Current Journal of Applied Science and Technology

41(36): 38-44, 2022; Article no.CJAST.92298
ISSN: 2457-1024
(Past name: British Journal of Applied Science & Technology, Past ISSN: 2231-0843, NLM ID: 101664541)

Morphometric Analysis Using Geospatial Techniques: A Case Study from Halayapura Micro-Watershed of Tumkur District, Karnataka, India

N. Manoj [a], K. S. Rajashekarappa [a], H. G. Ashoka [b], K. Devaraja [c] and Md. Majeed Pasha [d*]

[a] Department of Agricultural Engineering, University of Agricultural Sciences, Bangalore, India.
[b] Directorate of Research, University of Agricultural Sciences, Bangalore, India.
[c] AICRP on Dry Land Agriculture, University of Agricultural Sciences, Bangalore, India.
[d] WDPD, Project, College of Horticulture Bidar, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/CJAST/2022/v41i363965

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/92298

Original Research Article

Received 03 August 2022
Accepted 07 October 2022
Published 18 October 2022

ABSTRACT

Plans for land and water management in the Tumkur district of Karnataka's Halayapura micro-watershed were created using geospatial tools. The examination of morphological traits in a micro-watershed employed Arc GIS software. According to the current study, the drainage system had a dendritic design with trunk order 4. The micro-watershed has a maximum area of 503 ha, a maximum length of 4.40 km, and a maximum width of 2.20 km. The bifurcation ratio had a mean value of 2.5. It shows that there have been less structural disturbances to the micro-watershed. The region has permeable subsurface material, according to the drainage density value of 0.851 km. The micro-watershed is becoming closer to the watershed's elongated shape, according to the form factor value. The groundwater that can be used is 41.7 mm (70% of the expected recharge of 59.6 mm), and the recharge factor that was discovered was 7%. This indicates that 256.0 mm of water is total accessible resource, which includes soil moisture store, utilisable runoff, and recharge. Currently, 19.4% of the usable runoff is being used, and harvesting and conservation buildings are encouraging 9% of the extra water.

**Corresponding author: E-mail: 786012pasha@gmail.com;*

Keywords: Water management action plans; subsoil material; geospatial techniques; groundwater recharge.

1. INTRODUCTION

India's 329 million hectares (ha) of land area account for 2.40 percent of the world's total land area and provide 1/25th of the water supply. According to estimates, the nation's total usable water resources are 1086 km3. The average annual drainage flow in Indian river systems is assessed by the National Commission for Integrated Water Management Growth to be 1953 km3, and the country's annual surface water availability is 690 km3. The estimated natural groundwater recovery from rainfall in India is 342.43 km3, or 8.56% of the total annual precipitation in the nation. Nearly 89.46 km3 of additional groundwater might be enriched each year by canal irrigation.

About 7663 TMC of water resources are available throughout seven river basin basins. Currently, 58% of water sources are found in west-flowing rivers, where a greater proportion of water cannot be effectively used. Only 1695 TMC of surface water in the state is thought to be economically useable for agriculture.

In terms of groundwater, it has been estimated that the state has 485 TMC of groundwater available. However, there are differences in how groundwater is distributed around the state and used for irrigation. The coastal regions contain a significant amount of groundwater that cannot be used adequately. Karnataka has a surface water capacity of around 102 km3, of which roughly 60% originates from rivers flowing to the west and the remaining 40% from rivers flowing to the east. The Karnataka Rivers' total yearly production was calculated to be at 3475 TMC.

To produce statistics for the necessary hydrologic units, for instance, morphometric analysis of watershed b can be combined with other natural resource information layers, such as land use/land cover, wastelands, forest, villages, slope, etc. With the aid of this information, the watersheds may be prioritised, priority locations planned, and quickly chosen for treatment based on science [1-3]. Prioritizing watersheds, creating resource action plans, recommending ideal locations for groundwater recharge, and gathering socioeconomic and natural resource data are all possible uses for geographic information systems (GIS).

