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PRIORATIZATION OF SITES FOR ARTIFICIAL RECHARGE STRUCTURES USING MORPHOMETRIC PARAMETERS :CASE STUDY IN BASALTIC REGION, AMRAVATI DISTRICT, MAHARASHTRA.

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ABSTRACT

The criteria for the choice of sites depend not only on the groundwater conditions, but also on the suitability of the terrain for artificial-recharge. The suitability depends on analysis of drainage morphometry. Drainage basin morphometry is a quantitative way of describing the characteristics of the surface form of a drainage basin and provides important information about the region's topography and underlying geological structures. It plays an important role in hydrogeological investigations for delineating zones of adequate groundwater potential and selecting sites for construction of artificial recharge structures (Zaidi, 2011).

In order to identify regions having favorable groundwater-potential zones where artificial-recharge techniques can be employed, a set of decision rules involving the geomorphic parameters controlling the groundwater flow need to be considered. Geomorphic studies are helpful in regionalizing hydrologic models in basins. The morphometric analysis helps to understand complete terrain parameters which lead to finalize watershed development planning and management with respect to water conservation (Zende, Nagrajan, 2011). Linking of geomorphic parameters with hydrologic characteristics of the basin provides a simple way to understand the hydrologic behavior of different basins. Morphometry incorporates quantitative study of the area of drainage basin (Savindra Singh, 1972).

Drainage morphometric analysis is a useful tool in locating sites as they provide comparative indices of the permeability of rock surfaces. This can be combined with other hydrogeological characteristics for developing strategy for sighting water-harvesting structures. Hence, morphometric analysis of various drainage basins has been made to priorities location of sites for artificial recharge.

1. AIMS AND OBJECTIVES

The main aim of artificial recharge of groundwater in the watershed is to restore supplies from aquifers depleted due to excessive draft and /or to improve supplies from aquifers lacking adequate natural recharge both in time and space. This also helps in conserving excess surface water in underground for future use and also to improve physical and chemical quality of water. To achieve these objectives, it is essential that the site selected for recharge satisfies the basic requirements of storage and retrieval and requires proper scientific investigations. The main objectives of the proposed study is to understand the geomorphology of Percolation tank , the most practiced type of Artificial recharge structure in basaltic region and also to understand controls of morphometric parameters over it.

2. STUDY AREA

With the above aim in mind percolation tanks were selected from Amravati District, Maharashtra to evaluate their efficiencies in different geomorphological, conditions and develop guidelines for selection of appropriate techniques on scientific basis in the region. Amravati District is one of the eleven districts of Vidarbha region of Maharashtra. It is situated in the northern part of the State and lies between north latitudes 20°3 2' and 21°46' and east longitudes 76°37' and 78°27'. The total area of the district is 12210 sq. km. and falls in Survey of India degree sheets 55 G, 55 H, 55 K and 55 L. The district is bounded on the north by Madhya Pradesh State, on the east by Nagpur and Wardha districts, and on the south and south west by Yavatmal, Akola and Buldhana districts. Badnera and Amravati are nearest railway stations located at distance 20 km and 5 km respectively. Artificial recharge structures with their locations in Amravati district selected for present study are given in Table No.1.1 and Fig. No.1.1.

