Vol 3 Issue 1 Oct 2013 ISSN No : 2249-894X

Monthly Multidisciplinary Research Journal

Review Of Research Journal

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RNI MAHMUL/2011/38595 **ISSN No.2249-894X**

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Review Of Research
Vol. 3, Issue. 1, Oct. 2013
ISSN:-2249-894X
Available online at www.ror.isrj.net

ORIGINAL ARTICLE

MORPHOMETRY ANALYSIS OF VENNA RIVER BASIN (SATARA): APPLICATION OF GIS TECHNIQUES.

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Abstract:
Morphometric analysis has been carried out to determine the drainage basins Characteristic. In the present study the Venna river basin which is tributaries of the Krishna River are used for morphometric analysis by using Geographic Information System (GIS). An evaluation of morphometric characteristics of a drainage basin requires preparation ofStream Frequency, Drainage Density, Elongation Ratio, Circularity Ratio, Form Factor, Drainage Pattern, Relief Ratio, Relative Relief etc.which helps to understand the nature of drainage basin. A GIS technique is one of the most powerful tools for the analysis of morphometry.

KEYWORDS:

Morphometric,GIS, Georefrencing, Stream Frequency, Drainage Density, Constant of Channel Maintenance, Basin Perimeters, Elongation Ratio, Circularity Ratio, Form Factor, Drainage texture, Drainage Pattern, Relief Ratio, Relative Relief, Dissection Index, etc.

INTRODUCTION

Morphometry may be defined as "the measurement and mathematical analysis of the configuration of the earth's surface and of the shape and dimension of its landforms" (J.I.Clarke, 1970). The basin morphometry is defined as the measurement of shape, form and network analysis of drainage basin. Morphometric analysis helps in understanding the stream network as well as drainage basin characteristics of a river.

OBJECTIVE

To study the Morphometric analysis of Venna Basin (Areal and Relief Aspect).

STUDY AREA

The study area includes the mountainous region of the western part of Deccan plateau in Satara district. Study area is located at a latitude of 17º 54' 12" N to17 º 47'00" N and a longitude of 73 º 37'00"E to 74 º 03' 00"E. The Venna basin is located in the Western Ghats and is a part of the Deccan traps. The river Venna which is originated at 1411 m above the sea level (ASL) is a major tributary of right banks of Krishna River.

The study region that is Venna River is 6th order stream with a total length of 60.0133 km. The Venna river basin is covered by 334.6435 Sq.Km. The Venna River follows a dendritic pattern of drainage. Many peaks range between 1050 -1350 meter heights in the border of basin.