2. MATERIALS AND METHODS

The study area is a part of the Southern Transition Zone of Karnataka. December is the coldest month with mean daily minimum temperature of 18.30ºC, while May is the hottest month with mean daily maximum temperature of 38.10ºC. Relative humidity of over 87 per cent is common during monsoon period.The Survey of India (SoI) toposheet 4B3C5N1a of 1:50,000 scales with a contour interval of 20 m were used for the analysis of watershed characteristics namely, drainage pattern, network, contours, hydro geomorphological units and land use/ land cover respectively. ArcGIS is a software for creating, viewing, querying, editing, composing and publishing maps. It takes a lot of work to produce GIS data in the proper format, especially for hydrological analysis. ArcGIS 10.4 version was used to prepare the map layout and to get good output, which was easy to work and integrate the different feature class maps in a single layer [4-7].

Morphometry is the measurement and mathematical analysis of configuration of the earth’s surface and the shape and dimensions of its landforms. It includes, the analysis on systematic description of the watershed geometry and its stream channel system to measure the linear, aerial and relief aspects of the drainage network [8,9]. Morphometric analysis was carried out using topographical map of 4B3C5N1a.As per integrated missions for sustainable development (IMSD) guidelines, land use map, soil map, runoff potential map, stream order map, permeability map and slope maps are used for identifying the suitable sites for water harvesting structures by overlaying. Overlaying of these maps are done by using “Intersect” from “Overlay” option of “Analysis Tools” in ArcGIS. Percolation pond is normally suggested for recharging aquifer and used where surface storage is available for a restricted period. The required site conditions are having high permeability with higher stream order.

3. RESULTS AND DISCUSSION

Theexperimentisconductedaspertheexperimental planasdetailedundermaterialsand methods. The results of the experiment are detailed further under the following titles.

