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Rainfall-runoff modeling using SCS-CN method in Uri catchment

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Abstract

A rainfall-runoff model represents the catchment characteristics mathematically. SCS-CN is one such method which is very robust because it depends only on Curve Number which is a dimensionless number. The study was carried out in the catchment having geographical area 787 km^2 in the Narmada river Basin. The Everydayprecipitation and discharge figures for the time 2000 to 2011 was used to quantify the streamflow. The CN value was found out to be 90.The potential maximum retention is 28.2 and coefficient of determination (R^2) is 0.791. This yield is helpful for the catchment improvement and arranging of water resources efficiently.

Keywords: *Antecedent moisture condition, land use- land cover, runoff, SCS-CN, Uri basin*

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Introduction

Rainfall-runoff modelling is one of the most talked about hydrological phenomena till date in the field of Water Resources Engineering. Any R-R model represents the catchment characteristics in a mathematical form. More accurately, it produces a surface runoff hydrograph in response to a rainfall event, characterized by and input as a hyetograph. Runoff implies the depleting or streaming off of rainfall from a catchment region over a channel. It along these lines means the yield from the watershed in a given unit of time. When satisfied, the surplus shower run over the land surface to reach littler channels. This percentage of the runoff is named overland flow. The flow in this situation, where it moving constantly over the surface as overland streaming, but consider the channel would be as open channel flow and connection with the outlet of the catchment is called surface overflow (Subramanya 2008).

The aim of the present study is to estimate daily stream flow in Narmada river basin. Hawkins (1978), altered the SCS-CN technique by connecting ET and CN for use inconsistent hydrologic recreation model. The investigation failed to recognize the dynamic infiltration and the static infiltration and furthermore couples the between interim drainage with ET which was very opposing in light of the fact that the way that the water drainage down to water table may not be available for evapotranspiration. Bhola and Singh (2010), applied the SCS-CN technique with promising outcomes for Kosi River Basin in Nepal. Shadeed and Almasri (2010), applied an adjusted NRCS-CN strategy. Also, discovered that 42% of precipitation gets infiltration to ground and 58% precipitation flowed over the land as overflow.Kumar and Rishi (2012)also successfully applied this method in their study area**.** Vinitha and Yeshoda (2013) used SCS-CN method and multispectral remote sensing data for analysis and concluded that runoff mostlyhinge on upon rainfall and soil texture. Regulwar (2015)estimated the runoff by using the SCS–CN method and GIS technique in Dawarwadi Watershed, Aurangabad. Yang and Wang (2017) selected the HRB river basin of Northeastern Tibetan plateau with drainage area of

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10009 km^2. The value of R^2 is 0.37 and its precipitation lapse rate is 124mm/km.Shah and Motiani (2017), has taken Meshwo River Watershed and got the rainfall- runoff co-efficient R^2=0.77 which is considered as satisfactory result. Kumar et al (2017) has taken the pappiredipati watershed and got the satisfactory result of runoff co- efficient R^2=0.84and considered as a good result. Kumbhare and Rastogi (1984), tried the Nash calculated model and investigated that overflow created by the two-parameter brought about great concurrence with genuine runoff hydrograph.The peak time coincide with trend of rising, crest and falling limb.Rastogi and Kumar(1989), built up a scientific model of the quick unit hydrograph dependent on time zone histogram for a little watershed at Pantnagar. The momentary unit hydrograph was utilized for creation of overflow hydrograph.Shoemaker et al. (1997), Carried out a result that hydrological models, particularly simple rainfall precipitation overflow models, are generally utilized in comprehension and evaluating the effects of land-use changes, and to give data that can be utilized in land-use basic decision. Numerous hydrologic models are accessible, differing in nature, multifaceted purpose and nature.Thomas and Jaiswal (1998)foundoutofthetotal12rainguagesstationhavebeen found to influence the catchment. It has been noticed that river flow is very less. Ferdinand Van den Brink (2009) used Thiessen method is used for calculation of catchment and discharge is measured at the dam site .Which is located in the river 500m from the sea. The value of R^2=0.69.Nourani et al (2011), used TOPMODEL for rainfall-runoff modeling and got rainfall-runoff coefficient as 0.9.Reshma and Pratap (2012), used SWAT model for three months rainfall data. Jia and Suno (2012), used HBV modeling to calculate rainfall-runoff as it is used for largerivers.Chaudhary et al. (2013), experimentally verified the impact of watershed inclination on precipetation- createdoverflow and resulting *CN* for aidentified soil (Hydrologic Soil Group C) and terretories use of sugarcane. The examination found that the plot of 5% inclination outcome the biggest overflow contrasted with those because of the plots of 3% and 1% grades, for a similar precipitation, territories and soil, use.

