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Estimation of Surface runoff using geospatial model: A case study of Gandheshwari watershed, Bankura, West Bengal, India

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Abstract

The issue of surface runoff evaluation is one of the critical and important subjects of hydrological and in addition topographical research. The point of the paper is in this way to evaluate and survey surface runoff on the case of catchment which is situated in the upper compasses of Dwarkeswar watershed. For this reason, SCS runoff bend number technique, demonstrating in GIS and remote detecting were utilized. An essential undertaking was the formation of a computerized height display (DEM), which enters the surface runoff demonstrating and influences its exactness. The investigation range demonstrates that 10 % of region falls under high CN esteem which translates in more overflow to the examination zone. The yearly overflow profundity for catchment was registered for this un-gage catchment zone. The examination uncovers that the SCS-CN model can be utilized to appraise surface runoff profundity when sufficient hydrological data is not accessible. Precipitation overflow is a critical part contributing altogether to the hydrological cycle, plan of hydrological structures and morphology of the seepage framework. Estimation of the same is required keeping in mind the end goal to decide and conjecture its belongings. Estimation of direct precipitation runoff is constantly productive however is unrealistic for the vast majority of the area at wanted time. Utilization of remote detecting and GIS innovation can be utilized to defeat the issue of traditional strategy for evaluating runoff caused because of precipitation. In this paper, adjusted Soil preservation Framework (SCS) CN show is utilized for precipitation overflow estimation that considers parameter like slant, vegetation cover, region of watershed.

Introduction

Estimation and appraisal of surface runoff is a vital and important issue of hydrological and also topographical research. Surface runoff is a huge factor influencing the advancement and advance of surges, soil disintegration, and other hydrological risks. One of the strategies for its assurance is the SCS-CN runoff curve number method (Zhan et al., 2009; Stuebe et al., 1990, Roy, 2017). In this manner, utilization of GIS is favoured over the traditional systems in appropriate evaluation of surface overflow (Aich et al., 2017). In addition, the estimation procedure turns out to be more effective and intelligent when exclusively GIS is utilized for storage, examining, deciphering, and showing the information required in CN based overflow estimation strategies Learning of changes in the surface runoff conditions requires an examination of land utilize (Singh, 2016; Sreedevi et al., 2016; Kanga et al., 2017a; Sinha et al., 2014).

In late decades, there have been escalating anthropogenic effects on the scene which are caused by the horticulture, ranger service, water administration changes, structural technical and modern exercises, tourism, and so on (Jasima et al., 2015; Kanga et al., 2017b; Singh and Kanga 2017a, Ajmal et al., 2015; Anji, 2013). The results of these exercises are reflected in the difference in runoff conditions, deforestation, quickened soil disintegration, disturbance of hydrologic administration of scene, surface entertainment, and land cover or land utilizes change. Scene structure or land utilize decides, specifically, the hydrological change of precipitation in the catchment. The effect of current land use on hydrological change can be separated into two essential gatherings (Singh et al., 2017a; Dornado et al., 2010; Singh et al., 2017b).

The main gathering is spoken to by the effect caused by coordinate use of land use in rainfall-runoff relations while the procedures, for example, capture attempt and evapotranspiration are connected. The second vital gathering of impact is the capacity of land use as a defensive factor of soils where in its points of view, a generous piece of the change of storm water to runoff is being done(Kanga et al., 2017). Changes in the structure of vegetation or coordinate deforestation may start a transient reaction of the catchment and additionally a long haul reaction. The method for making land utilize maps is currently permitted by the advance of geoinformation advances, for example, remote detecting and GIS. Primarily the remote detecting strategies permit rapid accumulation of data on the current landscape in relating exactness and quality (Liu and Li 2008; Singh and Kanga, 2017b; Amutha et al., 2009; Tomar et al., 2017).The point of the paper is to present a basic GIS-based technique to evaluate surface runoff physiognomies, for example, profundity or volume on the example of a little catchment utilizing the SCS-CN method and recorded precipitation information, demonstrating in GIS and remote Sensing.

In India, the accessibility of precise data on overflow is hardly accessible in few chose locales. Be that as it may, reviving of the watershed administration program for protection and improvement of common assets administration has required the overflow data. Customary strategies for overflow estimation are costly, tedious and troublesome process and these techniques for runoff estimations are difficult for bumpy and out of reach landscapes (Singh et al., 2017c; Singh, 2017b). Remote detecting innovation can increase the customary techniques, all things considered, in precipitation runoff reflects nearby. It assumes an indispensable part in procurement of information in the diverse parts of land use and soil cover, which are basic parameters in the field of watershed runoff estimation (Mc-Cuen, 2008). Geographic Information System (GIS) gives a valuable approach since it gives a structure to gathering, putting away, breaking down, changing and showing spatial and non-spatial information for specific purposes. In this manner the utilization of GIS innovation as a spatial information administration and an examination instrument gives a viable component to hydrologic/water driven investigations (Kanga et al., 2013). Advances in computational power and the developing accessibility of spatial information from remote detecting systems have made it conceivable to utilize hydrological models like SCS cure number in spatial area with GIS.

