Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2020; 9(1): 1521-1525
Received: 16-11-2019
Accepted: 20-12-2019

G Thiyagarajan
Water Technology Centre, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

A Valliammai
Agricultural Research Station, Tamil Nadu Agricultural University, Bhavanisagar, Tamil Nadu, India

A Raviraj
Water Technology Centre, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

Balaji Kannan
Department of Soil and Water Conservation Engineering, Agricultural Engineering College and Research Institute, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

S Panneerselvam
Water Technology Centre, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

Corresponding Author
G Thiyagarajan
Water Technology Centre, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

Hydrological evaluation of Koraiyar watershed by morphometric analysis

G Thiyagarajan, A Valliammai, A Raviraj, Balaji Kannan and S Panneerselvam

Abstract
Morphometric analysis was conducted in Koraiyar watershed which lies in Walyar sub basin of Parambikulam Aliyar Project (PAP). It is in the over exploited groundwater extraction category. The quantitative morphometric analysis was carried out in 24 micro-watersheds of Koraiyar watershed using GIS technique for determining the linear aspects such as stream order, bifurcation ratio, stream length and aerialaspects such as drainage density, stream frequency, form factor, circulatory ratio, and elongationratio. Prioritization based on different morphometric parameters was done. The morphometric analysis of different micro-watersheds showed their relative characteristics with respect to hydrologic response of the watershed. Results of morphometric analysis show that micro-watersheds 5, 7, 13, 19, 21 and 23 are possibly having high erosion problems. Hence, suitablesoil erosion control measures are required in these micro watersheds to preserve the land from further erosion.

Keywords: DEM, GIS, koraiyar watershed, morphometric analysis, remote sensing, watershed

Introduction

A Watershed is an ideal unit for management of resources like land and water for mitigation of the impact of natural disasters for achieving sustainable development. It provides a powerful study and management unit, which integrates ecological, geographical, geological, and cultural aspects of the land. Water provides a focus for integrating various aspects of watershed use and for making regional and global connections (Yongsheng Ma, 2004) [16].

The response of a particular watershed to different hydrological processes and its behavior depends upon various physiographic, hydrological and geomorphological parameters. Though these are watershed specific and thereby unique, the characterization of a watershed provides an idea about its behaviour.

Morphometry is defined as the measurement and mathematical analysis of the configuration of the earth’s surface and of the shape and dimension of its landforms (Clarke, 1966) [2]. Morphometric methods, though simple, have been applied for the analysis of area-height relationships, determination of erosion surfaces, slopes, relative relief and terrain characteristics, river basin evaluation, and watershed prioritization for soil and water conservation activities in river basins (Kanth, 2012) [4].

Quantitative morphometric characterization of a drainage basin is considered to be the most appropriate method for the proper planning and management of watershed, because it enables us to understand the relationship among different aspects of the drainage pattern of the basin and also to make a comparative evaluation of different drainage basins, developed in various geologic and climatic regimes (Pingale *et al*. 2012) [8].

The measurement of morphological parameters is laborious by the conventional methods, but using the latest technology like GIS, the morphometric analysis of natural drain and its drainage network can be better achieved. Various morphometric parameters needs to measure in a drainage basin include stream order, stream length, stream number, and basin area. Other morphometric parameters are basin shape factor (e.g. circularity ratio, elongation ratio, form factor and compaction ratio), basin perimeter, bifurcation ratios, drainage density, stream frequency and drainage intensity (Shaikh and Birajdar, 2015) [11].

Geomorphological analysis helps in better understanding of hydrological system of watershed which is useful for carrying out management strategies.

Study area

Koraiyar watershed (5A2B5a) located in Kinathukadavu block of Coimbatore district was selected for the study (Fig. 1). This watershed lies in Walayar sub basin of Parambikulam

Aliyar Project (PAP) with an area of 289.83 sq.kms. This watershed comes under over exploited category in groundwater status. Lies between 10°43′07″ to 10°55′27″ N latitude and 76°53′32″ to 77°09′27″ E longitude. The watershed is covered in four toposheets (58B/13, 58B/14, 58 F/1, 58 F/2). The weighted average rainfall of the study area is 688.69 mm. The watershed has an undulating topography and elevation is from 220 to 420 m above the mean sea level. The base map of the study area was digitized from the toposheets. Various thematic maps (Fig. 2) were prepared and the watershed was delineated into 24 micro watersheds for morphometric analysis (Fig. 3.).