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These investigations uncovered that inferred CN values are genuinely near those from NEH-4 CN-values which bolster the pertinence of NEH-4 CN qualities to Indian watersheds. The results indicated that *CN* increases with slope and with AMC from I to III.Shrestha et al. (2013), discussed the impact of inclination on *CN* through investigatted plots of maize crop established on three different slopes of 1%, 3%, and 5%. They were used measured rainfall and runoff data to derived *CN*. Double ring infiltrometer test indicated HSG C category soil type in their study. These soils have a low pace of water transmission (1.27 mm/hr). The outcomes indicated a positive correlation among's CN and incline and CN and predecessor soil dampness content. Singh and Gangwar (2014)usedNAM with R^2 value of availilbility and model calibration were examined to be 0.75 and 0.79.BD et al (2014)used SWAT model and get the result as R^2= 0.72 and 0.82 which is greater than 0.5 and considered as good and satisfactoryresult.Rathod and Borse (2015)used HEC-HMSand SCS-CN to transform the precipitation into surface runoff into HEC-HMS model. Swain and Verma (2017), used SWAT modeling and got unsatisfactory result for NSE and coefficient of determination as 0.07 and 0.31 respectively.

Study Area and Data

Narmada basin stretches out over a territory of 92,672 Km2 and oriented between north scopes 21° 27' to 23° 37' and east longitudes 72° 38'to 81°43' which is about 3% of the all-out land zone of the nation. The basin has a stretched outline with a greatest distance of 953 km from east to west and a most extreme breadth of 234 km from north to south. The uneven locales are in the upper piece of the bowl, and lower-centre spans are wide and ripe territories appropriate for development. The normal yearly water capability of the basin is 45.64 BCM. The usable on earth Water in the basin records to 34.50 BCM.

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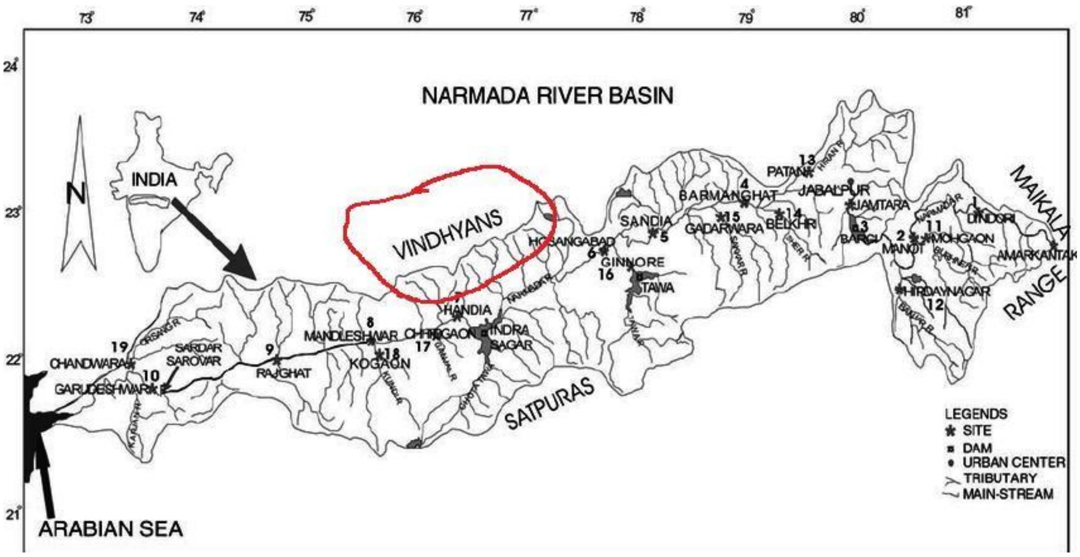