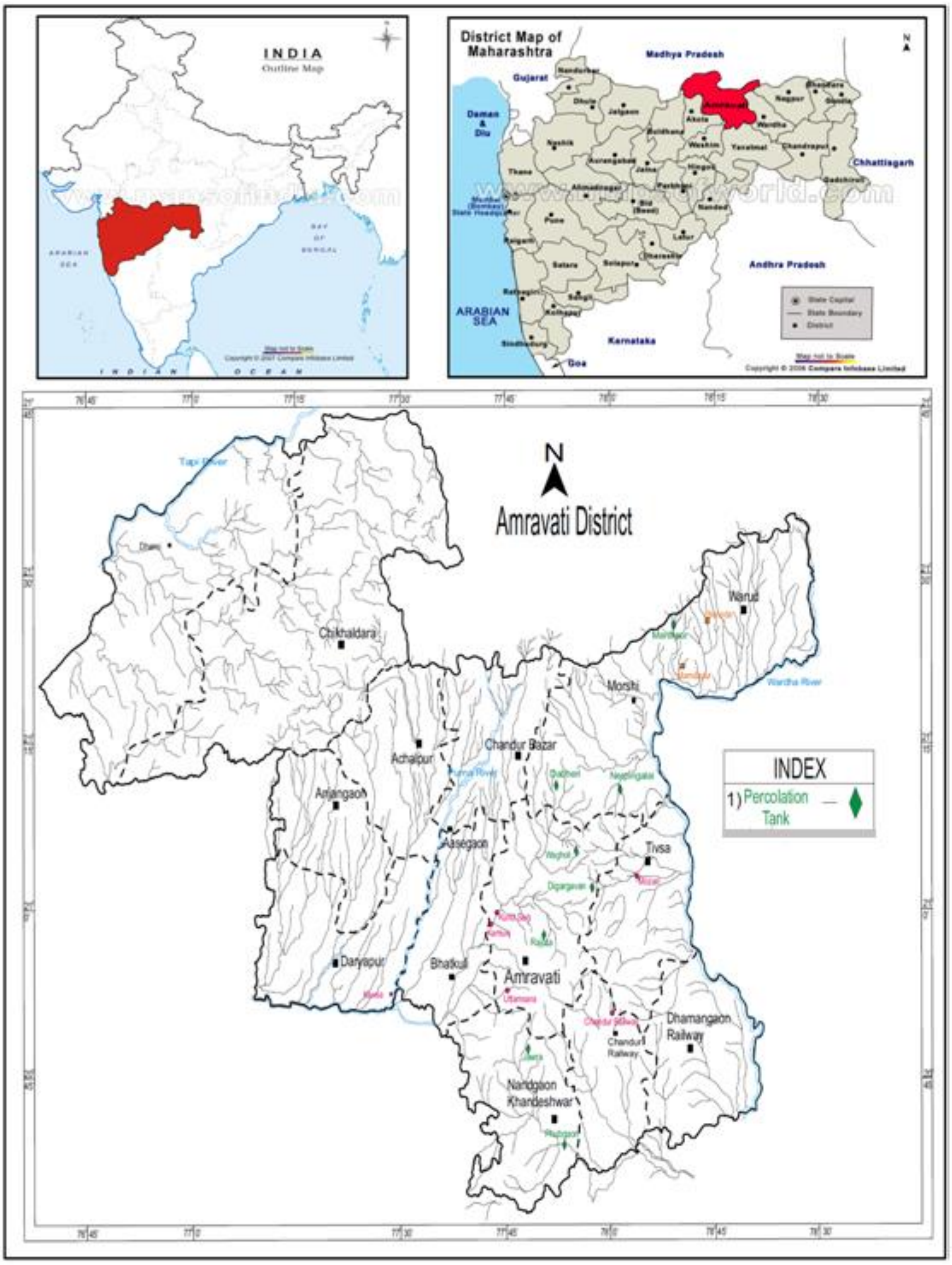


Fig No.1.1
Location map of the study area

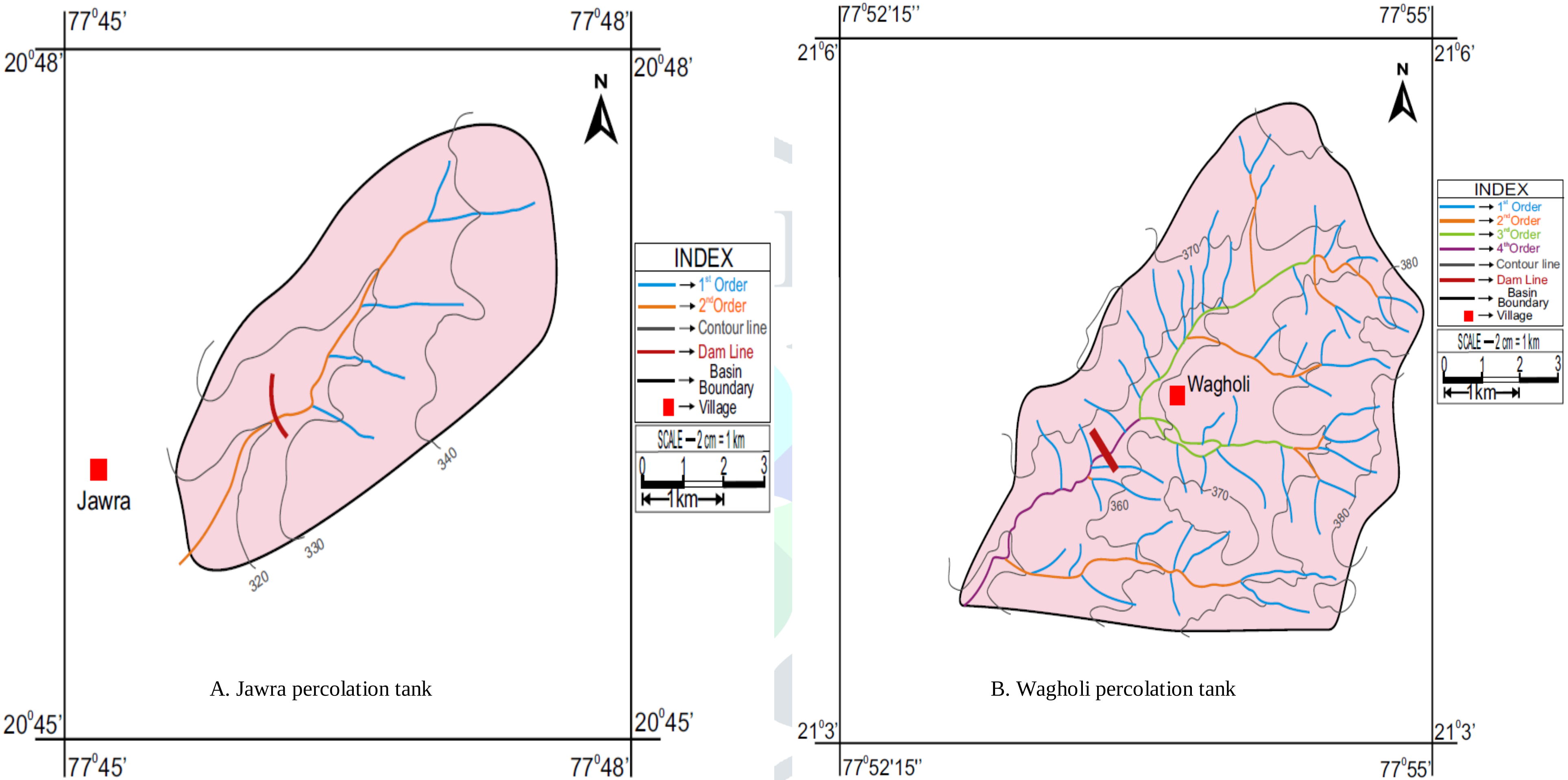
Table No. 1.1
Selected Artificial Recharge Structures

Sr. No.	Name of Structure	Location and Toposheet No.	Latitude - Longitude	Lithology
Percolation Tank				
1	Rajura	Amravati, 55H/13	N21^{0}55’30’’to21^{0}58’ and E77^{0}48’to77^{0}50’	Deccan Trap
2	Nerpingalai	Morshi, 55G/16, 55K/4	N21^{0}10’30”to21^{0}12’30”and E77^{0}59’to78^{0}1’30’’	Deccan Trap
3	Wagholi	Amravati, 55G/16	N21^{0}3’to21^{0}6’and E77^{0}52’15’’to77^{0}55’	Deccan Trap
4	Digargavan	Amravati, 55G/16	N21^{0}2’to21^{0}4’15’’and E77^{0}54’to77^{0}56’30’’	Deccan Trap
5	Jawra	Nandgaon Khandeshwar, 55H/13	N20^{0}45’to20^{0}48’and E77^{0}45’to77^{0}48’	Deccan Trap

3. METHODOLOGY

Following methodology has been adopted for the study:

Reconnaissance study of the data available for eleven artificial recharge sites was undertaken from the previous studies and reports. Preparation of drainage map of each artificial recharge structure on 1:50,000 scale using Survey of India Toposheets Numbered 55H/9, 55G/16, 55H/13, 55H/14, 55K/4, 55H/5 and 55K/3. Detailed morphometric analysis of the Percolation tank structures on 1:50000 scale. In the present study an attempt has been made to find out favorable locations for locating sites for artificial recharge by drainage morphometric analysis.

