ISSN (e): 2250 – 3005 || Volume, 07 || Issue, 09|| September – 2017 ||
International Journal of Computational Engineering Research (IJCER)

SCS-CN Method and Geomatics Approach for Fully distributed Runoff Modelling

G. Sreenivasa Rao[1], M.V.S.S. Giridhar[2], Shyama Mohan[3] and P.Sowmya[4]
[1] *Associate Professor,* [2]*Associate Professor and Head,* [3]*Student,* [4]*Research Scholar*
[1]*Department of Civil engineering, MVSR Engineering College Hyderabad, India*
[2,3,4] *Centre for water Resources, IST, JNTUH, Hyderabad*

ABSTRACT
Runoff is one of the most important hydrological factors used in most of the land and water resources applications. It is an essential parameter at micro level to address soil and water conservation practices in a watershed. Curve Number (CN) method is mainly used for estimating infiltration characteristics of the watershed, based on the land use property and soil property. The Curve Number (CN) is a land-cover index for the given land use-land cover class, elevation and soil type to determine the amount of rainfall that infiltrates into the ground and the amount that becomes runoff for a specific storm event (USDA, 1986). It is necessary to quantify the likely changes in the surface runoff in a watershed as an impact of the planned or unplanned changes made in the land use. The point of the present study is to analyze the runoff time series over a wide time interval, identifying potential patterns and evaluating their significance. In the present study the surface runoff is estimated for Kadam Watershed using SCS- CN method. Hydrological soil group (HSG), land use / land cover Map, Soil and multi spectral remote sensing data are used for the analysis. In this investigation rainfall-runoff model has been developed using Remote Sensing and GIS techniques. The statistics showed different runoff grid value throughout the year 0 being the lowest and 70 being the highest runoff. The highest runoff was shown during high number of rainfall of 156.00 cm where the runoff was abnormally high which was seen in the mandal of Kaddam. Mostly the recurring runoff values were between 0 – 27. 0 was mainly seen near the water bodies. For the average rainfall taken for 14 years was 50.06 mm and the average runoff was found to be 13.62.The estimated amount of average annual surface runoff is 13.62 mm, which corresponds to 30% of annual average rainfall of Kadam Watershed.
Key Words: SCS- CN method, Curve Number, Runoff, Remote sensing, Kadam Watershed.

Date of Submission: 13-09-2017 Date of acceptance: 25-09-2017

I. INTRODUCTION

Accurate estimation of runoff is not only important for the analysis but also for the proper management of watershed. Runoff can be estimated through various empirical formulas SCS-CN method being one of them. SCS-CN provides an empirical relationship for estimating runoff as a function of soil type and land use. The Curve Number (CN) is an index developed by using HEC-GeoHMS Geospatial Hydrological Modeling Extension in ArcGIS, to represent the runoff within a drainage area. The CN for a drainage basin is estimated using a combination of land use, soil, and DEM. There are four hydrologic soil groups: A, B, C and D. While Group A has high infiltration rates, Group D have low infiltration rates.

In this study the Soil Conservation Service Curve Number (SCS CN) method also known as hydrologic soil group method was used for runoff estimation. It requires details of soil characteristics land use and vegetation condition as input. The availability of spatial data from remote sensing techniques has made it possible to use hydrological models like SCS curve number in spatial domain with GIS. ERDAS has been used for the further computation of runoff by using the spatial modeler which has been found to perform well without much calibration.

There are have been several approaches to estimate runoff for example Nayak et al., (2012) computed he direct surface runoff volume by the SCS Curve Number method have been compared with the observed runoff calculated from recorded hydrograph at G&D site for the selected rainfall events. It was shown from the results that the agricultural area have been increased drastically and forest area has reduced considerably resulting in 20-40 % increased surface runoff volume in recent years (i.e. 2007) in comparison to those in 2001 for the similar rainfall events. AnubhaTopno et al (2015), incorporated SCS-CN model and GIS facilitates for runoff estimation to improve the accuracy of estimated runoff. The study also revealed for un-gauged watersheds accurate prediction of the quantity of runoff from land surface into rivers and streams requires much effort and time.