Water shortage in Indian urban areas has already become a serious social problem and is generally considered to be related to increase in population and rapid urbanization (Pandey et al., 2013). Urbanization increases impervious area, which directly affects the water cycle. Groundwater table depletion and increased flood peak are typical consequences from the distorted water cycle (Kanga et al., 2013). Impervious surface in urban environment has significant impacts on hydrology, in terms of both water quality and quantity, over a range of temporal and spatial scales. Accurate estimation of urban run-off is critical at all stages of urban planning and water resources management. It is worth mentioning that over the past two decades, the use of Remote Sensing and Geographic Information System (GIS) technologies in run-off estimation from urban watershed has gained increasing attention.

Materials and Methods

Study area

The investigation territory is situated in the upper compasses of Dwarkeswar watershed, from scopes 23˚13'15", to 23˚ 31'25" and from longitudes 86˚53'11" to 87˚08'2.5". Gandheshwari is a tributary of Dwarkeswar River, which covers a territory of 391.7616 km^2. The yearly precipitation of the examination region shifts in the vicinity of 1055 and 1070.3 mm. The greatest measure of precipitation got amid the rainstorm season from June to September around 80.73%. The relative moistness in the long stretch of April is 61(2008) and in the period of September is 99 (2008). The greatest height is 435 m., delineated in the centre part and the base rise is around 80 m. seen in the southern piece of the sub-watershed. This total help outline produced as appeared in Figure 1.

Data used and methodology

The land use and land cover map was prepared using supervised classification for LANDSAT 8 satellite imagery of Gandheshwari watershed during the year 2016 with a resolution of 30 m approximately. The drainage map was created for the study area using Arc GIS software for identification of drainage pattern. Survey of India (SOI) toposheets on 1:50000 scale were used for delineating the watershed boundary and preparation of base map and drainage map. The soil information was collected from the soil map of West Bengal, published by the National Atlas and Thematic Mapping Organization (NATMO). Contours available on SOI topographical maps have been used for the preparation of Digital Elevation Model (DEM). SRTM data, Geological map (1:250000 scale) published by Geological Survey of India was also used for preparation of various topographic analysis. In order to know the different natural resources and terrain conditions in the study area, toposheets along with the satellite data was used to prepare different thematic maps like updation of drainage, land use/ land cover, soil map etc. Fig. 2 shows the methodology followed to estimate runoff using SCS Curve Number model. Runoff was estimated with the aid of hydrological model using USDA (United States Department for Agriculture) methodology for estimation of surface runoff using SCS (Soil Conservation Service) Curve Number model.