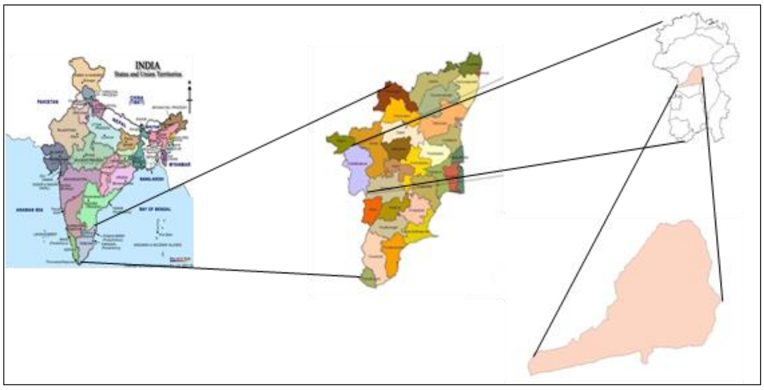

Fig 1: Location map of the study area

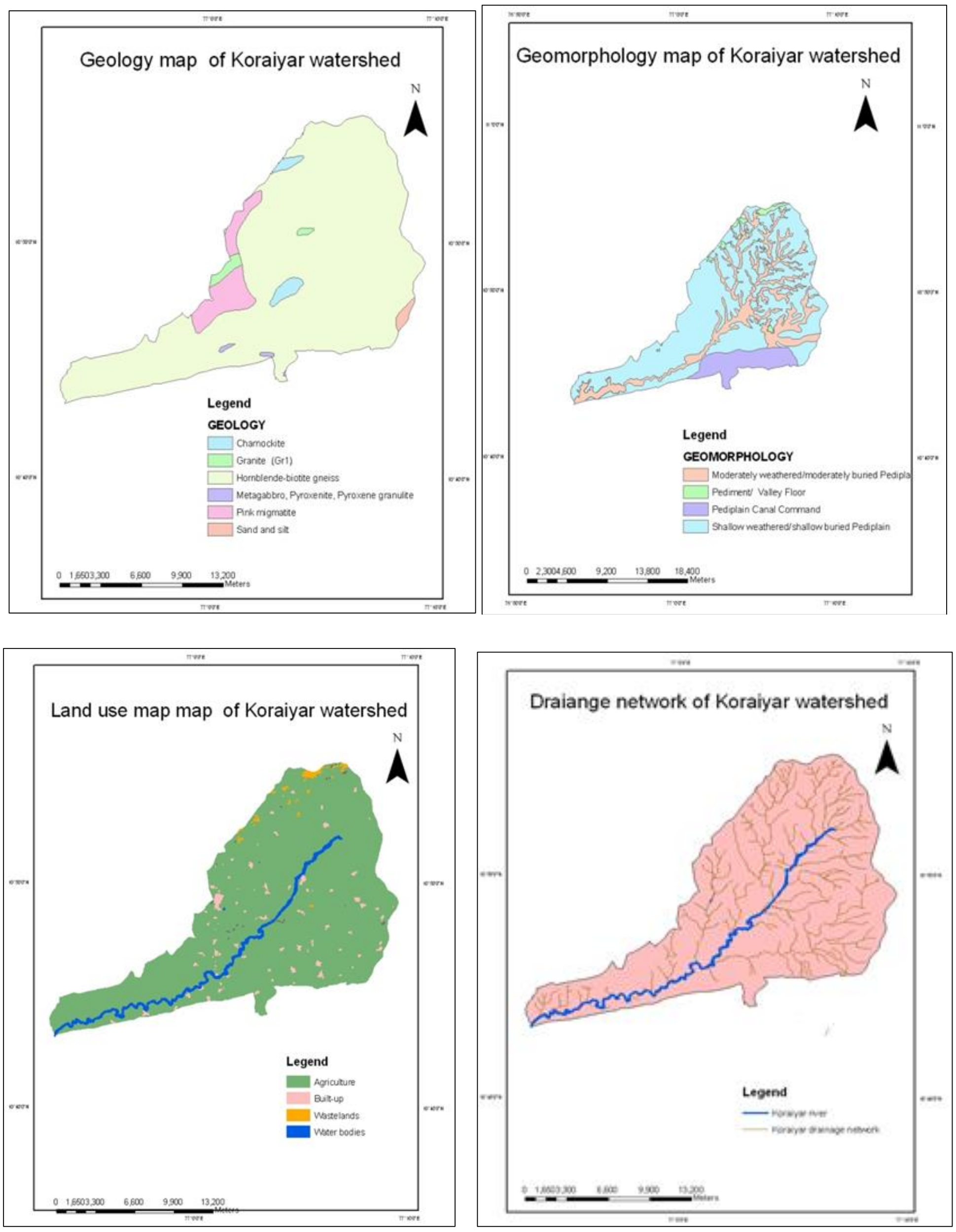

Fig 2: Thematic Maps

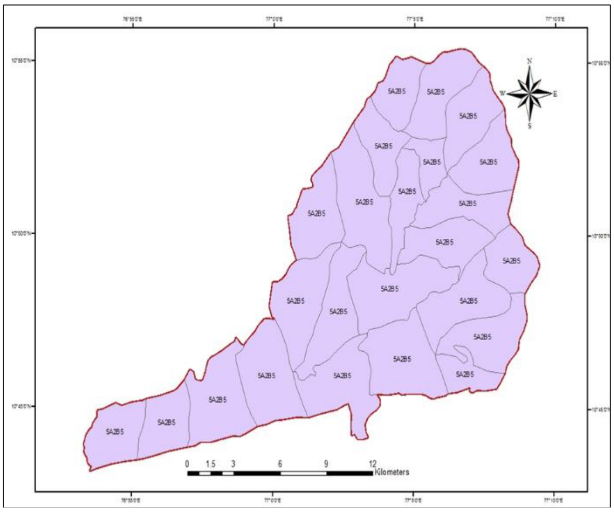

Fig 3: Delineated micro watershed of the study area for morphometric analysis

Methodology

Watershed morphometric characteristics contains linear aspects, areal aspects and relief aspects. The watershed delineation and stream network preparation were done in GIS platform from ASTER DEM having resolution 30 m. Other morphometric parameters were calculated manually.

Linear aspects of morphometric parameters

In this study, various linear aspects of the basin such as stream number, stream order, stream length, mean stream length, bifurcation ratio, and stream length ratio were calculated. These parameters and the formula to calculate them are described in Table 1.

Table 1: Formula to calculate linear aspects of morphometric parameters

Linear aspects	Formula	Reference
Stream order (U)	Hierarchical rank	Strahler (1964)
Stream length (L_u) in km	Length of the stream segment	Horton (1945)
Stream number (N_u)	Number of stream segments	Strahler (1964)
Mean stream length (L_{sm})	Ratio between L_u and N_u where L_u = Total stream length of order 'u' N_u= Total no. of stream segments of order 'u'	Strahler (1964)
