iJRASET
International Journal For Research in Applied Science and Engineering Technology



# INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

**Volume:** 7 **Issue:** IV **Month of publication:** April 2019

**DOI:** https://doi.org/10.22214/ijraset.2019.4666

www.ijraset.com

Call: 08813907089 | E-mail ID: ijraset@gmail.com

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
*ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.177*
*Volume 7 Issue IV, Apr 2019- Available at www.ijraset.com*

# Integrated Study of Hemavathy Catchment using Remote Sensing and Geographic Information System

K. Balakrishna[1], Dr. H. B. Balakrishna[2]
[1]*Research Scholar, Department of Civil Engineering, Bangalore Institute of Technology Bangalore-560004, Karnataka, India.*
[2] *Professor and Head, Department of Civil Engineering, Bangalore Institute of Technology, Bangalore-560004, Karnataka, India.*

***Abstract:*** ***Watershed management involves proper utilization of water, land and other natural resources for planning, development of water resources. The present study is made to understand the hydrological characteristics of the Hemavathyriver basin including quantity of runoff and soil loss estimations. Remote Sensing, GIS techniques are used in integrated study for sustainable management of natural resources. Morphometric analysis was done to understand drainage characteristics of river basin. These dimensionless and dimensional parametric values are interpreted to understand the watershed characteristics. Catchment at the watershed level divided into 46 sub watersheds, and the prioritization using the SOI toposheets and satellite data, using remotely sensed data and ArcGIS software was done. The drainage map is prepared and morphometric parameters such as linear, aerial and relief aspects of the watershed have been determined. The study shows the highest stream order was 7th order, and designated as seventh order catchment. Stream frequency is low in most of the sub watersheds with low relief. Soil Conservation Services(SCS) Curve Number model was used to calculate runoff occurring based on land use land cover and hydrological soil group of the area. Runoff estimated for the years 2005 to 2015 clearly shows that watershed 9 generates more runoff during the year 2007. It was observed that runoff potential of the watershed that about 40% of area interprets in more runoff. As per records available 15000-250000 cum of water has flown over and above the commitment for a period of 23 years out of documents period of 33 years, since the project is aimed at abstracting only small quantity of the daily flood waters, implies that the project will not exhaust the flood waters during dry years with lowest rainfall. Soil erosion was estimated by using Universal Soil Loss Equation (USLE) to estimate soil erosion in all sub watersheds of catchment. In the present study, watershed 2,3,6,7 is experiencing high erosion and considered as highly critical, and watershed 16-21 experience least erosion. Average annual soil loss of River Basin was estimated to be 8.00 t/ ha/ yr.***

***Keywords: Catchment, GIS, Morphometric analysis, Remote sensing, Runoff, Soil loss. Watershed***

## I. INTRODUCTION

Land, water and soil are limited natural resources and is important to conserve them for sustainable development. Morphometric analysis provides the useful parameter for assessment of surface and groundwater resource management, runoff , geographic characteristics of the drainage system, watershed characterization and plays significant role in watershed prioritization .The information extracted from Remote sensing technology with GIS and other sources stored as a georeferenced database provides efficient tools for data input into data base, for further processing and software modules to analyze and manipulate the retrieved data in order to generate desired information on specific form.

The Morphometric analysis includes the linear and aerial aspects, in the linear aspects the stream ordering, stream length, stream length ratio, and bifurcation ratio and in the aerial aspect the drainage density, stream frequency, form factor, circulatory ratio, and elongated ratio has been calculated. which helps to understand the nature of drainage basins[1].Drainage network of the basin was analyzed as per Horton laws and stream ordering made after Strahler (1964) [2].

Characterization of rainfall-runoff behavior of a watershed is the primary study in any watershed management programme. Runoff is one of the most important hydrologic variables used in most of the water resources applications Remote sensing technology can augment the conventional methods to a great extent in rainfall-runoff studies provides a source of input data for estimating equation coefficients and model parameters.

Watershed management requires runoff estimation to provide important information on soil and water conservation planning. This research aimed at estimating the annual rainfall- runoff potential of Hemavathy river watershed by applying Soil Conservation Service-Curve Number (SCS-CN) method using the properties of watershed. land use, soil permeability and antecedent soil moisture condition (AMC) [3]. Prioritization of sub-watersheds involves ranking them by taking into consideration the amount of

©IJRASET: All Rights are Reserved

soil loss [4], Soil erosion is a serious problem as it removes soil nutrients can lead to reduction in crop production potential. Universal Soil Loss Equation (USLE)model is used to compute longtime average soil losses integrated with analysis of spatial data using GIS[5]. The equation is presented as: A= R.K.L.S.C.P, Where, A - computed soil loss (t/ha/year); R - rainfall erosivity factor K - Soil erodibility factor; L - Slope length factor (m); S - Slope steepness factor, C– Cover and management factor; P - Conservation practices factor. The estimation of soil erosion of critical area is required for planning, conservation and management measures.

