream length ratio from one order to another order indicating their late youth stage of geomorphic development (Singh and Singh 1997) [15]. The variation in stream length ratio was due to change in slope and topography.

Table 3: Bifurcation ratio and stream length ratio of Yarehalli micro-watershed

Stream order (U)	Bifurcation ratio (Rb)	Stream length ratio (RL)
I	2.21	-
II	3.50	2.44
III	4.00	1.18
IV	-	4.65
Mean	3.23	2.75

Aerial aspects of drainage network: Aerial aspects of drainage network include measurement of aerial elements *viz.*, drainage area, form factor, drainage density, drainage texture, stream frequency, circulatory ratio, elongation ratio and length of overland flows were represented in a systematic way. From the study it was revealed that, the value of form factor (Rf) was found to be 0.50 (Table 4). Since the value of form factor was less than 0.78, it indicates an elongated shape of the micro-watershed (Horton, 1932). An elongated basin with low form factor shows flatter peak flow for longer duration (Mahadevaswamy *et al*., 2011) [8].

The value of drainage density (Dd) was found to be 2.31 km km-2 (Table 4) which falls in the range of 2.0 to 2.5 km km-2 and indicated that the region is having permeable subsoil material and good vegetation cover (Mallik *et al*., 2011) [9]. The value of drainage texture (Dt) was found to be 5.00 km-1 (Table 4), which indicates about the Moderate drainage texture of the micro-watershed (Smith, 1950) [16]. The value of texture ratio is 3.1 which indicates, the rocks which are hard and with vegetative cover produce coarse texture Nikhil Raj (2012).

The value of stream frequency was found to be 5.11 km-2 (Table 4) which indicates the watershed is having impermeable subsurface material and sparse vegetation (Malik *et al.*, 2011). Circulatory ratio (Rc) and elongation ratio (Re) were found to be 1.22 and 0.80 respectively (Table 4). The greater circularity ratio than elongation ratio results in circularity formation of watershed than elongation watershed. In the present study, the value of Circulatory ratio (1.22) indicates circular shaped micro-watershed.

The length of over land flow is the length of water over the ground before it gets concentrated into definite stream channels and is equal to half of drainage density (Horton, 1945) [5]. Length of overland flow relates inversely to the average channel slope. In the present study, the lower values of length of overland flow due to low drainage density and which confirm with Horton's (1945) [5].

Table 4: Aerial aspects of Devanayakanahalli micro-watershed

Sl. No.	Aerial aspects	Value
1	Drainage area (A), ha	977
2	Form factor (Rf)	0.50
3	Drainage density (Dd), km km-2	2.31
4	Drainage texture (Dt), km-1	5.00
5	Texture ratio (Rt)	3.10
6	Stream frequency (F), km-2	5.11
7	Circulatory ratio (Rc)	1.22
8	Elongation ratio (Re)	0.80
9	Length of overland flow (Lg), km	0.21

Relief aspects of drainage network: Relief aspects of drainage network for Yarehalli micro-watershed were calculated and represented in the Table 5. The estimated value of Maximum watershed relief (H), Relative relief (RR) and Relief ratio (Rr) were found to be152 m, 0.0152 and 0.034 respectively. The lower value of relief ratio indicates a presence of basement rocks that were exposed in the form of small ridges and mounds with lower degree of slope (Praveen *et al*., 2012) [13]. Addition to these properties, ruggedness number value was computed and it was found to be 0.35. The lower value of ruggedness number indicates that, the area was less prone to soil erosion and had an intrinsic structural complexity in association with relief and drainage density (Guha, 2015) [2]. Time of concentration directly influences on runoff generation from the watershed. In the present study the time of concentration is is 45 min and it indicates more time is required for water to travel from the most distant part of watershed to its outlet.

