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Estimation of Runoff using SCS-CN Method and Geomatics Approachfor Rela Watershed, Rajasthan.

K. Hema Narayana Reddy[1], Dr. Mahesh Kothari[2], Dr. K. S. Reddy[3], Dr. P. K. Singh[4] and Dr. K. K. Yadav[5]

[1]*PhD Scholar,* [2]*Professor and Head,* [3]*Principal Scientist,* [4]*Professor,* [5]*Assistant Professor*

[1,2,4,5] *Department of Soil and Water Conservation Engineering, College of Technology and Engineering, Udaipur, Rajasthan.*

[3]*Central Research Institute for Dryland Agriculture, Hyderabad, Telangana.*

Abstract

Runoff is one of the most significant hydrological factors utilized in the vast majority of the land and water assets applications. It is a fundamental parameter at smaller scale level to address soil and water protection rehearses in a watershed. Curve Number (CN) technique is primarily utilized for assessing infiltration attributes of the watershed, in view of the land use property and soil property. The Curve Number (CN) is a land-cover list for the given land use-land cover class, elevation and soil type to decide the measure of precipitation that infiltrate into the ground and the sum that becomes overflow for a particular tempest occasion (USDA, 1986). It is important to measure the possible changes in the surface runoff in a watershed as an effect of the arranged or spontaneous changes made in the land use. The purpose of the current examination is to investigate the spillover time arrangement over a wide time interim, distinguishing potential examples and assessing their importance. In the current examination the surface runoff is evaluated for Rela Watershed utilizing SCS-CN technique. Hydrological soil group (HSG), land use/land cover Map, Soil and multi ghostly remote detecting information are utilized for the examination. In this examination rainfall runoff model has been created utilizing Remote Sensing and GIS procedures. For Rainfall Runoff model 30 years rainfall data used i.e. from 1988 to 2017. The insights indicated diverse runoff framework esteem during the time 19.5 mm being the most minimal and 527.3 mm being the maximum runoff for Rela Watershed. The average annual runoff is 162.6 mm i.e. 28% of total rainfall in Rela Watershed.

Key Words: *Rainfall, SCS-CN, Runoff, Remote sensing and GIS, Land Use/ Land Cover, Rela Watershed, Curve number.*

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I. INTRODUCTION

Exact estimation of runoff isn't just significant for the examination yet in addition for the proper management of watershed. Runoff can be evaluated through different observational equations SCS-CN method being one of them. SCS-CN gives an observational relationship to evaluating runoff as an element of soil type and land use. The Curve Number (CN) is a list created by utilizing HEC-GeoHMS Geospatial Hydrological Modeling Extension in ArcGIS, to represent the runoff within runoff region. The Curve Number for a drainage basin is assessed by using of land use, soil, and DEM. There are four hydrologic soil gatherings: A, B, C and D. While Group A, Group B, Group C and Group D has low infiltration rate, moderately low infiltration rate, moderately high infiltration and high infiltration rates respectively. The Curve Number for each sub watershed is estimates by using the Land use Land Cover and Soil maps of the study area in ArcGIS 10.5 software. In this study SCS – CN method is used to find the runoff for 30 years from 1988 to 2017 for Rela Watershed.

II. STUDY AREA

Rela watershed is located in Southern Rajasthan in Sarada block of Udaipur district is about 40 km from Udaipur. The study area is bounded between the latitude 24°23' - 24°17' N and 73°46' - 73°52' E longitude. Rela Watershed which is under Mahi river basin. The total area of Rela Watershed is about 4510.65 ha with highest elevation of 629 m and lowest elevation of 241 m above mean sea level.Rela watershed has 9 classes

of land use/land cover which are cultivable land, scrub land, pasture land, fallow land, forest land, mixed forest land, barren land, wet land and water bodies. Rela watershed comes under IVA (sub-humid southern plains) agro climatic zone of Rajasthan. The region has a moderately warm climate in summers and with mild winters. The average annual rainfall is 558 mm. The rainfall is received during monsoon moths from June to September. Distribution of rainfall during monsoon season is uneven and erratic. The temperature remains between 4^{o}C to 29^{o}C in winters, while it goes up to 44^{o}C in summer. The soils in Rela Watershed are mostly Red loam which are under hydrologic soil groups B. Soils are shallow to moderately deep and are very well developed in the valleys.

