Estimation of SCS-Curve Number for Kaddam Watershed Using Remote Sensing and GIS

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Abstract: The SCS-CN method is the most widely used method and the curve number is a function of land use and hydrologic soil group. 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). Usually the curve number is classified according to the United State land features classification which may not be applicable to the Indian land features. A high curve number means high runoff and low infiltration (urban areas), whereas a low curve number means low runoff and high infiltration (dry soil). In this study, a rainfall map of the study area was prepared by Thiessen polygon method for years 2000-2014 and the rainfall data for daily was obtained from which normal average monthly, yearly was analyzed. Soil maps have been prepared for the watershed. GIS is used to explore spatial patterns of the trends over the entire Kaddam basin. GIS software can easily handle, store, analyze, manipulate and retrieve spatial data map preparation can be easily implemented using GIS environment. The data over the years was collected and maps were obtained with the help of GIS. Eight rain gauge stations namely Inderavelly, Ichoda, Bazarhathnoor, Boath, Naranoor, Khanapur, Kaddam and Utnur located within the Adilabad district, Telangana, have been analyzed for the period 2000–2014. The land use and land cover map have been obtained by the supervised classification for the different seasons of kharif and Rabi. Giving the input of land use land cover and soil map the Curve Number (CN) grid have been obtained by the SCS method. 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. There has been considerable increase in the percentage of runoff during the years 2003, 2005, 2010 and 2013 in which rainfall has been high.

Index Terms: **SCS-CN method, Curve number, runoff, Kaddam watershed, ArcGIS**

1. Introduction

Curve number is an important parameter for the estimation of runoff. Runoff depends on a various parameters like type of soil, land use, land cover, surface condition and antecedent moisture condition. These factors are incorporated in a single CN parameter (Nayak et.al, 2003). 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.

There are have been several approaches to estimate runoff for example K. Ibrahim-Bathis and S. A. Ahmed (2015) determined SCS curve number loss method which is used to estimate the excess rainfall and surface runoff in Doddahalla watershed. Careful study has done to assign the CN for the different land use. The simulated results provide essential information on the rainfall-runoff, watershed runoff characteristics, stream flow and their velocity, peak flow and their respective time. The study concludes that the simulated result can be useful for the water and land resource planning and management practice in the Doddahalla watershed. The studies by S.Gajbhiye and S. K. Mishra (2012) showed the curve number method was followed to estimate runoff depth for selected storm events in the watershed. Effect of slope on CN values and runoff depth was determined. Statistically positive correlations were detected between estimated and observed runoff depth is 0.77 and slope adjusted vs. observed runoff depth is 0.76. Remote sensing and GIS is very reliable technique for the preparation of most of the input data required by the SCS curve number model.

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. But this information is essential in dealing with watershed development and management problems. Remote sensing technology can augment the conventional method to a great extent in rainfall-runoff studies. In this study SCS CN modified method is implemented in GIS for estimation of runoff of the watershed area.

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.

2. 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.