Table 5: Relief aspects of Devanayakanahalli micro-watershed

Sl. No.	Relief parameters	Value
1	Maximum watershed relief (H), m	152
2	Relative relief (RR)	0.0152
3	Relief ratio (Rr)	0.034
4	Ruggedness number (Rn)	0.35
5	Time of concentration (Tc), min	45

Conclusion

From the study it was revealed that, Yarehalli micro-watershed had 4th order trunk stream and drainage pattern was dendritic which indicates the homogeneity in texture and lack of structural control. The values of drainage density and drainage texture were found to be 2.31 km km-2, 5.00 km-1 and 3.1 respectively and these values indicates that micro-watershed has permeable sub soil geology and good vegetation cover. From the relief aspect it was found that, time of concentration is 45 min. It indicates more time is required for water to travel from the most distant part of micro-watershed to outlet and leads to low runoff due to permeable soils and gentle slope in study area.

The use of GIS can make the cumbersome geomorphological analysis as an easy task as compared to traditional methods. It saves time and helpful in planning of resource conservation techniques in the watershed area for sustainable development. This study indicates that, systematic analysis of morphometric parameters using GIS can provide significant value in understanding basin hydrological characteristics for watershed planning and management.

References

1. Agarwal CS. Study of drainage pattern through aerial data in Naugarh area of Varanasi district, UP. J Ind. Soc. Remote Sens 1998;26(4):169-175.
2. Guha S. Mathematical analysis of Solani Watershed, North India. Int. J Geomat. Geosci 2015;6(2):1512-1529.
3. Hajam RA, Hamid A, Bhat S. Application of morphometric analysis for geo hydrological studies using geo-spatial technology: A case study of Vishav drainage basin. Hydrology Curr. Res 2013;4(3):2-12.
4. Horton RE. An approach toward a physical interpretation of infiltration-capacity. Soil Sci. Soc. American J 1940;5:399-417.
5. Horton RE. Erosional development of streams and their drainage basins; hydro physical approach to quantitative morphology. Geological soci. America bulletin 1945;56(3):275-370.
6. Kirpich TP. Time of Concentration of Small Agricultural Watersheds. J Civil Engg 1940;10(6):362.
7. Kuldeep P, Upasana P. Quantitative Morphometric Analysis of a Watershed of Yamuna Basin, India using Aster (DEM) Data and GIS. Int. J Geomat. Geosci 2011;2(1):248-269.
8. Mahadevaswamy G, Nagaraju D, Siddalingamurthy S, Lone MS, Nagesh PC, Rao K. Morphometric analysis of Nanjangud taluk, Mysore District, Karnataka, India, using GIS techniques. Int. J Geomat. Geosci 2011;1(4):721-734.
9. Mallik MI, Bhat MS, Kuchay NA. Watershed based drainage morphometric analysis of Lidder catchment in Kashmir valley using GIS. Recent Res. Sci. Tech 2011;3(4):118-126.
10. Melton MA. An analysis of the relations among elements of climate, surface properties and geomorphology (No. CU-TR-11). Columbia Univ. New York 1957.
11. Nag SK. Morphometric analysis using remote sensing techniques in the Chaka sub- basin, Purulia district, West Bengal. J Indian Soc. Remote Sensing 1998;26(1):69-76.
12. Pande CB, Patode RS, Moharir KN. Morphometric Analysis Using Remote Sensing and GIS Techniques: A Case Study of Devdari Watershed, Patur Tq., Akola District, Maharashtra. Trends Biosci 2017;10(1):219-223.
13. Praveen R, Kumar U, Singh VK. Geomorphometric characterization of upper south Koel basin, Jharkhand: A remote sensing & GIS approach. J Water Res. Prot 2012;4(12):1042-1050.
14. Schumm SA. Evaluation of drainage systems and slopes in bad land at Parth Ambo, New Jersy. Bulletin Geological Soc America 1954;67:597-646.
15. Singh S, Singh MC. Morphometric analysis of Kanhar river basin. National Geographical J India 1997;43(1):31-43.
16. Smith. Standards for grading textures of erosional topography. American J Soc 1950;248:655-668.
17. Sreenivasa A, Asode AN, Murgod S. Drainage evaluation of Doddhalla sub basin, Karnataka, India using GIS. Int. J Res. App. Sci. Engg. Tech 2016;4(3):89-93.
18. Strahler AN. Quantitative geomorphology of drainage basin and channel networks. Handbook applied hydrology 1964;23:543-552.