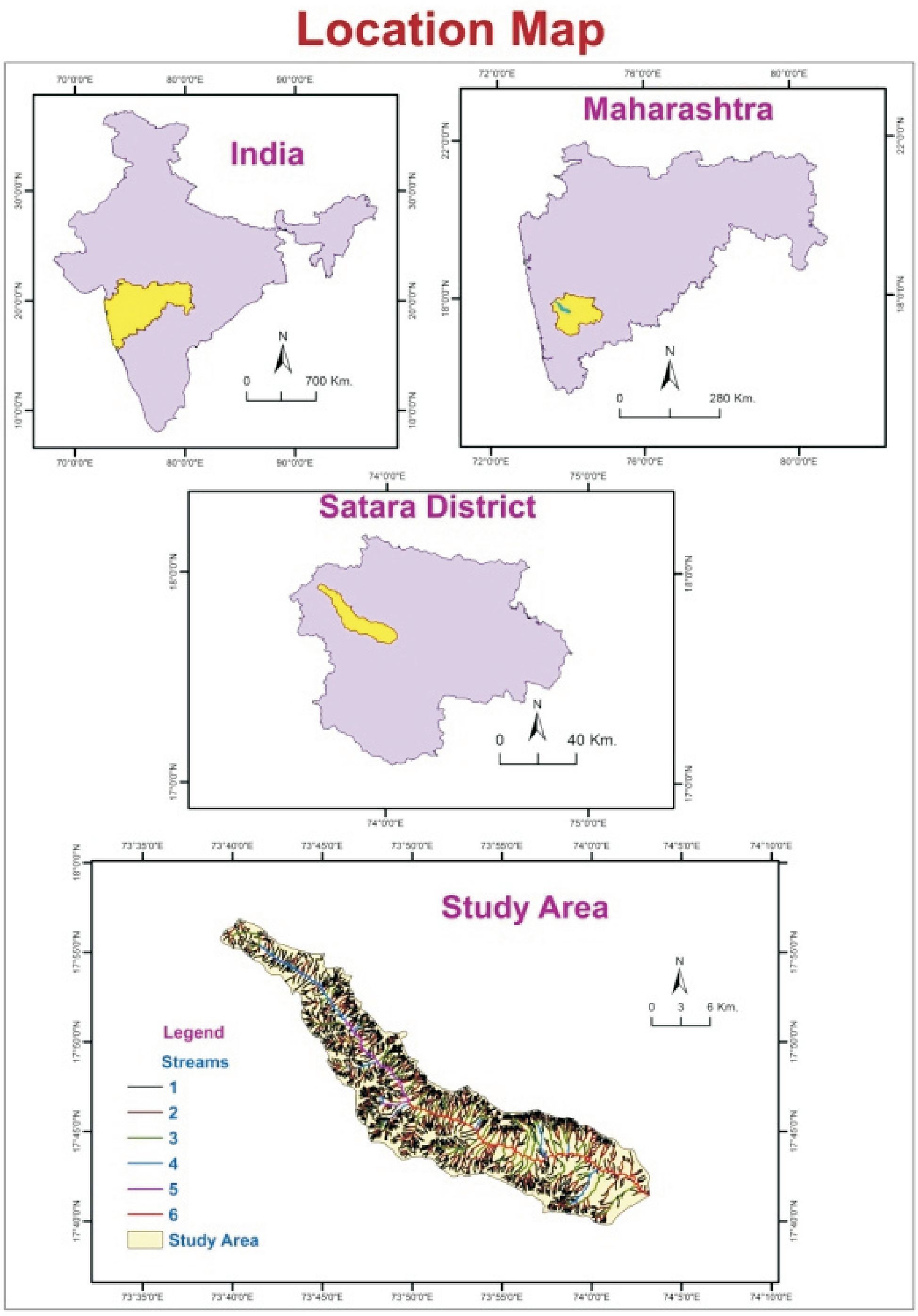
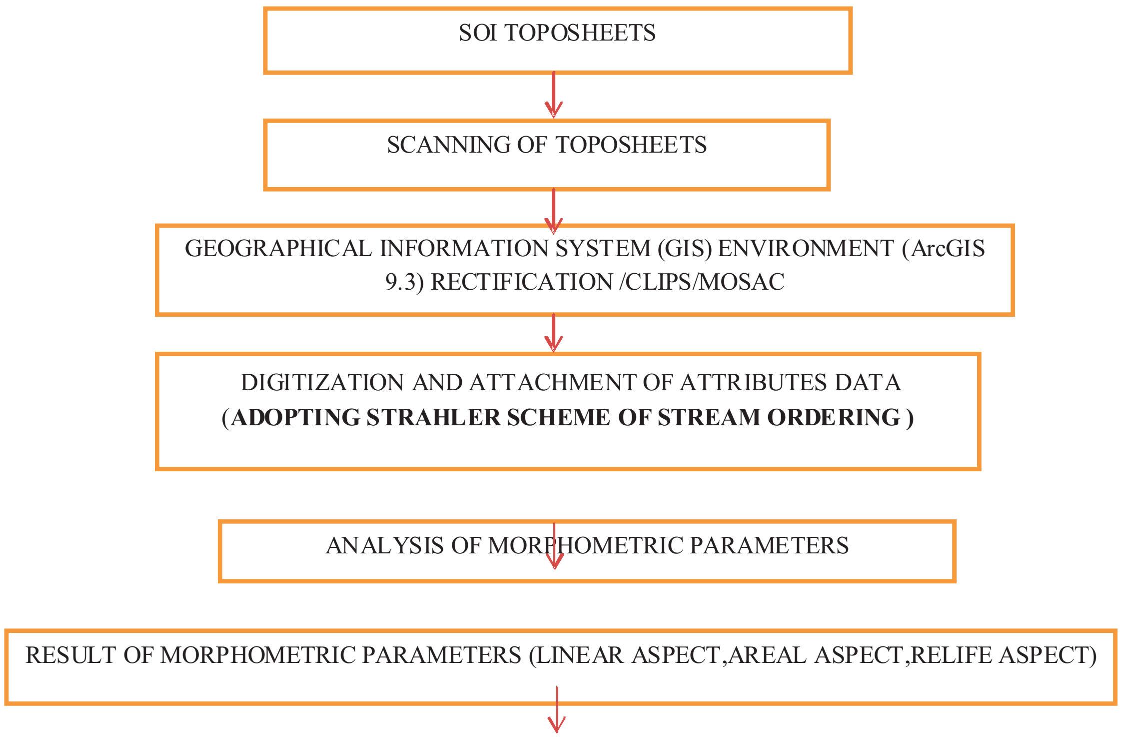