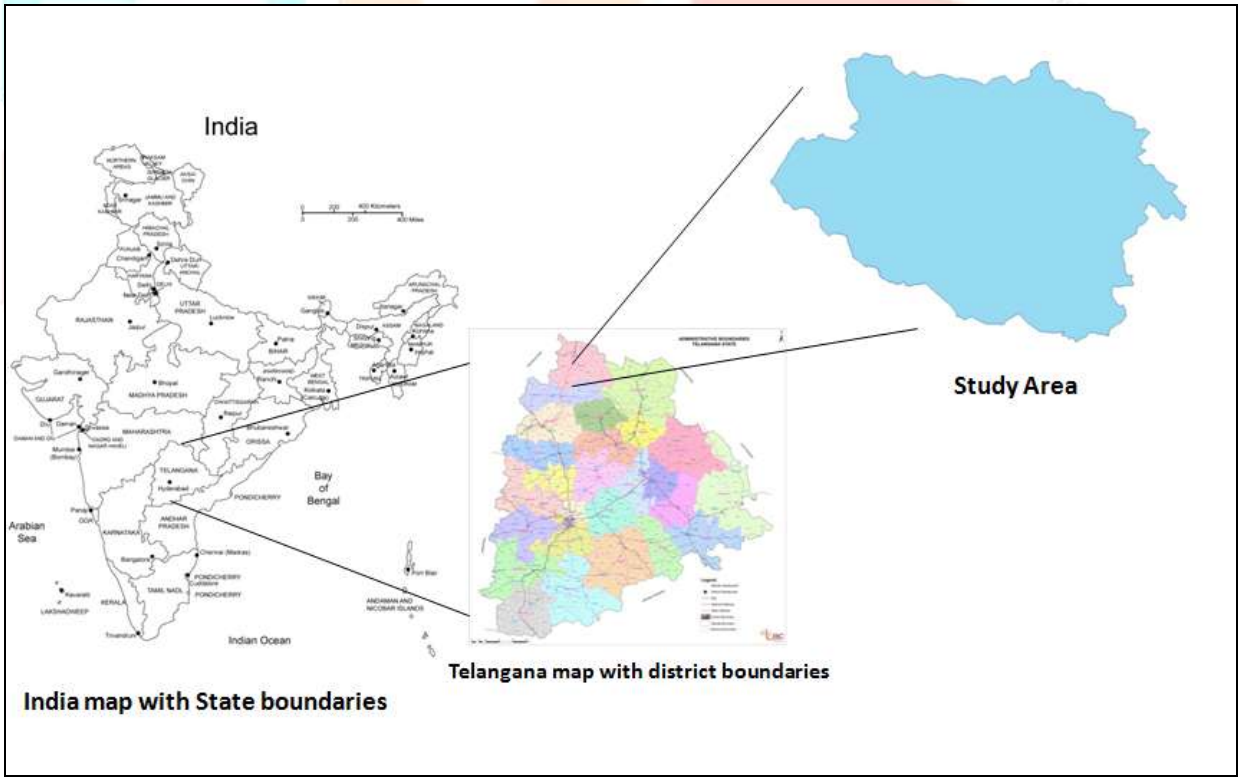

Figure 1 Location map of Kaddam Watershed

3. 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. Arc GIS software version 9.3 was used for creating, managing and generating maps.

3.1 Preparation of Rainfall maps

For the preparation of rainfall maps, the daily rainfall data is collected for the years 2000 to 2014. The rainfall data is from the eight rain gauge stations viz., Boath, Khanapur, Bazarhatnoor, Kaddam, Ichchoda, Utnur, Indervelly, Narananoor. The Thiessen Polygon method is an interpolation method is used for precipitation of maps in ArcGIS.

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 Figure2. 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