## II. STUDY AREA

Hemavathy river starts in western ghats in Chickmaglur district and flows through Chickmaglur, Hassan, Mandya and Mysore districts covers geographically between 75°30'00" to 76° 15' 00"E longitude 12° 30' 00" to 12° 30' 00" N latitude, with watershed area of 2855km$^2$. It is 245 km long and has a drainage area of about 5,698.65 km$^2$. A large reservoir has been built on the river at Gorur in the Hassan district. In the entire Cauvery basin, the Hemavathy watershed is second largest in terms of area.

## III. OBJECTIVES OF STUDY

The objectives of work to be carried out is summarized as follows,

*A.* Preparation of different thematic maps using Survey of India top maps and remotely sensed data.
*B.* Detailed morphometric analysis of the watershed to evaluate the morphometric parameters and its influence on Watershed.
*C.* Computation of runoff by SCS Curve Number model,
*D.* Soil loss estimation using Universal Soil Loss Equation (USLE).

## IV. MATERIAL AND METHODS

Survey of India (SOI) topo maps 57C/04,57D/1, 57D/2, 48O/08, 48O/11, 48O/12, 48O/15, 48O/16,48P/09, 48P/10, 48P/13 and 48P/14 in 1:50000 scales are procured, serve as study area for preparing base map and thematic maps. The recent changes are updated with the help of Remote sensing satellite data.

The drainage map is prepared by extracting all the rivers, tributaries and small stream channels shown on the toposheet and morphometric parameters are determined. In the study area, satellite data of IRS–P6 LISS III was used to prepare the drainage map of the river basin.

These dimensionless parametric values are interpreted to understand the watershed characteristics. Figure1 shows the Drainage map and Figure 2 shows the stream ordering map of the catchment.

The entire catchment area was divided into number of sub watersheds based on topography and drainage pattern. Daily Rainfall data for 11 years (2005-2015) of 38 rain gauges in the catchment were obtained from Water Resources Department Karnataka. The daily runoff was determined by means of polygon method.

Land Use/Land Cover map of the study area is prepared from satellite imagery using visual interpretation technique. Runoff from the watershed was determined using SCS Curve Number method and soil loss was determined using USLE equation.

### *A. Morphometric Analysis*

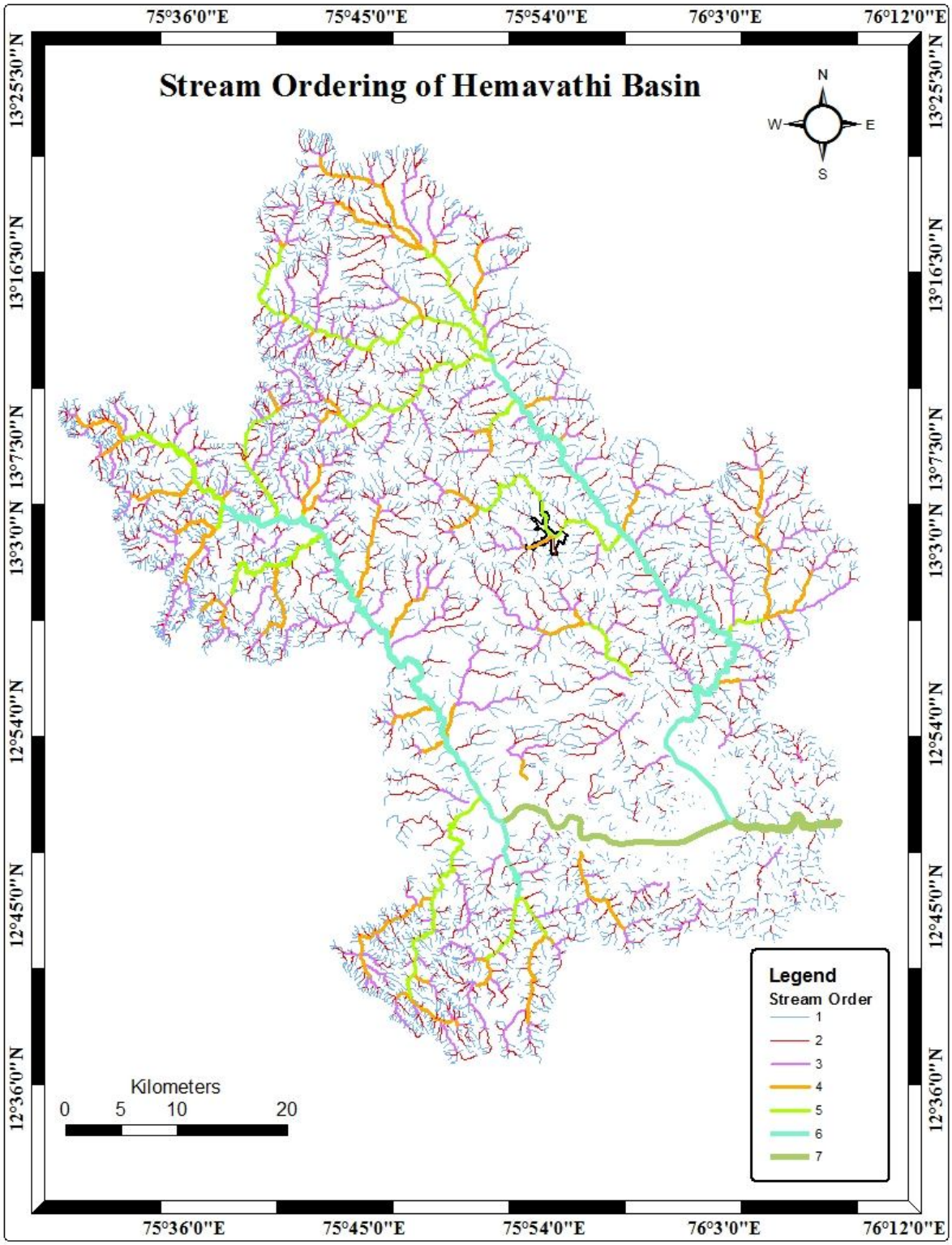
The Morphometric analysis includes the evaluation of morphometric parameters linear and aerial aspects, in the linear aspects the stream ordering, stream length, stream length ratio, and bifurcation ratio and in the aerial aspect the drainage density, stream frequency, form factor, circulatory ratio, and elongated ratio which help to understand the nature of the drainage basin.

