Estimation of Surface Runoff by Soil Conservation Service Curve Number Model for Watershed, Bangalore, India

Nanjundi prabhu1, Dr.M.Inayathulla2, K.Chalapathi[3], Nagesh Hanche[4]
[1]Assistant Professor, Department of Civil Engineering, NMIT, Bangalore-560064.Karnataka, India.
[2]Professor, Department of Civil Engineering, UVCE, Bangalore-560056.Karnataka, India
[3]Assistant professor,Department of Civil Engineering,CBIT,Kolar-563101.,Karnataka, India.
[4]**5VX15PCJ10,**Research Scholar,VTU-RRC Belagavi-5900018,Karnataka,India.

Abstract- *Runoff is one of the most significant hydrological variables used in most of the water resources applications. In the Suryanagara watershed is situated on the anekal Bangalore. was selected since it is in the rocks and granite area of Karnataka state, India is carried out using SCS and GIS techniques. The study area covers an area of 172.41 km2 and comprise of eleven micro watersheds. 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 a 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 monthly as well as yearly rainfall and runoff were estimated easily.*

Keywords- Arc GIS , SCS CN, runoff, watershed.

I. INTRODUCTION

Runoff is the drainage of flowing off of rain from a watershed area through a surface of earth. It represents the output from the watershed in a given unit of time. For capable design, planning and management of river watershed projects estimation of runoff magnitude is necessary to determine the quantity of surface run off that takes place in any watershed, understanding the rainfall and runoff processes, which depends on many geomorphologic and climatic factors are necessary. In this study, the informations such as land use/land cover and hydrological soil group derived from remotely sensed data are integrated through Arc GIS software to assigning the curve number on polygon wise to determine surface runoff using SCS curve number models.

II. STUDY AREA DETAILS

The study area is located between Latitude 12°47′31″N and Longitude 77°41′56″ E as shown in figure. The study area covers an area of 172.41 km2and attains maximum elevation 951m and minimum elevation of 881m. Suryanagara watershed is located on the anekal main road, near attibele, Bangalore district. Suryanagara located at distance of 24 km from Bangalore. physiography of the area is composed by undulating topography with pedi plains, pediment and valleys . The mean annual total precipitation is about 921 mm with about 60 rainy days in a year over the last ten years. The summer temperature ranges from 18° C to 35° C, at the winter temperature ranges from 11° C to 24° C. Thus, Bangalore having a good climate entire year.

The area of the watershed is obtained from delineating the topo sheets covering 56 H/9 and 56 H/10 of 1:50000 scale by using ARCGIS software. The area of the watershed is found to be 172.41km2

The Location map of the study area is shown in Fig 1

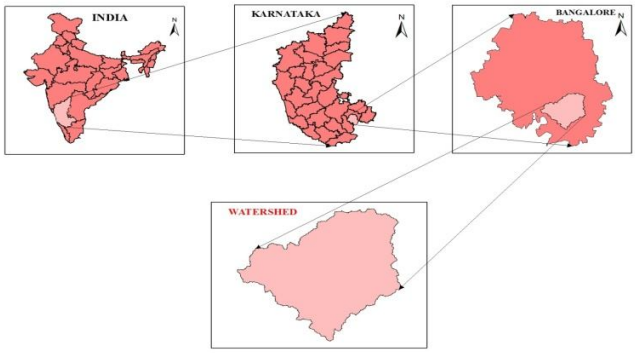

Fig:1 The Location of watershed in the study area

III. LAND USE/COVER OF THE STUDY AREA

The vegetation in the study area is characterized by agricultural activity, Main crops during Kharif season are ragi, pulses, oil seeds. where as paddy is grown in the area of tank. As a result of this increased irrigation by bore wells, croping pattern has changed and irrigated crops are mulberry,

sugarcane, cash crops have replaced the olden days crops. Later the plantations replaced the commercial crops and the gradual change in the terms of modernization has converted the agricultural plantations into Scrub lands. At Present the scrub lands are being getting converted into Settlement. Hence, there is a much scope for modernization.

IV. SOIL IN THE STUDY AREA

The soil in the watershed represent one of the oldest soil in the world as seen from organic carbon dating and Archean age rocks. The soils in the watershed are deep red loam. They are derived from igneous rock, majorly granitic gneisses. The soil represent the running slopes, plains, undulating uplands with lowlands. The red soil is characterized by the light texture of sandy loam and clay loams, weak granular structure, porous, sticky and plastic, non gravelly and subsoil with a argillaceous clay. A soil maps showing various textured soils present in the study area is obtained from the KSRSAC, Bangalore.

The following data products are used in the present study: Survey of India topo maps on 1:50000 scale. Karnataka State Remote Sensing Application Centre (KSRSAC) , Rainfall Data from Statistical Department and Water level from Central Groundwater Board (CGWB), Bangalore.