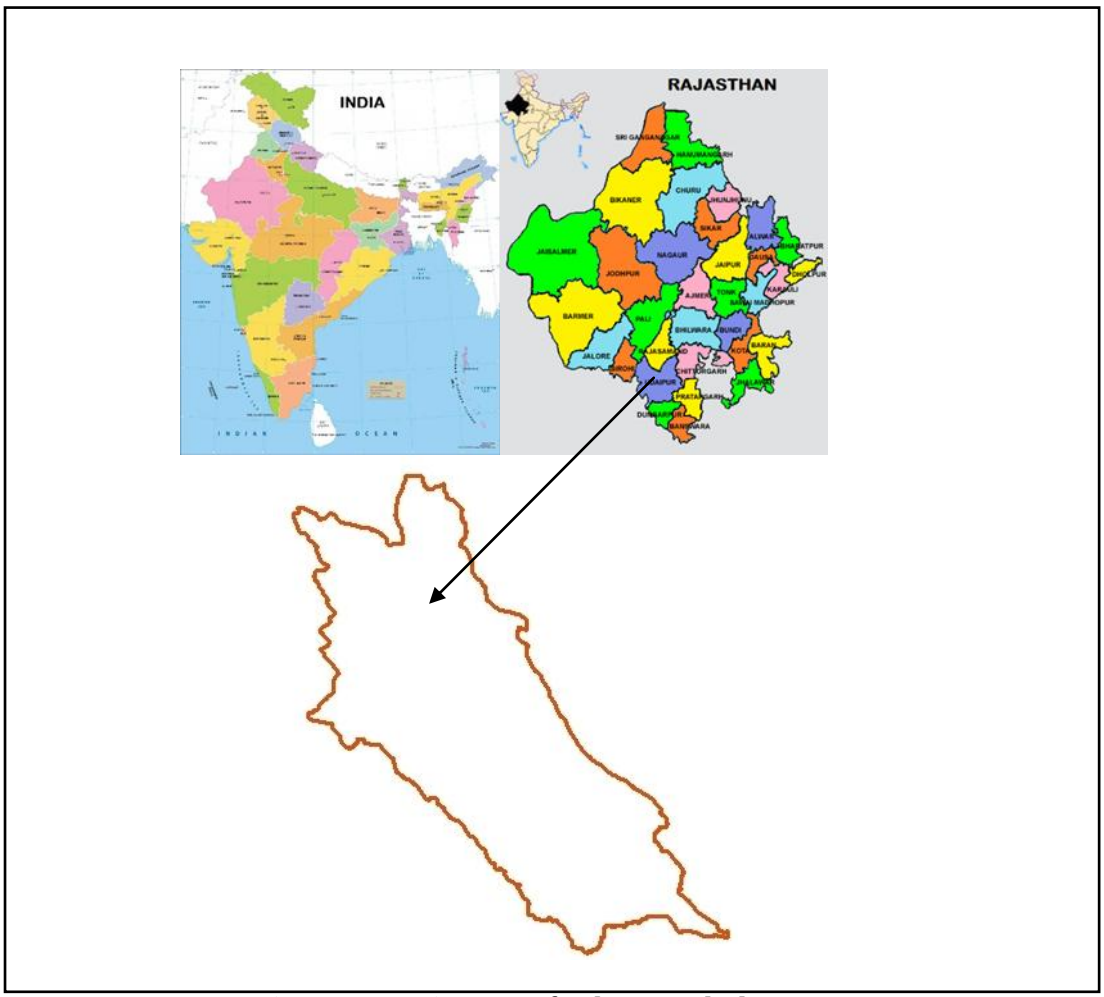

Figure 1: Location Map of Rela Watershed.