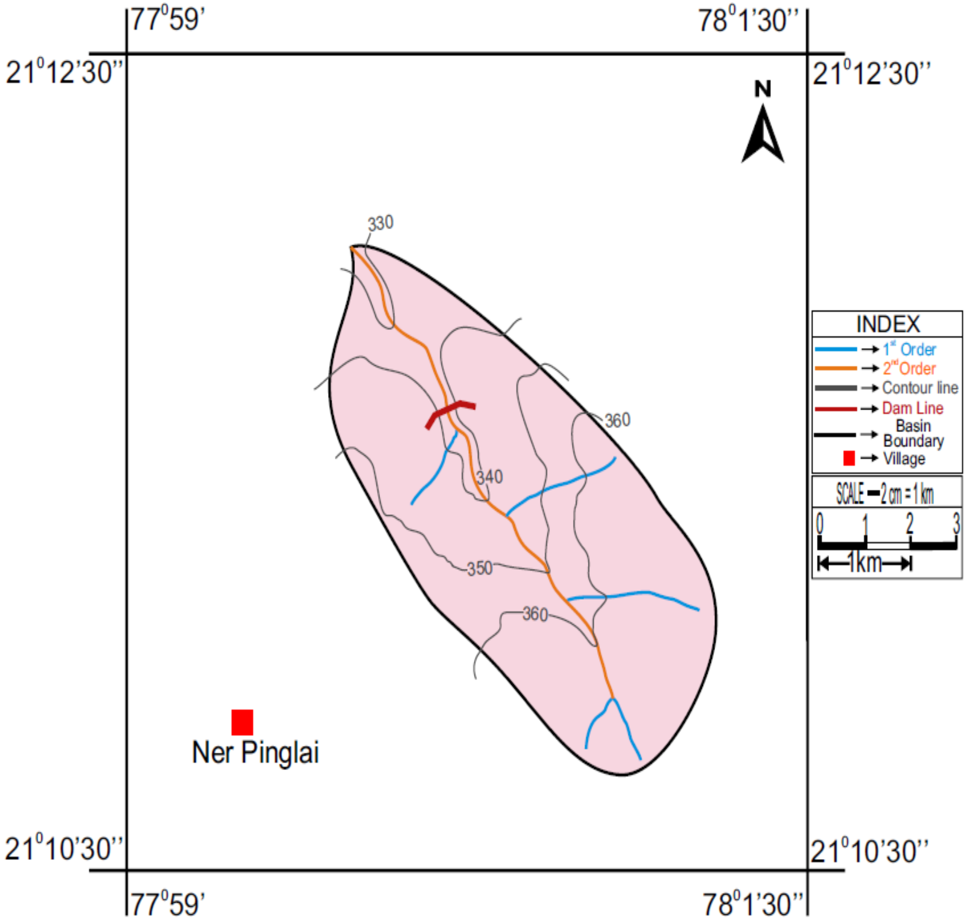


A. Jawra percolation tank

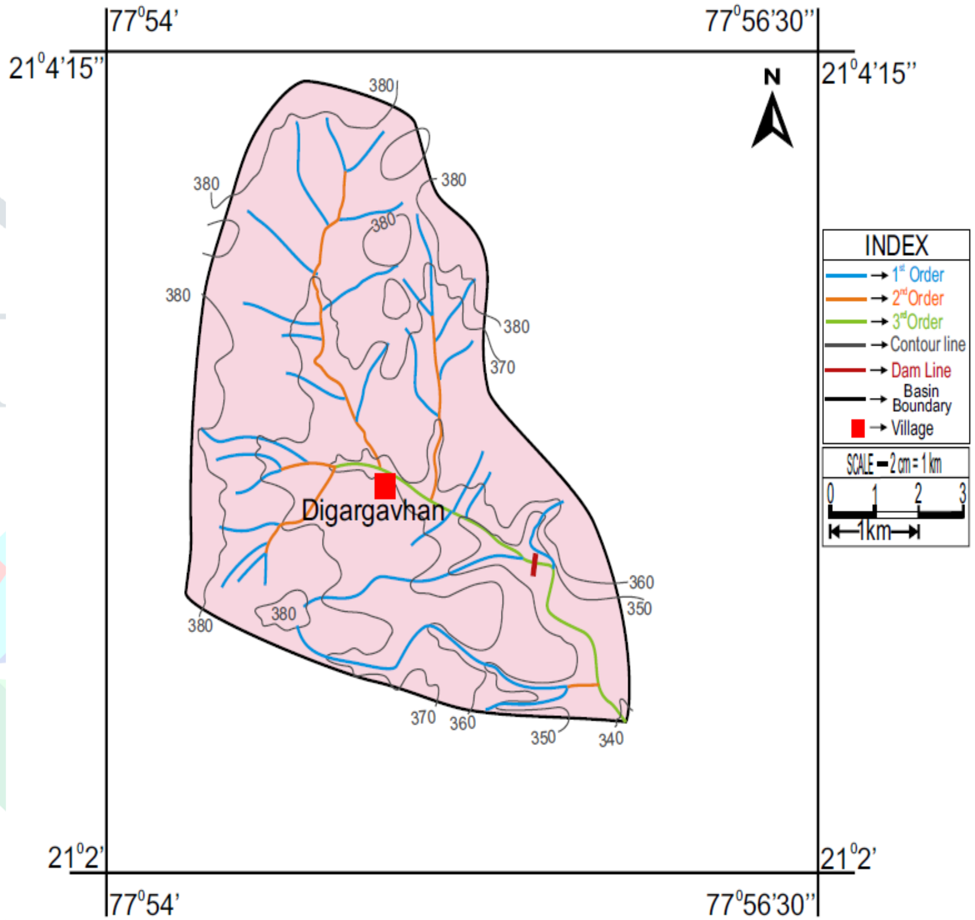
B. Wagholi percolation tank

Fig. No. 3.1

Drainage map of Jawra and Wagholi percolation tanks

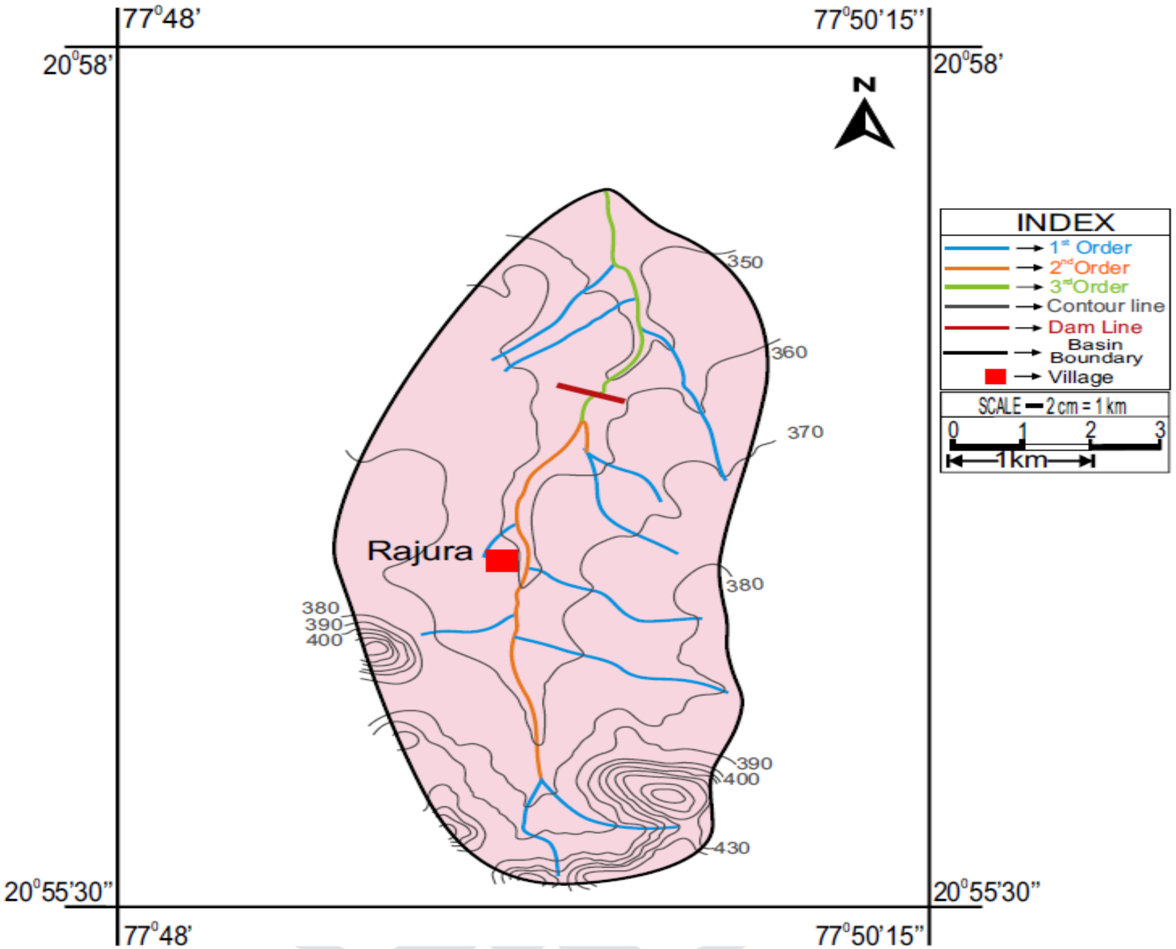


C. Nerpinglai percolation tank



D. Digargavan percolation tank

Fig. No. 3.2
Drainage map of Nerpinglai and Digargavan percolation tanks



E. Rajura percolation tank

Fig. No. 3.3

Drainage map of Rajura percolation tank

4. MORPHOMETRIC ANALYSIS

Morphometry may be defined as the measurement and mathematical analysis of the shape and dimensions of its landforms (J. I. Clarke, 1996). It incorporates quantitative study of the area, altitude, volume, slope of the land and drainage basin characteristics of the area concerned (Savindra Singh, 1972). Detailed morphometric analysis of basins of each structure has been carried out on 1:50,000 scale using Survey of India toposheets Nos. 55H/13, 55G/16, 55K/4, 55H/14, 55 H/9 and 55K/3. The drainage patterns of the five percolation tanks are represented in Fig. No. 3.1, 3.2 and 3.3

4.1 Linear Aspects

Linear aspects of the basins are related to the channel pattern of the drainage network wherein the topological characteristics of the stream segments in terms of open links of the network system (streams) are analyzed (Savindra Singh, 2009). The linear aspects include stream order, stream number, bifurcation ratio, stream lengths, length ratio, length of overland flow, constant of channel maintenance etc. and the observations presented in Table No. 4.1.

Stream Order

The primary step in drainage basin analysis is order designation and is based on a hierarchic ranking of streams. Stream ordering was developed by Horton (1932) and slightly modified by Strahler (1952). In the present study, ranking of streams has been carried out based on the method proposed by Strahler (1969). When two first-order streams come together, they form a second order stream. When two second order streams come together, they form a third order stream. Streams of lower order joining a higher order stream do not change the order of the higher stream. As regard stream order three percolation tanks, Phubgaon, Nerpingalai and Jawara falls on second order streams, Rajura, Digargavan on third orders while percolation tank of Wagholi is on fourth order (Table No.4.1).