SOI Topo sheets:

SOI Topomaps on 1: 50,000 scale numbers 56 H/9 and 56 H/10 are used. Topomaps provides information's such as longitude, latitude, drainage patterns, contour and its intervals, transportation network and taluk boundaries, settlement location and forest boundaries etc. The topomaps are used for delineating and the watershed and preparation of base maps, drainage maps, Land use/ land cover maps etc.

Rainfall Data

Daily rainfall data for 15 years (1999 to 2012) were collected from the Statistical Department Bangalore recorded from different Rain gauge stations. The rainy season is from June to October and the dormant season is from November to march for the watershed.

Soil Conservation Service Curve Number Model

Measurement of surface runoff is difficult as it depend on many factors. Soil Conservation Service (SCS) Curve Number model is the method to determine surface runoff. This method described by Soil Conservation Services (1986) was evolved for uniform precipitations using the assumptions for a hydrograph. from this method, runoff will be estimated as a function of current soil moisture content, soil condition and management practice. Runoff is determined from the water available to enter the soil prior to the infiltrations.

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,

$$\frac{Q}{P-I_a} = \frac{F}{S} \quad (1.1)$$

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 vegetations, 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 variables are,

$$CN = \frac{25400}{S+254} \quad (1.2)$$

Or

$$S = \frac{25400}{CN} - 254 \quad (1.3)$$

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

Finding of Curve Number (CN)

The curve numbers is an tool that represent the combination of hydrologic soil groups and antecedent moisture conditions. The curve number values are finding from hydrological soil groups and antecedent moisture conditions of the watershed. For curve number determination the land use and land cover and hydrological soil group maps are integrated and based on their combinations the curve numbers are selected from the available sources. Table 1 shows the curve number (AMC II) available in the literatures to estimate runoffs.

The CN values are obtained after integrating the land use and land cover maps and hydrological soil group maps which are prepared from the remotely sensed data.

Hydrological Soil Group Classifications

The hydrologic soil group as defined by the SCS (1972) are classified into A, B, C and D according to their minimum infiltration rates. The hydrologic soil groups were used to get curve number from look up from table. The hydrological soil group, as defined by SCS soil groups are as fallows.

Group A:

Soil in this groups have a lowest runoff potentials (high-infiltrations rate) when thoroughly wetted. They consists of deep, well to excessively well-drained sands or gravel. These soils are having high rate of water transmissions.

Group B:

Soil in this group have moderate infiltration rate when thoroughly wetted and consists of chiefly of moderately deep, well-drained to moderately well-drained soil with moderately fine to moderately coarser textures. These soil have a moderate rate of water transmission.

Group C:

Soils have a slow infiltration rate when thoroughly wetted and consists of chiefly of soils with a layer that impedes the downward movements of water, or soil with moderately fine texture. These soils have a low rate of water transmissions.

Group D:

Soil having a highest rate of runoff potentials when thoroughly wetted. These soils consists of clay soil with high swelling potential, soil with a permanent high-water table, soil with a clay layer near the surface and shallow soil over nearly impervious material. These soil have a very low rate of water transmissions.

Table 1 Minimum infiltration rate associated with each of soil groups (Mc Cuen, 1982)

Groups	Minimum infiltration rates (cm/hr)
A	0.760
B	0.38-0.760
C	0.13-0.380
D	0.0-0.130

Antecedent Moisture Condition (AMCs)

Antecedent Moisture Condition (AMC) refer to the water portion present in the soils at a given time. The AMC value is intend to reflect the effect of infiltrations on both the volume and rate of runoff according to the infiltration curves. The SCS has three antecedent soil-moisture conditions and labeled as I, II, III. These AMC's correspond to the following soil moisture conditions. Table1.5 shows the AMC's classification as below.

AMC I: Soil is dry but not to the wilting point, satisfactory cultivation has taken place.
AMC II: Average condition taken place.
AMC III: more rainfall or light rainfall and low temperatures have occure within last 6 days; Saturated soils. Table shows the rainfall units for the AMC classifications and for CN.

Table 2 Antecedent Moisture Condition (AMCs)

AMCs	FIVE DAYS ANTECEDENT RAINFALL (mm)	
	Dormant season	Growing season
I	< 12.8 mm	<35.57 mm
II	12.8-27.95 mm	35.56-53.35 mm
III	> 27.97 mm	53.35 mm

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 CN_1 and CN_3 equations for conservation methods are as follows:

$$CN_1 = \frac{CN_2}{2.281 - 0.01281 CN_2} \quad (1.5)$$

$$CN_3 = \frac{CN_2}{0.427 + 0.00573 CN_2}$$

(1.6)

A weighted runoff was estimated for the watershed as

$$Weighted Q = \frac{(A_1 * q_1 + A_2 * q_2 + \ldots\ldots\ldots + A_n * q_n)}{(A_1 + A_2 + \ldots\ldots\ldots + A_n)}$$

(1.7)

Where A_1, $A_2 \ldots A_n$ are the areas of the watersheds having respective runoff q_1, $q_2 \ldots q_n$. The weighted runoff approach was again extended to quantify the total amount of runoff from the entire watershed.

