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Estimation of Runoff by GIS approach and SCS-CN method in Urban area

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Abstract

The objective of the study was to estimate the runoff which is one of the relevant as well as important topics in geographical research and hydrology. The method used was through GIS approach and SCS-CN method in estimation of runoff in the study area of Rajarajeshwari nagar , Bengaluru. The GIS and REMOTE SENSING techniques were used in obtaining thematic maps like base map, curve number map, hydrological soil group map, land use land cover map.

Keywords: Runoff, SCS-CN method ,GIS, REMOTE SENSING.

1.Introduction

Planning and execution of water resource project require the estimation of runoff. The soil conservation service curve number (SCS-CN) method is been applied widely to ungauged watershed systems and has proved to be accurate and rapid estimator of surface runoff. The antecedent moisture conditions (AMC I, AMC II, AMC III) is used.

The remote sensing data is useful in spectral characteristics synoptic coverage and repetitive nature of information. The information on Land use Land cover and hydrological soil type can be synchronized in GIS for an accurate and quick estimation of curve numbers.

2. Decripition of the study area

The Rajrajeshwari nagar watershed area part of Vrusbhavati valley located in the southwestern part of Bengaluru along the mysore road. Since water logging is a major problem in this area, the storm water drains has to be updated.

3. Methodology and data collection

From the GIS software the following base map of the watershed was obtained which gives information about the place, type of road, railway line, drainage, water body.

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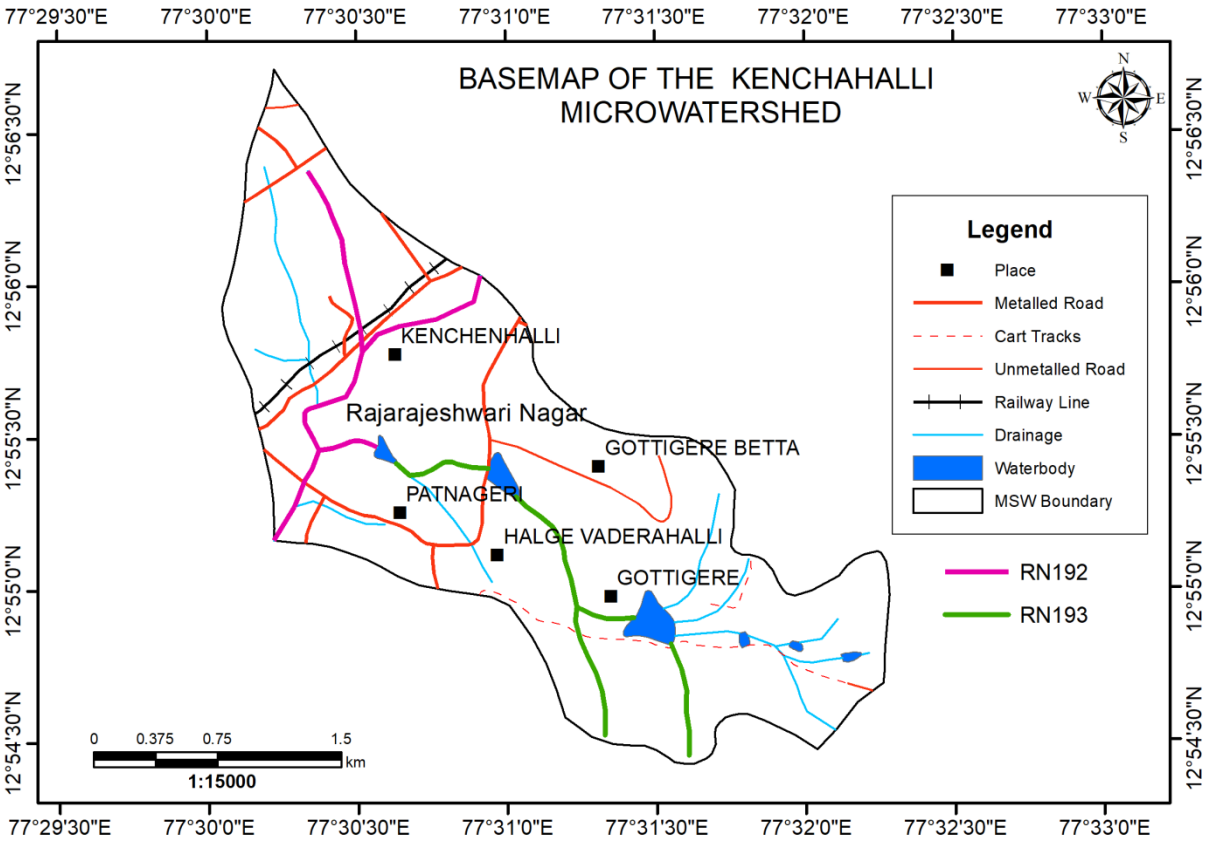

