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Research Article

# ESTIMATION OF GEOMORPHOLOGICAL CHARACTERISTICS OF A SMALL WATERSHED IN RAICHUR DISTRICT OF KARNATAKA STATE

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**Abstract:** The present study was conducted in a watershed located in Raichur district of Karnataka state. The objective of the study was estimation of geomorphological characteristics of the watershed. All three aspects of watershed characteristic *viz*., Linear, Spatial and Relief aspects were determined. The watershed had an area of 289.39 ha. It was classified as micro watershed on the basis of size. Some important geomorphological characteristics that were determined are shape index, form factor, circularity ratio, elongation ratio. The values are 1.78, 0.55, 0.94, 0.84 respectively. The slope of the watershed was found to be 0.45%. Time of concentration ($T_c$) of the watershed was observed as 59.63 min. The length ratios ($R_L$) for two I order streams were 0.52 and 0.25 respectively. Drainage density ($D_d$) of the watershed was found to be 0.00079 m/m$^2$. Length of overland flow ($L_g$) was determined as 632.91 m. Constant of channel maintenance (C) was 1265.82 m. Relief ratio (Rh) of the watershed was found to be $4.44\times10^{-3}$. Relative relief ($R_{hp}$) was 0.15%. Ruggedness number was found to be 0.0079. Two I order streams and an II order stream were identified. Two checkdams were constructed across the I order streams. The storage volumes of both the check dams were determined as 48.51 m$^3$ and 286.77 m$^3$ respectively. The study has helped to assess the runoff potential of the watershed.

**Keywords:** *Watershed, Checkdam, Geomorphology, Shape, Stream*

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## Introduction

The demand of water resources is continuously increasing to maintain the food security that meets the demand of the population's domestic and industrial requirements. The existing water resources are not adequate to meet the demand [2]. However, there is surplus monsoon runoff which can be harnessed for creating surface and sub-surface storages by constructing different structures along the different drainage lines. It thus becomes essential to study important geomorphological characteristics of a watershed to calculate the potential runoff. Geomorphological characteristics of a watershed such as size, slope, shape and vegetation are important factors affecting various aspects of runoff (e.g., water yield, peak flow, base flow, direct storm runoff. A study found that the drainage morphometry is the study based on the measurement and mathematical analysis of geometry of relief features, shape and dimensions of drainage basin characteristics [3]. In a study of analysis watershed characteristics, it was concluded that the topography factor influences the watershed surface runoff time and rate. The shape of watershed influences the formation of hydrograph characteristic [4]. Hence the study was undertaken in Raichur district of Karnataka state with a specific objective of estimation of different watershed characteristics of a small watershed.

## Materials and Methods

The present study was carried out as a part of assessment of water harvesting potential of a small watershed in Raichur district of Karnataka state. The study area watershed was located at a Longitude from 77°29'45"E to 77°31'E and 16°13'30"N to 16°14'N Latitude. The watershed is covered in the Survey of India Topo Sheet No. 56 H/8 NW.

## Hydrology

The tank has an independent catchment of 283.39 ha. There are twenty bore wells in the catchment area. Analysis of 38 years of rainfall data from influencing Rain gauge station situated at Chandrabanda, about 8 km to the south of study area, shows that the average annual rainfall in the village is 630 mm with an annual average runoff of 283.90 mm. The study has indicated that the tank has received average minimum rainfall of 132.90 mm during 1997 and the average maximum rainfall of 1471 mm during 1975 [1]. The tank has surplus water during the 23 years with an average spill over of 0.109488 Mm$^3$ every year.

## Watershed characteristics of the watershed

The watershed under study had two I order streams and an II order stream contributing to the tank. A road was located on one end of the watershed. Two checkdams were constructed across both I order streams. Stream network, road and contours of the watershed are depicted in [Fig-1]. Various watershed characteristics like Shape, Size, Form factor, Circularity ratio, Elongation ratio, Bifurcation ratio, Length ratio, Time of concentration *etc* were found for the study watershed.