Stream Number (N)

The numbers of stream segments (N) at percolation tanks are presented in Table No.5.1. Among second order basins both Ner Pinglai and Jawra have total 6 streams. In third order basins, Rajura has total 14 streams, Digargavan has total 35 streams and the basin of Wagholi is of fourth order including total 59.

Stream Length (L)

Streams of relatively smaller lengths are characteristics of areas with larger slopes and finer textures. Longer lengths of streams are generally indicative of flatter gradients. Generally, the total length of stream segments in first order streams is maximum and decreases as the stream order increases. Length of streams for all percolation tanks are shown in Table No.5.1. The total stream length varies from 3m to 6.9 m for second order stream while 8m to 24.43m in third order and 41.35m for fourth order.

Mean Stream Length (L/N)

The mean stream length is a dimensionless property, characterizing the size aspects of drainage network and its associated surface (Strahler, 1964). It is obtained by dividing the total length of stream of an order by total number of segments in the order and are presented in Table No.5.1.The mean stream length for three percolation tanks; Nerpingalai and Jawara located on second order streams was found to be 1.15 and 1.0 respectively while three percolation tanks Rajura, Digargavan located on third order streams was found to be 0.75, 0.70 respectively and the Wagholi percolation tank located on fourth order stream had 0.7 m.

Length Ratio (RL)

It is the ratio between the mean lengths of streams of any two consecutive orders. Horton's law (1945) of stream length states that the mean length of stream segments of each of the successive orders of a basin tends to approximate a direct geometric series, with stream lengths increasing towards higher stream order. Change in stream length ratio from one order to another order indicating their late youth stage of geomorphic development (Singh and Singh, 1997). Higher length ratios show high surface permeability and gentle slope. The Average length ratio for three percolation tanks; Nerpingalai and Jawara located on second order streams was found to be 5.15 and 5.0 respectively, while two percolation tanks Rajura, Digargavan located on third order streams was found to be 1.45, 2.24 respectively and the Wagholi percolation tank located on fourth order stream had 1.63.

Bifurcation Ratio (Rb)

The term bifurcation ratio (R_b) is used to express the ratio of the number of streams of any given order to the number of streams in next higher order (Schumn, 1956). The bifurcation ratio is controlled by basin shape and shows a very little variation in homogeneous bedrock from one area to another (Chorley, 1984). Bifurcation ratios characteristically range between 3.0 and 5.0 for basins in which the geologic structures do not distort the drainage pattern (Strahler, 1964). Strahler (1957) demonstrated that bifurcation ratio shows a small range of variation for different regions or for different environment dominates. Bifurcation Ratio can be calculated as follows:

$$R_b = \frac{N\mu}{N\mu + 1}$$

Where Nμ = number of streams of given order

Nμ+1= number of streams of next higher order

Bifurcation Ratio varied from 3 to 5 for second order, 1.0 to 5.4 for third order and 4 for fourth order. The bifurcation ratio of all percolation tanks except Digargavan varies from 3 to 5 indicating general absence of significant structural control on the development of the drainage. For Digargavan it is 5.4 indicating presence of structural control.

Constant of channel maintenance (Cc)

Schumm (1956) used the inverse of drainage density or the constant of channel maintenance as a property of landforms. The constant indicates the number of Kms2 of basin surface required to develop and sustain a channel one km long. Higher constant of channel maintenance indicates higher permeability of rocks of that basin.

The value of constant of channel maintenance for percolation tanks on second order stream varies from 0.57 to 0.87, 0.35 to 0.51 for third order and 0.30 for fourth order. Jawara have relatively high value of constant of channel maintenance.

Length of overland flow (Lg)

Horton (1945) used this term to refer to the length of the run of the rainwater on the ground surface before it is localized into definite channels. It is calculated as reciprocal of half of drainage density. Large value of length of overland flow indicates longer flow path and gentler slope. Length of overland flow ranges from 0.28 to 0.44 for second order streams, 0.17 to 0.26 for third order streams and 0.15 for fourth order (Table No.4.1). Among second order Jawara has relatively high Length of overland flow .

Table 4.1
Linear aspects for the basins of percolation tanks

Name of Percolation Tank	Nerpingalai	Jawara	Rajura	Digargavan	Wagholi
Order of stream	II	II	III	III	IV
Number of streams (N)	6	6	14	35	59
Length of streams (Km.) (L)	6.9	6	10.45	24.43	41.35
Mean Stream Length (L/N)	1.15	1	0.75	0.7	0.7
Length Ratio (RL)	5.15	5	1.45	2.24	1.63
Bifurcation Ratio (Rb)	5	5	3.75	5.4	4
Length of overland flow (Lg)	0.28	0.44	0.25	0.17	0.15
Constant of Channel Maintenance (Cc)	0.57	0.87	0.5	0.35	0.303

Table No. 4.2
Aerial Aspects of the basins of percolation tanks

Name of Percolation tank	Nerpingalai	Jawra	Rajura	Digargavan	Wagholi
Area of stream (Sq. Km.) (A)	3.92	5.22	5.22	8.5	12.54
Mean Area	0.65	0.87	0.37	0.24	0.213
Area Ratio (Ra)	13.9	10.66	6.88	9.75	7.1
Drainage Frequency (DF)	1.53	1.15	2.68	4.12	4.7
Drainage Density (Dd)	1.76	1.15	2	2.87	3.297
Basin Length (Km) (Lb)	4	4	4.65	3.35	5.2
Perimeter (Km) (P)	8.75	8.5	10	8.5	13
Circularity Ratio (C)	0.64	0.91	0.66	1.48	0.93
Elongation Ratio (Re)	0.32	0.36	0.31	0.98	0.43
Form Factor (F)	0.25	0.33	0.24	o.76	0.46
Texture Ratio (T)	0.57	0.59	1.1	3.41	3.692
Infiltration number (If)	2.69	1.32	5.37	11.83	15.51

4.2 Aerial Aspects

Aerial aspects include study of basin area, Mean area, area ratio, drainage frequency, drainage density, basin perimeter, Circularity ratio, elongation ratio, form factor, texture ration and infiltration number etc. and the data obtained for the study locations are presented in Table No. 4.2

Basin Area (A)

Basin area (A) is very important morphometric attribute. The drainage basin area is delineated on the basis of water divides and the areas of all stream segments of each order are measured. The entire ground surface, which directly feeds the first order segments, is included in the areas of first order basins. The area of second order stream segments includes the area of first order segments plus the areas of inter-basins, which are triangular patches of ground surface contributing directly to the second order streams segments. The same principle works for all the increasing successive order segments (Singh and Shrivastava, 1974). Thus the basin area becomes automatically cumulative from the first order to the successive higher orders (Table No.5.2).

