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Estimation of surface runoff, using SCS model from micro watershed in semi arid region

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ABSTRACT

Soil Conservation Service model, has been applied for the estimation of surface run-off in a micro-watershed 3.38 Km^2 of semi-arid region located in the Mahi river basin in Panchmahals district of Gujarat state. The thematic map i.e. land use/cover, drainage and hydrological soil group have been prepared by actual ground truth to derive the modified run off curve number. The SCS model was then applied to estimate the surface run off and compare with the measured run off of five events of monsoon, year 2004. The deviation ranged between 4 to 7 per cent.

Key words: Watershed, curve number method, rainfall, runoff, hydrological soil group and land use pattern.

A watershed is a natural and complete hydrological entity, which collects and coverage's all the rain falling on it to a common outlet, for storage and utilization. Therefore, a watershed is an ideal unit for the management of sustained development.

Several studies have been carried out in the past to predict the quantity of excess water (run off) available from watersheds. Soil Conservation Services (SCS) model is widely used for estimation of run off on small and medium sized watershed.

It depends on only one parameter curve number (CN) and its responsiveness to four important watershed properties: soil type, land use, surface condition and wetness of soil of watershed (Durbhude and Chandramohan, 2000). The curve number is dimensionless and its value varies from zero for the most permeable surface to a maximum as 100 for an impervious surface.

In this method, problem arises in the application; first the surface runoff estimation is more sensitive to the curve number selection than the actual rainfall depths (Hawkins, 1975). Second, this method was developed based on the individual rainfall events and limited availability of such data may be limitation.

MATERIALS AND METHODS

In the present study, micro-watershed areas were discretized into smaller homogeneous units before estimating run off depth. Daily rainfall was recorded by non-recording rain gauge located within the watershed for the period

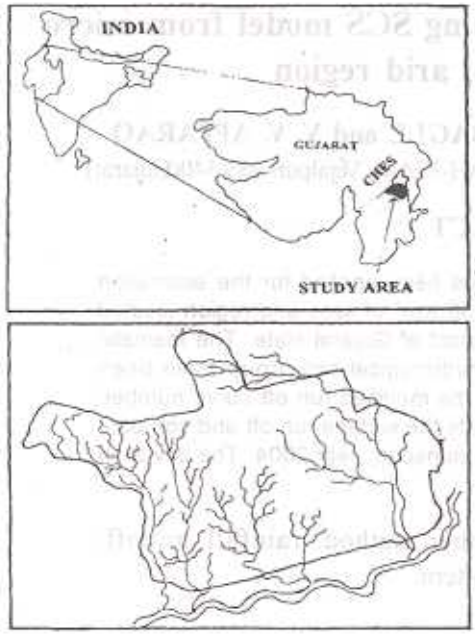
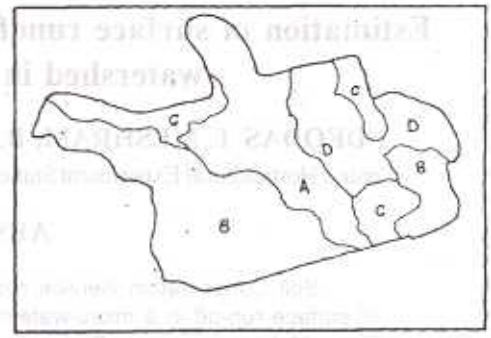


Fig. 1: Location map of study area.



LEGEND		
Hydrological Soil Group	Area (Ha)	Capability Class
A	78 (23.07%)	II
B	160 (47.33%)	I
C	62 (18.35%)	III
D	38 (11.24%)	IV

Fig. 2: Various hydrological soil groups present in the study area.

1999 to 2004. For SCS method, the weighted curve numbers were found out by watershed characteristics and soil moisture condition at the time of occurrence of rainfall. It can be evaluated from tables as a function of hydrologic soil group (USSCS, 1964) and land use/land cover and percentage followed in the area (Table1).

The Soil conservation Services (SCS) model was applied as follows

$$Q = (P - I_a)^2 / (P - Ia + S_m) \quad \text{--------(1)}$$

Where, Q – Run off, P – Rainfall, I_a – Initial abstraction of rainfall by soil and vegetation; S_m – Potential maximum retention, all values expressed in mm.

Dhruvanarayana, (1993) used the relationship, $I_a = 0.1 * S_m$, while calculating the curve number for micro-watershed with average land slope greater than 0.5 per cent. This has been followed in the present study as well to relate I_a with S_m.

$$CN = 25400 / 254 + S_m \quad \text{—— (2)}$$

Here, Curve Number has been calculated for different land use/ land cover and conservation practices. Since, it has different values under different situations, a weighted CN was obtained in the following manner.