The high priority areas are delineated based on considering the important aerial and linear parameters by giving proper weightage. Aerial parameters except compactness coefficient and length of overland flow are ranked in a decreasing order; higher values assigned a rank of six and lowest valued assigned as a rank of one, the linear parameters, are rated as rank one, the second lowest as rank two and so on. Based on these ranking, the compound value is finally calculated by averaging all the ranks of each sub-watershed. Based on the analysis sub-watershed with highest compound value is given a priority of 1, followed by sub-watersheds of other ranks. Table 1 shows morphometric parameters of the catchment and Table 2 shows morphometric characteristics of catchment.

.

©IJRASET: All Rights are Reserved

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
*ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.177*
*Volume 7 Issue IV, Apr 2019- Available at www.ijraset.com*




©IJRASET: All Rights are Reserved

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
*ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.177*
*Volume 7 Issue IV, Apr 2019- Available at www.ijraset.com*

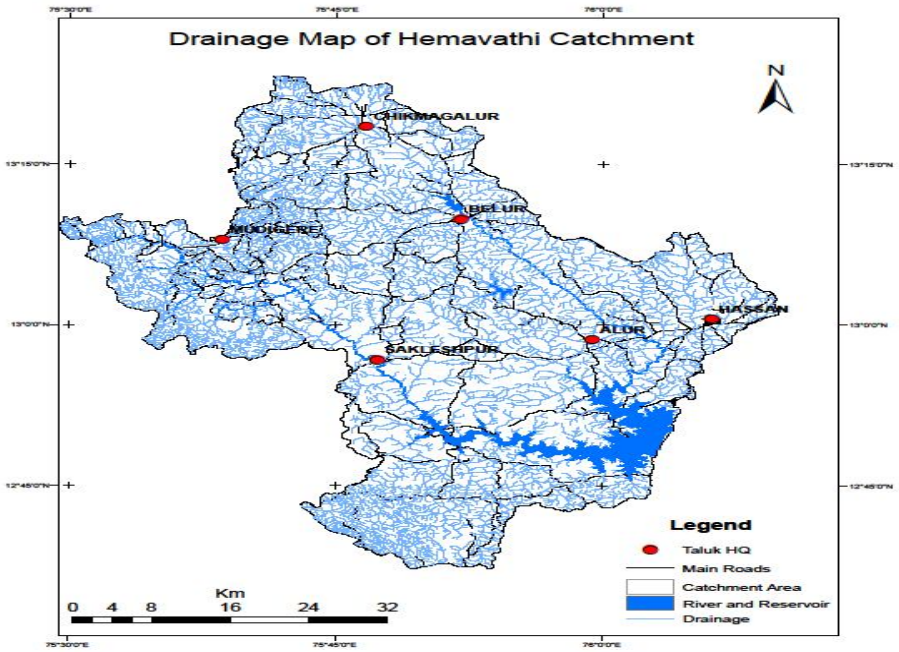



Table 1. Different Morphometric Parameter of Hemavathy Catchment

| Sl No | Watershed parameters | Units | Values |
|---|---|---|---|
| 1 | Watershed area | $Km^2$ | 2855.11 |
| 2 | Perimeter of Watershed | Km | 2080.43 |
| 3 | Watershed highest order | No | 7 |
| 4 | Maximum length of Watershed | Km | 15.27 |
| 5 | Maximum width of Watershed | Km | 10.63 |
| 6 | Form factor | | 0.518 |
| 7 | Shape factor | | 1.884 |
| 8 | Cumulative stream segment | Km | 9143 |
| 9 | Cumulative stream length | Km | 5058.32 |
| 10 | Stream frequency | $No/Km^2$ | 3.11 |
| 11 | Drainage density | $Km/Km^2$ | 1.800 |
| 12 | Constant of Channel maintenance | $Km^2/Km$ | 0.564 |
| 13 | Length of Overland flow | Km | 0.27 |
| 14 | Bifurcation ratio | | 4.818 |
| 15 | Stream length ratio | | 1.868 |
| 16 | Circularity ratio | | 0.404 |
| 17 | Elongation ratio | | 0.87 |
| 18 | Compactness coefficient | | 1.65 |
| 19 | Total relief of watershed | Km | 0.760 |
| 20 | Watershed relief ratio | | 0.018 |
| 21 | Relative relief ratio | | 0.0046 |
| 22 | Ruggedness number | | 0.00036 |

©IJRASET: All Rights are Reserved