Figure 3.1: Location map of Narmada river basin along with Location numbers of gauging station (Source: Harish Gupta 2005).

The Dhulsarcatchment is a piece of the Uri-sub-basin in the Narmada waterway situated in the middle part of Madhya Pradesh. Uri catchment has bumpy territory and undulating geography, therefore delivering high waste thickness. The atmosphere of the bowl is tropical and moist. It gets almost 60% of the everyday precipitation and release information for the period 2000 to 2011. Exposed to the harsh elements climate, the day by day precipitation temperature changes from 5˚C to 21˚C and in the sweltering climate from 33˚C to 48˚C.Ground water condition varies with the litho logical characteristics of the Geological total depth of bores ranges from 100 to 300 m depth below ground level.

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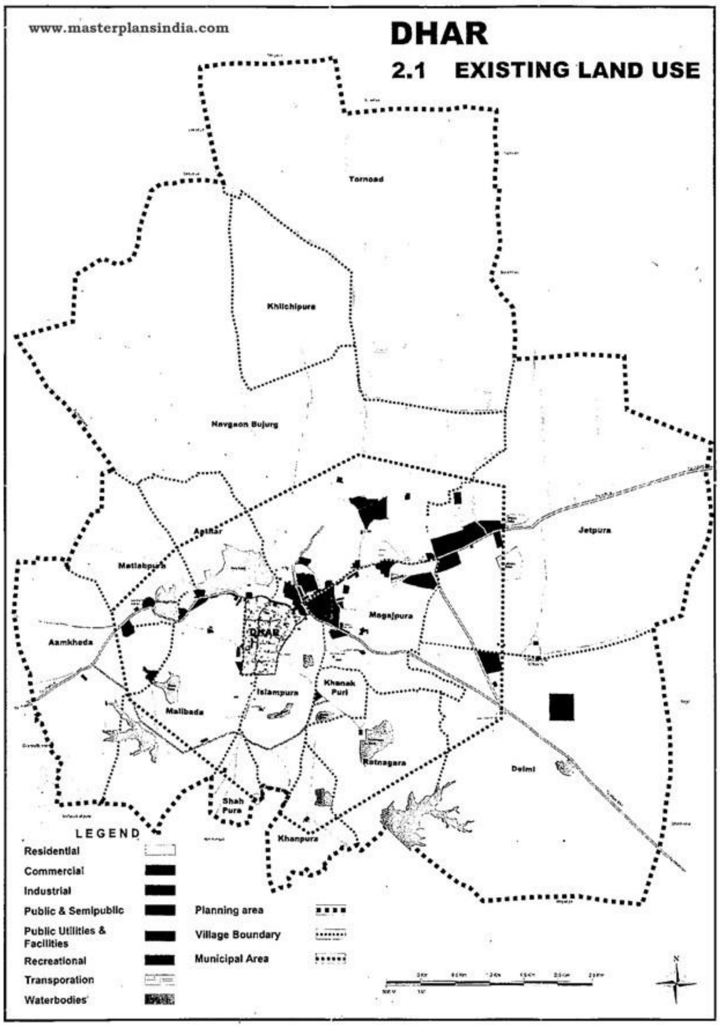

Figure 3.2: LULC map of the Narmada river (Source: Raj Kumar 2014)