Location Map
India
0 700 Km.
Maharashtra
0 280 Km.
Satara District
0 40 Km.
Study Area
0 3 6 Km.
Legend
Streams
1
2
3
4
5
6
Study Area

Fig.1

DATA BASE AND METHODOLOGY
FLOWCHART

SECONDARY DATABASE



The Morphometric analysis of the Venna river basin was based on the Survey of India Toposheets (47G/2, 47G/9, 47G/13, 47G/14, 47K/2) at 1:50000 scale. It is scanned and geometrical parameters were rectified and geo-referenced with appropriate projections (Universal Transverse Mercator Projection, Zone 43 N and Datum GCS. WGS.1984). Thedigitization work of Toposheet (SOI) has been carried out for entire analysis of the basin morphometry using GIS software (ArcGIS 9.3 version).The stream delineation was done digitally in ArcGIS (9.3.version). The stream orders were calculated using the Strahler (1964) method.

1. AERIAL ASPECT OF DRAINGE BASIN

Morphometric parameter includes drainage density, stream frequency, drainage texture, form factor, elongation ratio , circularity ratio.

1.1.STREAM FREQUENCY (Fs)

Stream frequency or Channel frequency (Fs) is the total number of stream segments of all orders per unit area (Horton 1932). There is a positive correlation between stream frequency and drainage density.

The stream frequency is an important indicator of the drainage pattern. High stream frequency indicates a larger run off of the basin. Less runoff of the basin indicates low stream frequency. Area indicates increasing stream frequency value with respect to increase in drainage density. The spatial pattern of stream frequency is studied through choropleth maps. Mathematical Formula,

$$\mathrm{Fs} = \frac{Nu}{A}$$

Where,
Fs=Stream Frequency.
Nu=Number of Stream Segment.
A=Area of the Basin in Square km.

The Stream Frequency of Venna river basin is 5.4475 Sq. km. The value of stream frequency indicates a high relief and larger run off.

TABLE NO .I
VENNA RIVER BASIN
STREAM FREQUENCY

Types	Value	Result
Very Poor	Less than 2	
Poor	2 to 4	
Moderate	4 to 6	5.4475.
High	6 to 8	
Very High	More than 8	