Total area of stream at Nerpinglai and Jawara percolation tanks located on second order streams varied from 2.05 to 5.22,while Rajura, Digargavan located on third order ranged from 4.11 to 8.50 and for Wagholi located on fourth order stream it is 12.54 .

Area Ratio (Ra)

Area ratio (Ra) denotes proportion of increase of mean basin areas between two successive orders and can be calculated by the following equation as suggested by A. N. Strahler (1969)

$$Ra = \frac{\bar{A}\mu}{\bar{A}\mu - 1}$$

Where, $\bar{A}\mu$ is mean area of a given order of the basin.

When $\bar{A}\mu = \sum \frac{A\mu}{N\mu}$, Where, $N\mu$ = number of all segments of a given order

$\sum A\mu$ = total area of all stream segments of the same order

Since the area becomes cumulative with increasing orders, the area ratios decrease with increasing orders within the basin. The salient features of the observations are given in Table No.5.2.

Total area ratio of stream at Nerpinglai and Jawara percolation tanks located on second order streams was found to be 13.9 and 10.66 respectively, while Rajura, Digargavan located on third order had 6.88, 9.75 respectively and for Wagholi located on fourth order stream it was 7.1.

Basin Perimeter (P)

Basin perimeter (P) is the outer boundary of the watershed that enclosed its area. It is measured along the divides between watersheds and may be used as an indicator of watershed size and shape. The basin perimeter of the percolation tanks under study is shown in Table No.4.2.

Basin perimeter of stream at Nerpingalai and Jawara percolation tanks located on second order streams was found to be 8.75 and 8.5 respectively, while Rajura, Digargavan located on third order had 10, 8.5 respectively and for Wagholi located on fourth order stream it is 13.

Basin Length (Lb)

Basin length (Lb) is defined in different ways, such as Schumm (1956) defined the basin length as the longest dimension of the basin parallel to the principal drainage line. Gregory and Walling (1973) defined the basin length as the longest in the basin in which are end being the mouth. Gardiner (1975) defined the basin length as the length of the line from a basin mouth to a point on the perimeter equidistant from the basin mouth in either direction around the perimeter. Basin length of stream at Nerpingalai and Jawara percolation tanks located on second order streams was found to be 4.0 and 4.0 respectively, while Rajura, Digargavan located on third order had 4.65, 3.35 respectively and for Wagholi located on fourth order stream it was 5.2.

Drainage Density (Dd)

Drainage density (Dd) is an important indicator of landform elements in stream-eroded topography (Horton, 1932). It is the ratio of total channel segment lengths cumulated for all orders within a basin to the basin area, which is expressed in terms of m/sq. mi or km/sq. km. High drainage density is the resultant of weak or impermeable subsurface material, sparse vegetation and mountainous relief (Nag, 1998). Low drainage density leads to coarse drainage texture while high drainage density leads to fine drainage texture (Strahaler, 1964).

Drainage density values for all percolation tanks are presented in Table No.5.2. Drainage density of stream at Nerpinglai and Jawara percolation tanks located on second order streams was found to be 1.76 and 1.15 respectively, while Rajura, Digargavan located on third order had 2.0, 2.87 and 1.95 respectively and for Wagholi located on fourth order stream it was 3.29. Nerpingalai, Digargavan and Wagholi have relatively high drainage density.

Drainage Frequency (DF)

Drainage frequency (DF) is the total number of stream segments of all orders per unit area (Horton, 1932). Higher stream frequency points to a larger surface runoff and steeper ground surfaces.

Drainage frequency of stream at Nerpingalai and Jawara percolation tanks located on second order streams was found to be 1.53 and 1.15 respectively, while Rajura, Digargavan located on third order had 2.68, 4.12 respectively and for Wagholi located on fourth order stream it was 4.7. (Table No.4.2) The basins of Rajura, Digargavan, Wagholi have relatively high stream frequency value indicating less permeable rocks which facilitates greater runoff, less infiltration and steep slopes. It is observed that the maximum frequency is in the case of first order streams. It is also noticed that there is a decrease in stream frequency as the stream order increases.

Basin Shape (Bs)

The geometry of basin shape is of paramount significance as it helps in the description and comparison of different forms of drainage basins and it is also related to the functioning of the units of the basins and its genesis. The shape of drainage basin is dependent on the size of the basin and the length of the master stream of the basin and basin perimeter, which are themselves dependant on other variables such as reliefs, slopes, geological structure and lithological characteristics etc. and hence a wide range of variation in basin shape is bound to happen.

Various methods have been suggested to calculate the shapes of the basins such as Horton's form factor (1932), Stoddert's elipticity index (1969), Miller's circularity ratio (1953), Schumm's elongation ratio (1956), etc. Among these Horton's form factor, Miller's circularity ratio and Schumm's elongation ratio have been determined in the present study.

Form factor (F)

The form factor (F) points out the shape of a drainage basin and affects stream discharge behaviors. The ratio of the basin area to the square of basin length is called the form factor (Horton, 1932). It is dimension less property and is used as a quantitative expression to describe the shape of basin form. It can be calculated as follows:

$$F = \frac{A}{L^2}$$

Where, F = form factor indicating elongation of basin shape
A = basin area
L = basin length

The value of Form Factor varies from 0 (highly elongated shape) to the unity i.e.1 (perfect circular shape). Thus, the higher the value of form factor, the more circular the shape of the basin and vice-versa.