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Methodology

SCS-CN Method

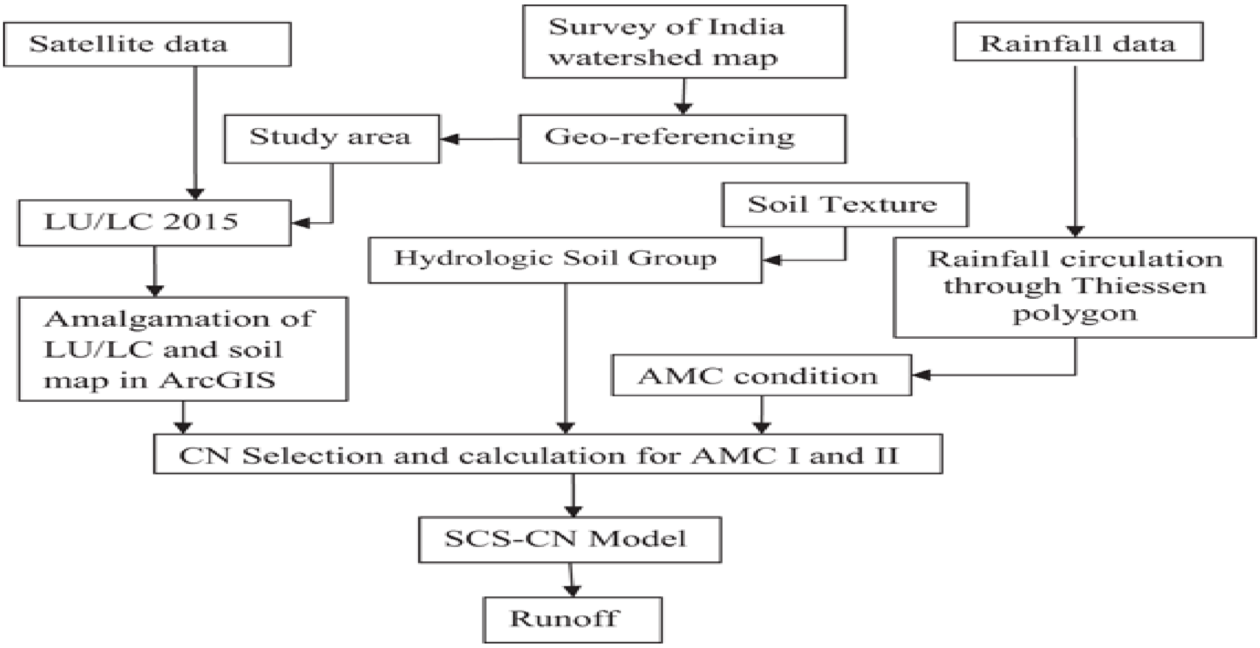

Figure 4.1: Flow chart of Methodology for Rainfall-Runoff (Source: S. Satheeshkumar 2017)

The CN depends on AMC, Soil profile and Land use Land cover of the study area. The above-mentioned flow chart represents the method. In deciding CN, the hydrological arrangement is assumed. Here soils are arranged into 4 classes A, B, C and D dependent on the penetration and different qualities. The significant soil attributes that impact the hydrological grouping of soils are powerful profundity of soil, normal clay content, penetration qualities and the porousness. The three AMC conditions are as below:

AMC-I: Soils are aridbut then not at wilting point. Agreeable development has occurred.. AMC-II: meansituations

AMC-III: enoughprecipetation has transpired within the last five days. Drenched soil situationprevails.