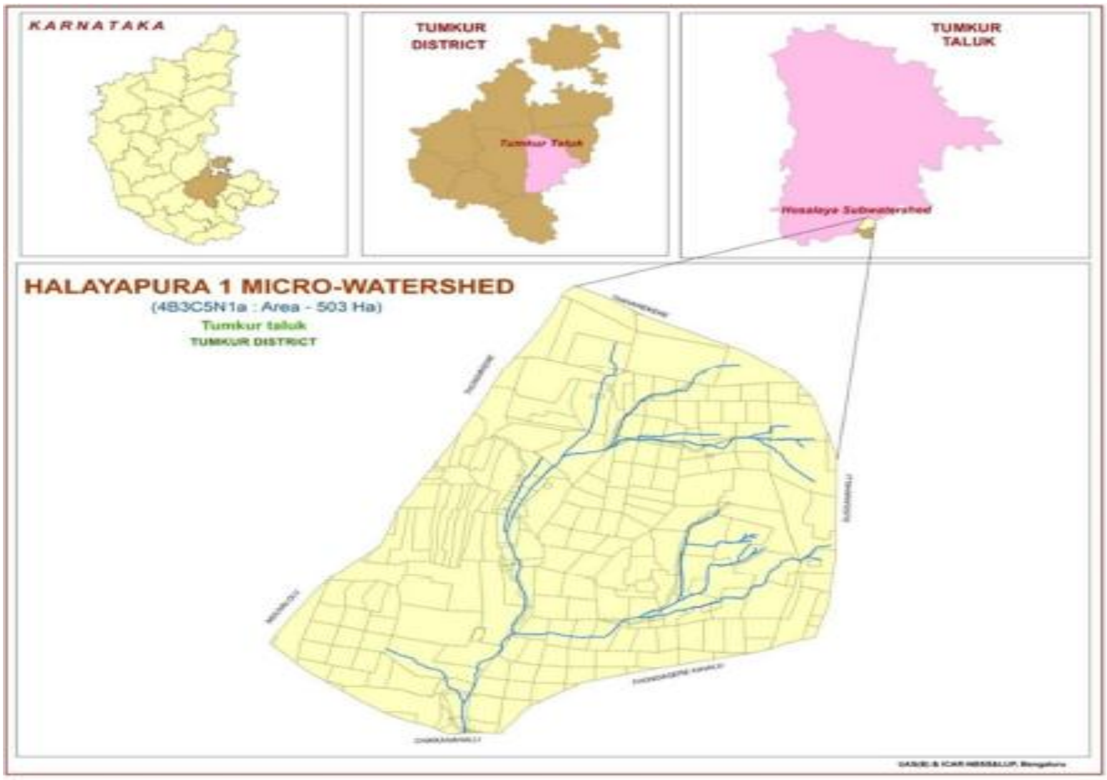

Fig. 1. Location map of Halayapura micro watershed

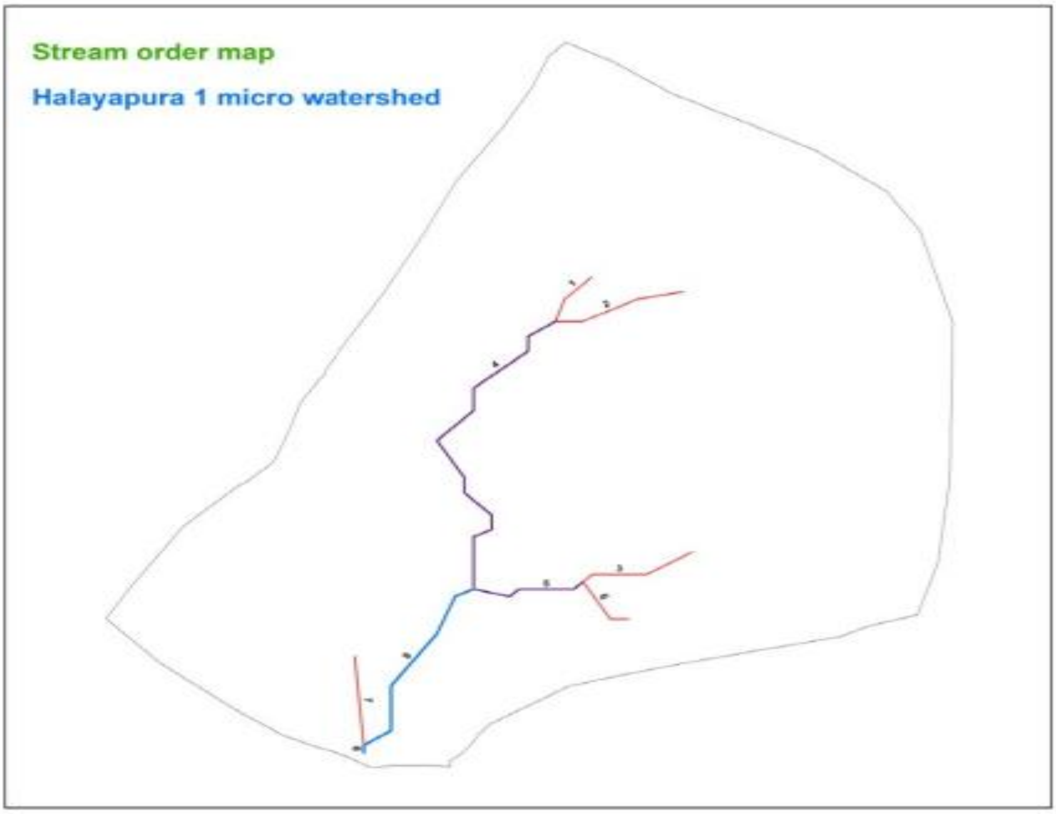

Fig. 2. Stream order map of Halayapura micro-watershed

Table 1. Equations adopted for estimating the morphometric analysis

Linear Aspects			
Sl. No.	**Parameter**	**Equations**	**Reference**
	Bifurcation ratio (R_b)	$R_b = \frac{N_u}{N_{u+1}}$ Nu = Number of streams of the given order Nu+1 = Number of streams of the next higher order	Schumn
Aerial aspects			
	Stream frequency (S_f)	$S_f = \frac{Nu}{A}$ N_u = Number of streams of order u A = Area of basin km^2	Horton [10]
	Drainage Density (D_d)	$D_d = \frac{N_l}{A}$ N_1= Length of streams of all orders A= Area of the basin	Horton
	Shape factor (S)	$S = \frac{L^2}{A}$ S= Shape factor in km A= Area of the basin km^2	Horton
	Form factor (R_f)	$R_f = \frac{A}{L_b^2}$ A = Area of watershed, km^2 L_b = Length of basin, km	Horton
	Elongation ratio (R_L)	$R_L = \left(\frac{1}{L_b}\right)\sqrt{\frac{A}{\pi}}$ L_b= Main channel length A = Area of the basin	Schumn
	Circulatory ratio (R_f)	$R_f = \frac{4\pi A}{P^2}$ A= Area of basian km^2 P= Perimeter of bas in km	Miller
	Length of overland flow (L_f)	$L_f = \frac{0.5}{D_d}$ L_f = Length of overland flow D_d = Drainage density	Horton

	Drainage texture (D_t)	$D_t = \frac{N_u}{P}$ N_u= Number order of stream u P = Perimeter of basin in km	Horton
Relief Aspects			
	Infiltration number (In)	$I_n = D_d * S_f$ D_d =Drainage density S_f =Stream frequency	Faniran
	Constant of channel maintenance (C_c)	$C_c = \frac{1}{D_d}$ C_c = Constant channel maintenance D_d = Drainage density	Schumn
13	Basin relief (R_b)	$R_b = E_{max} - E_{min}$ E_{max}= Maximum elevation, E_{min} = Minimum elevation	Strahler,
14	Relief ratio (R_r)	$R_r = \frac{R_b}{L}$ R_b = Basin relief L= Channel length in km	Schumn

3.1 Linear Aspects of Drainage Network

After analysis it was found that, the micro-watershed has 3rd order trunk stream and type of 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 4.29 km and 2.20 km respectively. The values of linear aspects are given in Table 1. The stream length of different orders and respective mean stream lengths were found out by digitizing the stream networks using ArcGIS software.

