ESTIMATION ANALYSIS OF RUNOFF FOR UDAYGIRI MANDAL USING A POTENTIAL METHOD: A MODEL STUDY

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ABSTRACT
The most commonly used hydrological models for runoff estimation in soft bedrock, is the Soil Conservation Service Curve Number (SCS-CN) model. For a heterogeneous geomorphic land form the model may limit its applicability. Therefore, the SCS-CN model is tested to a small watershed, Udaygiri mandal of Nellore district, Andhra Pradesh. A linear regression method was employed to quantify the SCS-CN model performance. SCS-CN method estimation was evaluated with the help of runoff data, simulated data and actual rainfall data. It was found an accuracy of R2=0.966 for a 5 years (2012-2016) rainfall data.

Keywords: SCS-CN Method, Rainfall Runoff Modelling.

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1. INTRODUCTION
Rain fed agricultural regions like semi-arid and sub-humid regions are most prone to agricultural drought. Therefore, it is necessary to find out the methods of soil water conservation in such areas. In this aspect two inevitable components plays a major role: simulation of soil moisture available in the crop root zone and the estimation of accumulated...
runoff available in the watershed (Reshmidevi et al., 2008). Simulation of spatio-temporal variation in soil moisture helps in identifying the areas of significant water stress with an accurate time period. Whereas, the surface runoff estimation provides information of water harvesting potential of the watershed which is a supplementary for irrigation. The SCS-CN method is mostly used for the estimation of runoff from small agricultural watersheds (SCS, 1971). This method is based on the concept of Hortonian overland flow which says that the surface runoff occurs when the rainfall rate is more than the infiltration rate. Different researchers has been employed this method to examine the evaporation rate to a deep drainage basin (Moore, 1985), to predict sediment production and discharge rates (Moore and Clarke, 1983). Hosking and Clarke (1990) proposed the extension of the Moore and Clarke work, to derive a relationship between the frequencies of storm rainfall and flow peak magnitudes in an analytical form (Sunder Kumar, 2013).

For Hydrological models the most required information is runoff. To estimation the runoff a number of methods are available. Among them, the USDA Soil Conservation Service curve number (SCS-CN) method is the most popular and widely used method. The main inputs required for the SCS-CN methods are delineation of the watershed boundary, preparation of soil map, preparation of land use/land cover thematic map and antecedent moisture condition to estimate daily runoff. The main objective of this paper is to evaluate the potentiality of SCS-CN, method for runoff estimation in Udayagiri Mandal in the Nellore district, Andhra Pradesh, India for the years 2012-2016.

1.1. Description of Study area

Udayagiri is a Mandal in the Nellore district, Andhra Pradesh is located at 14.86°N, 79.31°E with an average elevation of 230 meters. The annual rainfall for this area is 700-1000 mm in the month of January to December. Hence, it is subjected to both droughts and floods condition. The soil type in this area is Black soil, red soil. The population of this district according to the Census 2011 was 2,966,082 of which 29.07% were urban. It is having geographical areal extension of 11000 ha, out of which cultivated land is 3300 ha. Both the surface and ground water irrigation is found in this region. The district has one major (Pennar River Canal System) and five medium (Telugu Ganga, Somasila, Kanpur canal, Gandipalem project and Swarnamukhi Barrage) canals for irrigation purpose. According to the central ground water board the area irrigated through canals and tanks is 96889 ha and 70783 ha respectively, and irrigation through lift and other sources is 5124 ha. 92175 ha area is irrigated through tube well sand dug wells.
2. OBJECTIVE
To evaluate the potentiality of SCS-CN, method for runoff estimation in Udayagiri Mandal

3. METHODOLOGY

3.1. DATA USED
The data used for the present study are: daily precipitation and runoff data for period of five years (2012-16) data collected from Udayagiri Mandal Office, Nellore District, Andhra Pradesh.

3.2 SCS-CN Method of Estimating Runoff Volume:
SCS-CN strategy created by Soil Preservation Administrations (SCS) of USA in 1969 is a basic, unsurprising and stable theoretical technique for estimation of direct spillover profundity in view of tempest precipitation profundity. It depends on just a single parameter, CN. At present, it is an entrenched technique, having been broadly acknowledged for use in USA and numerous different nations. The points of interest of the strategy are depicted in the area. The SCS-CN technique depends on the water adjust condition and two central theories. The main speculation compares the proportion of the measure of direct surface overflow $Q$ to the aggregate precipitation $P$ (or greatest potential surface to the spillover) with the proportion of the measure of penetration $F_c$ measure of the potential maximum retention storage $S$. The second to the potential theory relates the underlying deliberation $I_a$ most extreme maintenance. In this manner, the SCS-CN strategy comprised of the accompanying conditions.

Water balance equation:

Proportional equality $P = I_a + F_c + Q$  \hspace{2cm} (1)

Hypothesis $Q/(P - I_a) = F_c /S$  \hspace{2cm} (2)

$I - S$ hypothesis: $I_a = \lambda S$.  \hspace{2cm} (3)
Where,

\( P \) is the total rainfall, \( I_a \) the initial abstraction, \( F_c \) the cumulative infiltration excluding \( I_a \),
\( Q \) the dependent on geologic and climatic factors (0.1<\( \lambda \)<0.3).