III. METHODOLOGY

SCS-CN method developed by Soil Conservation Services (SCS) of USA in 1969 is a simple, predictable and stable conceptual method for estimation of direct runoff depth based on-storm rainfall depth. It is a versatile and widely used procedure for runoff estimation. The SCS approach involves the use of simple empirical formulas and readily available tables and curves, developed by the Soil Conservation Service (SCS, 1985). The SCS runoff expressed in unit depth spread over the watershed for Indian conditions is given by

$$Q = \frac{(P-0.2S)^2}{P+0.8S} \quad (1)$$

$$S = \frac{25400}{CN} - 254 \quad (2)$$

Where, Q direct flow volume expressed as a depth, P total rainfall, S potential maximum soil retention, CN curve number value used to estimate potential maximum soil retention (S).

The potential maximum soil retention estimation, the initial abstractions (IA) was calculated. Initial abstractions are water losses, e.g. plant interception ns, infiltration and surface storage which occur prior to runoff and are then subtracted from the total runoff (USDA - SCS 1985). The standard assumption is that

$$I_A = 0.2S \quad (3)$$

Everyday Rainfall were collected for 30 years from 1988 to 2017 from the water resources department of Rajasthan. Those data were processed in Excel sheets for the desired area and land use/ land cover map were prepared for the desired location by using ArcGIS 10.5. The ArcGIS 10.5 is also used for the creation, manage and also for generation of maps. Methodology for runoff estimation shown in Figure 2.

