ISSN No. 2395-0900
IJESTA International Journal of Engineering Studies and Technical Approach

Computation of Runoff by SCS-CN Method and GIS

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ABSTRACT:

A study was conducted to estimate the runoff by using SCS – CN method and GIS technique. The study area considered is Dawarwadi Watershed, in paithan taulaka Dist – Aurangabad with an area of 380.25 sq.km. the spatial and nonspatial data were collected from various department and thematic layers of soil hydrologic group and land use maps were prepared and overlaid with one another. the overlaid outputs results were assigned by curve numbers with respect to soil and land use categories. The most prominent land use classes were cultivated land, water bodies, residential area and 3 types of soils hydrologic groups were identified as B,C and D.At final stage runoff is calculated by taking 26 years rainfall data i.e. from 1986 to 2013.the average curve number for normal condition is 85.92.the result obtained by the SCS – CN method ,show that the average annual runoff depth of watershed is 488.4mm and total runoff volume is 4828.58Mm3.

Index Terms—*Rainfall, Runoff, SCS-CN, GIS, Spatial*

I. INTRODUCTION

Hydrology plays a vital role in protection and management of water and other environment resources associated with the occurrence and distribution of water above and below the land surface .Rainfall and Runoff is an important component contributing significantly to the hydrological cycle, design of hydrological structures and morphology of drainage system. Rainstorms generate runoff, and its occurrence and quantity are dependent on the characteristics of the rainfall event, i.e. the intensity, duration and distribution. The rain falling on a catchment undergoes number of transformations and abstractions through various component processes such as interception, detention, evapotranspiration, overland flow, interflow, percolation, sub-base flow, etc. and emerges as runoff at catchment outlet. There are so many methods to estimate runoff but SCS -CN is mostly used it is also called as Natural Resources Conservation Service Curve Number method (NRCS – CN).it is a simple, predictable and stable conceptual method for estimation of direct runoff depth based on strom rainfall depth. The method combines the watershed parameters and climatic factor in one entity called the curve number P. Sunderkumer et.al (2010) and Tejram Nayak et.al. found that in general good correlation has been found between observed and computed runoff by using SCS- CN method. Ratika Pradhan et.al (2010) concluded that Remote sensing data are of great use for the estimation of relevant hydrological data when conventional hydrological data are inadequate for the purpose of design and operation of water resources system. M.P. Tripathi et.al suggested that the runoff curve number can be successfully included in the empirical models to predict surface runoff. A Bhadra et.al concluded that during validation ,ANN model was proved to be better than SCS CN model .in addition to that runoff from the catchment was predicted using rainfall data of only five rain gauge stations. The results of

ISSN No. 2395-0900
International Journal of
Engineering Studies and Technical Approach
IJESTA

SCS CN model could have been improved if more rain gauge data were available in the large test catchment.

2. STUDY AREA

Study Area i.e. Dawarwadi lies A study area i.e. Dawarwadi watershed lies in GV-53 and GV -54 located in taluka Paithan, 28km away from Jayakwadi Dam. The watershed having 75 30' 51''- 75 31'25'' E longitude and 19 25' 30" -19 41' 25" N latitude. The watershed contains 11 sub watersheds having total area of 380.27sq.km.the watershed elevation ranges from 439m to 613m above from mean sea level. the major land use and land cover are agricultural built up and water body. The rainfall data of 26 years is used and obtained from IMD Pune.

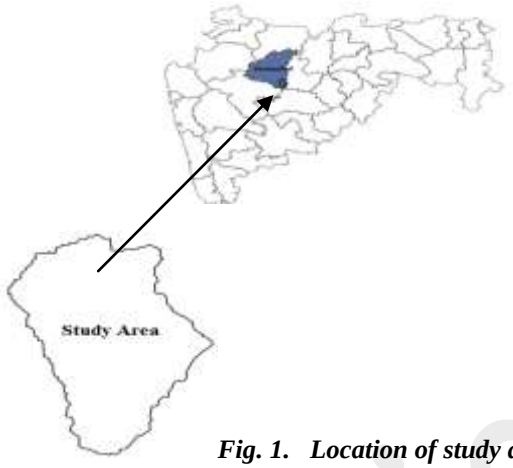


Fig. 1. Location of study area.