Solving equation (2)

\[
Q = \frac{(P - I_a)^2}{P - I_a + S} \quad (4)
\]

\[
Q = \frac{(P - \lambda S)^2}{P - (\lambda - 1)S} \quad (5)
\]

The relation between \( I_a \) and \( S \) was developed by analyzing the rainfall and runoff data from experimental small areas and is expressed as \( I_a=0.3S \). Combining the water balance equation and proportional equality hypothesis, the SCS-CN method is represented as

\[
Q = \frac{(P - 0.3S)^2}{P + 0.8S} \quad (6)
\]

The potential maximum retention storage \( S \) of area is related to a CN, which is a function of land use, land treatments, soil type and antecedent moisture condition of area. The CN is dimensionless and its value varies from 0 to 100. The \( S \)-value in mm can be obtained from CN by using the relationship

\[
S = \frac{25400}{CN} - 254 \quad (7)
\]

### 3.3. ESTIMATION OF RUN-OFF

The appropriated CN system was utilized to estimate runoff. An underlying deliberation (\( I_a \)) of 0.3S was utilized, where \( S \) is the maximum potential retention talked about in segment The CN value for every polygon was utilized to figure greatest potential maintenance \( S \) for every polygon by utilizing Equation 3. At that point runoff of every polygon was assessed with the assistance of Equation The day by day overflow of every down-pouring month May, June, July, August, September were evaluated for 4 year time frame (2012-, 2013, 2014, 2015, 2016) utilizing day by day precipitation information of these months. The everyday runoff was changed over into month to month overflow. The graphical representations of monthly runoff potential for years (2012, 2013, 2014, 2015, and 2016) were displayed (Fig. 2). The spatial appropriation of runoff depth in wet year, dry year and normal year is presented in the respectively.

### 3.4. CURVE NUMBER MAP

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. 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 area will also increase. As explained earlier CN is derived from Land use/Land cover classification and hydrological soil group the land use coverage and soil coverage were merged using UNION command of Arc-GIS software. Using ARC-GIS software total 78 polygons were developed. All these polygons having a particular land use and a hydrologic soil group and then curve numbers were assigned to these polygons. Thus a curve number coverage was generated in which different polygons had different curve number values. The pictorial presentation of CN for various land cover and Hydrological soil group is presented spatial distribution of Curve Number.
4. RESULTS AND DISCUSSIONS

Graphical representation of mean monthly rainfall versus months gives information about the rainy months of the year. It was seen from the six months (May, June, July, August, September and October) are the rainy months of the year and ready to create extensive measure of runoff in the study area.

Table 1.0 Total rain fall 2012-2016.

<table>
<thead>
<tr>
<th>Months</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>Average Rainfall (mm)</th>
<th>Observed Runoff(mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>21.2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>4.44</td>
<td>0.888</td>
</tr>
<tr>
<td>February</td>
<td>0</td>
<td>37.2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>7.44</td>
<td>1.488</td>
</tr>
<tr>
<td>March</td>
<td>0</td>
<td>63.6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>12.72</td>
<td>2.544</td>
</tr>
<tr>
<td>April</td>
<td>33.6</td>
<td>23.4</td>
<td>36.6</td>
<td>33.4</td>
<td>0</td>
<td>25.4</td>
<td>5.08</td>
</tr>
<tr>
<td>May</td>
<td>54.2</td>
<td>31.4</td>
<td>68</td>
<td>16.4</td>
<td>0</td>
<td>34</td>
<td>6.8</td>
</tr>
<tr>
<td>June</td>
<td>28.4</td>
<td>52.8</td>
<td>18.4</td>
<td>52</td>
<td>57.6</td>
<td>41.84</td>
<td>8.368</td>
</tr>
<tr>
<td>July</td>
<td>121</td>
<td>109</td>
<td>80.6</td>
<td>9.6</td>
<td>91.8</td>
<td>82.4</td>
<td>16.48</td>
</tr>
<tr>
<td>August</td>
<td>91</td>
<td>69</td>
<td>58.8</td>
<td>78.8</td>
<td>30</td>
<td>65.52</td>
<td>13.104</td>
</tr>
<tr>
<td>September</td>
<td>75.6</td>
<td>121.2</td>
<td>26.2</td>
<td>76.4</td>
<td>25.2</td>
<td>64.92</td>
<td>12.98</td>
</tr>
<tr>
<td>October</td>
<td>84.6</td>
<td>154.6</td>
<td>277</td>
<td>19</td>
<td>11.24</td>
<td>109.29</td>
<td>21.86</td>
</tr>
<tr>
<td>November</td>
<td>168.8</td>
<td>109.4</td>
<td>84.4</td>
<td>771</td>
<td>0</td>
<td>226.72</td>
<td>45.34</td>
</tr>
<tr>
<td>December</td>
<td>23.2</td>
<td>3.2</td>
<td>27</td>
<td>29.6</td>
<td>0</td>
<td>16.6</td>
<td>3.32</td>
</tr>
</tbody>
</table>

![Figure 2](http://www.iaeme.com/IJCIET/index.asp)  
Figure 2 Comparison of the observed Runoff and estimated of Runoff (SCS-CN)
Estimation Analysis of Runoff For Udaygiri Mandal Using A Potential Method: A Model Study

Figure 3 Observed (OBS) Runoff and SCS/Calculated Runoff

From the Fig. 2 it is found that the SCS-CN model is giving an accuracy of $R^2= 0.965$ for rainfall runoff prediction. Also it is observed from fig. 3 that the maximum runoff is observed in the month of November and the lowest runoff is observed in the month of January.

REFERENCES


