Estimation of Surface Runoff in an Ungauged Basin Using SCS-CN Method, A Case Study of Manair River Basin in Telangana, India

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Abstract The present research work was carried out for estimation of surface runoff in an ungauged basin by SCS-CN curve method. Satellite Images, digital elevation model data, hydrological Soil Data and precipitation data combined with Geo spatial technologies was used for land use/land cover classification, drainage extraction, basin delineation and for the surface runoff estimation of the study area. The study area Manair basin is located under 4 districts Karimnagar, Kamareddy, Medak and Rajanna-Sircilla districts of Telangana State, Southern India. Manair River is one of the major tributary to the Godavari River. The Manair Basin is further divided into three sub basins in which three dams named Upper Maniar dam, Mid Manair dam and Lower Manair dam are there across the Manair river basin. In the present study the surface runoff estimation is computed for the entire Manair basin. The total drainage area of basin is 6668.212 sq. km and morphometric analysis shows sub-dendritic and dendritic pattern. The Maniar basin is in Elongated shape which indicates heavier flow for the long duration. The runoff estimation by SCS-CN curve method is determined by integrating land Use/land cover classification with antecedent moisture condition and hydrological soil groups. The study area receives the good rainfall but most of it is lost by surface runoff due to overland flow and Clay soil texture present in the study area. It was perceived from the results that overall increase in runoff is directly proportional to precipitation in the study area. The daily precipitation data from 11 weather stations which are present in the study area have been collected during the years 2010 - 2018 and were used to estimate the daily runoff from the basin. Daily and annual runoff has been calculated from the monthly rainfall data for the years of 2010 to 2018 in the basin.

Keywords: Remote Sensing and GIS SCS-CN, Rainfall-Runoff, Land use/ Land cover, Basin

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1. Introduction

The surface Runoff is one of the vital hydrologic variables used for effective water resources management and planning. Estimating surface runoff is a very complex process as it is nonlinear, time-varying and spatially distributed.it is estimated by determining the gradient, soil type, permeability and land use.

Surface runoff is a larger for areas with low infiltration (pavement, steep gradient), and lower for permeable, well vegetated areas (forest, flat land) with respect to the precipitation.

The importance of estimating surface runoff is not only to know the hydrological processes of the area but also to determine flooding areas during storms and also to build flood control channel where ever there is possibility of flash flood.

There are many methods for rainfall runoff Modelling like Soil water Analysis tool(SWAT), MIKE 11, HEC-RAS etc., among that SCS-CN curve is the simplest method for estimating runoff in a basin after rainfall event. It has been developed by Soil Conservation Service (SCS-1985), United States Department of Agriculture (USDA). The surface runoff estimation by SCS-CN curve method is determined by integrating land Use/land cover classification with antecedent moisture condition and hydrological soil groups. The SCS-CN method is adaptable in any study area and used for runoff estimation in ungauged basins. In the present case study, the SCS-CN method has been modified according to the Indian conditions with the help of remote sensing data and GIS techniques.
2. Study Area

The study area Manair basin lies between 17.70°N to 18.62°N latitude and 78.22°E to 79.28°E longitude (Figure 1). The total geographical area of the basin is 6668.212 sq. km. The streams in the study area form dendritic to sub-dendritic drainage pattern and feeds through several small reservoirs and percolation tanks. Manair River is the major tributary for the Godavari River.

Manair basin experiences southwestern monsoon rains in June-September with an annual rainfall of 600 mm. May is the hottest month with a maximum temperature of 44°C and minimum temperature 27°C in the month of December. The average annual rainfall is 907 mm.

3. Materials and methods

The Following Data sets were used for the present study. The flowchart of the adopted methodology for the present study is shown in the Figure 2.

Sentinel satellite data of 10 m resolution and Survey of India toposheets were Geo-Referenced with reference to Ground control points and mosaics of toposheets were done in the GIS software.