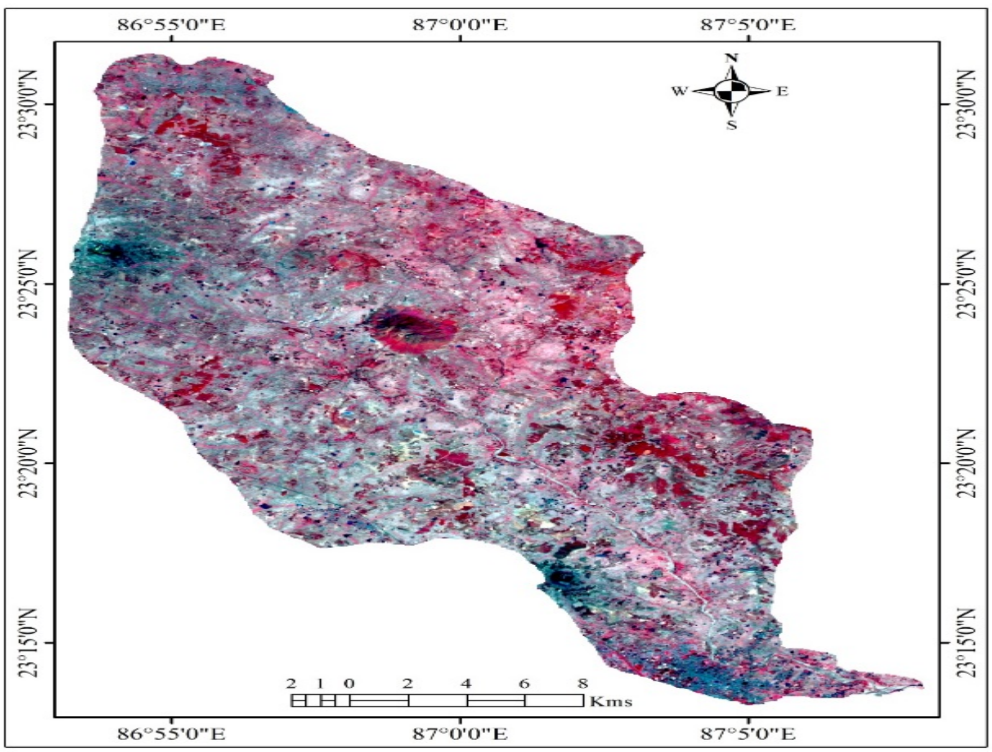

Figure 1. Study area of Gandheshwari watershed

Results

Water is the most vital necessities for monetary and social improvement. In India human populace is continually expanding along these lines water interest for local, horticultural and modern utilize likewise expanding. Be that as it may, the critical of rain and ground water accessibility has bringing about finished usage of surface water, diminishing water table levels and water quality crumbling. To enhance watershed at miniaturized scale level it is required to lessen the runoff, increment the groundwater level and quality. Influencing varieties in arrive administration or building appropriate structures to can accomplish decline of surface overflow. Point by point comprehension and examination of a few precipitation overflow model, for example, pressure driven properties of the dirt, arrive utilize, precipitation power, incline soil dampness, and lithology is required to ponder small scale watershed advancement approach. Each and every watershed has certain highlights, for example, shape, measure, seepage, incline, geography, vegetation, geomorphology, soil, arrive utilize and atmosphere. Water shed administration shows appropriate use of water for normal assets and land in a watershed for valuation of runoff helps for creating, arranging and dealing with the water system planning and water assets. In the administration arranging and water assets applications overflow is essential hydrologic factors utilized. Valuation of overflow requires much time and exertion ashore surface and streams for gaged watershed exactness. In this examination to create precipitation runoff display by coordinating spatial contrast of the different physiographic highlights like as geography, geomorphology, arrive utilize/arrive cover, structures, soil and waste example utilizing SCS-CN procedure with the assistance of RS information and GIS methods.

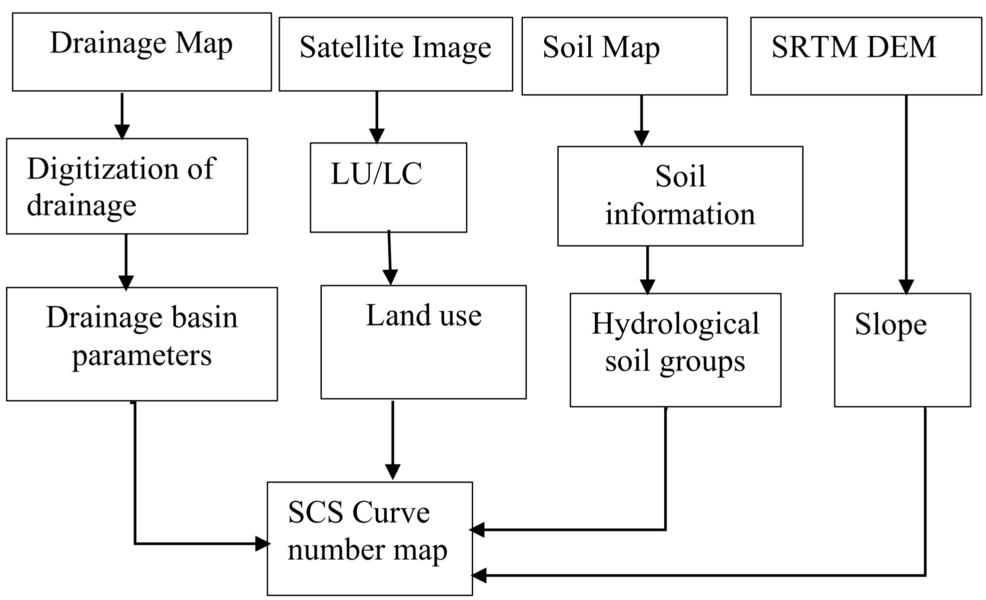

Figure 2 Flow chart showing Methodology to estimate runoff by SCS CN model)

Hydrological soil group (HSG) or soil map

Soil map of scale 1:50000 was obtained from the National Bureau of Soil Survey and Land Use Planning (*NBSS&LUP)* Nagpur. The soil map was geometrically rectified in ERDAS Imagine and boundaries of different hydrological soil groups were digitized in ArcGIS software. The study area was divided into two types of soil - loamy and fine loamy. The hydrological soil group classification A, B, C and D were analysed and mapped as per terrain conditions.