The bifurcation ratio (Rb), which represents the geological and tectonic characteristics of the watershed, is one of the other crucial characteristics of a drainage network's linear components. The stream's bifurcation ratio (Rb) value was determined to be 2.5. Because of this, the bifurcation ratio result was low, indicating that the micro-watershed had seen minimal structural disruption and that the drainage pattern had not been altered.

The stream length ratio (RL) has a value of 1.218. Changes in stream length ratios from one order to another indicate the geomorphic development of these streams is still in their early stages (Singh and Singh, 1997). Changes in slope and terrain were the cause of the variance in stream length ratio. Major valley length and main stream length were the two linear features of a micro-watershed that were discovered using ArcGIS software.

Table 2. Linear aspects of drainage network

Sl no.	Parameters	Output
1.	Stream order	3
2.	Stream length	4.299 km
3.	Streams number	8
4.	Bifurcation ratio	2.5
5.	Stream length ratio	1.218
6.	Mean stream length	477.66 m

3.2 Aerial Aspects of Drainage Network

The length of overland flows was represented in a systematic manner, as well as measurements of aerial features such drainage area, form factor, drainage density, drainage texture, stream frequency, circulatory ratio, elongation ratio, compactness co-efficient, and ellipticity index. The results showed that the form factor (Rf) value was found to be 0.2721 (Table 2). Low farm factor produces an elongated basin with flatter peak flow that lasts longer.

It was discovered that the drainage density (D_d) value was 0.851 km km-2. According to the stream frequency value of 1.78 km-2, the watershed has scant vegetation and impermeable subsurface material. The results showed that the circulating ratio (R_c) and elongation ratio (R_e) were, respectively, 0.786 and 0.872. Other morphological characteristics of the drainage basin that are connected to drainage density (D_d) include shape factor, texture ratio (R_t), and length of overland flow (L_g), which were determined to be 3.67, 0.557, and 0.558km, respectively.