Table 1. Data sets used for the present study

| Si No | Data Set                                           | Data Set Source                                      |
|-------|----------------------------------------------------|------------------------------------------------------|
| 1     | Sentinel satellite data 10 m resolution            | USGS Earth Explorer portal                           |
| 2     | SRTM Digital Elevation Model 30m resolution         | USGS Earth Explorer portal                           |
| 3     | Survey of India toposheets of Nos E44G3, E44G6, E44G7, E44G8, E44G10, 6 E44G11, E44G12, E44G14, E44G15, E44G16, E44M9, E44M10, E44M13, E44H2, E44H3, E44H4, E44H8, E44N1 | Open Series map from Survey of India Nakshe portal |
| 4     | Soil Map                                           | Regional Agricultural Department, Telangana          |
| 5     | Rainfall data                                      | Weather stations installed by planning department of Government of Telangana |
Maniar river basin area and stream network was delineated and stream order was determined by using SRTM Digital Elevation Model data of 30m resolution with the help of spatial Analyst tool as shown in Figure 3 and with respect to the delineated basin the area of interest is extracted from the Satellite image and toposheets in the GIS software for generating land use and land cover map of the study area as shown in Figure 4.

Soil texture map of the area from the regional State Agricultural Department of Telangana State is used as a reference in identifying different soil texture classes. Depending upon the soil types and their infiltration abilities the hydrologic soil groups A, B, C and D were determined and then hydrologic soil map was then generated Figure 5.

The Superimpose of Land use map on hydrologic soil map have been done to obtain each land use soil group polygon and area of each polygon was found and then curve number was assigned based on the standards of SCS curve number method as shown in the Table 2.

The rainfall data was collected during the years 2010 to 2018 from the weather stations installed in the study area and by using the rainfall data the antecedent soil moisture condition of the study area was determined as shown in the Table 3.

The curve number for each drainage basin of area-weighting calculated from the land use-soil group polygons within the drainage basin boundaries
**4. SCS-CN Model**

The SCS-CN model was developed by the USDA SCS (1974) and it is mostly used as empirical method to estimate direct runoff of the watershed.

The Soil conservation Service-Curve Number method is centered on the water balance calculation.

Two fundamental hypotheses had been proposed [19]. The first suggestion states about that the ratio of the amount of direct runoff to the maximum possible runoff is equal to the ratio of the total of infiltration to the capacity of the potential maximum retention. The second hypothesis states about that the amount of early abstraction is some fraction of the probable maximum retention.
Table 2. Soil Conservation Service classification (USDA1974)

| Hydrologic soil (HSG) | Type of soil                                                                 | Runoff potential | Water transmission | Final infiltration |
|-----------------------|------------------------------------------------------------------------------|------------------|--------------------|--------------------|
| Group A               | Deep, well drained sands and gravels                                         | Low              | High rate          | > 7.5              |
| Group B               | Moderately deep, well drained with Moderate                                  | Moderate         | Moderate rate      | 3.8-7.5            |
| Group C               | Clay loams, shallow sandy loam, soils with moderate to fine textures         | Moderate         | Moderate rate      | 1.3-3.8            |
| Group D               | Clay soils that swell significantly when wet                                 | High             | Low rate           | < 1.3              |

The infiltration losses are combined with surface storage by the relation of

\[ Q = \frac{(P - Ia)^2}{P - Ia + S} \]  \hspace{1cm} (1)

\[ Ia = 0.3S \]  \hspace{1cm} (2)

For Indian condition the form S in the potential maximum retention is given by,

\[ S = \left( \frac{25400}{CN} \right) - 254 \]  \hspace{1cm} (3)

Where CN is known as the curve number. Hence, the equation can be rewritten as,

\[ P = \frac{(P - 0.3S)^2}{P + 0.7S} \]  \hspace{1cm} (4)

After getting the significant value of CN, the Runoff of the basin was calculated from Eq.s 3 & 4.

In SCS curve number runoff is estimated by the ability of soils to allow infiltration of water with respect to land use/land cover and antecedent soil moisture condition (AMC) of the watershed. Based upon the U.S. soil conservation service, soils are divided into four soil groups namely A, B, C & D according to their rate of runoff potential and final infiltration rate of the soils as shown in Figure 5.

5. Hydrological Soil Group (HSG)

The Soil map was developed from the data of Regional Agricultural Department of Telangana. Soil texture refers to relative proportion of various soil separates in a soil material and is related to soil-water inter relationship. Clay content present in the soil is considered for determining the soil group.

The Soil textures in the study area were digitized and depending upon the soil texture and infiltration ability the soil groups (Table 2) were assigned to the soils as A, B, C and D in the as shown in Figure 4.

