Estimation of Yield by Soil Conservation Service Curve Number Model for Watershed of Manvi Taluk Raichur District Karnataka

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***Abstract*- Runoff is one of the most significant hydrological variables used in most of the water resources applications. Physiographically the area is characterized by undulating topography with plains and valleys. The Soil Conservation Service Curve Numbers also known as hydrologic soil group method were used in this study. This method is adaptable and suitable approach for quick runoff estimation and is approximately easy to use with minimum data and it gives good result. From the study yearly rainfall and runoff were estimated easily. The study area covers an area of 466.02 km2, having maximum length of 36.5 km. The maximum and minimum elevation of the basin is 569 m and 341 m above MSL, respectively.**

Index terms- AMC Condition, Curve Number, Infiltration, Rainfall, Runoff

1. INTRODUCTION

Runoff is one of the most important hydrologic variables used in most of the water resources applications. Reliable prediction of quantity and rate of runoff from land surface into streams and rivers is difficult and time consuming to obtain for ungauged watersheds, however, this information is needed in dealing with many watershed development and management problems. Conventional methods for prediction of river discharge require hydrological and metrological data. Experience has shown that SOI topomap data can be interpreted to derive thematic informations on land use/land cover, soil, vegetation, drainage, etc. which combined with conventionally measured climatic parameters (precipitation, temperature etc) and topographic parameters such as height, contour, slope provide the necessary inputs to the rainfall- runoff models. Watershed is a hydrologic unit and the term is defined as "the total area of land above a given point on waterway that contributes runoff to the flow at that point". The watershed management is to protect the proper utilization of all land, water and natural resources of watershed.

2 MATERIALS AND METHODS

A Study Area

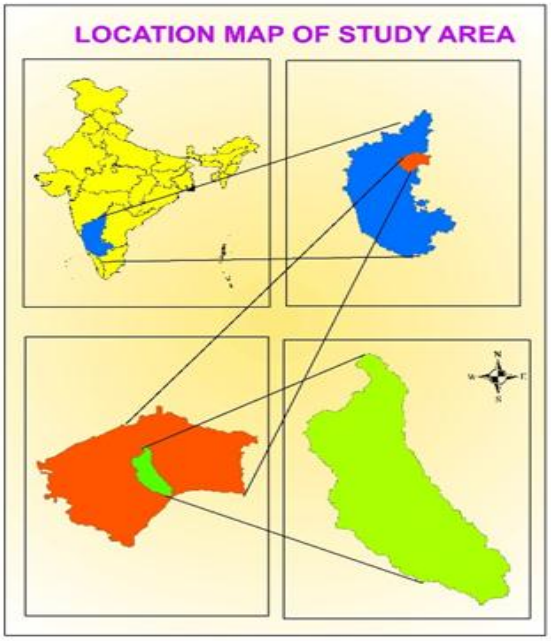

Fig 1 Location Map of Study Area

The Study area located between Latitude 15º54′2″ N to 16º16′19″ N Latitude and 76º48′40″ E to77º4′21″ E Longitude. The study area covers an area of 466.02 km2, having maximum length of 36.5 km. The maximum and minimum elevation of the basin is 569 m and 341 m above MSL, respectively.

B Methodology

Soil Conservation Service (SCS) Curve Number Model

In this model, runoff will be determined as a function of current soil moisture content, static soil conditions, and management practices. Runoff is deduced from the water available to enter the soil prior to infiltration. Fig.2 shows the methodology adopted for runoff estimation using SCS curve number method. The SCS curve number method is developed from many years of stream flow records for agricultural watersheds in several parts of the United States. The method is also called hydrologic soil cover complex number method. It is based on the recharge capacity of a watershed. The recharge capacity can be determined by the antecedent moisture contents and by the physical characteristics of the watershed. Basically the curve number is an index that represents the combination of hydrologic soil group and antecedent moisture conditions. The SCS prepared an index, which is called as the runoff Curve Number to represent the combined hydrologic effect of soil, land use and land cover, agriculture class, hydrologic conditions and antecedent soil moisture conditions. These factors can be accessed from soil survey and the site investigations and land use maps, while using the hydrologic model for the design. The specifications of antecedent moisture conditions is often a policy decision that suggest the average watershed conditions rather than recognitions of a hydrologic conditions at a particular time and places.