**i. Shape:** The shape of watershed is concern, coon shapes are:

1. Square
2. Rectangular
3. Triangular, *etc.*

The watershed shapes can be described by "shape index", given as:

$$Sw = \frac{L}{W} \text{ or } \frac{L^2}{A}$$

**ii. Form factor ($R_f$):** Basin shape was explained through a term called as form factor, which is defined as the ratio of basin area ($A_u$) to the square of the basin length ($L_b$), given as:

$$R_f = \frac{A_u}{L_b^2}$$

**iii. Circularity ratio ($R_c$):** It is used to mark the basin shape, which is the ratio of basin area ($A_u$) to the area of a circle ($A_c$) having equal perimeter as the perimeter of drainage-basin. It is given as:

$$R_c = \frac{A_u}{A_c} = \frac{p_c}{p} = \frac{2\sqrt{\pi A_u}}{p}$$

**iv. Elongation Ratio ($R_l$):** It is used as an index to mark the shape of drainage basin. It is defined as the ratio of diameter of a circle having same area as the drainage basin ($D_c$) to the basin length ($L_{bm}$), expressed as:

$$R_l = \frac{D_c}{L_{bm}} = \frac{2}{L_{bm}}\sqrt{\frac{A_u}{\pi}}$$

Where,
$A_u$ = Area of drainage basin, $m^2$
$L_{bm}$ = Basin length, m

**v. Slope:** The average slope of watershed can be determined from the topographic map of the watershed, by using following formula.

$$S = \frac{Elevation\ difference\ between\ outlet\ and\ most\ distant\ ridge}{Approximate\ average\ length\ of\ watershed}$$

**vi. Time of concentration ($T_c$):** The time taken by water to travel from the most distant point of the watershed to the outlet or some other downstream point of reference is called as time of concentration

$$T_c = 0.01947\ L^{0.77} S^{-0.385}$$

Where,
$T_c$ = Time of concentration, min
L = Length of the main stream along the watershed, m
S = Average slope of the watershed, m/m

**vii. Bifurcation ratio ($R_b$):** It is defined as the ratio of number stream segments of a given order (u) to the number of stream segments of next higher order (u+1), expressed as:

$$R_b = \frac{N_u}{N_{u+1}}$$

viii.**Length ratio (RL):** It is defined as the ratio of mean length of stream segment ($(\bar{L}_u)$of the order 'u' to the mean length of stream segment of next lower order $(\bar{L}_{u-1})$ , expressed as:

$$R_L = \frac{\bar{L}_u}{\bar{L}_{u-1}}$$

**ix. Drainage density ($D_d$):** It is treated as the important indicator of linear scale of land-form elements in the stream-eroded topography. The Drainage density ($D_d$) is defined as the ratio of total length of all stream - segments (*viz*., cumulative length of stream segments of all order) within the specified basin to the basin area, projected on the horizontal surface, expressed as,

$$D_d = \frac{\sum_{i=1}^{N} L_u}{A_u}$$

**x. Length of overland flow ($L_g$):** Length of overland flow is defined as the length of flow path, projected on the horizontal plane of non-channel flow, from the point on drainage divide to the adjacent stream channel. The length of overland flow is calculated as one-half of the reciprocal of the drainage density ($D_d$)

$$L_g = \frac{1}{2D_d}$$

**xi. Constant of channel maintenance (C):** It is used to describe the morphological property of drainage basin. Defined as inverse of drainage density *i.e.,*

$$C = \frac{1}{D_d} = \frac{A_u}{\sum_{i=1}^{N} L_u}$$

**xii. Relief ratio ($R_h$):** It is the ratio of relief (H) to the horizontal distance (L) on which the relief was measured. *i.e.,*

$$R_h = \frac{H}{L}$$

**xiii. Relative relief ($R_{hp}$):** This term is used to measure the relief of watershed and defined as the ratio of relief (H) to the perimeter (p) of the watershed.

$$R_{hp} = \frac{H}{p} \times 100$$

**xiv. Ruggedness number:** The product of relief (H) and drainage density ($D_d$) is denoted as the ruggedness number.
*i.e.,* Ruggedness number = $H \times D_d$

**Storage capacity of check dams**

There were two checkdams located in the watershed across the streams. One of the checkdams is depicted in [Fig-2]. The checkdam with the dimensions are shown in [Fig-3]. The volume of water storage of check dams in the study watershed was calculated using the following formula:

$$V = \frac{2}{3} \times h \times l \times w$$

Where,
V = Volume of water storage ($m^3$)
h = Height of head wall (m)
l = Length of water storage area (m)
w = Length of head wall (m)