Source - Savindra Singh .Geomorphology

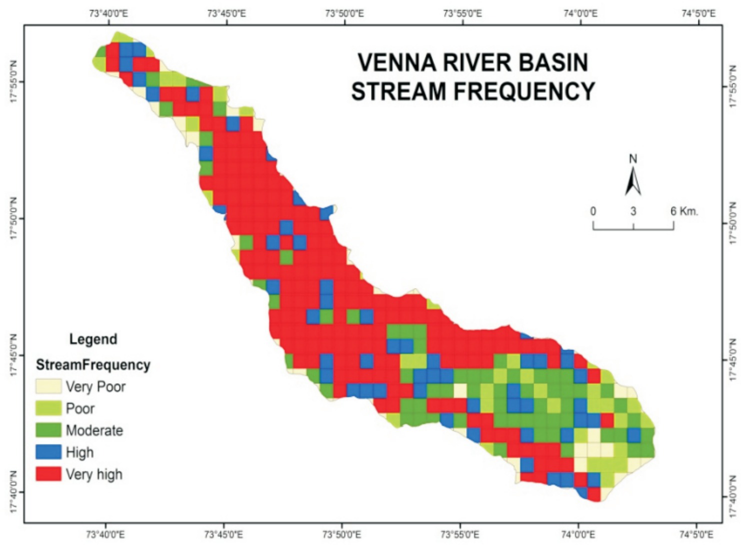
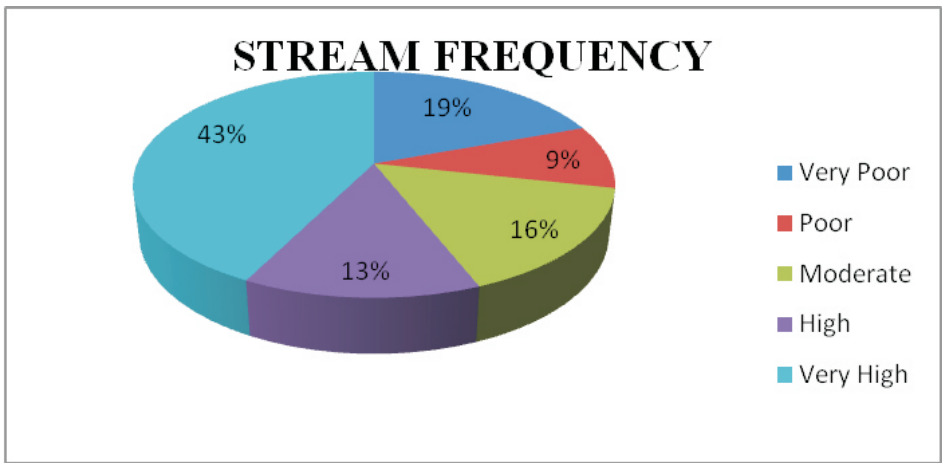


Fig .2.

VENNA RIVER BASIN
DISTRIBUTION OF STREAM FREQUENCY



Source- Computed By Researcher

Fig.3.

1.2. DRAINAGE DENSITY (Dd)

The Drainage density (Dd) is an important indicator of the linear scale of landform elements in stream eroded topography. According to Horton (1932) drainage density gives the mean length of the streams within a basin per unit area and it is obtained by dividing the total stream length (L) by the total basin area (A). The drainage density will be calculated by length of all order divided by basin area.

Drainage density indicates the closeness of spacing of channels thus providing a quantitative measure of the mean length of stream network for the whole basin. The amount and type of precipitation directly influence the quantity and character of surface runoff

Generally, the stream population increases with respect to increase in drainage density. A high drainage density represents a relatively higher number of streams per unit area and thus rapid storm response representing high erosion. Lower drainage density represents a relatively lower number of streams per unit area and lower erosion. The different types of rocks also affect the drainage density

According to Langbein (1947), Strahler (1964), Nag (1998), low drainage density generally results in the areas of high resistance on permeable subsoil material, dense vegetation, low relief and coarse drainage texture. High drainage density is result of a weak or impermeable subsurface material, sparse vegetation, mountainous relief and fine drainage texture. If rainfall intensity is high the drainage density is also high.

Mathematical Formula,
Drainage Density (Dd)

$$Dd = \frac{Lu}{A}$$

Where
Dd=Drainage Density in kilometre per square kilometre.
LU=the total length cumulated for each stream order in km.
A=the total area of the basin in square kilometre.