Expressed mathematically as given,

$$\frac{Q}{P-Ia} = \frac{F}{S} \quad (1)$$

Where Q is the runoff, P is the precipitation and F is the infiltrations and it is the difference between the potential and accumulated runoff. Ia is begining abstraction, which represents all the losses before the runoff begins. It include water retained in surface depressions, water intercepted by vegetation, and initial infiltrations. This is variable but generally is correlated with soil and land cover parameter; S is the potential infiltrations after the runoff begins.

Thus, a runoff curve numbers is defined to relate the unknown S as a spatially distributed variable are,

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

$$Q = \frac{(P-0.2S)2}{(P+0.8S)} \quad (3)$$

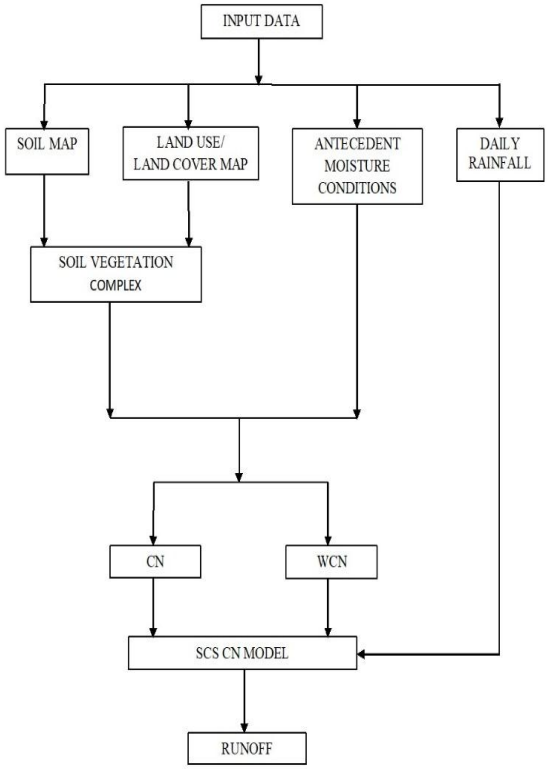

Fig 2: Methodology SCS Curve Number

Determination of Curve Number (CN)

The SCS cover complex classification consists of three factors: land use, treatment of practice and hydrologic condition. There are approximately eight different land use classes that are identified in the tables for estimating curve number. Cultivated land uses are often subdivided by treatment or practices such as contoured or straight row. This separation reflects the different hydrologic runoff potential that is associated with variation in land treatment. The hydrologic condition reflects the level of land management; it is separated with three classes as poor, fair and good. Not all of the land use classes are separated by treatment or condition.

CN values for different land uses, treatment and hydrologic conditions were assigned based on the curve number table. Runoff Curve Numbers for (AMC II) hydrologic soil cover complex is shown in Table 1.

Table 1 Runoff Curve Numbers for (AMC II) hydrologic soil cover complex

Sl No	Land use	Hydrologic Soil Group			
		A	B	C	D
1	Agricultural land without conservation (Kharif)	72	81	88	91
2	Double crop	62	71	88	91
3	Agriculture Plantation	45	53	67	72
4	Land with scrub	36	60	73	79
5	Land without scrub (Stony waste/rock outcrops)	45	66	77	83
6	Forest (degraded)	45	66	77	83
7	Forest Plantation	25	55	70	77
8	Grass land/pasture	39	61	74	80
9	Settlement	57	72	81	86
10	Road/railway line	98	98	98	98
11	River/Stream	97	97	97	97
12	Tanks without water	96	96	96	96
13	Tank with water	100	100	100	100

Hydrological Soil Group Classification

SCS developed a soil classification system that consists of four groups, which are identified as A, B, C, and D according their minimum infiltration rate. The identification of the particular SCS soil group at a site can be done by one of the following three ways (i).soil characteristics (ii).county soil surveys and (iii).minimum infiltration rates. Table 2 shows the minimum infiltration rates associated with each soil group.

The value of CN is shown for AMC II and for a variety of land uses, soil treatment, or farming practices. The hydrologic condition refers to the state of the vegetation growth. The Curve Number values for AMC-I and AMC-III can be obtained from AMC-II by the method of conservation. The empirical CN1 and CN3 equations for conservation methods are as follows:

$$CN_1 = \frac{CN_2}{2.281 - 0.01281 CN_2} \quad (4)$$

$$CN_3 = \frac{CN_2}{0.427 + 0.00573 CN_2} \quad (5)$$

A weighted runoff was estimated for the watershed as

$$WeightedQ = \frac{(A_1 * q_1 + A_2 * q_2 + ... + A_n * q_n)}{(A_1 + A_2 + ... + A_n)}$$

where A1, A2…An are the areas of the watersheds having respective runoff q1, q2….qn. The weighted runoff approach was again extended to quantify the total amount of runoff from the entire watershed.