Bifurcation ratio (R_b)	$R_b = \frac{N_u}{N_{u+1}}$ Where N_u = Total no. of stream segments of order 'u' N_{u+1} = Number of segments of the next higher order	Schumm (1956)
Mean bifurcation ratio (R_{bm})	R_{bm} = Average of bifurcation ratios of all orders	Strahler (1957)
Stream length ratio (R_L)	$R_L = \frac{L_u}{L_{u-1}}$ L_u = Total stream length of order 'u' L_{u-1} = Total stream length of its next lower order	Horton (1945)

Areal aspects of morphometric parameters

The areal aspects of the watershed like drainage density, stream frequency, drainage intensity, drainage texture, infiltration number, texture ratio, elongation ratio, circulatory ratio, form factor, length of overland flow and channel maintenance factor were calculated as described in Table 2.

Table 2: Formula to calculate areal aspects of morphometric parameters

Areal aspects	Formula	Reference
Drainage density (D) in km/km^2	$D = \frac{L_u}{A}$ Where L_u = Total stream length of order (km) A = Area of the basin (km^2)	Horton (1945)
Stream frequency (F_s)	$F_S = \frac{N_u}{A}$ Where N_u = Total no. of streams of all orders A = Area of the basin (Km^2)	Horton (1945)
Drainage texture (R_t)	$R_t = \frac{N_u}{P}$ Where N_u = Total no. of streams of all orders P =Basin Perimeter (km)	Horton (1945)
Elongation ratio (R_e)	$R_e = \frac{\sqrt{\left(\frac{4 \; x \; A}{\pi}\right)}}{L_b}$ Where A = Area of the Basin (km^2) L_b = Basin length (km)	Schumm (1956)