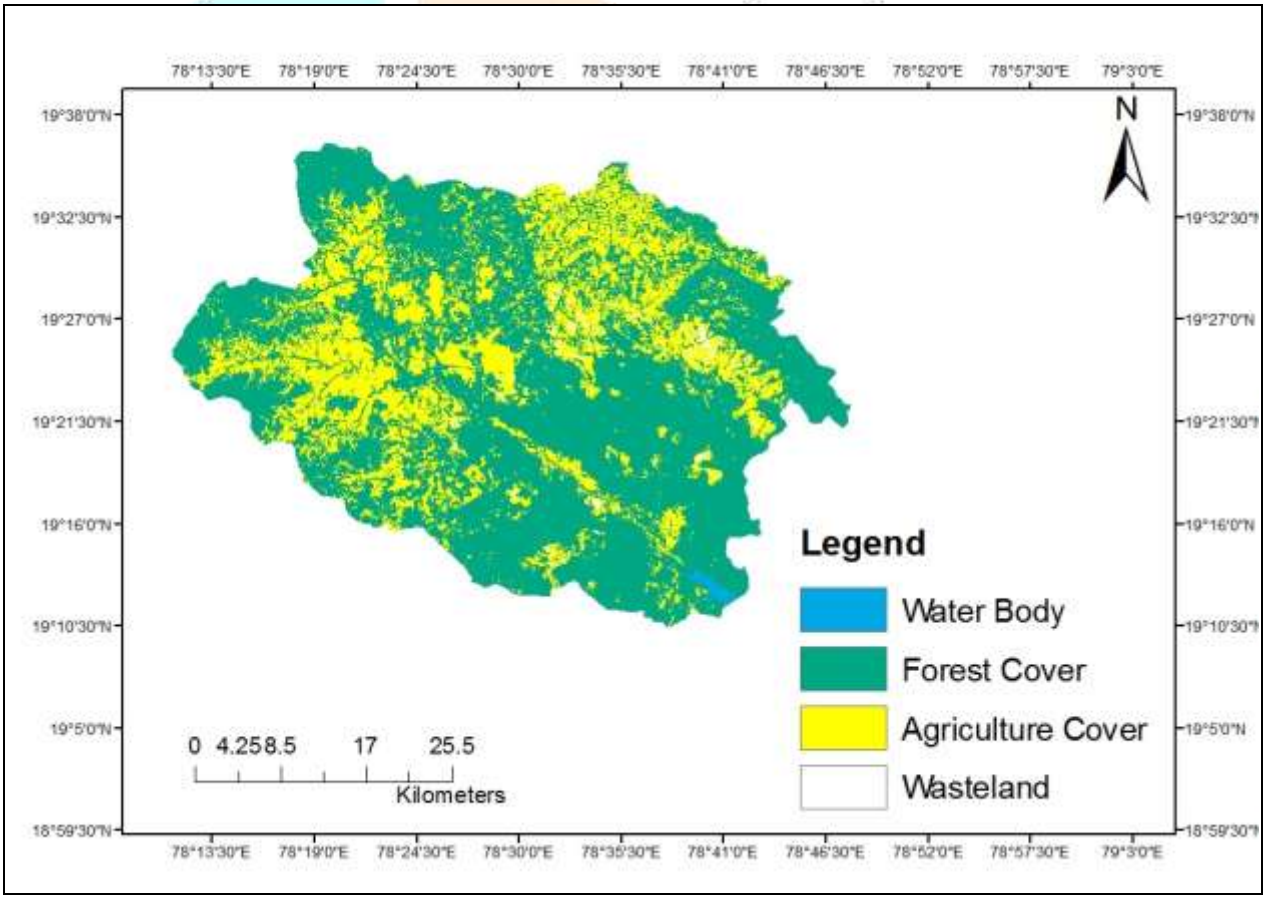

Figure 2 Land Use Land Cover map of Kaddam Watershed

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 3) was thus created. The study area comprised of five different types of soil dominated by clay soil.