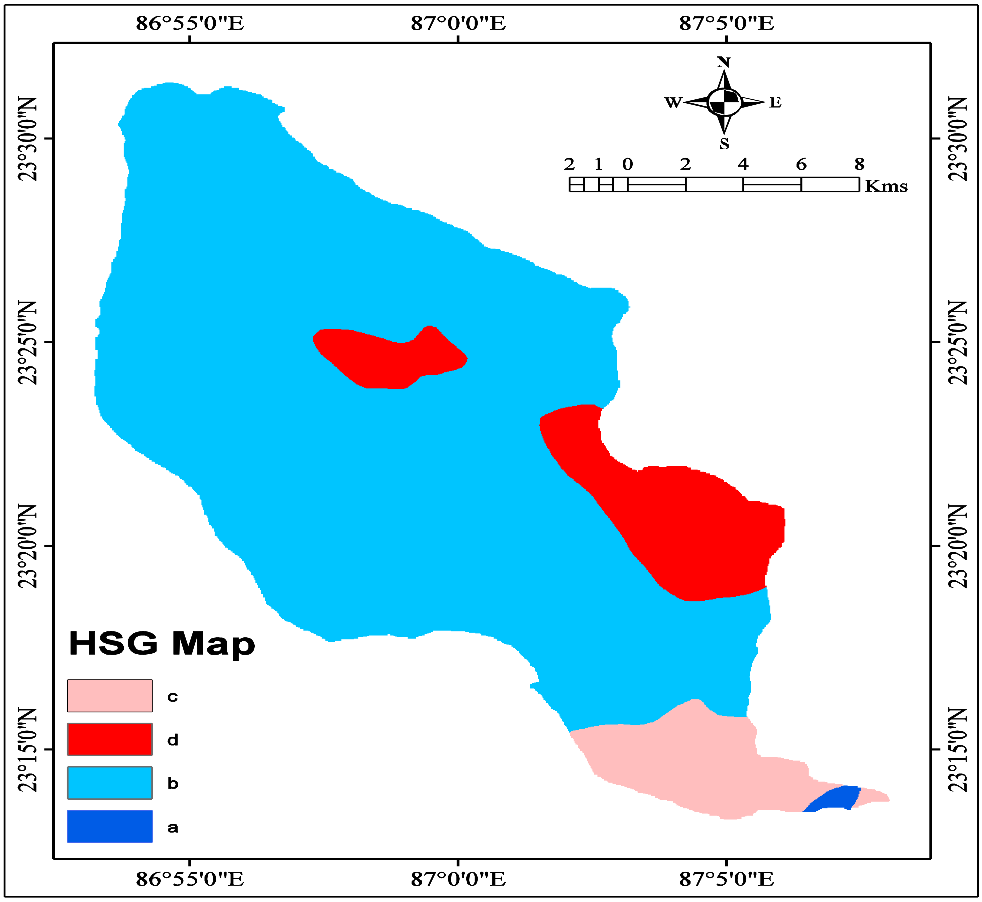

Figure 3 Hydrological soil group of the study area)

Drainage network

This study is undertaken to work out the morphometric characteristics of Gandheshwari watershed was analysed using Watershed Atlas of India, on a scale of 1:50,000. The measurement of assorted aspects of basin evacuation network characteristics reveals complicated morphometric attributes. In the geographic area analysis the primary step is to work out the stream orders and relies on a stratified ranking of streams within the study, the stream segments of the geographic area are hierarchical as per Strahlers stream ordering system. As per Strahler (1964), the tiniest tip tributaries are selected as order one, where 2 first-order stream be a part of, a channel section of order two is made; wherever 2 section of order two be a part of, a section of order three is made; then on. The trunk stream through that all discharged of water and sediment passes is thus the stream section of the very best order. The study space belongs to the seventh order geographic area.

Table 1. Hydrological soil group characteristics

Sl.No.	HSG Type	Soil Characterization
1	Group A	Soils having high infiltration rate and have low runoff potential. Very deep, poorly drained, fine loamy soils developed on old alluvium occurring on gently sloping to undulating dissected up land with loamy surface and slight erosion associated with very deep, poorly drained, fine soils.
2	Group B	Soils having moderate infiltration rates and have moderately low runoff potential. Very deep, moderately well drained, fine loamy soils occurring on very gently sloping to undulating plain with loamy surface and moderate erosion.
3	Group C	Soils having slow infiltration rates and have moderately high runoff. Very deep, moderately well drained, fine loamy soils occurring on very gently sloping flood plain with loamy surface, moderate erosion and moderate flooding.

Table 2. Curve numbers for different land use-hydrological soil groups)

Sl. No.		Hydrological soil group			
Land use class		A	B	C	D
1	Dense forest	26	40	58	61
2	Open forest	28	44	60	64
3	Scrub forest	33	47	64	67
4	Wasteland	71	80	85	88
5	Built up area	77	85	90	92
6	Agriculture	76	86	90	93
7	Water bodies	98	98	98	98

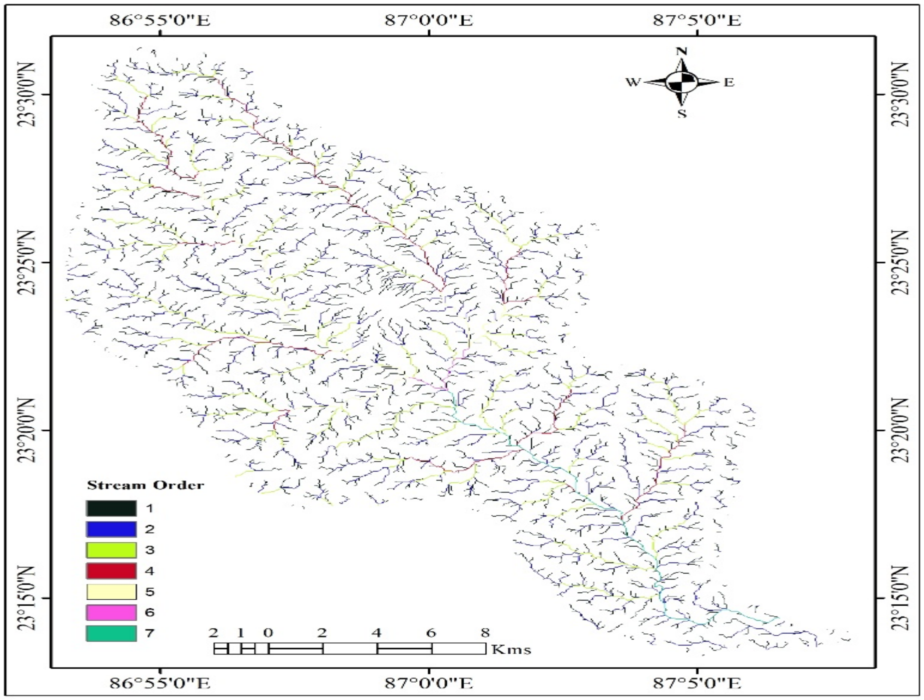

Figure 4 Drainage network map of the study area).