Form factor of stream at Nerpinglai and Jawara percolation tanks located on second order streams was found to be 0.25 and 0.33 respectively, while Rajura, Digargavan located on third order had 0.24, 0.76 respectively and for Wagholi located on fourth order stream it was 0.46. The values of form factor indicate Digargavan and Wagholi are more or less in circular shape while Nerpingalai, Jawra, Rajura have elongated shape (Table No.4.2).

Circularity Ratio (C)

Miller (1953) defined circularity ratio (C) as the ratio of basin area to the area of circle having the same perimeter as the basin. It can be expressed as follows:

$$C = \frac{4\pi A}{\rho 2}$$

Where, C = circularity index
A = basin area
P = basin perimeter

The value of Circularity Ratio varies from 0 (a line) to 1 (a circle). Thus, higher the value of circularity ratio, the more circular will be the shape of the basin and vice-versa. The circular basins are characterized by steep slopes and large surface runoff.

Circularity ratios of stream at Nerpinglai and Jawara percolation tanks located on second order streams was found to be 0.64 and 0.91 respectively, while Rajura, Digargavan located on third order had 0.66, 1.48 and 0.41 respectively and for Wagholi located on fourth order stream it was 0.93. According to circularity ratio Jawra, Digargavan and Wagholi are nearly of circular shape while Nerpingalai, Rajura have nearly elongated shape (Table No.4.2).

Elongation Ratio (Re)

Elongation ratio is defined as the ratio of diameter of a circle of the same area as the basin to the maximum basin length Schumm (1965). It is expressed as follows:

$$Re = \frac{\sqrt[2]{A/\pi}}{Lb}$$

Where A = basin area, Lb = basin length

Strahler states that this ratio runs between 0.6 and 1.0 over a wide variety of climatic and geologic types.

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 (less than 0.5).

Elongation ratios of stream at Nerpingalai and Jawara percolation tanks located on second order streams was found to be 0.32 and 0.36 respectively, while Rajura, Digargavan located on third order had 0.31, 0.98 respectively and for Wagholi located on fourth order stream it was 0.43.

Texture Ratio (T)

Texture ratio is an important factor in the drainage morphometric analysis which is depending on the underlying lithology, infiltration capacity and relief aspect of the terrain. The texture ratio is expressed as the ratio between the first order streams and perimeter of the basin, Schumm (1965).

$$T = \frac{N1}{P}$$

Texture ratios of stream at, Nerpinglai and Jawara percolation tanks located on second order streams was found to be 0.6, 0.57 and 0.59 respectively, while Rajura, Digargavan located on third order had 1.1, 3.41 respectively and for Wagholi located on fourth order stream it was 3.69.

Infiltration Number (If)

Infiltration number of a drainage basin is the product of drainage density and stream frequency of a basin. It is the number by virtue of which an idea regarding the infiltration characteristics of the basin is obtained. The higher value indicates low infiltration and high runoff (Yusuf et al, 2011).

Infiltration number of stream at Nerpinglai and Jawara percolation tanks located on second order streams was found to be, 2.69 and 1.32 respectively, while Rajura, Digargavan located on third order had 5.37, 11.83 respectively and for Wagholi located on fourth order stream it was 15.51.

4.3 Relief Aspects

The relief aspects of the drainage basin are related to the study of three dimensional features of the basin involving area, volume and altitude of vertical dimension of landforms wherein different morphometric methods are used to analyze terrain characteristics, which are the result of basin processes. Thus, relief aspects includes relief, relief ratio, average ground slope and hypsometric analysis i.e. area and altitude analyses etc. The salient features of them are represented in Table No. 4.3.

Table No. 4.3
Relief Aspects of the Basins of Percolation Tanks

S. N.	Name of Percolation tank	Relief (m) (R)	Relief Ratio (Rr)	Ruggedness Number (Rn)	Hypsometric Integral (in %)	Stage of Basin Development
1	Nerpingalai	39	9.75	68.64	58.38	Equilibrium
2	Jawra	30	7.5	34.5	67.75	Youthful
3	Rajura	116	24.95	232	21	Old
4	Digargavan	45	13.43	129.15	66.75	Youthful
5	Wagholi	36	6.92	118.69	50	Equilibrium

Relief (R)

Relief is the maximum vertical distance between the lowest and the highest points of a basin. Basin relief is an important factor in understanding the denudational characteristics of the basin.

Relief of stream at Nerpinglai and Jawara percolation tanks located on second order streams was found to be 39 m and 30 m respectively, while Rajura, Digargavan located on third order had 116 m, 45 m and 46 m respectively and for Wagholi located on fourth order stream it was 36 m.

Relief Ratio (Rr)

The relief ratio may be defined as the ratio between the total relief of a basin and the longest dimension of the basin parallel to the main drainage line. It measures overall steepness of drainage basin and is an indicator of intensity of erosional processes operating on slope of the basin (Schumm, 1956). It is noticed that the high values of relief ratios indicate steep slope and high relief while low value of relief ratios are mainly due to the resistant basement rocks of the basin and low degree of slope. In the present study using the basin relief, a relief ratio was computed as suggested by Schumm (1956). Relief ratios of stream at Nerpingalai and Jawara percolation tanks located on second order streams was found to be 9.75 and 7.50 respectively, while Rajura, Digargavan located on third order had 24.95, 13.43 respectively and for Wagholi located on fourth order stream it was 6.92.

Ruggedness Number (Rn)

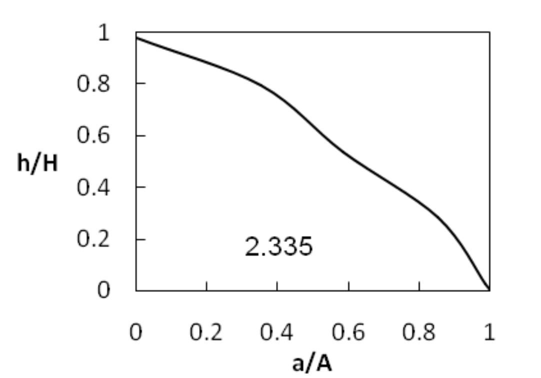
Strahler's (1968) ruggedness number is the product of the basin relief and the drainage density and usefully combines slope steepness with its length. In the present study ruggedness number for the stream of Nerpinglai and Jawara percolation tanks located on second order streams was found to be 68.64 and 34.50 respectively, while Rajura, Digargavan located on third order had 232.00, 129.15 respectively and for Wagholi located on fourth order stream it was 118.69.