Circularity ratio (R_c)	$R_c = \frac{(4\ x\ \pi\ x\ A)}{P^2}$ Pi = 'Pi' value i.e. 3.14 A = Area of the Basin (km^2) P = Perimeter (km)	Miller (1953)
Form Factor (F_f)	$F_f = \frac{A}{(L_b)^2}$ Where A = Area of the Basin (km^2) L_b^2= Square of Basin Length (km)	Horton (1945)
Length of overland flow (L_g)	$L_g = \frac{1}{2D}$ Where D = Drainage density	Horton (1945)
Channel maintenance factor (C_m)	$C_m = \frac{1}{D}$ Where D = Drainage density	Schumm (1956)

Relief aspects of morphometric parameters

Relief aspects of a drainage basin replicate the topographical gradient characteristics of the basin and give a bird's eye view of the whole area (Pophare and Balpande, 2014) [9]. The relief aspects of watershed such as total relief, relief ratio, relative relief and ruggedness number were computed by the method as described in Table 3.

Table 3: Formula to calculate relief aspects of morphometric parameters

Relief aspects	Formula	Reference
Total relief (H)	Maximum vertical distance between the lowest (outlet) and highest (divide) points on the valley floor of a watershed	-
Relief ratio (R_h)	$R_h = \frac{H}{L_b}$ Where H = Total relief of the basin (km) L_b = Basin length (km)	Schumm (1956)
Relative relief (R_p)	$R_p = \frac{H}{P}$ Where H = Total relief P = Basin perimeter	Melton (1958)
Ruggedness number (R_n)	R_n = H x D Where D = Drainage density H = Total relief of the basin (km)	Strahler (1964)

Result and Discussion

Linear Aspects

Total number of 21 streams are identified of which 14 are 1st order streams, 3 are 2nd order, 3 are 3rd order and one is indicating 4th order stream. Total length of 1st order streams is 5.214 Km, 2nd order streams 4.113 Km, 3rd order streams 1.987 Km and 4th order stream is 0.022Km. The mean stream length of the watershed is found to be 0.372, 1.371 and 0.662 km for 1st, 2nd and 3rd order streams respectively. Stream length ratio for the basin varies between 0.011 to 0.789. The stream length ratio (RL) is estimated of 0.789, 0.483 and 0.011 for II/I, III/II and IV/III orders, respectively.

In the present study, R_b varies from 1 to 4, 7 with an average of 2.9. It is estimated of 4.7, 1 and 3 for I/II, II/III and III/IV orders, respectively. R_b is not same from one order to its next order. It is observed that watershed is neither elongated nor circular in shape. The high value of R_b indicates structural complexity and low permeability (Pankaj, 2009). It also indicates that the value of R_b is not same from one order to next order. The higher value of R_b indicated strong structural control on the drainage pattern. This shows it's usefulness for hydrograph shape for watersheds similar in other respect. An elongated watershed has higher bifurcation ratio than normal and approximately circular watershed (Singh, 2003) [13]. It is indicated that the watershed chosen for the study is not circular in shape and would produce delayed peak flow.

Areal Aspects

The form factor for the study area is 0.214. For perfectly circular basin it should be greater than 0.78 (Choudhari *et al.*, 2014) [1]. Smaller the value of form factor more will be elongated basin and high peak flows of shorter durations. The value of Circulatory ratio for the watershed is 0.25. The value of Rc is influenced by the length and frequency of streams, geological structures, land use/land cover and slope of the basin.

The elongation ratio of watershed is 0.718. The varying slopes of watershed can be classified with the help of the index of elongation ratio, i.e. circular (0.9-0.10), oval (0.8-0.9), less elongated (0.7-0.8), elongated (0.5-0.7), and more elongated (<0.5). It is observed that the watershed is less elongated. The stream frequency of the watershed is 0.072**.** The drainage density of the watershed is 1.012 Km/Km^2. A low value of the drainage density indicates a relatively low density of streams and thus a slow stream response (Singh, 2004) [12]. Drainage texture is one of the important concepts of geomorphology which means the relative spacing of drainage lines. Value of Constant of channel maintenance (C) for the basin is 0.988 Km which is reciprocal of drainage density.

Relief Aspects

The maximum relief for the watershed is 0.324 Km. Relative relief for the watershed is 0.0211. The relief ratio for basin is 0.012. The Ruggedness number for the basin is 0.328 Km. This number represents that if drainage density is increased, keeping relief as constant then average horizontal distance from drainage divide to the adjacent channel is reduced. On the other hand, if relief increases by keeping drainage density as constant, the elevation difference between the drainage divide and adjacent channel will increase.