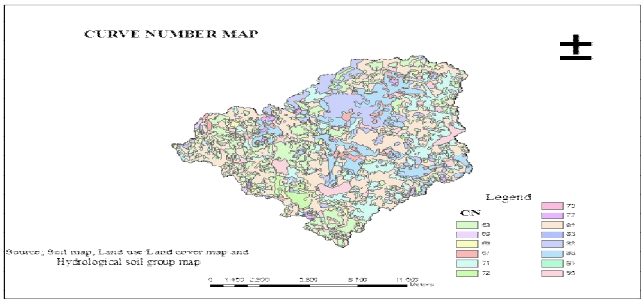

Table 3 Weighted Curve Number for suryanagara water shed

Watershed.	Area (Sq km)	CNI	CNII	CNIII
Suryanagara.	172.46	58.18	75	88.13

Table 4 surface Runoff estimated for suryanagara catchement

Year	Rainfall(mm)	Runoff(mm)
1998.	1387.4	498.85
1999.	1518.5	560.49
2000.	1374.2	427.68
2001.	886.8	313.97
2002.	669.4	227.66
2003.	617.7	58.24
2004.	1111.3	251.25
2005.	1204.3	352.64
2006.	417.3	48.68
2007.	1076.7	259.76
2008.	1079.9	329.58
2009.	1196.6	390.74
2010.	898.9	209.66
2011.	903.3	240.19
2012.	584.5	141.58
Average	995.03	287.36
Maximum	1518.5	560.47
Minimum	417.3	48.62

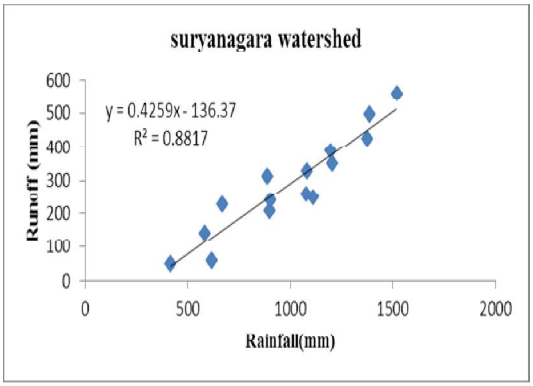

Figure 2. shows Rainfall-Runoff relationship of watershed

V. RESULTS AND DISCUSSIONS

it is observed that during the year 1999 maximum runoff of 561.48. It was also observed that the minimum runoff of 49.66 mm has obtained in the year 2005. 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.

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] Rodriguez, S.K., (1993). Neotectoˆnica e sedimentac-aˆo quater-na´ria na regiaˆo de ‘‘Volta Grande’’ do Rio

Xingu, Altamira, Para´. M.Sc. Thesis. Instituto de Geocieˆncias, Universidade de Sa˜o Paulo, Sa˜o Paulo, 160pp.

[4] Salvador, E.D., Riccomini, C., (1995). Neotectoˆnica de regia˜o do alto estrutural de Queluz (SP-RJ, Brasil). Revista Brasileira de Geocieˆncias 25, 151–164.

[5] Sant'Anna, L.G., (1994). Mineralogia de argilas e evoluc-a˜o geolo´gica da Bacia de Fonseca, Minas Gerais. M.Sc. Thesis, Instituto de Geocieˆncias, Universidade de Sa˜o Paulo, Sa˜o Paulo, 151pp.

[6] Sant'Anna, L.G., Schorscher, H.D., (1995). Leques aluviais cenozo´icos do flanco leste da Serra do Carac-a, MG: a Formac-a˜o Chapada de Canga. Anais da Academia Brasi-leira de Cieˆncias 67, 519.

[7] Sant'Anna, L.G., Schorscher, H.D., Riccomini, C., (1997). Cenozoic tectonics of the Fonseca Basin region, eastern Quadrila´tero Ferrı´fero, MG, Brazil. Journal of South American Earth Sciences 10, 275–284.

[8] Strahler, A.N., (1952). Hypsometric (area-altitude) analysis of erosional topography. Bulletin of the Geological Society of America 63, 1117–1142.

[9] Teixeira, W., Figueiredo, M.C.H., (1991). An outline of Early Proterozoic crustal evolution in the Sa˜o Francisco craton, Brazil: a review. Precambrian Research 53, 1–22.

[10] Hawkins R. H. (1993), Asymptotic determination of runoff curve numbers from data, Journal of Irrigation and Drainage Engineering, ASCE, Vol. 119(2), pp. 334 -345.