Table 2. Different Morphometric characteristic of Hemavathy catchment

| Stream order | No of segments (Nu) | Total Stream length "L " (Km) | Bifurcation ratio (Rb) Nu/(Nu+1) | Mean length Lu (Km) | Cumulative length (Km) | Stream Length Ratio (RL= Lu/(Lu1)) | Drainage density Dd= ∑L /A (Km/Km²) |
|---|---|---|---|---|---|---|---|
| 1 | 7821 | 2753.02 | | 0.352 | 2753.02 | | 1.80 |
| 2 | 985 | 1089.58 | 7.94 | 1.105 | 3842.60 | 3.139 | |
| 3 | 228 | 509.28 | 4.32 | 2.232 | 4351.88 | 2.019 | |
| 4 | 54 | 240.58 | 4.22 | 4.444 | 4592.46 | 1.990 | |
| 5 | 29 | 187.07 | 1.86 | 6.44 | 4779.53 | 1.449 | |
| 6 | 21 | 229.05 | 1.38 | 10.904 | 5008.58 | 1.693 | |
| 7 | 5 | 49.74 | 4.2 | 9.988 | 5058.32 | 0.915 | |

*B. Runoff Estimation*

Runoff was estimated using SCS- CN Model. The IRS-P6 LISS III satellite data was used to prepare the land use land cover, soil and drainage maps. soil map was classified into four hydrological soil groups, contour map was prepared at 10 m interval and digital elevation model(DEM) prepared to generate slope map. Table 3 shows the hydrologic soil group in the catchment. The mean rainfall for the area was determined by means of theissen polygon method. The watershed is divided into 26 sub watersheds and runoff estimation was carried out sub watershed wise. Runoff curve number is defined as

$$CN = \frac{25400}{S + 254}$$ where S is in mm.

The curve numbers for (AMC II) condition were taken by overlaying the land use / land cover and hydrological soil groups of the watershed and from this condition curve number for AMC. I and III were obtained. Figure.3 shows the curve number map prepared by integrating land use/land cover and hydrological soil group map through ArcGIS software of the catchment. Weighted runoff estimated based on the runoff and area of polygon/watershed. The values of the observed annual rainfall and the estimated annual runoff were plotted on x-y scatter plot and a linear model was fitted to find linear relationship between two data. Figure.4 shows the typical graph depicting the rainfall runoff relationship of watersheds for the year 2005.A graph of cumulative value of runoff plotted against time in a Mass curve, is plotted for 11 years of cumulative daily runoff shows runoff, summation of flow during the intervening period of time. Table 4 shows rainfall-runoff of the catchment.