Summary and Conclusion

Geographical Information System (GIS) tools are used in the drainage delineation and their updation. Morphometric analysis is carried out through updated drainage. Linear aspects, areal aspects and relief aspects of the basin are measured for the analysis. The number of streams of various orders in watershed are counted and their lengths from mouth to drainage divide are measured with the help of GIS software. The circularity ratio is influenced by stream length, stream frequency (Fs), geological structures, land cover, climate, relief and slope of the basin. It is an important parameter, which indicates the stage of the basin. The watershed has less elongated shape and having strong relief and steep ground slope. The value of stream frequency (Fs) for the basin exhibit positive correlation with the drainage density value of the area indicating the increase in stream population with respect to increase in drainage density. According to Schumm (1956) [10], there is direct relationship between the relief and channel gradient. There is also a correlation between hydrological characteristics and the relief ratio of a drainage basin. The study will be useful for the planning of watershed harvesting and groundwater recharge projects on watershed basis.

Results of morphometric analysis show that micro-watersheds 5, 7, 13, 19, 21 and 23 are possibly having high erosion problems. Hence, suitablesoil erosion control measures are required in these micro watershedsto preserve the land from further erosion.

References

1. Choudhari K, Panigrahi B, Paul JC. Morphometric analysis of Kharlikani watershed in Odisha, India using spatial information technology. International Journal of Geomatics and Geosciences. 2014; 4(4).
2. Clarke JI. Morphometry from Maps. Essays in geomorphology. Elsevier Publ. Co., New York, 1966, 235-274.
3. Horton RE. Erosional development of streams and their drainage basins Hydrophysical approach to Quantitative Morphology, Bulletin of Geological Society of America. 1945; 56:276-370.
4. Kanth TA. Morphometric analysis and prioritization of watersheds for soil and water resource management in Wular catchment using Geo-spatial tools. Inter. J of Geo, Earth and Environ. Sci. 2012; 2(1):30-41.
5. Melton MA. Correlating structure of morphometric properties of drainage system and their controlling agents. The Journal of Geology. 1958; 66(4):442-460.
6. Miller VC. A quantitative geomorphic study of drainage basin characteristics on the Clinch mountain area, Virgina and Tennessee. Columbia University. Department of Geology. ONR, New York, 1953, 389-402.
7. Pankaj A, Kumar P. GIS-based Morphometric Analysis of Five Major Sub-watersheds of Song River, Dehradun District, Uttarakhand with Special Reference to Landslide Incidences. Journal of Indian Society of Remote Sensing. 2009; 37(1):157-166.
8. Pingale Santosh M, Harish Chandra, Sharma HC, Sangita Mishra S. Morphometric analysis of Maun watershed in Tehri-Garhwal district of Uttarakhand using GIS. International Journal of Geomatics and Geosciences. 2012; 3(2):373-784.
9. Pophare AM, Balpande US. Morphometric analysis of Suketi river basin, Himachal Himalaya, India. Journal of Earth System Science. 2014; 1237:1501-1515.
10. Schumm SA. Evolution of drainage systems and slopes in Badlands at Perth Amboy, New Jersey. Geological Society of America Bulletin. 1956; 67(5):597-646.
11. Shaikh Mustaq, Farjana Birajdar. Analysis of Watershed Characteristics Using Remote Sensing and GIS Techniques. International Journal of Innovative Research in Science, Engineering and Technology. 2015; 4(4):1971-1976.
12. Singh A, Nestmann K, Franz, Eldho TI. Estimating hydrological parameters for Anas catchment from watershed characteristics, International Conference on Advanced Modelling Technique for Sustainable Management of Water Resources, 2004, 30-33.
13. Singh RK, Bhatt CM, Prasad VH. Morphological Study of a watershed using remote sensing and GIS techniques. Hydrology Journal Indian association of hydrologists. 2003; 26(1-2):55-66.
14. Strahler AN. Quantitative Analysis of Watershed Geomorphology. Transactions American Geophysical Union. 1957; 38:913-920.
15. Strahler AN. Quantitative geomorphology of drainage basins and channel networks In: Chow VT (ed) Handbook Applied Hydrology, McGraw-Hill Book Company New York, 1964, 4-11.
16. Yongsheng Ma. GIS Application in Watershed Management. Nature and Science. 2004; 2(2):1-7.