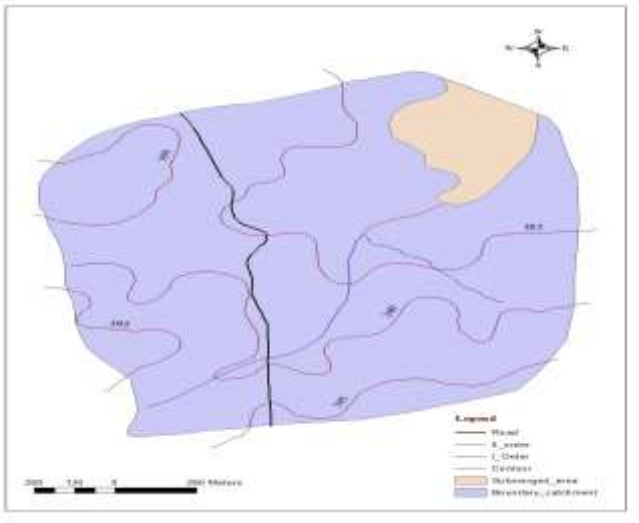

Fig-1 Stream network, road network and contours in study watershed

**Results and Discussion**

Several characteristics of watershed were observed and the results are summarized in [Table-1]. The area of the watershed ($A_u$) was measured and it was found to be 283.39 ha, the perimeter (p) of the watershed was 6344.79 m. The maximum length of watershed along the main stream ($L_b$) was recorded as 2250 m. Average width (W) of the watershed was determined by dividing the area by maximum length and it was found to be 1259.52 m. There are two I order streams and one II order stream in the watershed.

The lengths of I order streams were measured as 1309.10 m and 621.32 m respectively whereas the length of the II order stream was 326.75 m. The maximum and minimum elevations in the watershed were recorded as 395 and 385 m respectively. Based on the above observations, different geomorphological characteristics were determined and presented in [Table-2]. The shape of the watershed is described by shape index. The shape index of the Wadlamdoddi watershed was found to be 1.78. The form factor ($R_f$) was found to be 0.55. Circularity ratio ($R_c$) is another aspect which predicts the shape of the watershed and it was observed to be 0.94. Elongation ratio ($R_l$) of the watershed was determined and has the value of 0.84. The slope of the watershed was found to be 0.45per cent. Time of concentration ($T_c$) of the watershed was observed as 59.63 min. The bifurcation ratio ($R_b$) was determined and it has the value of 2. The length ratios ($R_L$) for two I order streams were 0.52 and 0.25 respectively. Drainage density ($D_d$) of the watershed was found to be 0.00079 m/m$^2$. Length of overland flow ($L_g$) was determined as 632.91 m. Constant of channel maintenance (C) was 1265.82 m. Relief ratio ($R_h$) of the watershed was found to be $4.44\times10^{-3}$. Relative relief ($R_{hp}$) was 0.15 per cent. Ruggedness number was found to be 0.0079. The results of the present study were on par with the findings of (Chitra *et al*., 2011) and (Tran and Melinda, 2013).