The soils of group A have low runoff potential with high infiltration rate, group B soils have moderate infiltration rate, moderately well drained. Group C soil indicates moderately fine textures and moderate rate of water transmission and the soils of group D pointed to slow infiltration and possible high runoff.
6. Antecedent Soil Moisture Condition

The soil moisture condition in the basin before the storm event occurs is another important factor influencing the surface runoff. In the Curve Number Method, the soil moisture condition is classified into three Antecedent Moisture Condition (AMC) Classes:

AMC I: The soils in the basin are dry,
AMC II: Average condition.
AMC III: The soils in the basin are practically saturated from antecedent rainfalls (i.e. the soil moisture content is at maximum field capacity).

The above classes were based on the 5-day antecedent rainfall (i.e. the accumulated total rainfall preceding the runoff under consideration). In SCS method, a distinction was made between the dormant and the growing season to allow for differences in transpiration as shown in Table 3.

The following equations are used in the cases of AMC-I and AMC-III [20]:

$$CN(III) = \frac{CN(II)}{0.427 + 0.00573CN(II)}$$  \hspace{1cm} (6)

Where, CN (II) is the curve number for normal condition, CN (I) is the curve number for dry condition, CN (III) is the curve number for wet conditions.

$$CW_n = \sum CN_i \frac{A_i}{A}$$  \hspace{1cm} (7)

Where is the weighted curve number; is the curve number from 1 to any number N; is the area with curve number; and A is the total area of the watershed.

7. Integration for Estimating Surface Runoff Potential

The soil group and land use/ Land cover layers were overlaid and intersected on one another in GIS software. For Estimation of the curve number HSG and the LULC classes namely Agricultural Crop Land, fallow, plantation, built-up forest land and barren lands were taken into consideration in order to determine the curve number values. Curve numbers are allotted for each land use-soil group combination of the classes (Table 4).

The result obtained from this intersection was used to compute total area weighted curve number of the study area to calculate the AMC II as shown in Table 5.

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### Table 3. Antecedent soil moisture classes (AMC)

| AMC Group | Soil characteristics | Five day antecedent rainfall in mm |
|-----------|---------------------|-----------------------------------|
|           |                     | Dormant season | Growing season |
| I         | Wet condition       | Less than 13   | Less than 36   |
| II        | Average condition   | 13-28          | 36-53          |
| III       | Heavy rainfalls     | Over 28        | Over 53        |

$$CN(I) = \frac{CN(II)}{2.281 - 0.0128CN(II)}$$  \hspace{1cm} (5)

### Table 4. Distribution of land use with corresponding CN and HSG

| S.NO | Land use            | Soil type | Area in Km2 | CN | % Area | % Area Weighted Curve * CN |
|------|---------------------|-----------|-------------|----|--------|----------------------------|
|      | Agricultural Crop Land | A         | 1.69        | 67 | 1.23   | 82.08                      |
|      |                     | B         | 582.79      | 78 | 8.74   | 681.71                     |
|      |                     | C         | 2561.42     | 85 | 38.41  | 3265.05                    |
|      |                     | D         | 1061.43     | 89 | 15.92  | 1416.68                    |
|      | Agricultural Fallow Land | A         | 14.17       | 76 | 0.21   | 16.15                      |
|      |                     | B         | 57.62       | 85 | 0.86   | 73.45                      |
|      |                     | C         | 334.37      | 90 | 1.32   | 118.93                     |
|      |                     | D         | 88.12       | 93 | 5.01   | 466.34                     |
|      | Agricultural Plantation | A         | 0.74        | 65 | 0.01   | 0.72                       |
|      |                     | B         | 1.8         | 73 | 0.03   | 1.97                       |
|      |                     | C         | 9.39        | 79 | 0.14   | 11.12                      |
|      |                     | D         | 8.31        | 81 | 0.12   | 10.09                      |
|      | Barren Land         | A         | 35.717      | 68 | 0.54   | 36.42                      |
|      |                     | B         | 63.26       | 80 | 0.95   | 75.89                      |
|      |                     | C         | 153.9       | 85 | 2.31   | 196.18                     |
|      |                     | D         | 447.425     | 88 | 6.71   | 590.46                     |
|      | Built up            | A         | 1.9         | 77 | 0.03   | 2.19                       |
|      |                     | B         | 14.99       | 85 | 0.22   | 19.11                      |
|      |                     | C         | 83.77       | 90 | 0.46   | 41.39                      |
|      |                     | D         | 30.67       | 92 | 1.26   | 115.58                     |
|      | Forest Land         | A         | 122.05      | 25 | 1.83   | 45.76                      |
|      |                     | B         | 11.19       | 55 | 0.17   | 9.23                       |
|      |                     | C         | 366.87      | 70 | 1.70   | 119.23                     |
|      |                     | D         | 113.58      | 77 | 5.50   | 423.64                     |
|      | Water bodies        | A         | 421.04      | 100| 6.31   | 631.41                     |
|      |                     | Total     | 6668.212    |    | 8450.80 |                            |