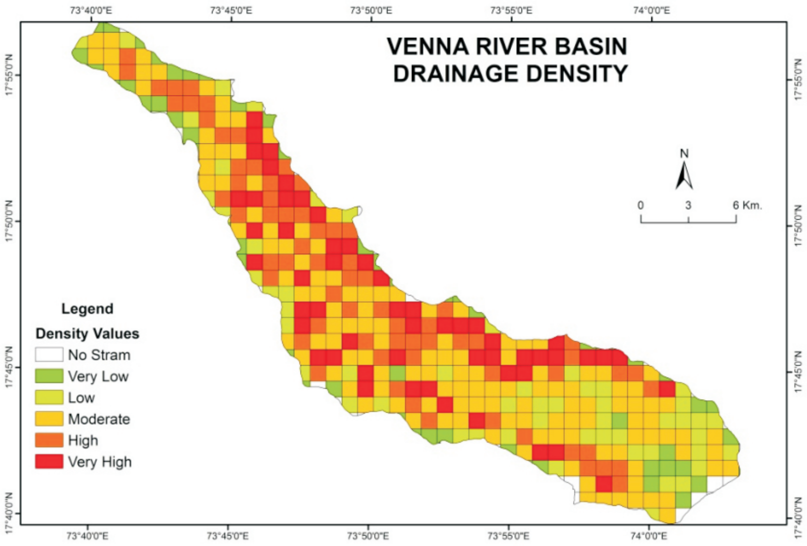
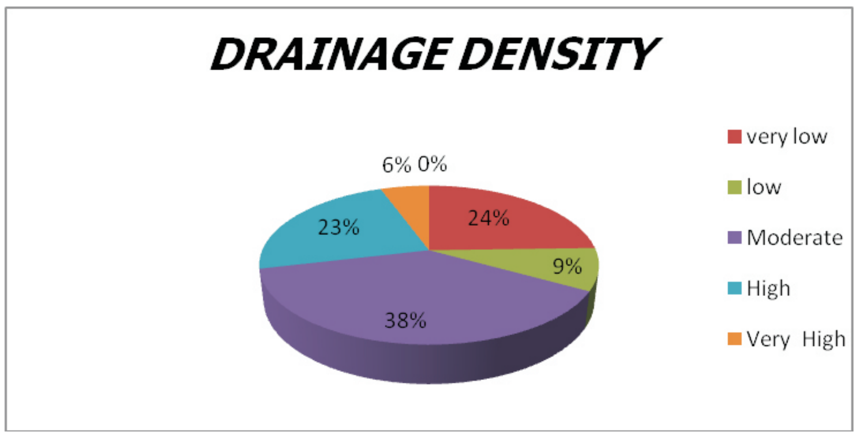


Fig..4

VENNA RIVER BASIN
DISTRIBUTION OF DRAINAGE DENSITY



Source- Computed by Researcher

Fig. 5

In present drainage basin the drainage density has been calculated by using ArcGIS software 9.3 version in which area (km/ km2) indicates high drainage density.The drainage density of Venna river is 4.032 which indicates a high number of streams per unit area, high erosion and little vegetation, low soil infiltration and permeability.
`

1.3. LENGTH OF THE BASIN (Lb)

According to Schumm (1956) the basin length (Lb) is defined as the longest dimension of the basin parallel to the principal drainage line. The length of basin is 49.8092 km,s of the Venna basin from source to mouth.

1.4. BASIN PERIMETER (P)

The basin perimeter (P) is an important parameter of basin Morphometry.The Basin perimeter (P) is the total length of the drainage basin boundary enclosing its area. The basin perimeter may be used as an important indicator of watershed size and shape. It is computed with the help of ArcGIS 9.3 software. The basin perimeter of the Venna basin is 125.7459 km,s as measured by the Topographical map.

1.5. AREA OF BASIN (A)

The drainage basin is one of the important parameters like stream number, length of stream etc. The drainage basin area is computed with the help of ArcGIS 9.3 software. The area of the basin is 334.6435 sq. km. Basin area is hydrologically important because it directly affects the size of the storm hydrograph and the magnitudes of peak and mean runoff.