Nayak and Jaiswal (2003) found that there was a good correlation between the measured and estimated runoff depth using GIS and CN. They concluded that GIS is an efficient tool for the preparation of most of the input data required by the SCS curve number model. In the present study fully distributed run off model using SCS-CN method has been processed in the GIS platform. The runoff has been estimated for the fifteen years from 2000- 2014 for the Kaddam watershed. The land use land cover maps have been generated using the supervised classification in ERDAS, and soil map have also been delineated which provide as input for the calculation of Curve number.

II. STUDY AREA

The Study area selected is Kaddam watershed (Figure 1) present in the G-5 sub basin which is the 'Middle Godavari' Sub basin of Godavari River Basin. The Godavari basin extends over an area of 3, 13,812 Sq.km. Godavari catchment is divided into eight sub basin in which G-5 sub basin is one of the basin, it lies between latitudes 17° 04' N and 79° 53' E longitude. The study area selected in the Middle Godavari sub basin is considered up to Kaddam reservoir watershed which lies between 19° 05' E and 19° 35' N latitudes and 78° 10' and 78° 55' E longitudes. The watershed covers a total of twelve mandals of which eight mandals are taken Khanapur, Boath, Ichchoda , Narnoor, Utnoor, Indervelly, Bazarhatnoor and Kaddam all of which fall under Adilabad district.

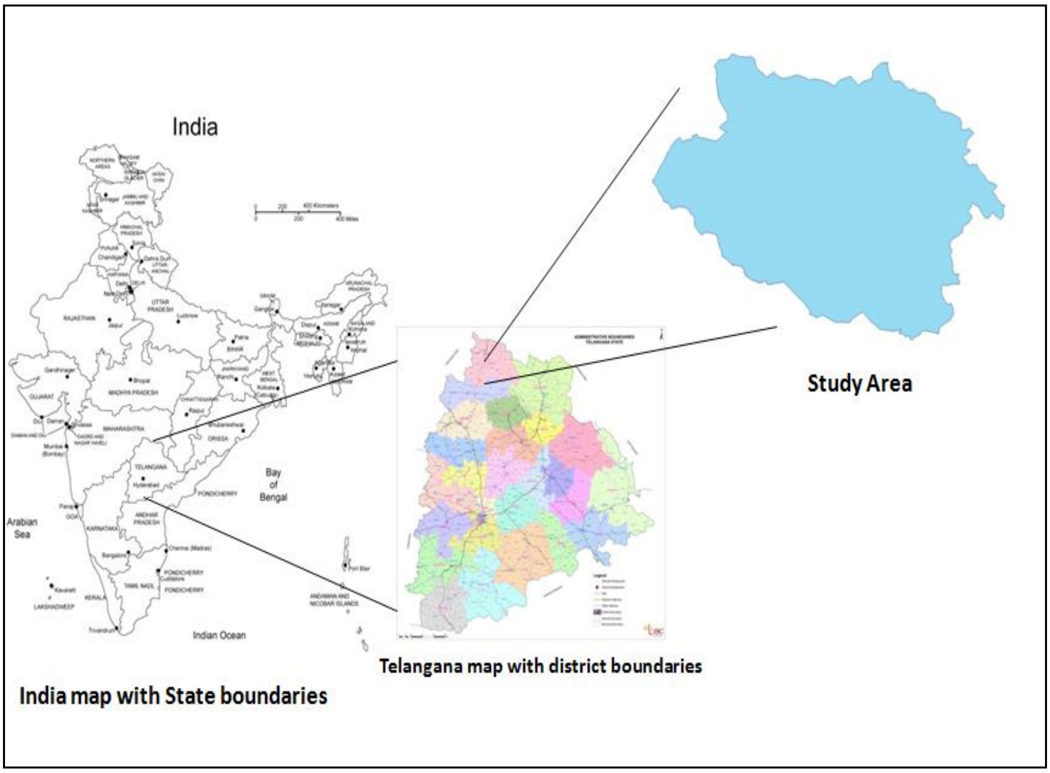

Figure 1 Location map of Kaddam Watershed

III. METHODOLOGY

Every day Rainfall Data for a period of 14 years from 2000 to 2014 of eight gauge stations are collected and processed on Excel sheets as indicated by the prerequisites to acquire interpretative area map. Land use land cover maps and soil maps have been prepared. Arc GIS software version 9.3 was used for creating, managing and generating maps. The frame work of methodology is shown in figure.2.