AMC - I = 71.00
AMC - II = 84.50
AMC - III = 92.85
8. Results & Discussions

The present study area basin has land use/land cover of about 64% area is of cropland, 7% area is of fallow land, 9% extent covers forest land, and remaining 20% of the area is occupied by others such as Built-up, water body, scrub land, hills and tanks. Forests play vital role in direct runoff in the watershed.

The soil type 'C' of soil group is predominately covered over 52% of the area which mainly has agriculture land which has moderate water transmission rate. The soil type 'D' of soil group has 26% cover of the total area which indicates slow infiltration and possible high runoff. The remaining 22% of the area comes under Group 'A' and Group 'B' Soils which have low runoff potential.

The calculated weighted CN values are 84.5 (CNII), 71(CN-I), and 92.85 (CN-III) for corresponding AMC-II, AMC-I, and AMC-III, respectively. Based on the precipitation data and weighted Curve numbers daily runoff for the years 2010 to 2018 was estimated for each storm event. It can be observed that precipitation is more during the south-west monsoon (June to September).

The precipitation varies between 523.1 to 1481 mm in the basin. Runoff varies 50.32mm-472.85 mm (2000-2018). The average annual runoff calculated come to be 893.45 mm and average Runoff volume for Nine years is 11,89,116.90 Mm².

It is observed that moderately less runoff due to presence of more vegetation in this area i.e. 20% of the total rainfall occurred in last 9 years in the area. Most of the precipitation during cyclonic storms results in maximum flows in the streams. The daily rainfall and runoff and annual runoff during 2010-2018 in the study area are shown in Table 6 & Table 7.