Weighted CN = $\sum$ % of land use* Curve Number / 100 —— (3)

Comparing the runoff estimated for

Table 1: Various land use/ land cover present in the study area

Sr.No.	Description of the LU/LC	Area (ha)	Percentage
1.	Horticulture crops land	71	21
2.	Fallow land	161	47.63
3.	Pastures/scrub land	40	11.43
4.	Rocky/gravelly waste	10	2.9
5.	Farmstead	4	1.18
6.	Ravines/gullies	34	10.04
7.	Roads	8	2.3
8.	Water bodies	10	2.9

Table 2: Comparison of estimated run off and observed run off

Storm date	Rainfall (mm)	Run-off observed (mm)	Estimated-run off (mm)	Deviation (%)
17.07.2004	16.40	4.30	4.12	4.18
26.07.2004	23.50	5.80	6.81	14.83
29.07.2004	38.00	15.50	16.3	4.90
31.07.2004	68.00	38.20	40.35	5.32
01.08.2004	43.00	21.4	19.92	6.91

CN with the observed run off during the five monsoon storms the estimated run off of the year 2004 was validated. Head was measured using stage level recorder and was converted to runoff by using rating curve. Based on hydrological soil group and land use, Curve Number were assigned for each combination. The curve number values were defined considering the average wetness index of soil condition (AMC-II) and standard USDA classification, 1972. The individual curve number values and the weighted CN for the whole watershed were also worked out.

Study area

The study was conducted at the Central Horticulture Experiment Station, regional station of CIAH Bikaner under the Basin of Mahi river. The watershed lies in lower part of Panchamahal district of Central Gujarat State (Fig.1) and located around 22° 41' 38" N latitude and 73° 33' 22" E longitudes. The watershed of 338 ha is mostly plane at an altitude of 110 to 115 m amsl. The mean monthly maximum temperature ranges between 26°C and 40°C, while the minimum monthly temperatures varies between 10.8° C and 26.4° C.

The watershed has black & sandy clay loam soil with highly truncated and gently sloping terrain on both the sides of the river which results in quick build up of run off into shallow precipitous tributaries that drain into Ruparail river. The watershed has a peculiar drainage system with one

tributary in about every one and half kilometer. This region is characterized by semi –arid climate with little or no water surplus (Bhattacharjee *et al*.1982).

RESULTS AND DISCUSSION

Based on the infiltration rate and soil map developed by NBSS & LUP, Nagpur, the micro- watershed could be divided into four hydrological soil groups (Fig.2). The hydrological soil group 'B' is found to be largest followed by 'A' in the study area with 47.33 and 23.07 per cent of the total area. The major land use categories of the watershed are fallow land and horticulture fruits crops (i.e. Mango, Alona, Ber, Pomegranate, Agroforesty, Drum Stick, Neem and Teak (21 per cent), Farmstead (1.18 per cent), Roads (2.3 per cent), Forest land (3 per cent), Shrubs land (11.43 per cent), Grass land (5 percent), Ravines (10.04 per cent), Stony Waste Land (2.9 per cent) and water bodies (2.9%). The weighted curve number of entire watershed was found as 87 (Table 1).

The average yearly runoff is found to be 15.26 cm, which is approximately 29 per cent of average rainfall. In order to verify the SCS model output, estimated runoff was compared to the measured for five events (Table 2) of the monsoon period – 2004. The deviations ranged between 4 to 7 per cent except for one event (15 %), which is well within permissible limit. From this, it can be concluded that the derived Curved Number can be used for run off estimation in the watershed under study.

REFERENCES

Anonymous.1964. SCS National Engineering Handbook, Hydrology, Section 4, USDA, US Government Printing Office, Washington D.C.

Bhattacharjee, J.C.; Roy Chowdhary, C; Landey, R.J., and Pandey, S., 1982. Bioclimatic Analysis of India N.B.S.H.& L.U.P. Bull No. 7, Nagpur.Water Balance of Panchmahals.

Dhurvanarayana, V.V.,1993 Soil and Water Conservation Research in India, ICAR, New Delhi, 1993.

Dhurbude, D.G. and Chandramohan, T. 2000. Application of remote sensing technique for estimation of surface run off from an ungauged watershed using SCS curve number method. *Applied Hydrology,* XIII (1&2): 1-9.

Hawkins, R.H. 1975. The importance of the accurate curve numbers in estimation of storm run off. *Water Resources Bulletin, AWRA,* 11:887-891.

USDA, Soil Conservation Services. 1972. National Engineering Handbook, Section 4: Hydrology. USDA, Soil Conservation Services,Washington.