Rainfall-runoff equations

The data generally available in India comprise rainfall measured by non-recording rain gauge stations. Rainfall-runoff relation developed for such data is given below

$$Q = [(P-I_a)^2] / [(P-I_a)+S] \qquad (1)$$

Where, Q = the actual runoff in mm, P = Rainfall depth in mm, S = the potential maximum retention in mm, and I_a = initial abstraction during the period between the beginning of rainfall and runoff in equivalent depth over the catchment in mm. In areas covered by black soils having Antecedent Moisture Conditions (AMC) II and III, Ia in the equation is equal to 0.1S, whereas in all other regions including those with black soils of AMC I, Ia is equal to 0.3S.

SCS-CN method

The runoff curve number or curve number or CN is an empirical parameter first issued by Soil Conservation System (SCS) in January 1975 used in hydrology for predicting direct runoff or infiltration from rainfall excess. The CN method developed by United States Department of Agriculture (USDA) Natural Resources Conservation Service. The runoff curve number was developed from an empirical analysis of runoff from small catchment and hill slope plots monitored by USDA. In order to show this relationship graphically, 'S' values are transformed into 'Curve Numbers (CN)' using the following equation

$$CN_w=\Sigma(CN_i * A_i)/A \qquad (2)$$

Where, CN_w= Weighted Curve Number, CN_i=Curve number from 1 to ith, A_i =Area with curve number CN_i, A= Total area of watershed

$$S=25400/CN -254 \qquad (3)$$

Using the above equation, the following equations have been developed:

$$Q = [(P-0.3S)^2]/ [(P+0.7S)] \qquad (4)$$

$$Q = [(P-0.1S)^2] / [(P+0.9S)] \qquad (5)$$

Equation 4 is applicable to all soil regions of India except black soil areas referred to in the section on 'Hydrological Soil Groups'. Equation 5 applies to black soil regions. These two equations got from Manual on Artificial Recharge of Groundwater from Central Groundwater Board (M.L.et. al2004, Kanga et.al2011). This equation should be used with the assumption that cracks, which are typical of these soils when dry, have been filled. Therefore, equation 2 should be used where AMC falls into groups II and III. In cases where the AMC falls in group I, equation 1 should be used. CN is dependent on HSG, land use/land cover and Antecedent Moisture Condition (AMC)(Rao et.al 1996,Ebrahimian et.al 2009).

Table 3. Classification of AMC

SI.No.	AMC class	5 Day cumulative rainfall	
		Growing season	Dormant season
1	AMC I (dry)	< 36 mm	< 13 mm
2	AMCII (average)	36-53 mm	13- 28 mm
3	AMC III (wet)	>53 mm	> 28 mm

Land use map

The land use / land cover map of the study area was prepared using visual interpretation of satellite images of LANDSAT 8 for the year 2016.The land use categories were reduced in to categories principally agriculture, wasteland, water bodies, forest and settlement area by exploitation the merge tool in editor in Arc Map. The watershed map was overlaid land use map by union overlay analysis in Arc Map. Among the land use categories agriculture covers regarding sixty five and it plays a crucial role in dominant surface runoff. The following percentage of the land use are found in the study area: settlement (6.938%), fallow (41.16%), agriculture (21.2%), waste land (9.601%), dense forest (9.845%) and water (1.021%).

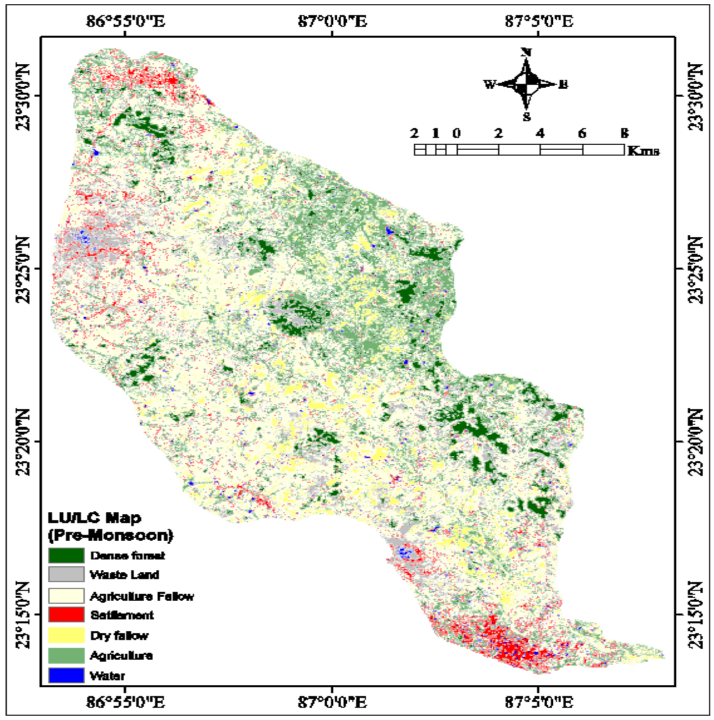

Figure 5 Land use land cover map of the study area)

Computation of weighted curve number

Each sub watershed consists completely different various curve numbers according different land use soil combos. The weighted curve numbers for every sub watershed equivalent to 3 antecedent wet conditions are given within the table. The runoff computation chiefly depends on CN value that may be an operate of land use, soil and AMC properties of space. High CN worth reflects high runoff potential and low tide retention. Low CN worth indicates high water retention potential so very little runoff.