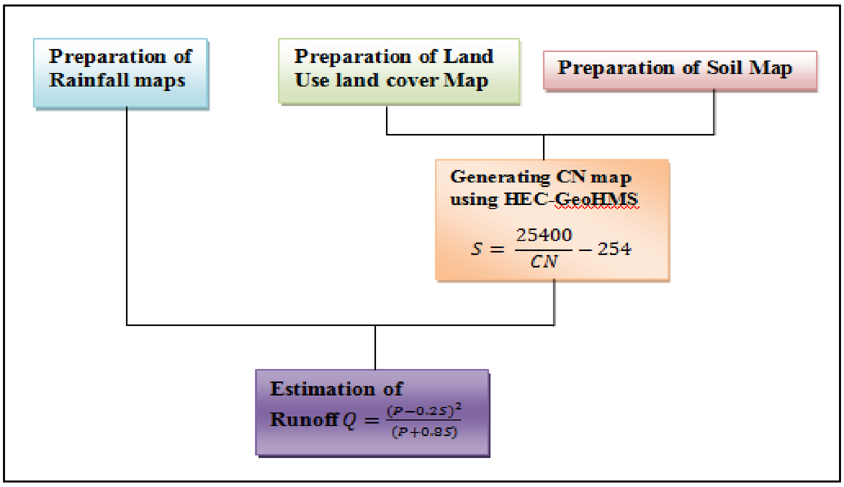

Figure 2 Flow chart of Methodology

3.1 Preparation of Rainfall maps

Every day Rainfall Data for a period of 14 years from 2000 to 2014 of eight gauge stations are collected and processed on Excel sheets as indicated by the prerequisites to acquire interpretative area map. Arc GIS software version 9.3 was used for creating, managing and generating maps.

3.2 Preparation of Land Use land cover

In the present study, the supervised classification is carried out in ERDAS IMAGINE 2014 software using a georeferenced satellite image of Landsat 7 ETM+. The images are classified for two seasons of Rabi and Kharif. In the image multiple training sets for each class were taken. Four land use land cover (LULC) classes were established here as Waterbody, Forest, Agriculture and Fallow or Wasteland. The land use land cover map is shown in Figure 3. The distribution of LULC classes is mentioned in Table 1.

Table 1 Area of Land Use Land Cover in Kaddam Watershed

S.No.	Land Use Type	Area in %
1	Waterbody	0.44
2	Forest	68.996
3	Agriculture	29.37
4	Fallow/Wasteland	1.18