1.6. FORM FACTOR (Rf)

According to Horton (1945), form factor is the ratio between the basin area and square of the basin length. Form factor represents the erosional potential of the catchment area. There is an inverse relationship between form factor and erosion. High form factor indicates less erosion and low form factor indicates high erosion in catchment area. The low value of form factor is observed in sub watershed leading to an elongated shape.

The form factor value is close to zero which indicates highly elongated shape and value close to one indicates circular shape.

Mathematical formula,

$$Rf = \frac{A}{Lb^2}$$

Where:
R_f= From Factor.
A= Area of the Drainage Basin in Sq.km
L_b= Length of Basin in km.

The Form factor value of the Venna river basin is .1348 which is a lower value and indicates that the drainage basin is elongated in shape.

1.7. CIRCULATORY RATIO (Rc)

Circulatory ratio as defined by Miller (1953) is the ratio of the area of a basin to the area of a circle having the same circumference as the perimeter of the basin. A high circulatory ratio indicates less erosion and low circulatory ratio indicate high erosion. It is the ratio of the area of the basin to the area of a circle having the same circumference as the perimeter of the basin. The circularity ratio (Rc) is influenced by the length and frequency of streams, geological structures, land use and land cover, climate, relief and slope of the basin. Rc 0.5 and above indicates that they are more or less circular and are characterized by high to moderate relief and drainage system is structurally controlled. The sub watersheds have an index of less than 0.50 indicating that the basin is more elongated shape.

Mathematical Formula

$$Rc = \frac{4\Pi A}{P^2}$$

Where
Rc= Circularity Ratio
A= Area of the Basin in Sq.km
P= Perimeter of the Basin in km.
$\Pi = 3.14$
For Venna river basin Circularity Ratio is 0.2658 that means the river basin is more elongated in shape indicating high erosion.

1.8. ELONGATION RATIO (Re)

Schumm (1956) defined elongation ratio (Re) as the ratio between the diameter of the circle of the same area as the drainage basin (D) and the maximum length of the basin (Lb). High elongation ratio indicates less erosion and less elongation ratio indicates high erosion. The relationship between elongation

ratio and erosion is vice versa. The value close to 1.0 are typical of region of very low relief (Strahler, 1964).The values of Re generally vary from 0.6 to 1.0 over a wide variety of climatic and geologic types.
Mathematical Formula

$$Re=\frac{D}{Ld}$$

Where
R_e = Elongation Ratio
D= Diameter of Basin
L_b= Maximum Basin Length.

TABLE NO.II.
VENNA RIVER BASIN
INDEX OF ELONGATION RATIO

VALUE OF ELONGATION RATIO	SHAPE	RESULT
0.9 –0.10	Circular	
0.8-0.9	Oval	
0.7-0.8	Less Elongated	
0.5-0.7	Elongation	
Less than 0.5	More Elongated	0.4145.

The elongation ratio of the Venna river basin is .4145 which indicates that the relief is high and shape is more elongated in catchment area.

1.9. DRAINAGE TEXTURE (Dt)

Generally drainage texture is defined as the "relative spacing of the drainage line". According to Horton (1945) drainage texture is defined on the basis of stream frequency (number of stream per unit area).The drainage texture (Dt) is an expression of the relative channel spacing in a fluvial dissected terrain. It depends upon a number of natural factors such as climate, rainfall, vegetation, rock and soil type, infiltration capacity, relief and stage of development of a basin (Smith, 1950).

Drainage Texture = (Dt)
Mathematical Formula

$$D= \frac{N_u}{P}$$

Where
T= Drainage Texture.
N_u= Total Number of Stream of all Segment.
P = Perimeter of Basin.
The drainage texture value of Venna basin is 14.4972 which indicate very Fine drainage texture.

1.10. LEMINSCATE,S (K)

Chorely (1957) expressed the leminscate's value to determine the slope of the basin.
Mathematical Formula, (Chorely, 1957)

$$K = \frac{Lb^2}{A}$$

Where
K =Leminscate's
L_b= Basin Length in Km
A= Area of the Basin in Sq.km

The Leminscate's (K) value for the watershed is 7.4137 which show that the watershed occupies maximum area in its regions of inception with large number of streams of higher order.