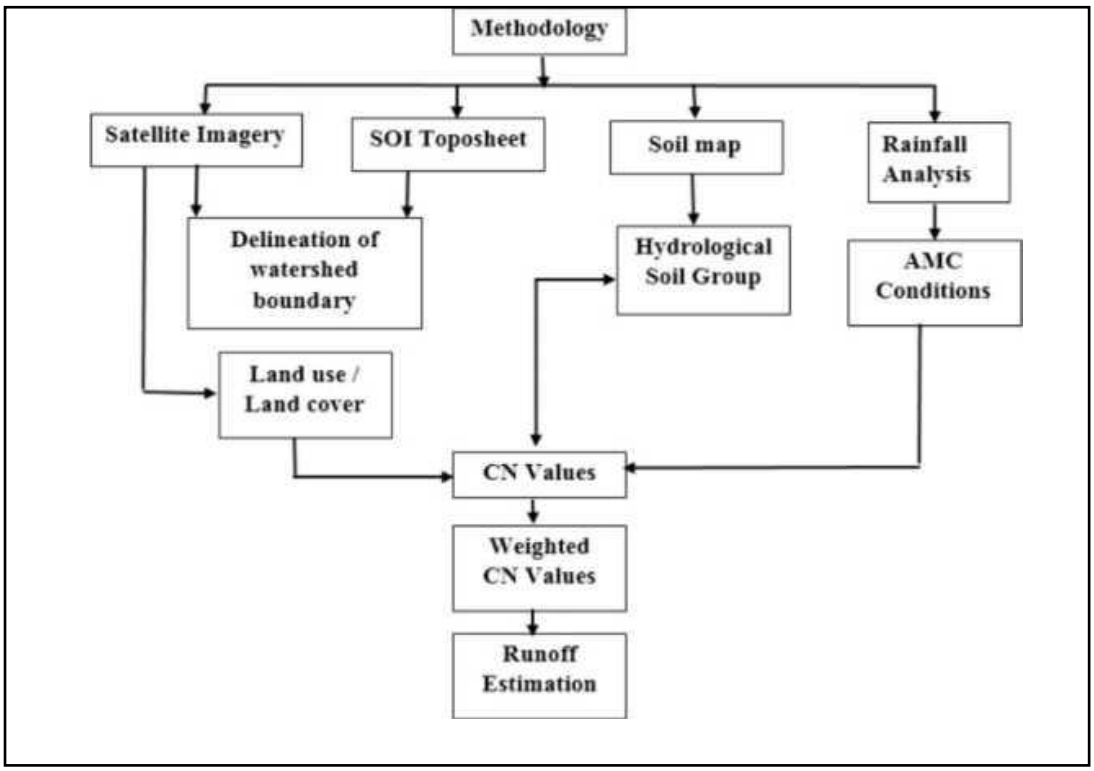

Figure 2: Methodology adopted for Runoff estimation

IV. RESULTS

4.1. Estimation of Runoff

4.1.1. Features of different thematic maps

In order to study runoff and site suitability different thematic maps such as Elevation map, Slope map, Soil map, Geomorphology and Land use/ Land cover map were prepared in Arc GIS.

4.1.1.1. Topographic elevation map

The elevation map was derived by using satellite imagery in Arc GIS. The highest elevation for the study area was 629 m and the lowest elevation was found to be 241 m.

4.1.1.2. Slope map

The slope map of Rela watershed was derived from the digital elevation map in Arc GIS. The slope of the area was classified in to very low (0-10%), low (11- 20%), medium (21-30%), Steep (31-50%) and very steep (>50%).

4.1.1.3. Soil map

The soil map obtained from NBSSLUP (National Bureau of Soil Survey and Land Use Planning) was digitized in Arc GIS and separated the boundary of watershed. The soils in the study area are classified in to coarse loamy and loamy skeletal which comes under hydrologic soil group B.

4.1.1.4. Land use/ Land cover map

In Rela watershed nine land use/ land cover classes were identified which are of Agricultural Cultivable Land, Scrub Land, Fallow Land, Forestland, Mixed Forest, Barren Land, Pasture Land, Wet Land and Water Bodies. The area and percentage under these classes is presented in table 1**.** The results revealed that about 59% of watershed was cultivable and the lowest area under built in land.

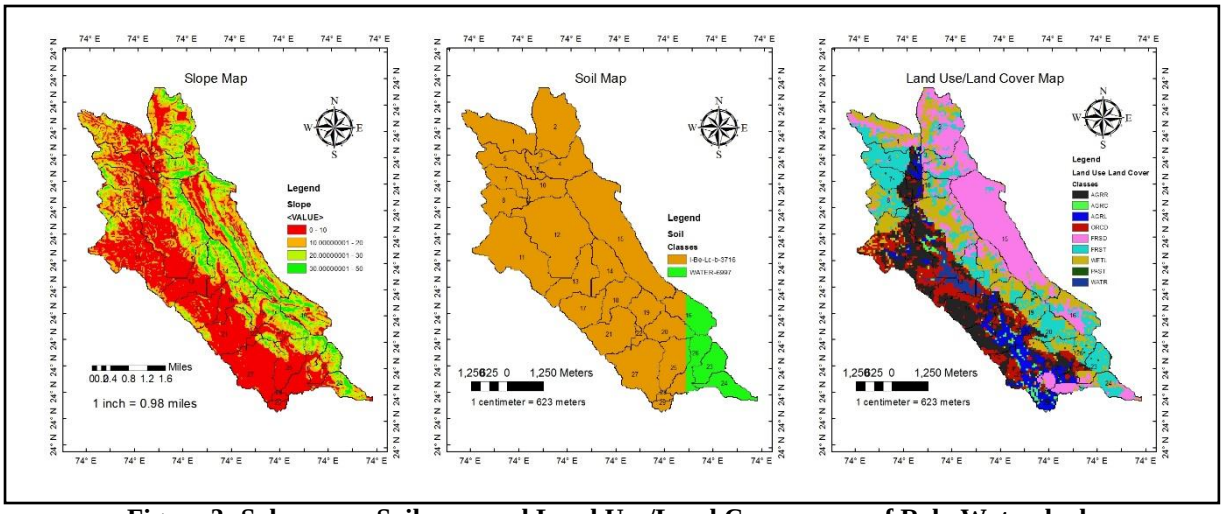

Figure 3: Solpe map, Soil map and Land Use/Land Cover maps of Rela Watershed

Table 1:Land Use Land Coverof Rela Watershed

S.No	Land Use Land Cover	Area (ha)	Percentage
1	Cultivable Land	682.0	15.12 %
2	Scrub Land	74.5	1.65 %
3	Fallow Land	277.9	6.16 %
4	Barren Land	487.7	10.81 %
5	Mixed Forest Land	1140.8	25.29 %
6	Forest Land	881.0	19.53 %
7	Wet Land	874.2	19.38 %
8	Pasture Land	16.3	0.36 %
9	Water Bodies	74.5	1.65 %