Table.3. Hydrological soil group in the catchment and their Spatial distribution (Sq.km)

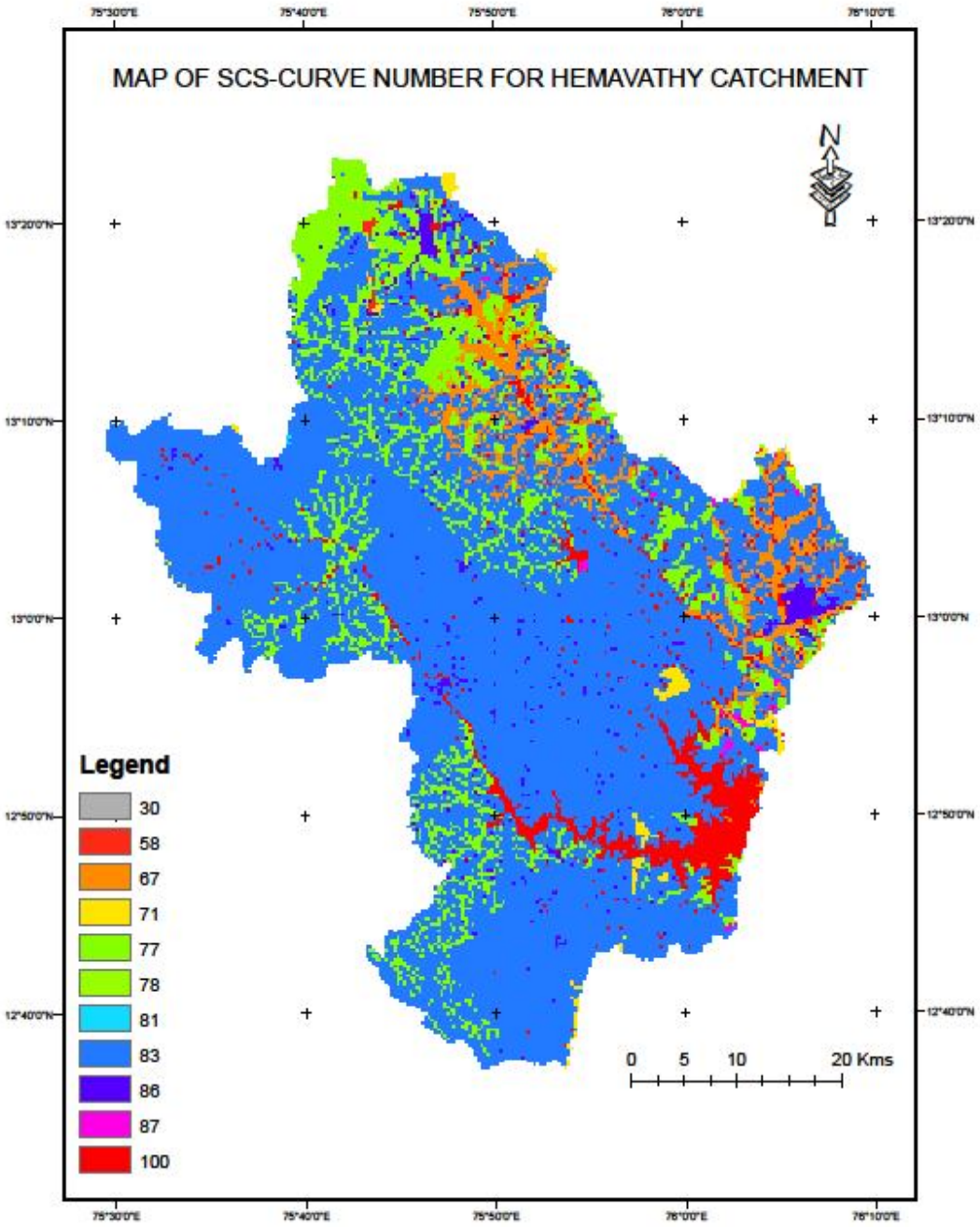
| HSG | Description | Area (Sq.km) | % of area |
|---|---|---|---|
| A | Soils with low runoff potential excessively drained, sands or gravels with high rate of water transmission. | 311.23 | 10.69 |
| B | Moderately, well drained, moderately fine to coarse textures with moderate rate of water transmission | 424.63 | 14.59 |
| C | Soils with moderately fine to fine texture with slow rate of water transmission. | 2098.72 | 72.12 |
| D | Clay soils with high swelling potential with very slow rate of water transmission | 75.14 | 2.58 |