1.11. LENGTH AREA RELATION (Lar)

Hack (1957) found that for a large number of basins the stream length and basin area are related by a simple power function.

Mathematical Formula

$$L_{ar} = 1.4 * A^{0.6}$$

Where
L_{ar} = Length Area Relation.
A= Area of the Basin in Sq.km.
Length Area Relation of Venna River basin is = 45.8

1.12. CONSTANT OF CHANNEL MAINTENANCE

Schumm (1956) used the inverse of drainage density or the constant of channel maintenance as a property of landforms. The constant of channel maintenance indicates the relative size of landforms units in a drainage basin and has a specific genetic connotation (Strahler, 1957). The unit of C is square mile per mile or square kilometre per kilometre. Generally higher the constant C of a basin greater the permeability of the rocks of the basin.

Mathematical Formula-

$$C = \frac{1}{Dd}$$

Where
C= Constant of Channel Maintenance.
D_d= Drainage Density.
0.2480 Km^2 /Km meaning that Venna river has a low constant channel maintenance in the river bed and is mostly up of basalt hard rock having low Erosibility and low permeability .

1.13. INFILTRATION NUMBER (If)

Infiltration number (If) of watershed is defined as the product of drainage density and stream frequency. It gives an idea about the infiltration characteristics of the watershed. The higher the infiltration number (If) the lower will be the infiltration and higher the run-off of the basin. The lower the infiltration number (If) the higher will be infiltration and lower the run-off of the basin.

Mathematical Formula (Faniran, 1968):-

$$I_f = F_s * D_d$$

Where
I_f= Infiltration Number.
F_s= Stream Frequency.
D_d= Drainage Density.

The Infiltration Number of Venna river is =21.9534 which indicates a high infiltration Number and low infiltration and high run-off of Venna basin.

1.14. DRAINAGE INTENSITY (Di)

Faniran (1968) defines the drainage intensity, "as the ratio of the stream frequency to the drainage density".

Mathematical formula

$$\mathrm{Di} = \frac{Fs}{Dd}$$

Where
D_i= Drainage Intensity.
F_s= Stream Frequency.
D_d= Drainage Density.

The Drainage Intensity values of Venna river basin is =1.3510

2. RELIEF ASPECT OF DRAINAGE BASIN
2.1. RELATIVE RELIEF (Rhp)

According to Schumm (1963) the relief ratio is the dimensionless height to length ratio equal to the tangent of the angle formed by two planes intersecting at the mouth of the basin one representing the horizontal and the other passing through the highest point of the basin. According to Schumm (1956) it is shown that higher relief surface shown increase in drainage density, channel length, and sediment production. The relative relief shows the difference between the maximum elevation and minimum elevation of the area.

Mathematical Formula
Relative Relief (Rhp) =Z-z
Where
Z= Highest Elevation in the Basin.
z= Lowest Elevation in the Basin.
= 1411m- 615m
= 796m

The Relative Relief of Venna River basin is = 796 m which indicated high relative relief of Venna Basin.

2.2. RELIEF RATIO (Rhl)

The relief ratio (Rhl) may be defined as the ratio between the total relief of a basin and the longest dimension of the basin is parallel to the main drainage line (Schumm, 1956).

Relief ratio (Rh) is the elevation difference between the highest point of watershed and lowest points on the valley floor of a sub-watershed.There is also a correlation between hydrological characteristics and the relief ratio of a drainage basin. It has been observed that moderate value of relief ratio is characterized by to moderate relief of an area. Runoff is generally faster in steeper basin.

The high value of relief ratio is characterized by high relief and steep slope and low value of relief ratio is characterized by low relief and low degree of slope.

Mathematical Formula

$$(\mathrm{Rhl}) = \frac{H}{Lb}$$

Where
H= Total Basin Relief.
L_b= Maximum Basin Length.

The Relief Ratio (Rhl) of Venna River Basin 0.01598 is characterised by high relief and steep slope of basin.