4.1.2. SCS-CN method

The thematic maps namely Slope Map, Digital Elevation Map, Geomorphology and Land use Land Cover Map along with Rainfall data for 30 years (1988-2017) was used to find out the runoff of the watershed from SCS-CN method. Higher CN value indicates for potentiality of higher runoff in a particular sub basin. Forest area was having the low curve number indicates low runoff, fallow and built in land having the highest runoff potentiality. The curve number map for the watershed is presented in Fig -.-. Maps for various parameters have been generated and finally a map showing variation in annual runoff potential has been prepared. From the rainfall data of 30 years, the study area was found as under AMCII and AMC III conditions.

The monsoon rainfall data from 1988-2017 was collected and used to find out the runoff from watershed. The calculated average runoff depth for 30 years was found to be as 162.6 mm. The maximum runoff of the watershed was observed during 2006 which about 572.4 mm and minimum runoff was found in 2002 about 19.5 mm. The calculated runoff values yearly and basin wise are presented in Table 1 and 2 respectively.

The change in land use is considered to be major factor in causing surface runoff. Dense vegetation cover facilitates low surface runoff conditions whereas sparse vegetation and bare surface was having relatively high runoff. It was observed that sub basin 21 having the highest runoff due to more percentage area covered in the basin by scrub with sparse vegetative cover and cultivated land. The lowest runoff observed in sub basin 23&24 may due to presence of forest cover and covered by phyllite and schist which was good in terms of infiltration may be the reason for the lowest runoff observed. The following table showing the runoff sub basin wise is presented in table 3.

Table 2: Yearly Rainfall(mm) and Runoff(mm) for Rela watershed(1988-2017)

S.NO	YEAR	RAINFALL(mm)	RUNOFF(mm)	PERCENTAGE
1	1988	535	156.4631	29 %
2	1989	740	246.8894	33 %
3	1990	576	108.888	19 %
4	1991	426	112.5975	26 %
5	1992	612	206.7191	34 %
6	1993	471	122.713	26 %
7	1994	973	357.0533	37 %
8	1995	382	56.31872	15 %
9	1996	525	135.5468	26 %
10	1997	436	72.53472	17 %

11	1998	560	105.3852	19 %
12	1999	288	32.86069	11 %
13	2000	302	54.6521	18 %
14	2001	475	101.3589	21 %
15	2002	267	19.53686	7 %
16	2003	428	56.51014	13 %
17	2004	584	132.0855	23 %
18	2005	698	272.543	39 %
19	2006	1155	527.3914	46 %
20	2007	410	91.82148	22 %
21	2008	617	205.5772	33 %
22	2009	533	133.3646	25 %
23	2010	600	145.313	24 %
24	2011	708	255.3911	36 %
25	2012	616	253.1564	41 %
26	2013	742	206.5292	28 %
27	2014	656	161.7209	25 %
28	2015	618	159.0515	26 %
29	2016	676	200.9381	30 %
30	2017	719	187.0644	26 %
31	**Average**	**577.6**	**162.6**	**28 %**