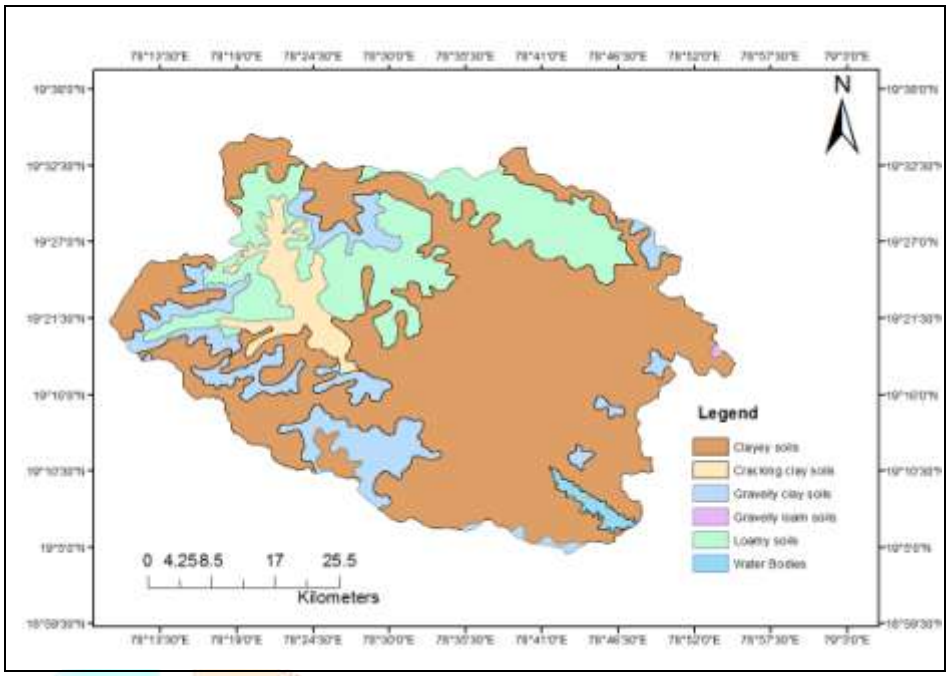

Figure 3 Soil map of Kaddam Watershed

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.

(1)

4. Results and Discussion

For the generation of curve number soil map, land use land cover map and hydrological soil map have been prepared and the results of these are explained below.

4.1. 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. The watershed has different soil group according to which the soil code has been assigned. The hydrologic group of 'A', 'B', 'C', 'D' groups are formed in Arc GIS is shown in Figure 5. It is obtained by performing Intersection operation between Soil map and Land use layer in GIS. In this map new polygons has been obtained and with each polygon the soil hydrologic group and landuse type are associated. The clayey soils have been given the hydrologic group D, the cracking clay soils are represented by soil group C, the loamy soils are given by soil group B, the gravely loamy soil and gravelly clay soil are given the hydrologic soil group A. Each of the soil group has a different runoff potential due to different infiltration rates (Table 2). The soil group A has the lowest runoff potential whereas the soil group D has the highest runoff potential.