3 RESULTS AND DISCUSSIONS

It is observed that during the year 2009 maximum runoff of 406.299mm. It was also observed that the minimum runoff of 32.627 mm has obtained in the year 2011. It can be seen that there is a strong positive linear dependence between the annual rainfall and runoff and it can be observed that in the regression equation as the values of slope increases the runoff generated also increases. The runoff estimation carried out by using SCS curve number method will help in proper planning and managements of catchment yield for better planning of river basins. Calculations of runoff which is balance of rainwater and the infiltration responsible for recharging the soil moisture is required for effective management of rain fed area. The inclusion of watershed characteristics such as soils, land use / land cover topography etc. in GIS software improves the accuracy and most importantly. The GIS method estimating runoff will tend to be advantageous if study area large, Runoff is modeled repetitively with alternate land use and land cover. Curve number determination using remotely sensed data has been shown to be most cost effective than conventional procedure.

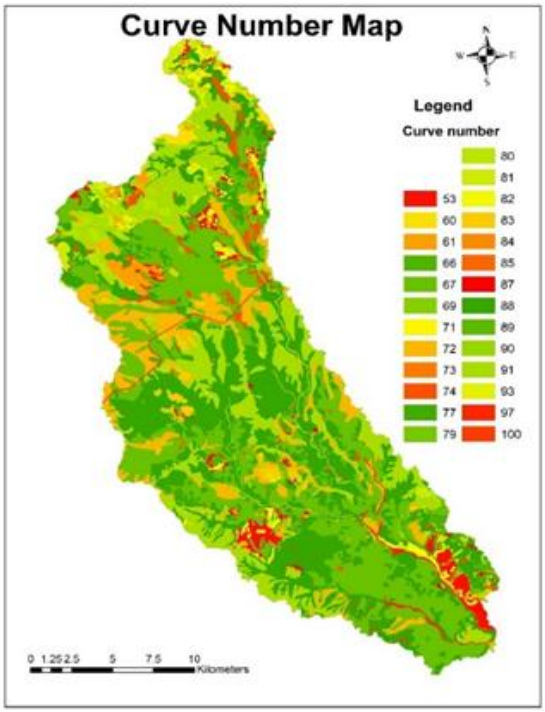

Fig 3: Curve Number Map

Table 4: Runoff for Mini watershed Manvi

Year	RainFall in mm	Runoff in mm	Runoff Coefficient
1998	727.500	119.887	16.479
1999	479.900	122.240	25.472
2000	620.000	123.880	19.981
2001	806.300	175.719	21.793
2002	417.600	51.967	12.444
2003	544.200	164.244	30.181
2004	595.600	126.147	21.180
2005	811.900	279.005	34.364
2006	590.400	117.300	19.868
2007	719.300	119.488	16.612
2008	567.500	88.736	15.636
2009	977.800	406.229	41.545
2010	883.500	243.934	27.610
2011	385.500	32.627	8.463
2012	537.000	106.049	19.748
2013	538.100	127.892	23.767
2014	604.100	119.370	19.760
2015	429.300	97.895	22.803
2016	565.300	78.070	13.810