3. METHODOLOGY

The study was conducted in three stages. At first, the spatial and non spatial data were collected from different sources in second stage, the thematic layers of soil hydrologic group and land use maps were prepared and overlaid with one another. The overlaid results were assigned by curve numbers. The final stage, the runoff was estimated based on rainfall occurred in study area.

3.1 Data Acquisition

The land use and land cover map is obtained from Satellite image LISS III and from IRS, toposheet were collected from Survey of India. Soil properties, soil map: - soil types (black soil, red soil, clay,) structure, Texture, structure, from NBSS Nagpur, digital Elevation model (DEM) derived from Shuttle Radar Topographic Mission (SRTM)and Rainfall Data from 1986 to 2013 from IMD Pune.

3.2 Software

The software used in this project consists of Quantum GIS 2.2, ERDAS Image 9.1and Microsoft Excel 2007.

ISSN No. 2395-0900
International Journal of
Engineering Studies and Technical Approach
IJESTA

3.3 land use and land cover

Different land use and land cover categories were interpreted from IRS LISS III satellite image. The most predominant land use land cover was agricultural covering 61.308% of total area. Water body, built up area and barren land as 7.678%, 23.113% and 7.901% respectively.

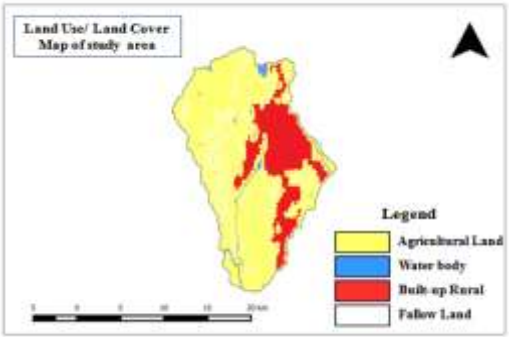


Fig. 2 Landuse and land cover map

Table 1: Landuse And Landcover %Wise

Sr. No.	*Type of Land use/Land cover*	*Percentage of Land under each LU/LC*
1	*Agricultural Land*	*61.308*
2	*Water body*	*7.678*
3	*Built-up Rural*	*23.113*
4	*Fallow Land*	*7.901*

3.4 Soil

The soil map obtained from NBSS Nagpur has been classified into three hydrologic groups as Group B as 46.063%, Group C as 41.938% and Group D as 12%.

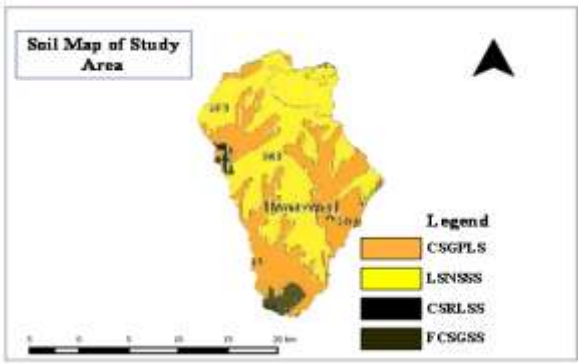


Fig. 3 Soil map

ISSN No. 2395-0900
IJESTA International Journal of Engineering Studies and Technical Approach

Table 2 :Type of Soil And %

Sr. No.	*Type of Soil cover*	*Percentage of Soil type*
1	*CSGPLS*	*41.938*
2	*LSNSSS*	*46.063*
3	*CSRLSS*	*3.608*
4	*FCSGSS*	*8.391*