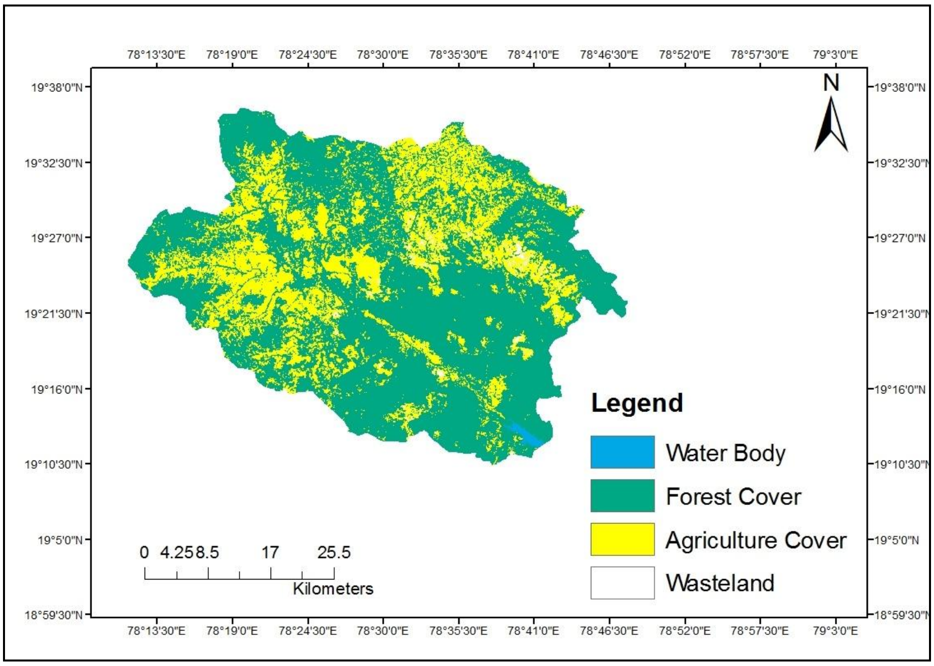

Figure 3 Land Use Land Cover map of Kaddam Watershed

3.3 Preparation of Soil Map

A soil map is collected and was georeferenced with respect to Study Area in ERDAS Imagine 9.2. With the help of ArcGIS software vector data layer of Soil map (Figure 4) was thus created. The study area comprised of five different types of soil dominated by clay soil.

3.4 Generating CN map

The inputs landuse map, soil map and the digital elevation model (DEM) is first added in the ArcMap of GIS. The HEC-GeoHMS extension tool of ArcGIS was used to generate the CN grid. The appropriate code is given to the soil code for the type of soil present in the area giving the hydrologic soil group. Then the landuse and hydrologic soil group are combined to form a new merged soil and landuse map. The CN look up table was created and the appropriate CN value for each soil land map was assigned. After generating CN, the surface retention (equation 1) is computed in the spatial analyst tool of ArcGIS.