Table 4. Runoff Q for the Catchment

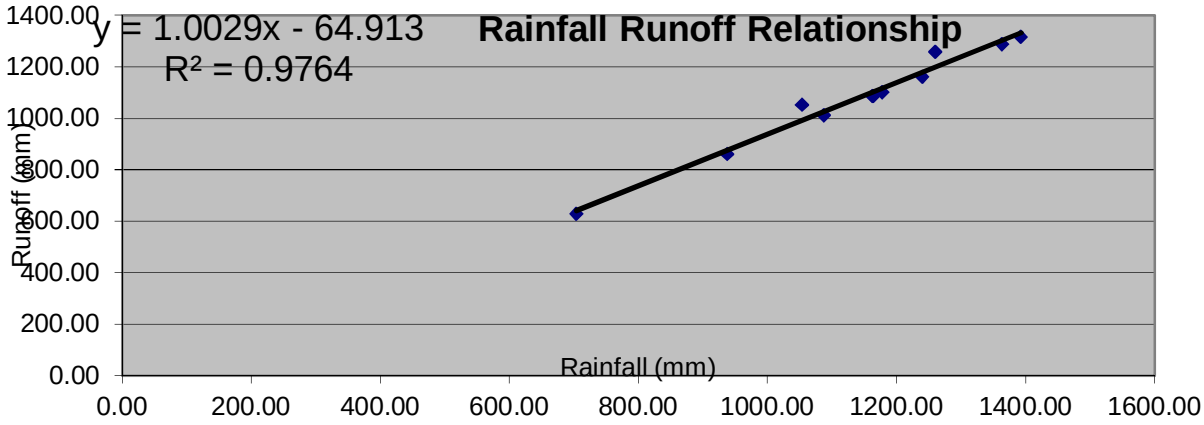
| Year | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|---|
| Rainfall (mm) | 2163 | 2012 | 2298 | 1881 | 1878 | 1990 | 1841 | 1305 | 1965 | 1820 |
| Runoff (mm) | 2096 | 1945 | 2230 | 1813 | 1811 | 605 | 1773 | 1238 | 1898 | 1753 |

©IJRASET: All Rights are Reserved

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
*ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.177*
*Volume 7 Issue IV, Apr 2019- Available at www.ijraset.com*

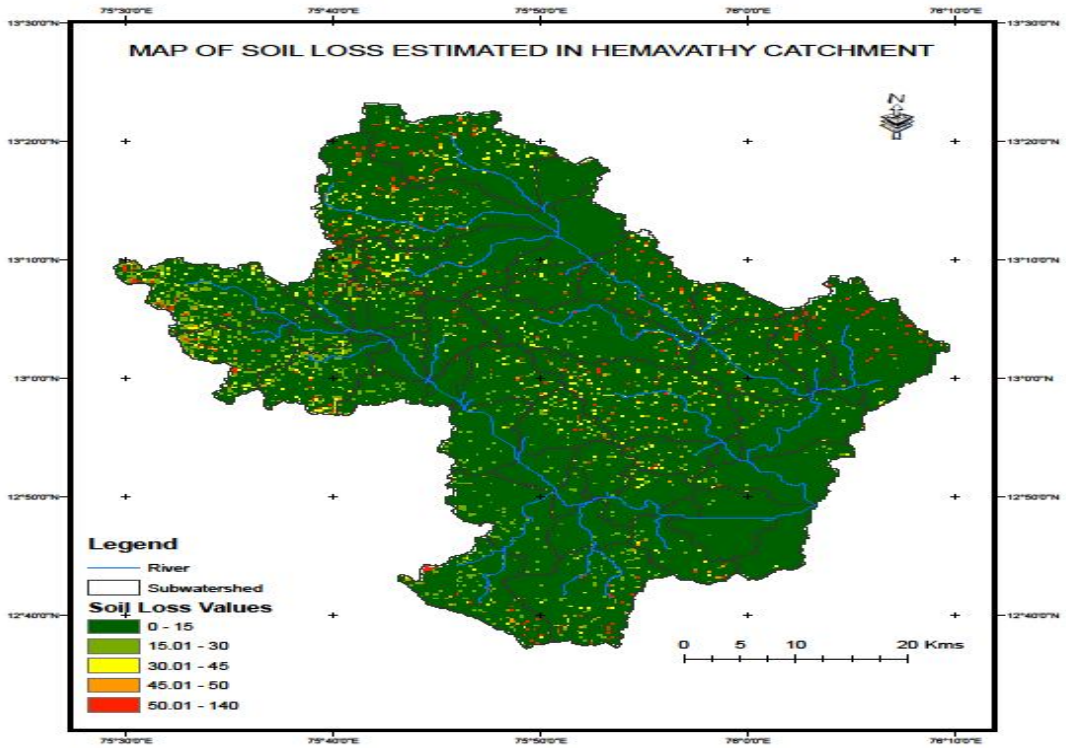



©IJRASET: All Rights are Reserved




*C. Soil Loss Estimation*

Soil map prepared by using the soil data obtained from Karnataka State remote sensing application center (KSRSAC), Bangalore. Using different year of rainfall data, ArcGIS 10.2 software base map was prepared, study area extracted from satellite image (IRS LISS-3) and Carto DEM, all maps generated was converted to Raster of cell size of 50m. Soil loss was estimated using the Universal soil loss equation (USLE) The equation is presented as : A= R.K.L.S.C.P ,Where, A - computed soil loss (t/ha/year); R - rainfall erosivity factor K - Soil erodibility factor; L - Slope length factor (m); S - Slope steepness factor ,C – Cover and management factor; P - Conservation practices factor. Finally, the soil loss map was generated. The result for the estimated gross soil erosion in t/(ha/year) is shown in Figure 5.