Table 4. Computation of weighted curve number for individual micro watershed

Land use/ Land cover	MWS-1				MWS-2			MWS-3		
	Area in Km^2	Soil Groups		CN-1	Area in Km^2	Soil Groups	CN-2	Area in Km^2	Soil Groups	CN-3
		B	D			B			B	
Settlement	2.871	75	87	1.187	0.114	75	0.022	1.377	75	0.264
Agriculture Fallow	11.04	81	91	4.846	0.47	81	0.097	3.64	81	0.753
Agriculture	24.83	78	89	10.58	1.712	78	0.341	10.54	78	2.098
Dry Fallow	6.478	79	89	2.778	0.388	79	0.078	2.436	79	0.491
Wasteland	4.604	80	88	1.975	0.335	80	0.068	0.935	80	0.191
Dense Forest	6.042	40	61	1.558	0.709	40	0.072	2.419	40	0.247
Water	1.123	100	100	0.573	0.063	100	0.016	0.374	100	0.096
TOTAL	57.25	533	605	23.5	3.791	533	0.695	21.72	533	4.139

MWS-4			MWS-5			MWS-6		
Area in Km^2	Soil Groups	CN-4	Area in Km^2	Soil Groups	CN-5	Area in Km^2	Soil Groups	CN-6
	B			B			B	
0.3	75	0.057	0.64	75	0.1225041	0.3096	75	0.05927062
0.898	81	0.186	2.924	81	0.60458099	2.6496	81	0.54782593
2.234	78	0.445	3.555	78	0.70780146	1.3203	78	0.26287209
0.292	79	0.059	1.371	79	0.27640555	0.5319	79	0.10725914
0.673	80	0.137	1.235	80	0.25213241	4.6494	80	0.94943262
0.685	40	0.07	0.624	40	0.06368146	0.6624	40	0.06763283
0.099	100	0.025	0.224	100	0.05720304	0.558	100	0.14243327
5.18	533	0.979	10.57	533	2.08430901	10.6812	533	2.1367265

MWS-7			MWS-8			
Area in Km^2	Soil Groups	CN-7	Area in Km^2	Soil Groups		CN-8
	B			B	D	
0.3312	75	0.06340578	0.2583	75	87	0.10681117
1.4094	81	0.29140469	1.3689	81	91	0.60100408
4.9032	78	0.97622845	2.2608	78	89	0.96373108
1.4535	79	0.2931024	0.252	79	89	0.1080655
3.1977	80	0.65298763	0.7956	80	88	0.34117822
2.34	40	0.23892033	2.1051	40	61	0.54271441
0.2412	100	0.06156793	0.04771	100	100	0.0243566
13.8762	533	2.5776172	7.08841	533	605	2.68786106

MWS-9				MWS-10			MWS-11		
Area in Km^2	Soil Groups		CN-9	Area in Km^2	Soil Groups	CN-10	Area in Km^2	Soil Groups	CN-11
	B	D			B			B	
1.8927	75	87	0.78266163	1.3059	75	0.2500048	0.2934	75	0.0561692
7.9479	81	91	3.48945892	5.1831	81	1.0716473	0.9405	81	0.1944559
3.9564	78	89	1.68652939	4.4712	78	0.8902171	3.3444	78	0.6658709
0.9954	79	89	0.42685873	0.5814	79	0.117241	0.3519	79	0.0709616
2.1897	80	88	0.93901201	2.1573	80	0.4405323	0.6012	80	0.1227683
1.5878	40	61	0.40934965	2.2545	40	0.2301905	1.0467	40	0.1068709
0.2304	100	100	0.11762231	0.2961	100	0.0755815	0.0684	100	0.0174596
18.8003	533	605	7.85149264	16.2495	533	3.0754146	6.6465	533	1.2345565

MWS-12			MWS-13				MWS-14			
Area in Km^2	Soil Grous	CN-12	Area in Km^2	Soil Groups		CN-13	Area in Km	Soil Groups		CN-14
	B			B	D			B	D	
1.26	75	0.24121764	0.297	75	87	0.12281424	0.2223	75	87	0.0919246
3.5937	81	0.74302613	0.8577	81	91	0.376566	1.6632	81	91	0.73021403
3.0663	78	0.61050116	3.537	78	89	1.50774806	3.2913	78	89	1.40301137
0.6309	79	0.12722278	0.2313	79	89	0.09918869	0.9207	79	89	0.39482503
0.4527	80	0.09244379	1.2195	80	88	0.52295983	0.8784	80	88	0.37668546
1.7586	40	0.17955781	3.7098	40	61	0.95642103	0.8973	40	61	0.23133231
0.1647	100	0.04204079	0.1017	100	100	0.05191922	0.1269	100	100	0.06478417
10.9269	533	2.03601009	9.954	533	605	3.63761709	8.0001	533	605	3.29277695