These abbreviations of type of soil cover can be explained as -

1. CSGPLS: - Clay soil, on gently sloping plains, moderately well drained;

2. CSRLSS: - Clay soil, excessively drained, on sloping rolling land;

3. LSNSSS: - Loamy soil on moderately sloped plain;

4. FCSGSS: - Fine calcareous soil on gentle slope;

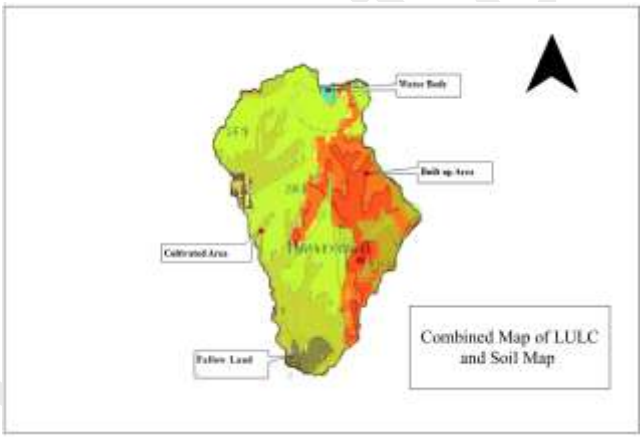


Fig 4 Combined map of land use/cover and Soil map

3.5 SCS- CN Method

This method is based on two parameters i.e. rainfall data and Curve number. The curve number is dimension less quantity and it ranges from 0 to 100.low curve number indicated by dry antecedent soil moisture condition (AMCI),high curve numbers indicate wet conditions(AMCIII)and average curve numbers indicate normal condition (AMC II).

3.6 Estimation of Direct Runoff depth

The SCS CN method calculates direct runoff depth (Q) using following equation

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

ISSN No. 2395-0900
International Journal of
Engineering Studies and Technical Approach
IJESTA

The parameter S representing the potential maximum retention depends upon the soil-vegetation-land use complex of the catchment and also upon the antecedent soil moisture condition in the catchment just prior to the commencement of the rainfall event. For convenience in practical application the soil conservation service of USA has expressed S term of a dimensionless parameter.

The empirical studies conducted by SCS further indicated that S can be estimated by,

$$S = \frac{25400}{CN} - 254$$

The constant 254 is used to express S in mm.

The curve number CN is related to S as

$$CN = \frac{25400}{S+254} - 254$$

And has a range of 0 to 100. A CN value of 100 represent a condition of zero potential retention (i.e. impervious catchment) and CN = 0 represent an infinitely abstracting catchment with S = infinity.

This Curve Number depends upon

Soil type
Antecedent moisture condition
Land use / land cover.
Runoff curve numbers taken from land use and soil type are for the average condition (AMC II). For dry conditions (AMC I) or wet condition (AMC III), equivalent curve numbers can be computed by using following equations.

$$CN\ (I) = \frac{CN\ (II)}{2.281 - 0.0128 CN\ (II)}$$

$$CN\ (III) = \frac{CN\ (II)}{0.427 + 0.00573\ CN\ (II)}$$

4. RESULT and discussion

The calculated normal, wet and dry conditions, curve numbers 85.92, 72.8 and 93.46.the Average annual Runoff calculated come to be 488.7mm and Runoff volume for 26 yr is 4828.58Mm3.the details are given in table 1

ISSN No. 2395-0900
International Journal of Engineering Studies and Technical Approach
IJESTA