| Date       | Rainfall in mm | AMC | Runoff in mm |
|------------|----------------|-----|--------------|
| 30-06-2010 | 134.2          | I   | 59.26        |
| 04-07-2010 | 5.4            | III | 0.11         |
| 10-07-2010 | 18.2           | II  | 1.42         |
| 19-07-2010 | 41.4           | I   | 3.43         |
| 22-07-2010 | 16.2           | II  | 0.89         |
| 23-07-2010 | 27.4           | III | 12.82        |
| 25-07-2010 | 17.2           | II  | 1.14         |
| 28-07-2010 | 11.2           | II  | 0.07         |
| 04-08-2010 | 24.4           | I   | 0.12         |
| 05-08-2010 | 25.2           | I   | 0.18         |
| 11-08-2010 | 51.4           | I   | 6.99         |
| 14-08-2010 | 20.2           | III | 7.40         |
| 20-08-2010 | 37.2           | I   | 2.25         |
| 23-08-2010 | 51.2           | II  | 19.83        |
| 28-08-2010 | 14.3           | III | 3.60         |
| 29-08-2010 | 31.2           | I   | 0.96         |
| 02-09-2010 | 21.4           | II  | 2.49         |
| 03-09-2010 | 46.6           | II  | 16.57        |
| 05-09-2010 | 8.4            | III | 0.84         |
| 06-09-2010 | 29.4           | I   | 14.42        |
| 25-09-2010 | 56.2           | I   | 9.03         |
| 02-10-2010 | 35.2           | I   | 1.77         |
| 20-10-2010 | 28.2           | I   | 0.50         |
| 21-10-2010 | 23.4           | II  | 3.27         |
| 22-10-2010 | 11.3           | III | 2.03         |
| 23-10-2010 | 21.3           | III | 8.18         |
| 11-07-2011 | 24.4           | I   | 0.12         |
| 12-07-2011 | 31.2           | I   | 6.99         |
| 14-07-2011 | 5.2            | I   | 0.08         |
| 18-07-2011 | 30.4           | III | 0.82         |
| 19-07-2011 | 30.4           | III | 0.82         |
| 20-07-2011 | 40.2           | III | 23.58        |
| 29-07-2011 | 43.2           | III | 3.99         |
| 01-08-2011 | 10.2           | I   | 0.02         |
| 02-08-2011 | 15.2           | I   | 4.13         |
| 25-08-2011 | 45.2           | I   | 4.66         |
| 29-08-2011 | 24.3           | I   | 3.65         |
| Date          | Rainfall in mm | AMC | Runoff in mm |
|--------------|----------------|-----|--------------|
| 01-09-2011   | 29.4           | II  | 0.67         |
| 21-09-2011   | 30.2           | I   | 0.79         |
| 12-05-2012   | 22.2           | I   | 0.02         |
| 01-07-2012   | 66.2           | I   | 13.85        |
| 16-07-2012   | 82.2           | I   | 22.86        |
| 17-07-2012   | 9.2            | III | 1.13         |
| 20-07-2012   | 8.2            | III | 0.77         |
| 24-07-2012   | 44.2           | I   | 4.32         |
| 26-07-2012   | 30.2           | III | 15.07        |
| 27-07-2012   | 11.3           | III | 2.03         |
| 28-07-2012   | 19.2           | III | 6.71         |
| 29-07-2012   | 35.0           | III | 19.08        |
| 31-07-2012   | 4.2            | III | 0.00         |
| 01-08-2012   | 10.0           | III | 1.45         |
| 13-08-2012   | 56.2           | I   | 9.03         |
| 15-08-2012   | 12.0           | III | 2.37         |
| 18-08-2012   | 9.0            | III | 1.05         |
| 26-08-2012   | 48.2           | I   | 5.74         |
| 29-08-2012   | 14.4           | III | 3.66         |
| 30-08-2012   | 15.3           | III | 4.19         |
| 12-09-2012   | 35.6           | I   | 1.86         |
| 20-09-2012   | 27.4           | I   | 0.40         |
| 05-11-2012   | 22.3           | I   | 0.02         |
| 06-11-2012   | 30.4           | I   | 0.82         |
| 22-02-2013   | 60.2           | I   | 10.87        |
| 11-04-2013   | 33.2           | I   | 1.33         |
| 16-06-2013   | 22.2           | I   | 0.02         |
| 24-06-2013   | 28.8           | I   | 0.58         |
| 25-06-2013   | 24.2           | II  | 3.60         |
| 14-07-2013   | 38.2           | I   | 2.51         |
| 25-07-2013   | 12.2           | II  | 0.17         |
| 26-07-2013   | 17.4           | II  | 1.19         |
| 27-07-2013   | 12.4           | III | 2.57         |
| 28-07-2013   | 61.2           | III | 42.71        |
| 30-07-2013   | 190.4          | III | 168.79       |
| 31-07-2013   | 30.5           | III | 15.32        |
| 02-08-2013   | 18.2           | III | 6.03         |
| 03-08-2013   | 38.2           | III | 21.83        |
| 11-08-2013   | 34.8           | I   | 1.68         |
| 12-08-2013   | 28.4           | I   | 0.53         |
| 13-08-2013   | 12.8           | III | 2.78         |
| 30-08-2013   | 25.2           | I   | 0.18         |
| 20-09-2013   | 25.2           | I   | 0.18         |
| 01-10-2013   | 28.4           | I   | 0.53         |
| 02-10-2013   | 28.2           | II  | 5.45         |
| 03-10-2013   | 15.2           | III | 4.13         |
| 15-10-2013   | 98.4           | I   | 33.24        |
| 16-10-2013   | 40.6           | III | 23.93        |
| 19-10-2013   | 16.6           | III | 4.99         |
| 05-11-2013   | 36.2           | I   | 2.00         |
| 06-11-2013   | 38.2           | II  | 11.05        |
| 07-11-2013   | 10.6           | III | 1.70         |
| 08-11-2013   | 13.2           | III | 2.99         |
| 05-03-2014   | 30.2           | I   | 0.79         |
| 08-03-2014   | 11.2           | II  | 0.07         |
| 09-03-2014   | 15.2           | II  | 0.66         |
| 14-03-2014   | 30.2           | I   | 0.79         |
| 15-07-2014   | 23.2           | I   | 0.06         |
| 03-08-2014   | 33.2           | I   | 1.33         |
| 04-08-2014   | 10.2           | II  | 0.02         |
| Date            | Rainfall in mm | AMC | Runoff in mm |
|-----------------|----------------|-----|--------------|