$$S = \frac{25400}{CN} - 254 \qquad (1)$$

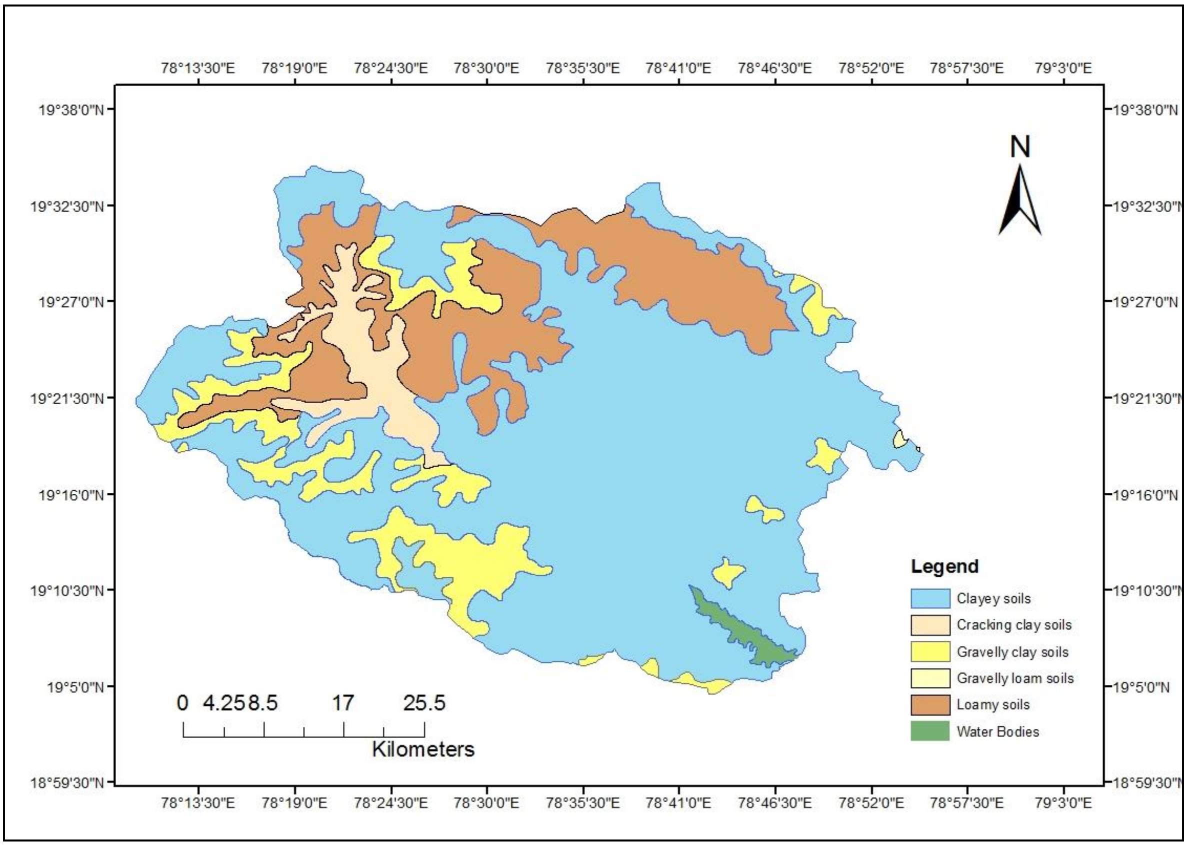

Figure 4 Soil map of Kaddam Watershed

3.5 Estimation of Runoff

The estimation of runoff is carried out in the spatial modeler of ERDAS IMAGINE 2014. The model (Figure 5) have been developed using the runoff equation (2) taking the input as rainfall map and the surface retention.

$$Q = \frac{(P-0.3S)^2}{(P+0.7S)} \qquad (2)$$

Where Q is runoff depth (mm)

P is rainfall (mm)

S is initial abstraction of rainfall by soil and vegetation

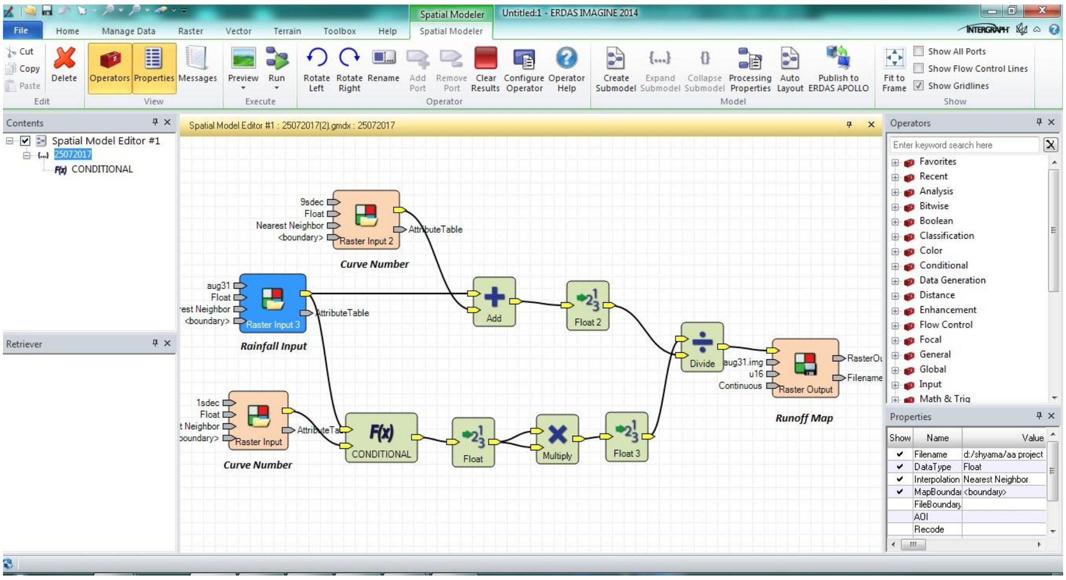

Figure 5 Spatial Modeler of ERADS IMAGINE 2014 for estimation of Runoff

IV. RESULTS

Hydrological Soil Map

The hydrologic soil group is generated as an input for the curve number in ArcGIS. It is an attribute of the soil mapping unit and each soil mapping unit is assigned to a particular hydrological group: A, B, C and D shown in figure 6. Each of the soil group has a different runoff potential due to different infiltration rates (Table 2).

Table 2 Infiltration rate and runoff potential of Soil type

S.NO.	Soil Type	Soil Code	Infiltration rates	Runoff Potential
1	Clayey soil	D	Low	High runoff
2	Cracking clay soil	C	Moderate	Moderately high runoff
3	Loamy soil	B	Moderate	Moderate runoff
4	Gravely loamy soil	A	High	Low Runoff
5	Gravelly clay soil	A	High	Low Runoff