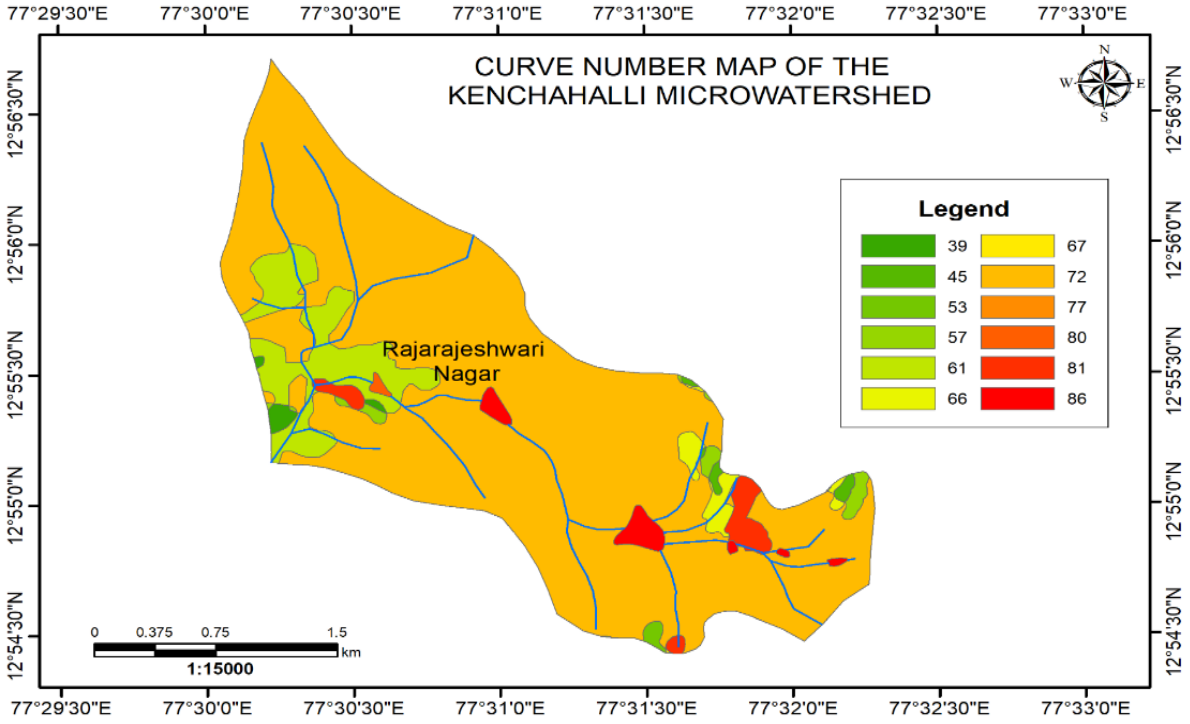

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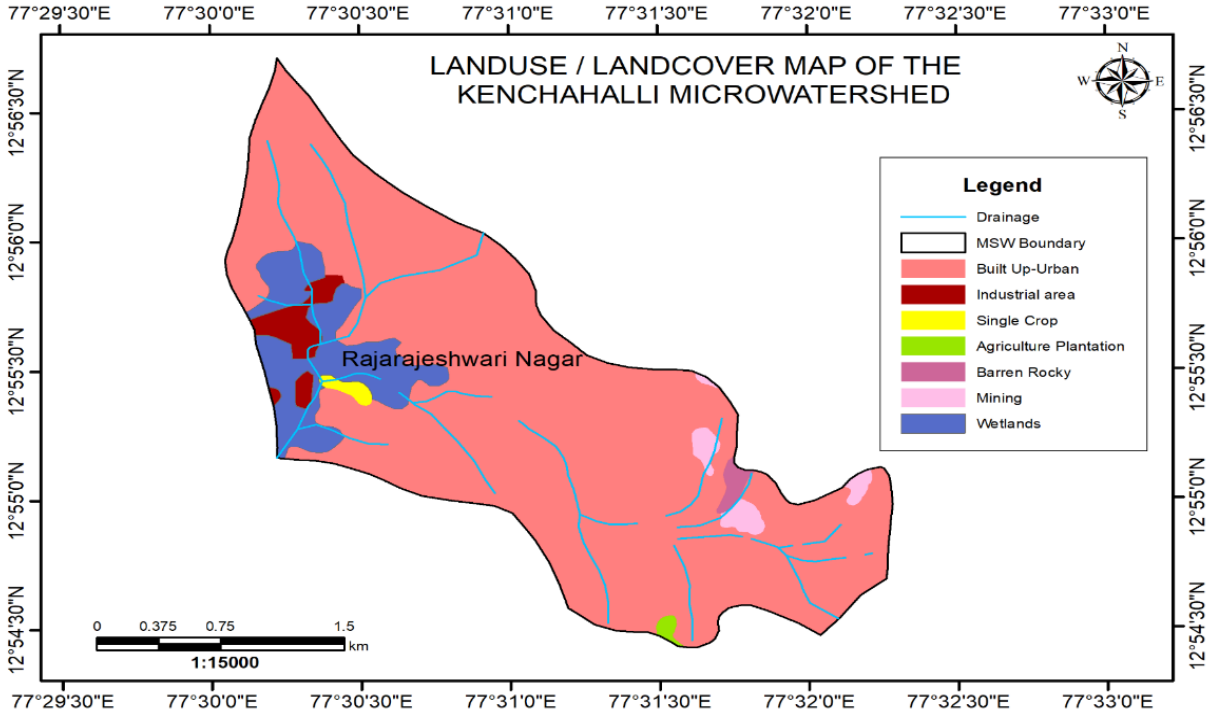