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AMC	Precipitation in five Days	
	Inactive season	**Emergent season**
i	< 130 cm	< 360 cm
ii	130-280cm	360-530cm
iii	>280cm	> 530 cm

The SCS-CN rule is depended on a water equalent equation. The initial abstractions has to be removed while doing the calculations. These are Infiltration, evaporation, transpiration etc. After satisfying all these demands, the rest of the water is calculated as runoff. This also depends on the season of the year. Usually the monsoon period i.e., June to September is considered as growing season and rest of the period of the year is known as dormant season. The summation of the last 5 days rainfall decides the AMC condition. There are three types of AMC conditions. Usually the calculations are done first for AMC-II condition and then it gets converted to other two conditions using empirical formulas. The value of λ is region specific. Usually it varies between 0.1 to 0.4. For Indian condition, it is considered as 0.2. The practical values of CN vary between 30 to 90. 100 represents zero infiltration i.e., all water is being converted to runoff. However, the value 0 represents 100% abstraction i.e., no water is being converted in to runoff. Although these are hypothetical numbers, this particular study area is located in Built-up area. Hence, the values are on the higher side. Considering all these values, the method was applied and the results of this study are explained in the next session.

Results and Discussions

The sequential modeling approach developed in the form of proposed methodology for CN determination has been described in previous chapter. Study application is extremely important to know the universality of the applied methodology. To test the methodological framework and investigate its performance with respect to a real watershed environment, the

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proposed methods are tested on the dataset of test watersheds viz. Narmada river watersheds of the Uri sab basin. Performance of the each proposed method is evaluated by using statistical criterion and compared with existing methods. The results obtained are presented in form of tables as well as graphs for better understanding in this chapter.except during the south west monsoon. The wind speed is higher during the pre-rainstorm period when contrasted with the post-storm period. The most extreme wind speed is 27.0 km/hr saw during the long stretch of June and at least 7.1 km/hr during the period of December. The normal ordinary yearly wind speed of the area is 15.9 km/hr.The main soil types developed in the area are black cotton soils, loamy soils and lateritic soils.

SCS-CN model has been applied to estimate the direct surface runoff in Uri river watershed. Different combinations of input parameters, i.e. curve number, initial abstraction and rainfall were applied to calibrate the SCS-CN model to get more accurate computed runoff. Total three alternate options of SCS-CN model applications were considered to finalise the best options of SCS-CN model suitable for lower Narmada basin. Two combinations of curve number is 90 and rainfall were applied in originally developed SCS-CN model considering the as 0.2 for AMC-I, II and IIIrespectively.

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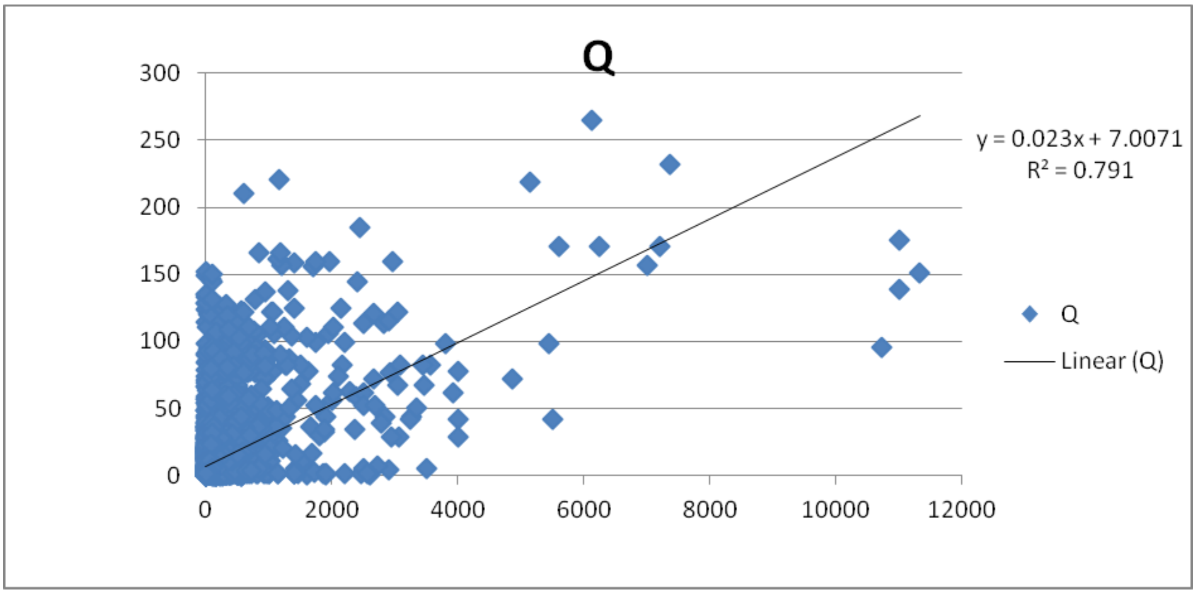