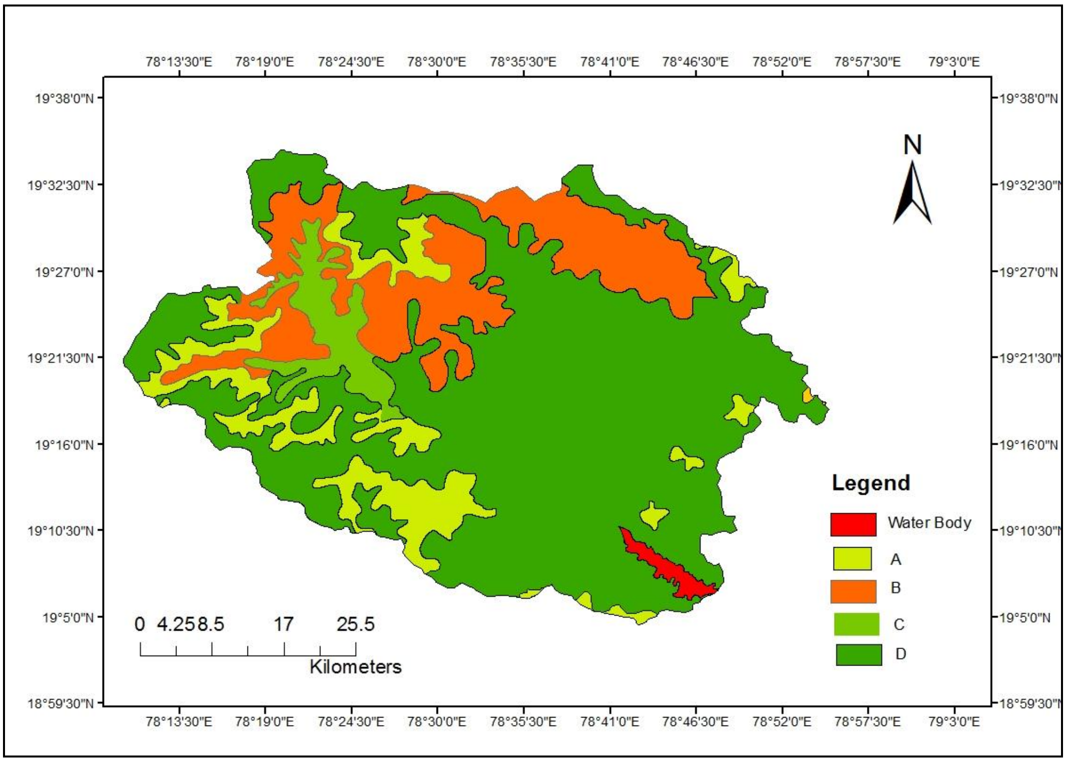

Figure 6 Soil map of Kaddam Watershed

4.2. CN Value

In terms of land use and hydrologic soil group combination, the lowest CN value was found to be 30 in Agriculture area and the highest CN value was found to be 85 in low forest area. High CN values in exposed land and rocky outcrop can be explained by low vegetation density, with the soil being compact proving the area having predominant clay soil and presence of stony surface which cause low infiltration rate. Figure 7 shows Curve Number map.

Table 3 Curve number and their respective land use land cover table of the study area

S.No.	LandUse Class	Dominant Hydrologic Soil group	CN number
1	Waterbody	-	100
2	Forest	D	78
3	Agriculture	A	30
4	Fallow/wasteland	D	67