MWS-15			MWS-16			MWS-17			
Area in Km^2	Soil Grous	CN-15	Area in Km^2	Soil Groups	CN-16	Area in Km^2	Soil Groups		CN-17
	B			B			B	D	
0.1845	75	0.03532115	0.3564	75	0.06823013	2.6325	75	87	1.08858073
0.9153	81	0.18924557	2.4435	81	0.50521311	9.936	81	91	4.36231757
1.4814	78	0.29494714	4.0032	78	0.7970382	13.2678	78	89	5.65578167
0.5796	79	0.11687799	1.3869	79	0.27967232	2.9574	79	89	1.26822584
0.342	80	0.06983825	1.1646	80	0.23781762	3.9591	80	88	1.69778621
0.261	40	0.02664881	1.3176	40	0.13453052	6.0426	40	61	1.55783863
0.0756	100	0.01929741	0.3393	100	0.08660862	1.0674	100	100	0.54492213
3.8394	533	0.75217632	11.0115	533	2.10911052	39.8628	533	605	16.1754528

MWS-18				MWS-19			MWS-20		
Area in Km^2	Soil Groups		CN-18	Area in Km^2	Soil Groups	CN-19	Area in Km^2	Soil Groups	CN-20
	B	D			B			B	
0.6822	75	87	0.282100579	0.9396	75	0.1798794	0.4945	75	0.09466835
2.8323	81	91	1.243497589	3.762	81	0.7778235	1.9323	81	0.39951843
2.8629	78	89	1.220393534	4.9977	78	0.9950434	4.8915	78	0.97389898
0.873	79	89	0.374369771	1.7955	79	0.3620677	0.999	79	0.20145119
0.4302	80	88	0.184483248	1.4031	80	0.2865206	1.494	80	0.30508288
0.3636	40	61	0.093739471	0.9531	40	0.0973141	1.4013	40	0.14307652
0.1791	100	100	0.091432971	0.3852	100	0.0983249	0.2655	100	0.06777067
8.2233	533	605	3.490017163	14.2362	533	2.7969736	11.9291	533	2.18546701

MWS-21				MWS-22			
Area in Km^2	Soil Groups		CN-21	Area in Km^2	Soil Groups		CN-22
	B	D			B	C	
0.693	75	87	0.28656655	0.3168	75	83	0.12776724
3.1662	81	91	1.39009359	1.2717	81	88	0.54859093
11.4705	78	89	4.88963081	2.0736	78	85	0.86275967
1.3653	79	89	0.58548345	0.6741	79	86	0.28391316
2.8341	80	88	1.21535094	1.0791	80	85	0.45448849
9.3186	40	61	2.40242198	0.6048	40	58	0.1512917
0.261	100	100	0.13324403	0.0927	100	100	0.0473246
29.1087	533	605	10.9027913	6.1128	533	585	2.47613579

MWS-23				MWS-24			
Area in Km^2	Soil Groups		CN-23	Area in Km^2	Soil Groups		CN-24
	B	C			B	D	
0.9936	75	83	0.40072452	4.1013	75	83	1.65407757
2.8728	81	88	1.23927973	4.059	81	91	1.78206995
1.3311	78	85	0.5538288	3.8097	78	85	1.58509622
0.414	79	86	0.17436589	0.4113	79	86	0.17322872
2.0936	80	85	0.88176915	0.8532	80	85	0.35934536
0.981	40	58	0.24539874	1.6893	40	58	0.42258114
0.1143	100	100	0.05835169	0.3375	100	100	0.17229831
8.8004	533	585	3.55371853	15.2613	533	605	6.14869727

Runoff mapping

In this study GIS technique provides curve range and runoff maps with the assistance of Arc GIS 10.2 as per SCS model. During this technique, soil and land knowledge are processed through the following 3 steps: (1) Soil and land use knowledge for the watershed are clipped employing a plane figure feature like the watershed physical phenomenon (2) interval is reduced by dissolving the soil and land use layers before intersection, supported the attributes 'hydro group' in soil and 'land cover' and land use, (3) Soil and land use layers are intersected to get new and smaller polygons related to soil 'hydro group' and land use and 'land cover'. This step keeps all the main points of the abstraction variation of soil and land use, and may be taken to be a lot of actual than victimization any average technique to see curve range (Mishra and Singh, 2003). Using this, the curve range for every plane figure made up our minds from the soil and land use knowledge.