Fig-2 A checkdam in the catchment of watershed

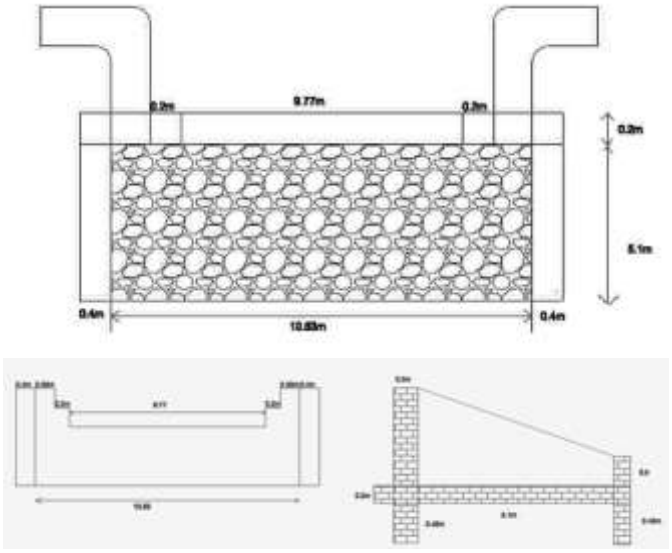

Fig-3 Conceptual drawing of checkdam

**Storage capacity of check dam**

There were two check dams located in the watershed at 16°12'37.9"N, 77°29'43.9"E and 16°12'46.1"N, 77°29'56.3"E. The locations of checkdams in the watershed are shown in [Fig-4]. Both the check dams were constructed across two I order streams and their dimensions are presented in [Table-3]. The lengths of head wall of two check dams were found to be. 10.63 m and 17.38 m respectively. Heights of head wall were 0.60 m and 1.00 m respectively. The length of head wall extensions were measured as 0.40 m and 0.45 m respectively. The aprons are sloping type and lengths of apron were 5.10 m and 7.35 m respectively. The slopes of apron were found to be 5:1 and 6.4:1 respectively. End sill is provided to both the check dams each at the height of 0.20 m and 0.25 m respectively. The height of cut-off wall was 0.45 and 0.60 m respectively. The storage volumes of both the check dams were determined and were found to be 48.51 m$^3$ and 286.77 m$^3$ respectively. Hence the total water storage by check dams was 335.28 m$^3$.

Table-1 *Watershed characteristics of the watershed*

| SN | Particulars | Values |
|---|---|---|
| 1 | Area, ha | 283.39 |
| 2 | Perimeter, m | 6344.79 |
| 3 | Maximum length along the main stream, m | 2250 |
| 4 | Average width, m | 1259.52 |
| 5 | Length of I order streams, m | i. 1309.10 |
| | | ii. 621.32 |
| 6 | Length of II order stream, m | 326.75 |
| 7 | Maximum elevation, m | 395 |
| 8 | Minimum elevation, m | 385 |

Table-2 *Geomorphological characteristics of the watershed*

| SN | Watershed characteristics | Values |
|---|---|---|
| 1 | Shape Index | 1.78 |
| 2 | Slope, % | 0.45 |
| 3 | Time of Concentration, min. | 59.63 |
| 4 | Bifurcation Ratio | 2 |
| 5 | Length ratio | 0.52 and 0.25 |
| 6 | Drainage density, m/m$^2$ | 0.00079 |
| 7 | Length of Overland Flow, m | 632.91 |
| 8 | Form Factor | 0.55 |
| 9 | Circularity Ratio | 0.94 |
| 10 | Elongation Ratio | 0.84 |
| 11 | Constant of Channel Maintenance, m | 1265.82 |
| 12 | Relief, m | 10 m |
| 13 | Relief Ratio | $4.44\times10^{-3}$ |
| 14 | Relative Relief, % | 0.15 |
| 15 | Ruggedness Number | 0.0079 |

Table-3 *Dimensions of the check dams located in Wadlamdoddi watershed*

| SN | Particulars | Checkdam I | Checkdam II |
|---|---|---|---|
| 1 | Length of head wall, m | 10.63 | 17.38 |
| 2 | Height of head wall, m | 0.60 | 1.00 |
| 3 | Length of head wall extension, m | 0.40 | 0.45 |
| 4 | Length of apron, m | 5.10 | 7.35 |
| 5 | Slope of apron | 5:1 | 6.4:1 |
| 6 | Height of end sill, m | 0.20 | 0.25 |
| 7 | Height of cutoff wall, m | 0.45 | 0.60 |

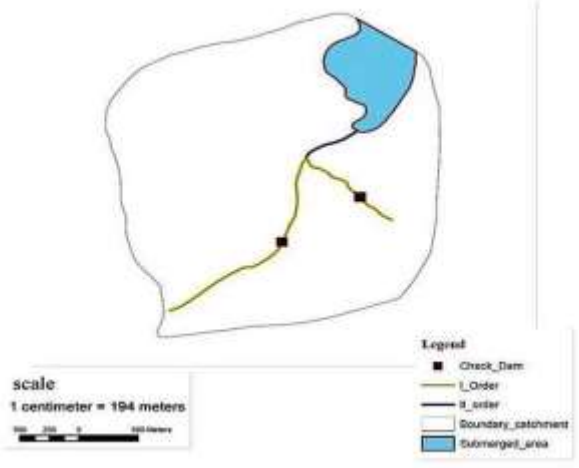


Fig-4 Location of check dams in the watershed

**Application of research:** Watershed management and tank development in the dryland catchment area

**Research Category:** Soil and water conservation

**Abbreviations:** None

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**Study area / Sample Collection:** Raichur District, Karnataka State

**Cultivar / Variety name:**

**Conflict of Interest:** None declared

**Ethical approval:** This article does not contain any studies with human participants or animals performed by any of the authors.
Ethical Committee Approval Number: Nil

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