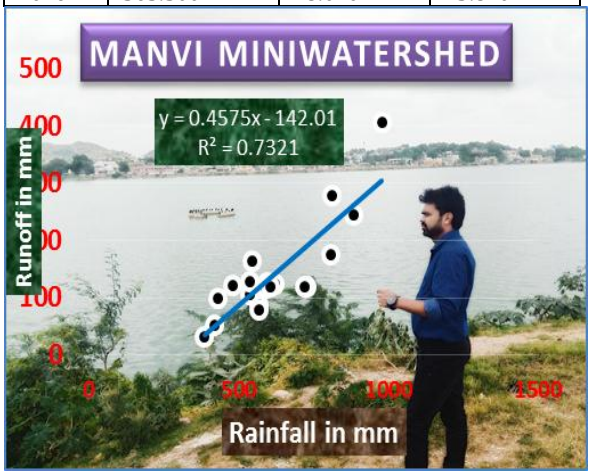

Fig 4: Rainfall Runoff Correlation

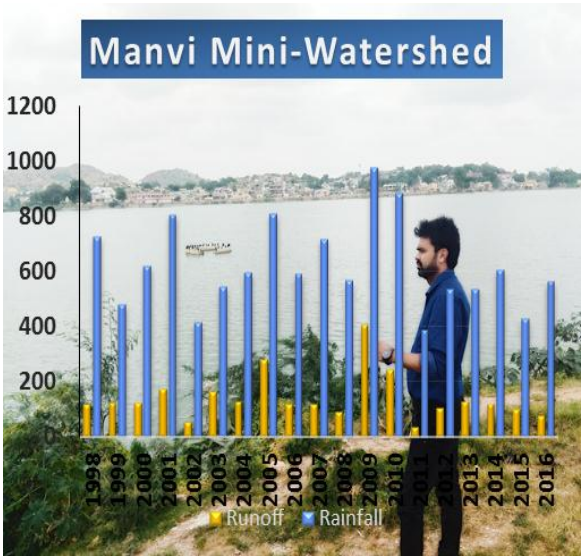

Fig 5: Rainfall (mm) and Runoff (mm) Bar Chart

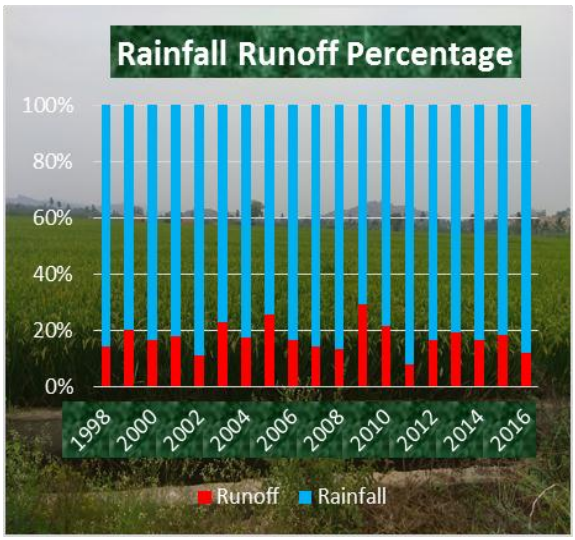

Fig 5: Percentage variation of Rainfall runoff

Closure

Surface runoff, the important parameter in the water balance equation, other than rainwater and infiltration (recharging factor to the soil as soil moisture) is necessary for efficient planning and management of the available water. The SCS curve number method uses, minimum data as input, and gives reliable output by using remote sensing and GIS techniques in most efficient way. The purpose of this study was to evaluate the performance of the procedure using land cover database from remotely sensed data. From the Table 4 it is observed that during the year 2009 maximum runoff of 406.299 mm has occurred. It was also observed that the minimum runoff of 32.627 mm has occurred in the year 1998. The values of correlation coefficients are very high as 0.731. Hence, it can be said that there is a strong positive linear dependence between the annual rainfall and annual runoff and it can be observed that in the regression equation as the values of slope increases the runoff generated also increases. The runoff estimation carried out by using SCS curve number method will help in proper planning and management of catchment yield for better planning of river basin.

REFERENCES

[1] Amutha R. and Porchelvan. P. (2009), Estimation of Surface Runoff in Malattar Sub – Watershed using SCS CN Method, Journal Indian Soc. Remote Sensing, Vol. 37, pp. 291 – 304.

[2] Clarke J. I. (1966), Morphometry from Maps, Essays in Geomorphology, Elsevier Publ. Co., New York, pp. 235- 274.
[3] Mohammed Badiuddin Parvez, and M .Inayathulla. "Morphometry, Hypsometry Analysis and Runoff Estimation of Aam Talab Watershed Raichur, Karnataka" International Journal of Advance Research and Innovative Ideas In Education Volume 5 Issue 3 2019 Page 1713-1727.
[4] Mohammed Badiuddin Parvez, M Inayathulla "Generation Of Intensity Duration Frequency Curves For Different Return Period Using Short Duration Rainfall For Manvi Taluk Raichur District Karnataka", International Research Journal of Engineering and Management Studies (IRJEMS), Volume: 03 Issue: 04 | April -2019.
[5] Mohammed Badiuddin Parvez, and M Inayathulla. "Generation of Short Duration Isohyetal Maps For Raichur District Karnataka" International Journal Of Advance Research And Innovative Ideas In Education Volume 5 Issue 2 2019 Page 3234-3242

BIOGRAPHY

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