Table 1: Rainfall And Runoff Computation

No	Year	Rainfall (mm)	CN (I)	S (mm)	Ia (0.2S)	Runoff (mm)	Area (Km2)	Runoff Volume (Mm3)
1	1988	908.20	85.92	41.64	8.33	860.08	380.27	327.06
2	1989	967.70	85.92	41.64	8.33	919.47	380.27	349.64
3	1990	558.00	85.92	41.64	8.33	510.97	380.27	194.30
4	1991	577.20	85.92	41.64	8.33	530.07	380.27	201.57
5	1992	539.50	85.92	41.64	8.33	492.56	380.27	187.30
6	1993	391.00	85.92	41.64	8.33	345.12	380.27	131.24
7	1994	268.90	85.92	41.64	8.33	224.67	380.27	85.43
8	1995	426.30	85.92	41.64	8.33	380.11	380.27	144.54
9	1996	727.30	85.92	41.64	8.33	679.61	380.27	258.43
10	1997	268.90	85.92	41.64	8.33	224.67	380.27	85.43
11	1998	714.60	85.92	41.64	8.33	666.95	380.27	253.62
12	1999	489.50	85.92	41.64	8.33	442.85	380.27	168.40
13	2000	267.20	85.92	41.64	8.33	223.00	380.27	84.80
14	2001	506.00	85.92	41.64	8.33	459.25	380.27	174.64
15	2002	586.90	85.92	41.64	8.33	539.73	380.27	205.24
16	2003	511.30	85.92	41.64	8.33	464.52	380.27	176.64
17	2004	716.70	85.92	41.64	8.33	669.05	380.27	254.41
18	2005	459.50	85.92	41.64	8.33	413.05	380.27	157.07
19	2006	727.80	85.92	41.64	8.33	680.11	380.27	258.62
20	2007	539.50	85.92	41.64	8.33	492.56	380.27	187.30
21	2008	469.40	85.92	41.64	8.33	422.88	380.27	160.81
22	2009	413.10	85.92	41.64	8.33	367.02	380.27	139.56
23	2010	625.10	85.92	41.64	8.33	577.77	380.27	219.70
24	2011	474.00	85.92	41.64	8.33	427.45	380.27	162.54
25	2012	268.80	85.92	41.64	8.33	224.57	380.27	85.40
26	2013	506.60	85.92	41.64	8.33	459.84	380.27	174.86
					Ave Runoff	**488.38**		**4828.58**

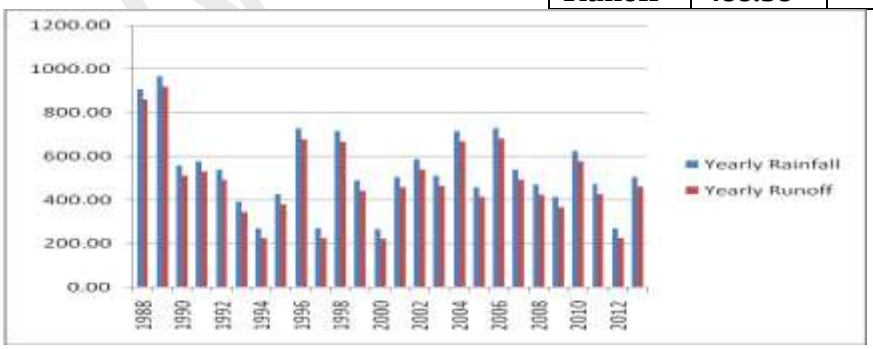
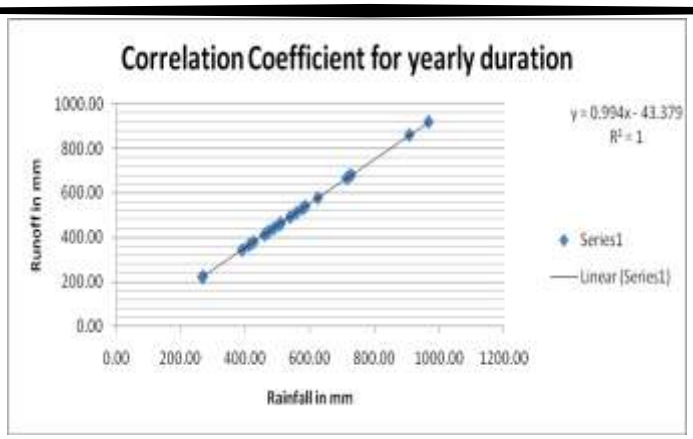


Fig 5 Graph of Rainfall and Runoff

International Journal of Engineering Studies and Technical Approach
IJESTA
ISSN No. 2395-0900



5. CONCLUSION

The integration of remote sensing data and application of the SCS CN model in a GIS environment provides a powerful tool for assessment of runoff. Thus; land use planning and watershed management can be done efficiently. Based on this study, the following conclusions are arrived at:

- GIS based SCS CN model can be used effectively to estimate the runoff from ungauged watersheds.

- The appropriate soil and water conservation measures must be planned and implemented first in the miniwatersheds classified as high followed by the watershed classified as moderately high for controlling runoff and soil loss.

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