2.3. DRAINAGE PATTERN (Dp)

The Drainage Patterns of Venna basins are dendritic and are included in sixth order stream. The Venna basin is elongated in shape along west to east direction while it is narrower in the source and mouth portions and wider in the middle part of basin .The dendritic pattern of drainage in general is typical of homogeneous crystalline rocks. In the present river basin homogeneous basaltic rock is present. Howard (1967) has shown a relation of drainage pattern to geological information. The drainage network pattern is dendritic type because it shows a tree like branching of streams in all directions in the study region.

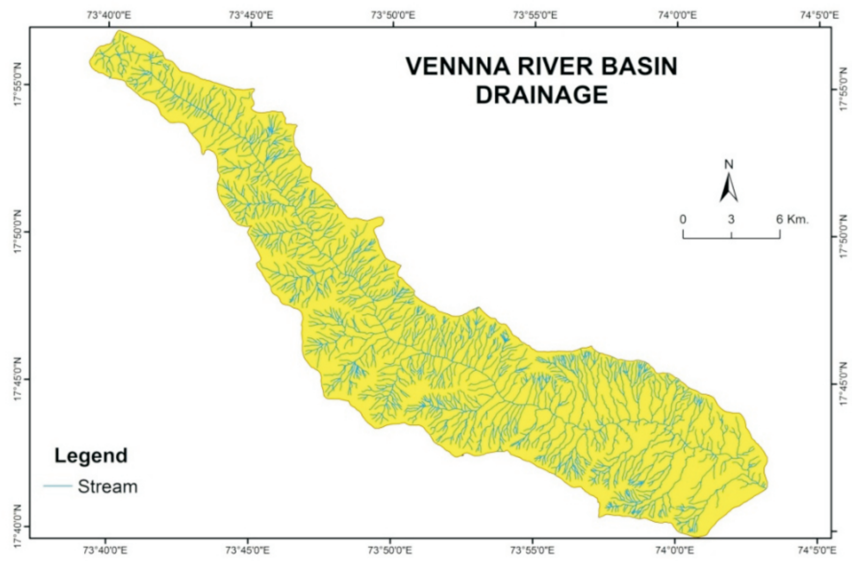


Fig.6

1.4. DISSECTION INDEX (Dis)

Dissection Index (Dis) is a parameter implying the degree of dissection or vertical erosion and expounds the stage of terrain or landscape development in any given physiographic region or watershed (Singh and Dubey 1994).

Mathematical Formula =

Di $= \frac{H}{Ra}$

Where
Di= Dissection Index
H = Relative Relief.
Ra= Absolut Relief.

The Dissection Index value of Venna river basin is 0.6 which indicated the watershed is very highly dissected.

CONCLUSION –

The quantitative analysis of morphometric parameters such as areal and relief aspects using GIS techniques. The Venna river basin is sixth order basin.The Stream Frequency of Venna river basin is 5.4475 Sq. km. The value of stream frequency indicates a high relief and larger run off.The drainage density of Venna river is 4.032 which indicates a high number of streams per unit area, high erosion and little vegetation, low soil infiltration and permeability. The Form factor value of the Venna river basin is .1348 which is a lower value and indicates that the drainage basin is elongated in shape.Circularity Ratio is 0.2658 km2 that means the river basin is more elongated in shape indicating high erosion.The elongation ratio of the Venna river basin is .4145 which indicates that the relief is high and shape is more elongated in catchment area. The drainage texture value of Venna basin is 14.4972 which indicate very Fine drainage texture.0.2480 Km2 /Km meaning that Venna river has a low constant channel maintenance in the river bed and is mostly up of basalt hard rock having low Erosibility and low permeability. The Infiltration Number of Venna river is =21.9534 which indicates a high infiltration Number and low infiltration and high run-off of Venna basin.The Relative Relief is 796 m which indicated high relative relief of Venna Basin.The Relief Ratio (Rhl) of Venna River Basin 0.01598 is characterised by high relief and steep slope of basin.The Drainage Patterns of Venna basins are dendritic and are included in sixth order stream.The Dissection Index value of Venna river basin is 0.6 which indicated the watershed is very highly dissected.

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