©IJRASET: All Rights are Reserved

## V. RESULTS AND DISCUSSION

Morphometricparameters estimated as per the Horton and Strahler's method, stream ordering, was carried out, the highest stream order obtained was7$^{th}$order. From themorphometric characteristics of catchment are seen average value of bifurcation ratio (Rb) for the catchment is 4.818 which is less than 5 shows watersheds has suffered less structural disturbances. The drainage densityof 1.80 indicates the catchment is a coarse texture. The total relief of catchment of 0.760 km shows that the river basin has sufficient slope for runoff to occur from the source to mouth of river basin.CN values are determined from hydrological soil group and antecedent moisture conditions of stream**.** The mean runoff for the area was determined by means of the issenpolygon method. The regression coefficient value for watersheds lies between0.81 to 0.97. It is also seen from the graphs as the slope increases the run off generated also increases. The losses are calculated in terms of evapo-transpiration and infiltration. The total loss found out is 52.20% of the total precipitation. During the year 2007 maximum rainfall2298mm and runoff of 1230 mm respectively have occurred and minimum runoff of 618 mm has occurred during the year 2012.It is observed positive correlation between rainfall and runoff in all the 26 sub watersheds. As per available records availability of water at Hemavathi reservoir 15000-250000 cum of water has flown over and above the commitment for a period of 23 years out of documents period of 33 years, implies that the project will still not exhaust the flood waters during dry years with lowest rainfall, like the case of the year 2002 which had the lowest runoff volume.

The soil loss for catchment estimated using Universal Soil Loss equation (USLE) the values of different factors are calculated using equations, the rainfall erodibility factor (K) estimated as of 0.04, the slope length and slope steepness of 1.28 was found. The crop management factor (C) based on average values for various crops grown was 0.50,As per study it was observed that slope (LS) and land cover (C) factors are the most significant ones to estimate the soil loss in the catchment. From soil loss estimation, found that83% of the area has soil loss between 0.0 and 15.0 t/ ha/ year. The average annual soil loss of the river basin was found to be 8.00 t/ ha/ yr. shows moderate soil loss from the watersheds as per ISRO-NNRMS-TR-103-2002. Based on the results of the model watershed 2,3,6,7 was experiencing high erosion and considered as highly critical and watershed 16-21 least erosion. The most affected watershed is preferred for soil conservation on top priority to reduce soil erosion.

## VI. CONCLUSION

The results of morphometric analysis help in prioritizing sub catchments and help better management of reservoir catchment. From the quantitative study it is observed that basin has suffered less structural disturbance and has sufficient slope for the runoff to occur. The estimated runoff shows that the watershed has a good surface runoff potential, the surface water can be recharged in to the ground by constructing suitable ground water recharge structures. Remotely sensed data in conjunction with GIS is best used to estimate surface runoff from the ungagged watershed. Moderate soil erosion in the catchment indicates suitable conservation methods can be proposed for conservation of natural resources in the basin for profitable and optimum utilization of land. The mapping of natural resources by digital interpretation of remotely sensed data is accurate, cost effective and less time consuming compared to conventional methods of natural resource mapping.