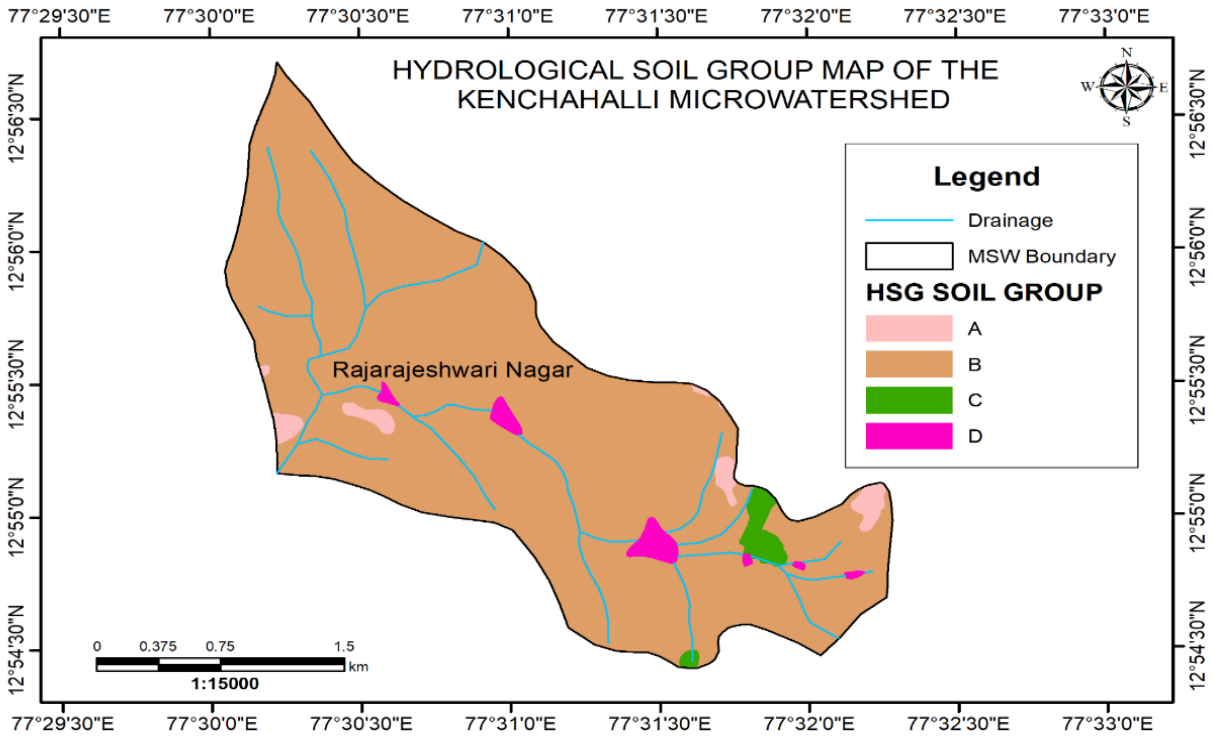

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SCS-CN Method

A conceptual model

$P = I_a+F+Q$

P=Total precipitation

F=Infiltration

I_a=initial abstraction

Q=Actual direct runoff

Runoff = $P-I_a-F$

Potential maximum runoff

(When F=0)= $P-I_a$

Actual direct runoff = Q

Potential maximum infiltration(retention) = S

Actual infiltration = F

S depends on soil, land use, antecedent moisture etc

SCS-CN Method

A conceptual model

Concept -1 $\frac{Q}{P-Ia} = \frac{F}{S}$

Concept-2 $I_a=$

λ = a constant fraction

$\frac{Q}{P-Ia} = \frac{F}{S}$

The ratio of actual direct runoff to potential maximum runoff is equal to the ratio of actual infiltration to the potential maximum retention (or infiltration)

$Ia = \lambda S$ Amount of initial abstraction is some fraction of the potential maximum retention (S)

$Q = \frac{(P-Ia)^2}{(P-Ia+S)} = \frac{(P-\lambda S)^2}{(P+(I-\lambda)S)}$ = for $P > \lambda S$

$S = 254((100/CN)-1)$

CN = SCS Curve Number Ranges from 0 to 100

$Q = \frac{(P-Ia)^2}{(P-Ia+S)} = \frac{(P-\lambda S)}{(P+(I-\lambda)S)}$ = for $P > \lambda S$

$S = 254((100/CN)-1)$

Curve number CN Depends on

1. Soil type.

2. Land use/ land cover

3. Antecedent moisture

P and Q are in mm For operational purpose, the computation is done at daily time step

Table 5.6(a) Runoff Curve Numbers [CN_{II}] for Hydrologic Soil Cover Complexes [Under AMC-II Conditions]

Land Use	Cover		Hydrologic soil group			
	Treatment or practice	Hydrologic condition	A	B	C	D
Cultivated	Straight row		76	86	90	93
Cultivated	Contoured	Poor	70	79	84	88
		Good	65	75	82	86
Cultivated	Contoured & Terraced	Poor	66	74	80	82
		Good	62	71	77	81
Cultivated	Bunded	Poor	67	75	81	83
		Good	59	69	76	79
Cultivated	Paddy		95	95	95	95
Orchards	With understory cover		39	53	67	71
