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Estimation of Weighted SCS-CN: Case of Narmada River Basin, India

Engineering

KEYWORDS: Weighted SCS-CN, LU/LC, HSG, AMC-Conditions, Narmada River Basin.

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ABSTRACT

Estimation of direct rainfall runoff is always efficient but is not possible for most of the location. To determine the depth of surface run-off, one of the most popular method is the Soil Conservation Service Curve Number (SCS-CN). The method takes into account the important parameters in the catchment such as soil moisture content, land use and land cover etc. The present study focuses on determining the SCS-CN for the Narmada River Basin located in the western part of India. Weighted curve number is calculated as per the land use and land cover distribution and SCS-CN is then determined.

Introduction

The Soil Conservation Service-Curve Number (SCS-CN) method is widely used by engineers, hydrologists and watershed managers as a simple watershed model, and as the runoff estimating component in more complex watershed models [1]. It computes the surface runoff volume for a given rainfall event from small agricultural, forest, and urban watersheds. The method is simple to use and requires basic descriptive inputs that are converted to numeric values for estimation of direct runoff volume [2]. "Curve number" indicates runoff potential of land area and it is the function of Hydrologic soil group, antecedent rainfall, land-use pattern, density of plant cover and conservation practices followed in the land area. Generally with time, all these patterns keep on changing and there is an impact on the runoff volume from that particular area.

Remote Sensing (RS) techniques have been applied extensively and are recognized as powerful and effective tools for detecting Land use changes. Remote sensing collects multi-spectral, multi-resolution, multi-temporal data, and turns them into useful information. GIS technology provides a flexible environment for entering, analyzing, and displaying digital data from various sources, for identifying urban features, detecting change, and developing databases. Many researchers have developed an integrated approach to combine RS and GIS techniques to elucidate the effects of land-use change on runoff using a simple Soil Conservation Service (SCS) model [4], [5].

In the present study an attempt has been made to estimate the Curve Number (CN) for entire Narmada river Basin. Land use/ Land cover maps, soil depth maps and Hydrologic Soil Group (HSG) maps were used to calculate the weighted curve number of the Narmada River basin.

Study Area & Data Collection:

Narmada River is, one of the major west flowing interstate river of India, draining into the Gulf of Khambhat. The Narmada basin flows in four states of India i.e. Madhya Pradesh (88.58%), Gujarat (8.98%), Maharashtra (1.7%) and Chhattisgarh (0.73%). The Narmada basin is comprised of three sub-basins:- Upper Narmada sub basin, Middle Narmada sub basin and Lower Narmada sub basin consisting of total of 150 watersheds. Narmada River Basin lies between 72°38' E to 81°43' E and 21°27' N to 22°37' N. The basin map is shown in Fig 1.

All the required data for the analysis i.e. LU/LC maps, soil depth maps, HSG maps etc. were obtained from the website of India-WRIS, watershed Info system[3].

Figure: 1 Narmada River Basin

(Source: India-WRIS website)

SCS-CN Method

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 relies on only one parameter, CN. Curve number is the governing factor, which predominantly affect the runoff amount which flows over the land after satisfying all loses. Although curve number itself having no physical meaning but also plays an important role in defining hydrological response [6].

Curve number varies from 0 to 100. Zero curve number describes the hydrological response only with infiltration. All the rainfall water will infiltrate to become subsurface flow. Whereas 100 curve number describes the hydrological responses of no infiltration. All the rainfall water will flow as surface flow as soil is in saturation limit that happens in continuous rainfall events. As 100 curve number is given to water bodies. CN values lies between 0-100 contribute the flow in both forms. As soon as CN is increased, runoff from that watershed will also increase. CN is derived from Land use/Land cover classification and hydrological soil group the land use coverage.

Methodology

The entire Narmada River Basin is spread in an area of 98796 km^2 and is divided into a total of 150 watersheds having a unique identification. All the details regarding these watersheds i.e. LU/LC maps, soil depth maps and HSG maps were obtained from India-WRIS website which is a WEB-GIS having open access.

Figure 2 and Figure 3 shows the LU/LC and Soil Texture Group map of Narmada River Basin. Analysis of whole river basin was done and the weighted Curve Number was estimated for each soil group.

Each soil group is having a considerable amount of area and in such scenario there is a variation of CN in the different parts of river basin. When a study area has more than one land use, a composite curve number can be calculated and used in the analysis. So it becomes necessary to determine the weighted CN instead of average CN as it takes into account the proper proportion of each and every aspect of the LU/LC in the basin.

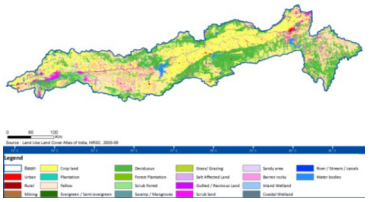

Figure: 2 LU/LC Map of Narmada River Basin

(Source: India-WRIS website)

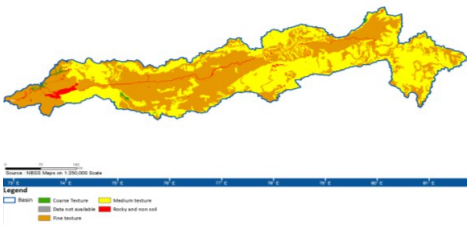

Figure: 3 Soil Texture of Narmada River Basin

(Source: India-WRIS website)

Calculations & Results

From Figure-3 and data available on India-WRIS website, more than 50 % of the basin is covered with soil of Fine texture followed by the medium texture soil (aprox. 45%) and remaining portion of the basin is covered with coarse texture as shown. So, in the calculation of the Curve Number, Weighted Curve Number should be taken. Calculation is shown in Table-1.

In this study area, Curve Number is taken as 0.5 of Group C, 0.45 of Group B and 0.05 of Group A. AMC-II condition was utilized for the calculation of runoff in this study area and after getting curve number for each soil group weighted curve number is estimated.

Conclusion

The application of the SCS-CN of any region is to determine the amount of infiltration of that soil of the region. Soil can have low, moderate, or high infiltration rate which leads high, moderate or low run-off in that region. Here, as we took 50% of group C (Moderate High Runoff Potential), 45% of group B (Moderately Low Runoff Potential) and 5% of group A (Low Runoff Potential), weighted CN has been obtained as 62.84 as per AMC-2.

The rainfall depth and the corresponding run-off from the basin can now be determined easily using the weighted CN estimated above. This method can also be applied to determine the SCS-CN of different basins around the world. Weighted SCS-CN enables us to develop a nearly accurate Rainfall –Runoff relationship in any given catchment area.

Table - 1 Weighted Curve Number Calculation of Narmada River Basin

Land Use	Area	%Area	CN	(%A/100)*CN	Weighted CN
Build up Land	1114.36	1.13	78.45	0.886485	62.84
Agricultural	56243.0	56.9	56.9	33.9124	
Forest	32483.2	32.88	61	20.0568	
Grass Land	2.2	0.01	66.4	0.00664	
Wasteland	6033.74	6.13	82.05	5.029665	
Water-Bodies	2919.32	2.95	100	2.95	

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