Hypsometric Analysis

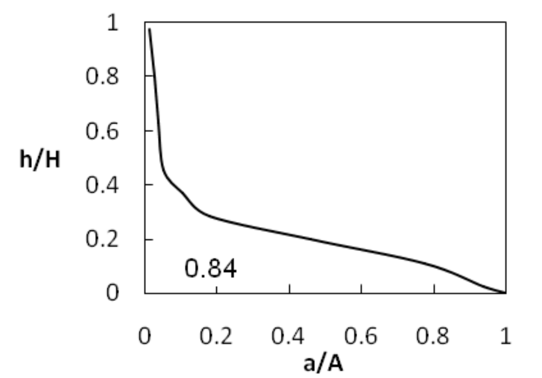
Langbein et al (1947) was first to use such analyses to collect hydrologic data. However, Strahler (1952) popularized the concept. According to Strahler (1952) topography produced by stream channel erosion and associated processes of weathering is extremely complex. The form of hypsometric curve and the value of the integral are important elements in topographic form. It show marked variations in regions differing in stage of development and geologic structure, because in the stage of youth hypsometric integral is large but it decreases as the landscape is denuded towards a stage of maturity and old age.

The erosional integral (EI) is a proportionate area above the curve and thus it indicates the volume of area which has been eroded by erosional processes. Strahler (1952) related the hypsometric integral of above 60%, 60%-35% and below 35% to youthful, equilibrium and old stages of the basin development respectively.

Hypsometric curves have been plotted for all the structures studied (Figure No. 4.3) and determined the hypsometric integral as given below (Table.4.3). The hypsometric integral provided the accurate knowledge of the stage of the erosion cycle and hence the volume of the area unconsumed by the dynamics of erosion.



Nerpingalai



Rajura

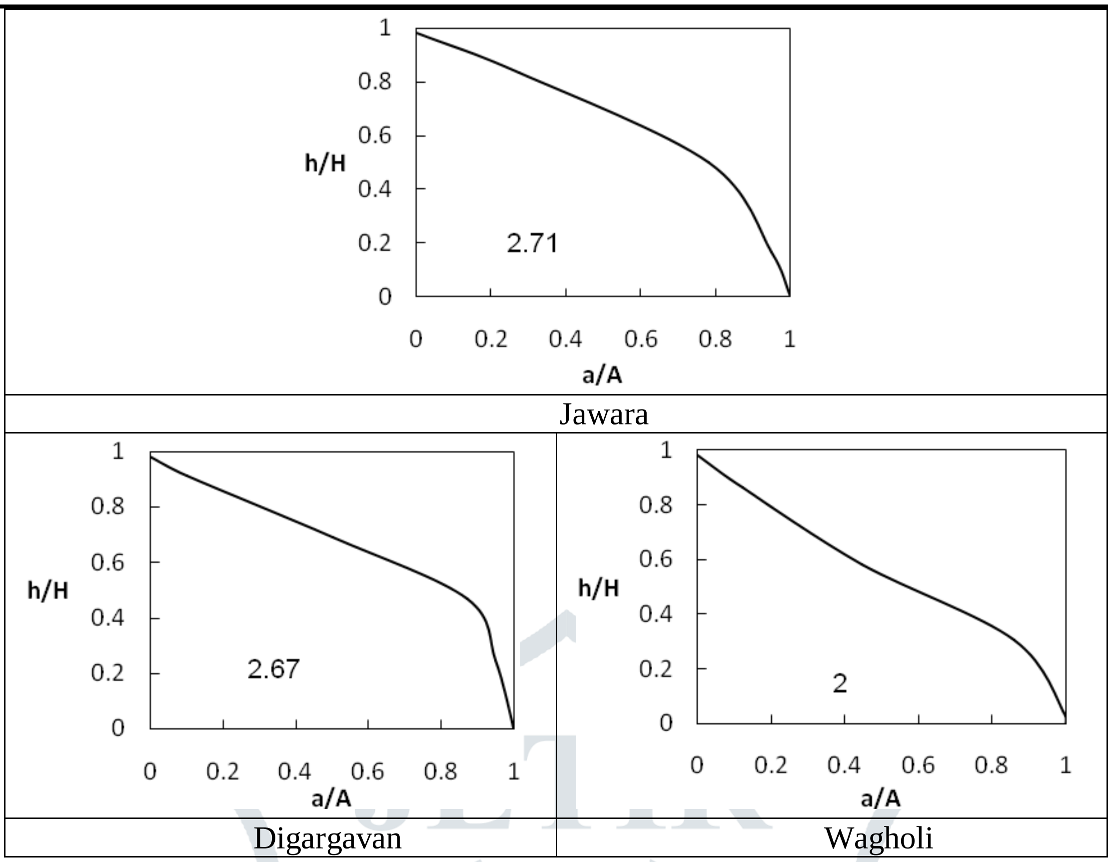


Fig. No. 4.3
Hypsometric graphs of Percolation tanks

5. Result And Disscussion

Morphometric analysis has assisted in location of favorable and unfavorable locations for artificial recharge. Basins having high drainage density, high stream frequency, low bifurcation ratio, lower value of constant of channel maintenance and length of overland flow indicated relatively impermeable surface material, larger surface runoff, steeper ground surfaces. High values of form factor and circularity ratio indicated circular shape of the basin which quantifies more discharge. The basins of Digargavan, Wagholi and Jawara come under this category. On the other hand basins having less drainage density, low stream frequency, high bifurcation ratio, higher value of constant of channel maintenance and length of overland flow indicated relatively permeable surface material, lesser surface runoff and gentle slopes. High values of elongation ratio indicated elongated shape of the basin which quantifies less discharge. Basin of Nerpingalai come under this category.

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