	Without understory cover		41	55	69	73
Forest	Dense		26	40	58	61
	Open		28	44	60	64
	Scrub		33	47	64	67
Pasture	Poor		68	79	86	89
	Fair		49	69	79	84
	Good		39	61	74	80
Wasteland			71	80	85	88
Roads (dirt)			73	83	88	90
Hard surface areas			77	86	91	93

Value of λ

For Indian catchments $\lambda = 0.1$ for Black soils under AMC I and II $\lambda = 0.3$ for Black soils under AMC III and for other soils

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Table 5.5 Antecedent Moisture Conditions (AMC) for Determining the Value of CN

AMC Type	Total Rain in Previous 5 days	
	Dormant Season	Growing Season
I	Less than 13 mm	Less than 36 mm
II	13 to 28 mm	36 to 53 mm
III	More than 28 mm	More than 53 mm

For AMC-I: $CN_I = \frac{CN_{II}}{2.281 - 0.01281\,CN_{II}}$

For AMC-III: $CN_{III} = \frac{CN_{II}}{0.427 + 0.00573\,CN_{II}}$

4.Results

Sl No	CN	Area	CN * Area
0	39	35581.63996	1387683.959
1	45	32090.52551	1444073.648
2	53	19005.53603	1007293.41
3	57	68805.36933	3921906.052
4	61	600508.4506	36631015.48
5	66	98295.28556	6487488.847
6	67	538.122536	36054.20991
7	72	5795700.696	417290450.1
8	77	62.657389	4824.618953
9	80	11326.11179	906088.9432
		6661914.395	**469116879.3**

CN2= 70.42

CN1= 51.07

CN3= 84.79

SlNo	DESCRIPTION	Area (sq.m.)
1	Agriculture Plantation	19543.65093
2	Barren Rocky	40288.11044
3	Built Up-Mining	112465.2233
4	Built Up-Urban	5882093.341
5	Industrial area	161702.083
6	single crop	32477.7615
7	Wetlands	647416.2034
		6895986.374

RUNOFF = 0.9964492033 m
TOTAL RUNOFF VOLUME = (AREA*Q)
Area=67416.203 m2
TOTAL RUNOFF VOLUME =67176.82177m^3

5. Conclusion

The GIS and SCS-CN method is proved to be an efficient method in determining the surface runoff. From the above mentioned method we were able to calculate the amount of runoff in the geographical area mentioned.

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