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

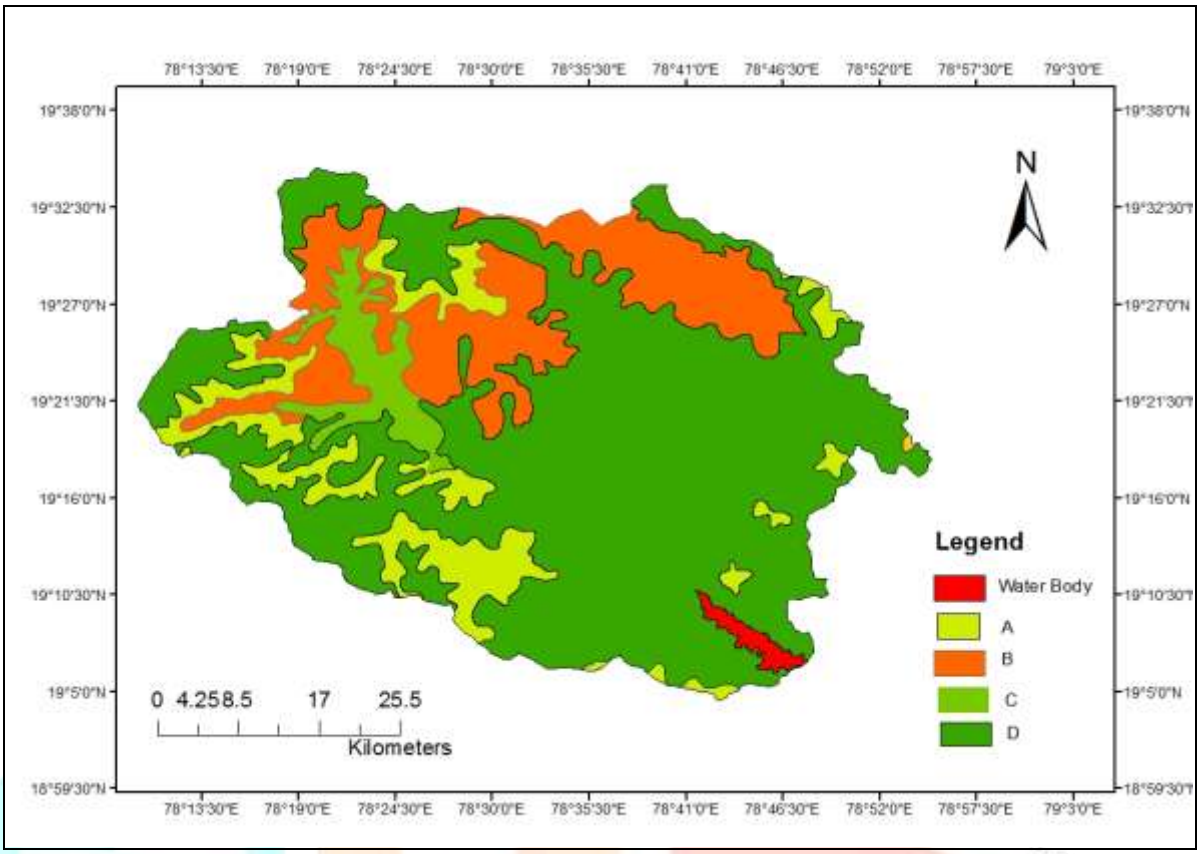

Figure 5 Soil map of Kaddam Watershed

4.2. CN Value

From the standard SCS-CN table the correct curve numbers were assigned for all the combinations. The calculated CN value for each polygon is for average conditions. The CN value of each hydrologic soil group and corresponding land use class are given in Table 2. Hydrologic soil group A indicates low CN value whereas hydrological soil group D indicates to high 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. These values show that agricultural area generates more runoff for a given rainfall in areas having greater CN values. Because by increasing the value of CN in a specific area, the amount of runoff will be increased. Figure 6 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

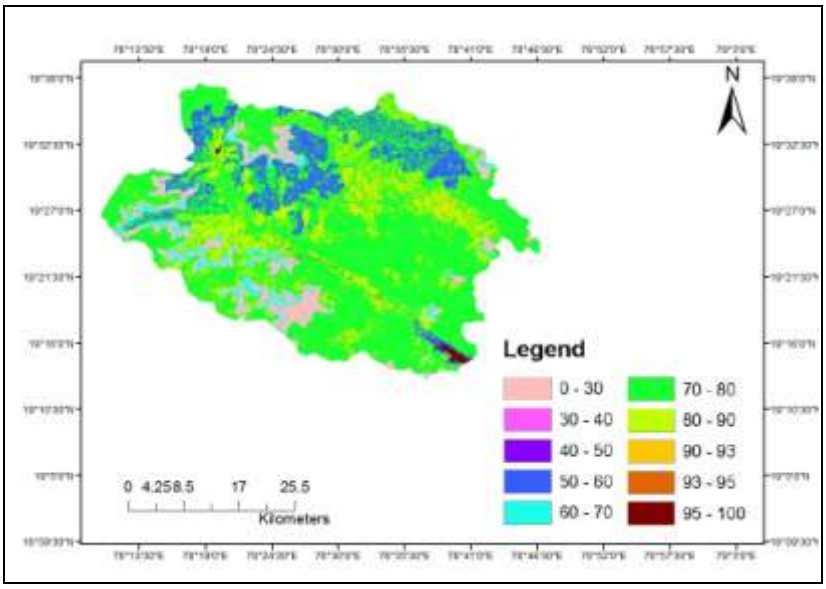

Figure 6 Curve number map of Kaddam Watershed

5. Conclusion

The classification of runoff manually for the whole watershed is not possible. The calculation of curve number in GIS has found to be very uncomplicated and easy. Each hydrological parameter like land use land cover, soil classification etc., are easily estimated using the remote sensing data. Remote sensing technology has been of great value that makes the conventional method easier to a great extent in rainfall-runoff studies. The SCS curve runoff incorporated in the GIS made the process accurate and fast. Remote sensing and GIS offers potential to increase the detail of spatial in both description and resolution of the image.

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