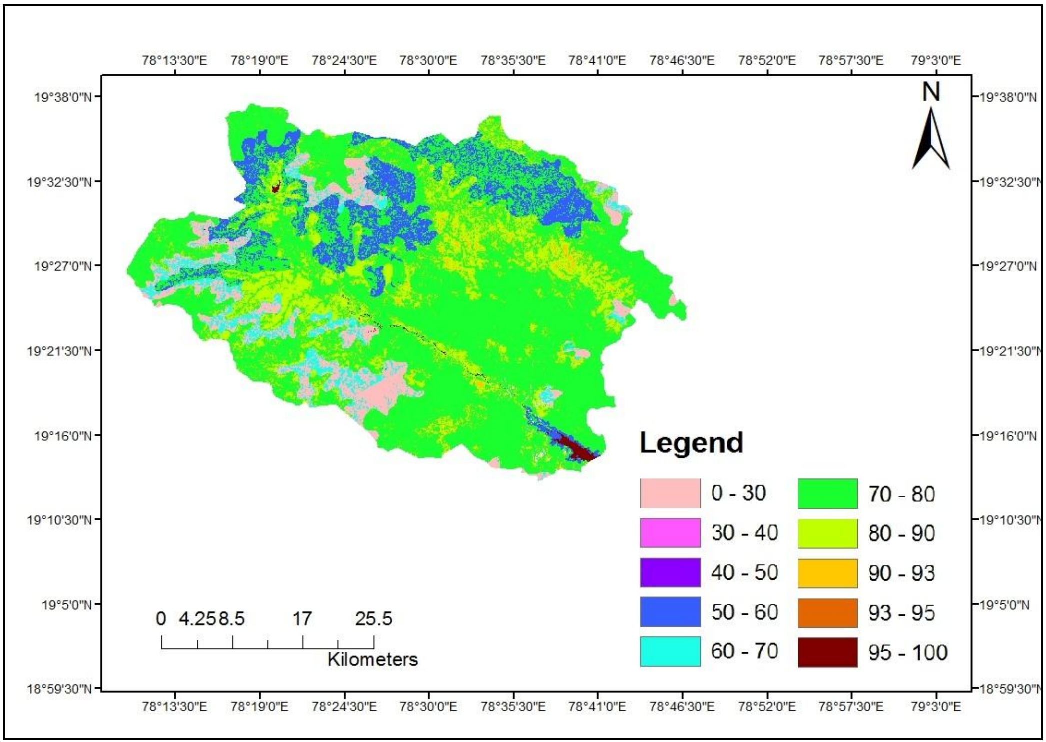

Figure 7 Curve number map of Kaddam Watershed

4.3. Runoff Map

Runoff is calculated using rainfall data. The runoff is mainly dependent on both soil type, landuse type and the slope of the catchment. For that, 14 year rainfall data was obtained. For this study we have used daily annual rainfall to calculate the daily runoff using SCS CN method. We have generated runoff for whole catchments lying in the study area. As the daily data is taken for 14 years being a large data, the result for only a month of august is shown (Figure 7 showing runoff Map generated in Arc GIS for the year 2000). However the average runoff for the 14 year is calculated from the ArcGIS (Table 4). The statistics showed different runoff grid value throughout the year 0 being the lowest and 70 being the highest runoff. The highest runoff was shown during high number of rainfall of 156.00 cm where the runoff was abnormally high which was seen in the mandal of Kaddam. Mostly the recurring runoff values were between 0 – 27. 0 was mainly seen near the water bodies. For the average rainfall taken for 14 years was 50.06 mm and the runoff was found to be 13.62 mm.

Table 4 Runoff grid value for average rainfall 50.06mm

S.no.	Runoff Grid Value	Pixel Count	Area in %
1	0	2459	5.72
2	4	629	1.46
3	9	870	2.02
4	12	33752	78.60
5	21	64	0.14
6	22	3172	7.38
7	33	215	0.50
8	50	1780	4.14