| 05-08-2014      | 70.2           | III | 51.19        |
| 08-08-2014      | 14.2           | III | 3.55         |
| 09-08-2014      | 4.4            | III | 0.01         |
| 29-08-2014      | 22.2           | I   | 0.02         |
| 04-09-2014      | 25.2           | I   | 0.18         |
| 05-09-2014      | 21.2           | I   | 0.00         |
| 06-09-2014      | 44.2           | II  | 14.93        |
| 07-09-2014      | 24.2           | III | 10.33        |
| 08-09-2014      | 22.2           | III | 8.84         |
| 06-01-2015      | 28.4           | I   | 0.53         |
| 13-03-2015      | 25.2           | I   | 0.18         |
| 18-03-2015      | 17.4           | II  | 1.19         |
| 28-03-2015      | 22.2           | I   | 0.02         |
| 15-05-2015      | 102.0          | I   | 35.69        |
| 20-05-2015      | 10.4           | III | 1.62         |
| 26-05-2015      | 12.6           | II  | 0.22         |
| 27-05-2015      | 22.2           | II  | 2.79         |
| 28-05-2015      | 8.4            | III | 0.84         |
| 08-06-2015      | 25.2           | I   | 0.18         |
| 18-07-2015      | 24.2           | I   | 0.11         |
| 19-07-2015      | 61.8           | I   | 11.64        |
| 20-07-2015      | 16.2           | III | 4.74         |
| 27-07-2015      | 44.4           | I   | 4.39         |
| 14-08-2015      | 70.2           | I   | 15.96        |
| 17-08-2015      | 4.2            | III | 0.00         |
| 24-08-2015      | 78.2           | I   | 20.48        |
| 03-02-2016      | 72.2           | I   | 17.06        |
| 10-04-2016      | 26.4           | I   | 0.29         |
| 12-04-2016      | 52.6           | II  | 20.84        |
| 30-05-2016      | 22.6           | I   | 0.03         |
| 31-05-2016      | 63.6           | I   | 12.5         |
| 01-06-2016      | 4.2            | III | 3.00         |
| 03-06-2016      | 9.2            | III | 1.13         |
| 04-06-2016      | 38.2           | III | 21.83        |
| 08-06-2016      | 14.2           | II  | 0.46         |
| 12-06-2016      | 23.4           | II  | 3.27         |
| 15-06-2016      | 23.4           | III | 9.73         |
| 16-06-2016      | 26.0           | III | 11.71        |
| 17-06-2016      | 18.2           | III | 6.03         |
| 18-06-2016      | 31.2           | III | 15.89        |
| 21-06-2016      | 10.4           | III | 1.62         |
| 27-06-2016      | 88.2           | I   | 26.38        |
| 30-06-2016      | 17.4           | III | 5.51         |
| 01-07-2016      | 21.4           | III | 8.26         |
| 02-07-2016      | 4.4            | III | 0.01         |
| 03-07-2016      | 10.2           | II  | 0.02         |
| 04-07-2016      | 10.6           | III | 1.70         |
| 07-07-2016      | 28.2           | I   | 0.50         |
| 09-07-2016      | 30.4           | II  | 6.57         |
| 10-07-2016      | 14.8           | III | 3.89         |
| 12-07-2016      | 4.6            | III | 0.02         |
| 04-08-2016      | 50.4           | I   | 6.59         |
| 05-08-2016      | 23.4           | II  | 3.27         |
| 07-08-2016      | 68.4           | III | 49.48        |
| 17-08-2016      | 45.4           | I   | 4.73         |
| 18-08-2016      | 20.2           | II  | 2.06         |
| 19-08-2016      | 21.2           | III | 8.11         |
| 20-08-2016      | 5.2            | III | 0.08         |
| 21-08-2016      | 15.2           | III | 4.13         |
| 22-08-2016      | 15.6           | III | 4.37         |
| Date       | Rainfall in mm | AMC | Runoff in mm |
|------------|----------------|-----|--------------|
| 23-08-2016 | 16.2           | III | 4.74         |
| 25-08-2016 | 11.2           | II  | 0.07         |
| 28-08-2016 | 56.8           | I   | 9.30         |
| 29-08-2016 | 80.2           | III | 60.72        |
| 30-08-2016 | 81.0           | III | 61.49        |
| 31-08-2016 | 75.6           | III | 56.32        |
| 01-09-2016 | 7.2            | III | 0.47         |
| 03-09-2016 | 20.0           | III | 7.26         |
| 14-09-2016 | 60.2           | I   | 10.87        |
| 15-09-2016 | 12.2           | III | 2.47         |
| 08-06-2017 | 100.4          | I   | 34.59        |
| 10-06-2017 | 20.2           | III | 7.40         |
| 12-06-2017 | 11.4           | III | 2.07         |
| 13-06-2017 | 62.2           | III | 43.64        |
| 14-06-2017 | 22.2           | III | 8.84         |
| 14-07-2017 | 23.4           | I   | 0.07         |
| 19-07-2017 | 11.2           | III | 1.98         |
| 14-08-2017 | 71.5           | I   | 16.67        |
| 19-08-2017 | 8.35           | III | 0.82         |
| 20-08-2017 | 38.8           | I   | 2.68         |
| 22-08-2017 | 19             | II  | 1.67         |
| 14-09-2017 | 21.23          | I   | 0.00         |
| 30-09-2017 | 47.9           | I   | 5.63         |
| 06-10-2017 | 44.13          | I   | 4.30         |
| 06-07-2018 | 29.7           | I   | 0.71         |
| 08-07-2018 | 16             | II  | 0.84         |
| 09-07-2018 | 12.4           | III | 2.57         |
| 10-07-2018 | 4.8            | III | 0.04         |
| 14-07-2018 | 22.3           | I   | 0.02         |
| 20-07-2018 | 36.5           | I   | 2.08         |
| 21-07-2018 | 15.4           | II  | 0.70         |
| 12-08-2018 | 80.7           | I   | 21.96        |
| 16-08-2018 | 33.9           | III | 18.15        |
| 17-08-2018 | 9.8            | III | 1.36         |
| 21-08-2018 | 40.8           | III | 24.11        |
| 23-08-2018 | 4.1            | III | 0.00         |
| 24-08-2018 | 4              | III | 0.00         |
| 22-09-2018 | 55.2           | I   | 8.59         |