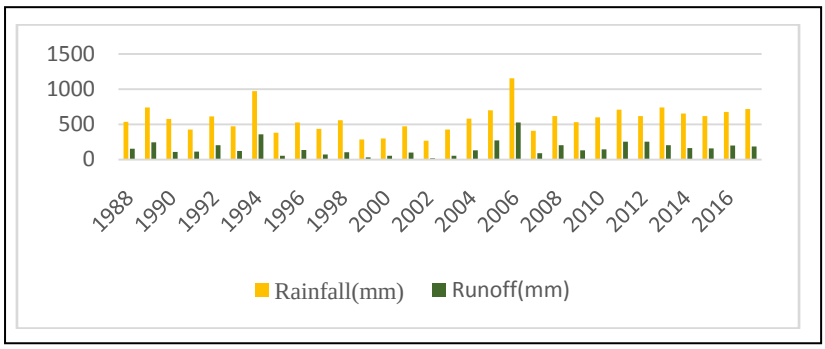

Figure 4: Yearly Rainfall and Runoff for Rela watershed (1988-2017)

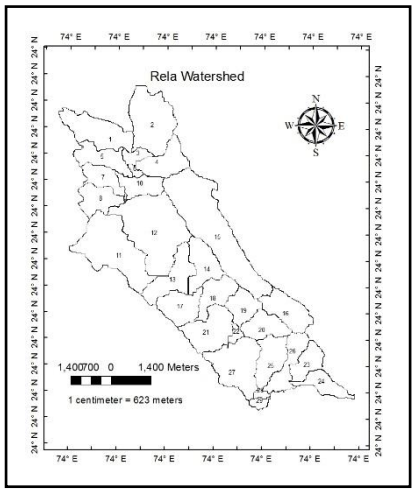

Figure 5: Sub Watershed map of Rela Watershed

Table 3: Basin wise Runoff depth(mm) for Rela Watershed.

S.NO	SUB BASINS	RUNOFF(mm)
1	1	169.7
2	2	145.8
3	3	170.5
4	4	145.1
5	5	124.5
6	6	204.4
7	7	122.1

8	8	121.6
9	9	223.2
10	10	221.4
11	11	223.2
12	12	169.6
13	13	146.8
14	14	165.1
15	15	145.7
16	16	96.0
17	17	223.3
18	18	169.4
19	19	165.6
20	20	120.5
21	21	223.4
22	22	204.3
23	23	58.6
24	24	58.6
25	25	223.2
26	26	58.6
27	27	205.1
28	28	205.3
29	29	205.2

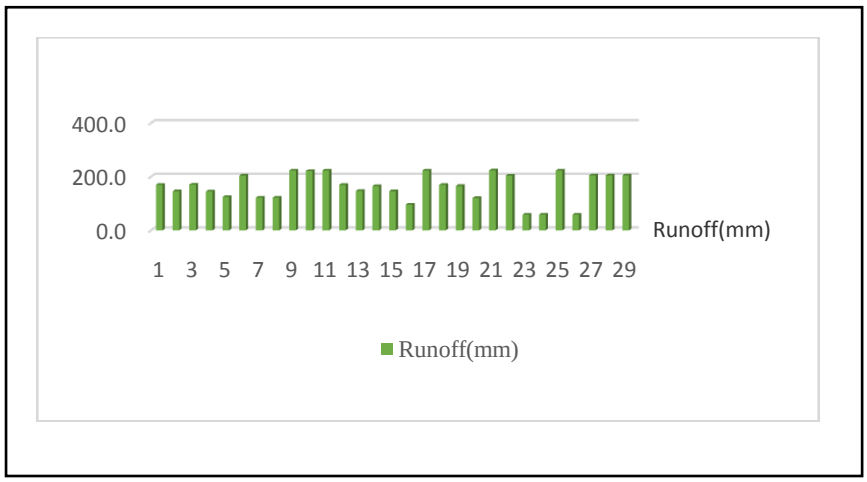

Figure 6: Basin wise Runoff depth for Rela watershed.

V. CONCLUSIONS

The following conclusions are made by the study of the Rela Watershed

1. The average runoff for the watershed basin wise was 160.8 mm of the average rainfall 577.6 mm.
2. The sub basin 21 was having the highest runoff of 223.5 mm followed by sub basin 17 of 223.3 mm and basin 11&25 with 223.2 mm.
3. The lowest runoff has been observed in sub basin 23&24 with same runoff which is 58.6 mm.

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