Figure 5.1: Comparison between observed and computed discharge

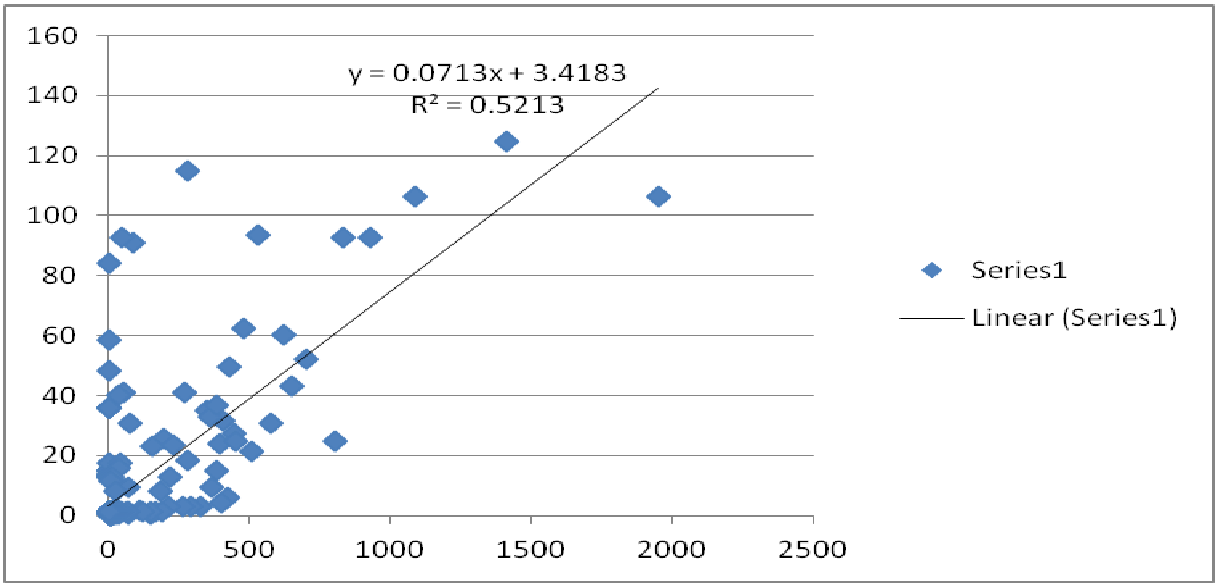

Figure 5.2: Comparison between observed and computed discharge

Conclusions

SCS-CN model is utilized in the recentactivityalong withsoil map and territory use as GIS input. Inthisinvestigation, the methodology for the solution of overflowusing SCS along with GISmethodcan be implemented in watersheds possesslikeattributes for conservation balancement. The honourable soil and water preservation estimates should be arranged and

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applied in the watersheds, for example, delegated high pursued by respectably high for controlling overflow and soil loss.It was useful for flood forecasting, flood contribution of watershed and flood discharge measurements. R-Rcorrelation was also recognized which was formed by seeing rainfall of last 15 years. In SCN Curve number strategy AMC of the soil assumes a significant job in light of the fact that the CN number differs as indicated by the soil and that is measured while evaluating overflow depth. As per a given report zone that is Bhullar catchment, CN equivalents to 90 for AMC-II for normal condition. Taking everything into account, SCS-CN methodology is productively demonstrated as a superior technique that uses less time and commodities to control the board informational collection and also a bigger environmental region to recognize site selection of artificial recharge structures.

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