Table 7. Annual runoff depth and volume

| Years | Rainfall in mm | Runoff in mm | Volume=Runoff*Area(m²) |
|-------|---------------|--------------|------------------------|
| 2010  | 1095.4        | 179.55       | 11,97,277.46           |
| 2011  | 523.1         | 50.32        | 3,35,544.42            |
| 2012  | 885.8         | 116.42       | 7,76,313.24            |
| 2013  | 1299.4        | 380.99       | 25,40,487.41           |
| 2014  | 625.4         | 92.76        | 6,18,543.34            |
| 2015  | 792.8         | 100.57       | 6,70,622.08            |
| 2016  | 1481          | 472.85       | 31,53,064.04           |
| 2017  | 722.5         | 130.36       | 8,69,268.11            |
| 2018  | 615.72        | 81.121       | 5,40,932.02            |

9. Conclusions

In the present study, a SCS-CN method is used to estimate surface runoff potential in an ungauged basin. Land use map and soil map of the study area as input in GIS software. The daily rainfall-runoff simulation was found in the basin. The amount of runoff represents 20% of the total annual rainfall. In SCN Curve number method Antecedent moisture condition of the soil plays a very important role as the Curve number varies according to the soil moisture and that is considered while estimating the runoff depth. Conversations Service Curve Number method is capably recognized as a good technique, which consumes less time for extensive data sets as well as bigger environmental area to recognize site selection of artificial recharge structures. The water and soil preservation actions need to be planned and applied in order to construct appropriate groundwater structures, namely
percolation tanks, check dams and contour bunds after comprehensive studies of groundwater Prospective zones

**Conflict of Interest**

The author declares that they have no conflict of interest.

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