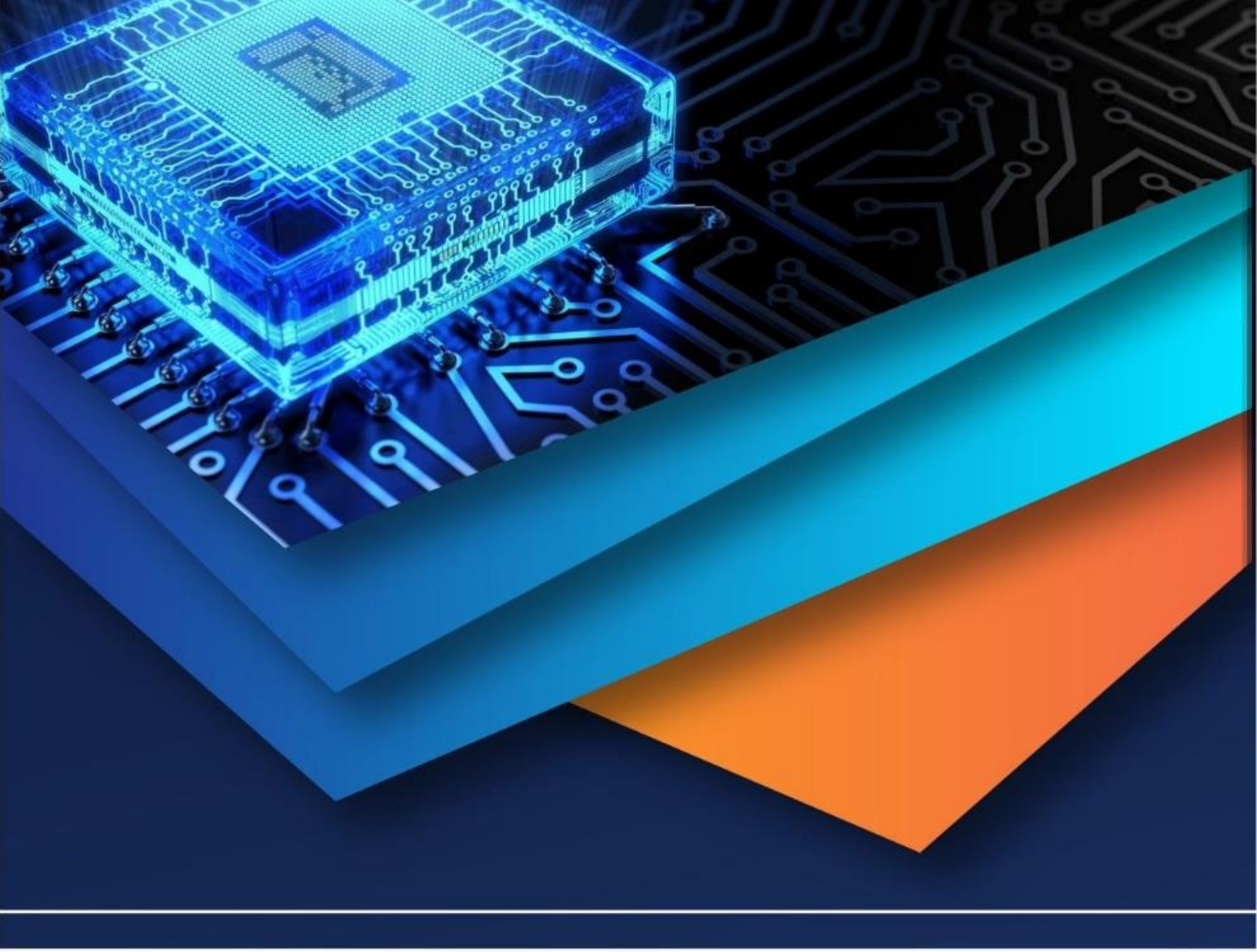
## VII. ACKNOWLEDGEMENT

The authors acknowledge the support provided by Karnataka state remote sensing application center (KSRSAC),Bangalore and State Data Centre, Water Resources Department, Karnataka

## REFERENCES

[1] Vijitha H. and Satheesh R. (2006) GIS Based Morphometric Analysis of two major upland sub-watershed of Meenachil river in Kerala, Journal of the Indian Society of Remote Sensing, Vol.34, pp.181-185.
[2] Strahler A.N, (1964) Quantitative Geomorphology of Drainage Basin and Channel Networks.
[3] Ashish Pandey and Dabral P.P (2004), Estimation of Runoff for Hilly Catchment using Satellite data, Journal of Indian Remote sensing,Vol.32, pp. 235-240.
[4] Srinivasa Vittala,S., Govindaiah and Honne Gowda,H(2008) Prioritization of sub-watersheds for Sustainable development and management of natural resources: An integrated approach using remote sensing, GIS and socio-economic data, Current Science, Vol 95, No 3, pp 345-354.
[5] Pandey.A, Chowdary.V.M, and Mal.B, "Identification of critical erosion prone areas in the small agricultural watershed using USLE, GIS and remote sensing", Water Resource Management vol 21, no, pp 729-746
[6] ISRO–NNRMS–TR–103-2002, Regional Remote Sensing Center, (2002) Watershed characterisation, prioritisation development, planning and monitoring – Remote Sensing approach, Indian Space Reseaerch Organisation, Bangalore.
[7] Soil Conservation services, (1972) National Engineering Handbook, Hydrology, Section 4, Chapter 4 to 10.

©IJRASET: All Rights are Reserved



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

# INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Call : 08813907089 (24*7 Support on Whatsapp)