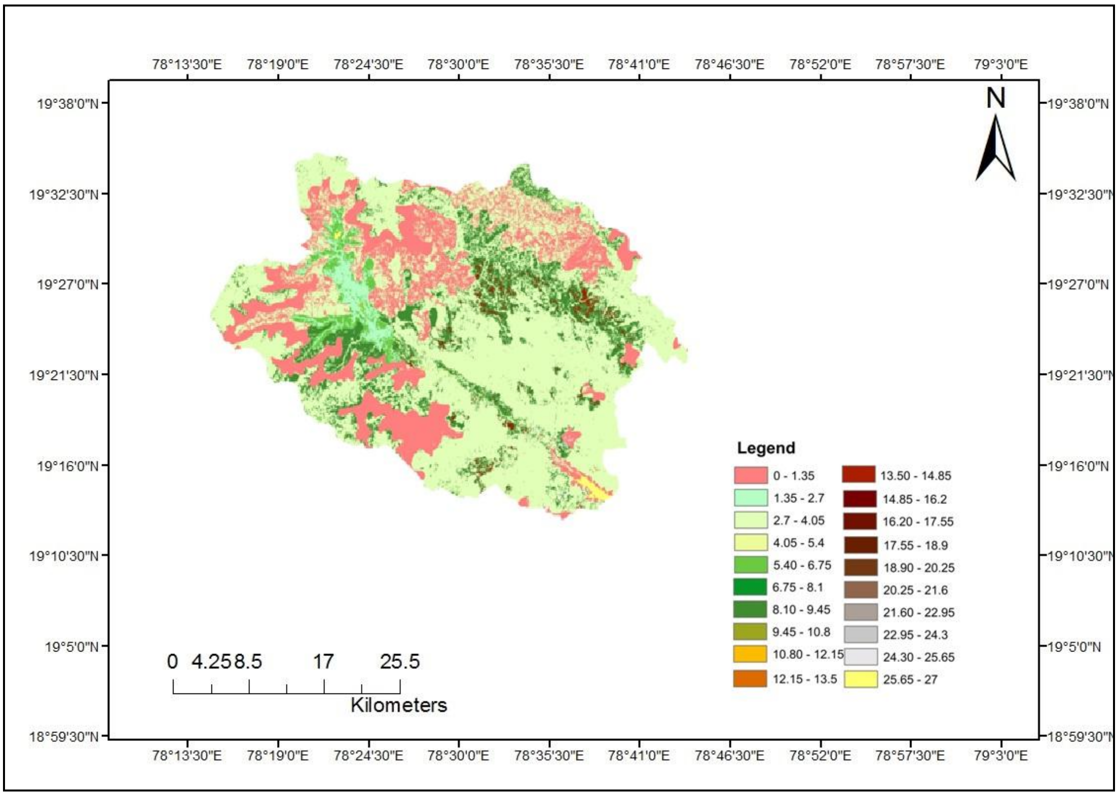

Figure 8 Runoff map of Kaddam Watershed

V. CONCLUSION

There are many empirical formulas for the calculation of runoff but it may be cumbersome to calculate the data for many years' data. Hence the calculation of runoff in GIS has found to be very uncomplicated and easy. The incorporation of SCS-CN model and GIS facilitates for runoff estimation improves the accuracy of estimated runoff. The accurate assessment of runoff for all the stream and watershed may take time and develop management problems. Remote sensing technology has been of great value that makes the conventional method easier to a great extent in rainfall-runoff studies. The developed ArcCN-Runoff tool reduced the technical processing from days to hours for varied spatial curve number and runoff maps.

REFERENCES

[1]. Anubha Topno, Singh A.K. and Vaishya R.C (2015) "SCS CN Runoff Estimation for Vindhyachal Region using Remote Sensing and GIS", International Journal of Advanced Remote Sensing and GIS 2015, Volume 4, Issue 1, pp. 1214-1223.

[2]. A.S Chandra Bose, MVSS Giridhar, GK Viswanadh (2013), "GIS-based fully distributed rainfall-runoff model for suggesting alternate land use patterns", World Environmental and Water Resources Congress 2013, ASCE publisher, p-2060-2068.

[3]. Chatterjee C, Jha R, Lohani AK, Kumar R and Singh R (2001) "Runoff curve number estimation for a basin using remote sensing and GIS". Asia Pacific Remote Sensing GIS J. 4, 1-7

[4]. G. Sreenivasa Rao, M.V.S.S. Giridhar and Shyama Mohan (2017) "Rainfall analysis with reference to Spatial and Temporal in Kaddam Watershed Using Geomatics", Nattional Conference on Water, Environment and Society (NCWES-2017).

[5]. Tejram Nayak, Verma M.K, Hema Bindu.S (2012)., SCS curve number method in Narmada basin, International Journal Of Geomatics And Geosciences, Volume 3, No 1, 2012 , ISSN 0976 – 4380.

[6]. Nayak, T.R. and Jaiswal, R.K., (2003), Rainfall-runoff modelling using satellite data and GIS for Bebas river in Madhya Pradesh, IE (I) Journal, 84, pp 47-50.

International Journal of Computational Engineering Research (IJCER) is UGC approved Journal with Sl. No. 4627, Journal no. 47631.

G. Sreenivasa Rao. "SCS-CN Method and Geomatics Approach for Fully distributed Runoff Modelling." International Journal of Computational Engineering Research (IJCER), vol. 7, no. 9, 2017, pp. 20–26.