Table 5 Calculation of CN, S and Q (Runoff) for individual micro watershed

MWS	CN	S	Q=Runoff in mm
1	23.5004556	826.8301095	106.3067284
2	0.69491814	36297.06773	4666.765851

3	4.13854801	5883.418229	756.4394866
4	0.97930914	25682.65163	3302.055209
5	2.08430901	11932.29286	1534.151939
6	2.1367265	11633.34262	1495.71548
7	2.5776172	9600.062116	1234.293701
8	2.68786106	9195.893217	1182.329128
9	7.8514926	2981.053676	383.2783298
10	3.0754146	8005.04904	1029.220591
11	1.2345565	20320.19	2612.595857
12	2.03601009	12221.38022	1571.320314
13	3.63761709	6728.593102	865.1048274
14	3.29277895	7459.849118	959.1234581
15	0.75217632	33514.67807	4309.030037
16	2.10911052	11788.99147	1515.727475
17	16.1754528	1316.280617	169.2360793
18	3.490017163	7023.901172	903.0730078
19	2.7969736	8827.244099	1134.931384
20	2.18546701	11368.22989	1461.629557
21	10.9027913	2075.678639	266.8729679
22	2.47613579	10003.91885	1286.218138
23	3.55371853	6893.442822	886.2997914
24	6.14869727	3876.956345	498.4658158

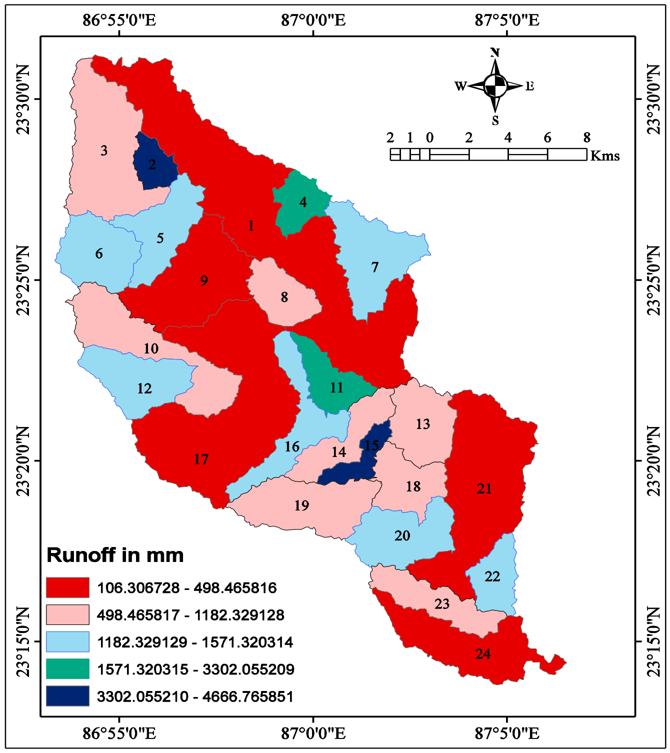

Figure 6 Surface runoff map of Gandheshwari watershed)

Conclusions

Water assets advancement assumes an imperative part in accomplishing multifaceted monetary and social improvement of a country. A watershed is the zone covering all the land that contributes overflow water to a typical point. It is a characteristic physiographic or natural unit made out of interrelated parts and capacities. Water rare districts in various parts of India are liable to different hydrological requirements. The asset poor rural groups that rely upon rain fed horticulture are the hardest hit. Precipitation designs in these regions are capricious. In this way, the capacity to productively collect the precipitation runoff is of basic significance to keep up rural generation, in a monetarily and earth maintainable way. Be that as it may, usage of overflow gathering in a broad path, with no unfavourable effects on downstream hydrological frameworks, requires a superior comprehension of the hydrological forms. For the viable administration of watershed exact comprehension of hydrological conduct is required and is required. Estimation of runoff from storm precipitation is often required for water asset arranging and ecological effect investigation. Among the most essential difficulties of hydrology are the expectation and measurement of catchment surface runoff. Remote detecting (RS) and Geographic data framework (GIS) can be adequately used to oversee spatial and non-spatial database that speak to the hydrologic qualities of the watershed. The Land utilize and Land Cover outline, delineate, information are gathered from various sources and handled. The weighted Bend numbers were resolved in light of precursor dampness condition with a coordination of hydrologic soil gatherings and land utilize/arrive cover classes. For higher watershed management system, runoff estimation by SCS CN methodology integrated with GIS is verified as an efficient methodology, particularly in ungauged watersheds, wherever discharge information is out of stock. The runoff behaviour of sub watersheds varies spatially per land use and soil conditions. The estimation of runoff exploitation GIS primarily based SCS curve range method will be utilized in watershed management effectively. All the factors in SCS model area unit geographic in character. Due to the geographic nature of those factors, SCS runoff model will be simply formed into GIS. The study demonstrates the importance of remotely perceived knowledge in conjunction with GIS to derive the model parameter to estimate surface runoff from the ungauged watershed. Results obtained clearly shows the variation in runoff potential with completely different land use/land cover and with completely different soil conditions. supported the digital database creation, conservation techniques like percolation pond, check dam etc., will be counselled for higher management of land and water resources for property development of the watershed. Remote sensing information square measure of nice use for the estimation of relevant hydrological information when standard hydrological information square measure inadequate for the aim of style and operation of water resources system. Remote sensing information are often used as model input for determination of construction characteristics, like land use/ land cowl, morphology, depth elevation model, emptying etc. Hybrid classifier is employed for land cover mapping, moving averaging methodology is employed for rain prediction, SCS model is employed for estimating runoff victimization land cover, soil sort and foretold rain worth.

Authors Contribution*:* Mohd. S. Ul Hasan *(project leader) guidance the research work and is the main corresponding author of manuscript;* Suraj K. Singh[2] *(Assistant Professor) has responsible for performing the research work and data collection;* Sudhanshu *(Assistant Professor) contributed to writing, editing and co-guidence.*

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