Table 3. Aerial aspects of drainage network

Sl no.	Parameters	Output
1.	Drainage density (km km^{-2})	0.851
2.	Stream frequency (km^{-2})	1.78
3.	Shape factor	3.67
4.	Circulatory ratio (R_c)	0.786
5.	Elongation ratio (R_e)	0.872
6.	Length of overland flow (L_g), (km)	0.588
7.	Form factor (R_f)	0.2721
8.	Texture ratio (R_t)	0.557

Table 4. Relief aspects of drainage network

Sl no.	Parameters	Output
1.	Basin relief, (m)	53
2.	Relative relief (R_R)	0.59
3.	Ruggedness ratio	$4.505*10^{-5}$
4.	Relief ratio (R_r)	0.018
5.	Time of concentration (T_c), (min)	48

3.3 Relief Aspects of Drainage Network

Relief ratio (Rr), relative relief (RR), and basin relief were calculated to be worth 53 m, 0.59, and 0.018 correspondingly. Ruggedness number value was computed as an addition to these attributes and was discovered to be 4.505*10-5. The current study's period of concentration is 48 minutes, which shows that more time is needed for water to travel from the watershed's far area to its outlet (Table 3).

4. CONCLUSION

The use of remote sensing and a geographic information system for planning water resource conservation was emphasised in the current study. Following the initial watershed delineation using Arc-GIS 10.40, many geomorphological parameters, including basin area and perimeter, linear aspects, aerial aspects, and relief aspects, were discovered. In terms of drainage basin characteristics, the estimated values of morphological characteristics have been interpreted. The third order trunk stream in the Halayapura micro-watershed has a dendritic drainage pattern, indicating a lack of structural control and homogeneity in texture. The micro-maximum watershed's length and width were discovered to be 4.40 km and 2.20 km, respectively. The drainage density value, which was discovered to be 0.854 km km-2, shows that the area has good plant cover and permeable subsoil.

It was discovered that the stream frequency value was 1.78 km-2, which denotes a high discharge carrying capacity and increased erosion risk. The results showed that the circulating ratio (Rc) and elongation ratio (Re) were, respectively, 0.786 and 0.872. The creation of the watershed is more elongated than circular as a result of the stronger elongation ratio than circulation ratio. The value of the elongation ratio in the current study, 0.872, implies a micro-watershed with an elongated shape. The results showed that the relative relief (RR) and relief ratio (Rr) were, respectively, 0.59 and 0.018. This demonstrates low relief value. The refractory basement rocks of the basin are mostly to blame for the low value of relief.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. 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.
2. Mallik MI, Bhat MS, Kuchay NA. Watershed based drainage morphometric analysis of Lidder catchment in Kashmir valley using GIS. Recent Res Sci and Tech; 2011.
3. Mesa LM, Morphometric analysis of a sub tropical Andean basin (Tucuman, Argentina). Environ. Geol; 2006.
4. Lakshmamma, Nagaraju D, Mahadevaswamy G., Siddalingamurthy S, Manjunatha S. Morphometric analysis of Gundal watershed, Gundlupettaluk, Chamarajanagar district, Karnataka, Indian Int. J. Geomatics Geosci; 2011.
5. Mohammed BP, Chalapathi K, Inayathulla M. Geomorphologic analysis of two mini-watersheds in raichur city Karnataka. Int. Res. J. Engg. Tech; 2019.
6. Nikam SP, Purohit RC, Shinde MG, Singh PK, Jain HK, Pravin Dahiphale. Principal component analysis for morphometric modelling for small watersheds of Tapi basin in India. Int Agri Engg;2014.
7. Patil NP, Kadale AS, Mhetre GS. Assessment of morphometric characteristics of Karwadi - Nandapur micro watershed using remote sensing and geographical information system. Int. J.Sci. Tech. Res; 2015.
8. Mittal HK. Anevaluatory study on morphological characteristics and ground water status in selected treated watersheds. Ph.D. Thesis, SWE Deptt. CTAE, MPUAT, Udaipur; 2002.
9. Nag SK. Morphometric analysis using remote sensing techniques in the Chaka sub-basin, Purulia district, West Bengal. J. of Indian Soc Rem Sens; 1998.
10. Horton RE. Erosional development of streams and their drainage basins; hydro physical approach to quantitative morphology. Geological Soci America Bull; 1945.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/92298