"Geoinformatics in water resource management at Micro watershed level; Dangra a Case, West Bengal"

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Abstract: This study sought to provide a protocol for defining sustainable watershed management. In the context of change in the landscape, induced by natural and physical processes or human activities and habitation, continues monitoring is essential for optimal utilization of the land and water resources as well as for improvement of the present-day scenario. It is now being an established fact that the special information technology is very suitable for one time inventories and surveys as well as for continues monitoring in time and space of natural resources and human activities. In the present study of an integrated approach has been made for micro watershed development of Dangra sub-watershed of Dwarakeswar watershed.

Key words: Scarcity, Morphometric, Run-off, SYI, Socio-economy, AHP and Management.

Introduction: Water and Land are the two greatest gift of nature (Bera & Bandyopadhyay, 2011). Natural resources must be conserved and maintained carefully for environmental protection and ecological balance. Land degradation reduces the world's fresh water reserves, river flow rates and lower ground water levels which lead to the silting up of estuaries, reservoirs, salt water intrusion, interfere with the operation of reservoirs and irrigation channels, increase coastal erosion and pollution of water by suspended particles and Stalinization, thus affecting human and animal health. Solution to all these problems is watershed management. Use of space technology and geographical information system (GIS) are the tools for extraction of watershed parameters for hydrological evaluation. Mathematical hydrologic simulation models and formula are among the best tools for analyzing water resources issues associated with land degradation by deforestation, urbanization, intensive unplanned agricultural activities etc. These analyses represent detailed watershed character with physical and biological processes and permit the incorporation of spatially distributed information. They also provide cost-effective means for determining best land management practice that minimize water scarcity for human and agricultural both in sub-watersheds. Distributed parameter, deterministic models not only capture the physical-mathematical relationships necessary to simulate non-point source (NPS) runoff, sediment and nutrient but also preserve the distribution of important spatially variable watershed characteristics. One of the most widely used techniques for estimating direct runoff depths from storm rainfall is the United States Department of Agriculture (USDA) Soil Conservation Service's (SCS) (now the Natural Resources Conservation Service) Curve Number (CN) method (USDA, 1985 and 1986). Traditionally CN is determined in compositing manner; however distributed CN approach can be adopted using GIS. It is important to know how results from distributed CN approach differ from results of the traditional composited CN technique. Due to unavailability of hydrologic data, a logical alternative is to estimate the hydrologic characteristics of a watershed by using morphometric parameters. These parameters can be accurately estimated in GIS and Microsoft Excel environment in less time and in a cost effective manner. From the analysis identify the details information of drainage, which helpful to water resources management at micro level. In India, so far very limited applications of geoinformatics techniques have been made in micro watershed wise modeling and to quantify the water problems. Multi criteria evaluation of each micro watershed wise is required to construct database for the simulate of water scarcity ground water potential zones, drainage character, surface runoff and sediment transport during rainfall events and evaluate the land capabilities and suitability's of it for Analytic Hierarchy Process (AHP) method based final action plan tacking. It is essential to identify areas most susceptible to demographic stretcher for best management practices on these areas and assessment of BMP implementation effectiveness on water availability improvement through monitoring strategies.

Keeping all the above points in mind a research work was formulated to hydrologically evaluate for sub-watershed and its micro watersheds with the following specific **objectives**.

1. Identify the high water scarcity area and low ground water availability area and its impacts on society.
2. Development of synthetic unit hydrograph using micro watershed morphometric parameters extracted by GIS techniques and then calculated by using formulas, for drainage characters.
3. Investigation of distributed curve number technique for runoff estimation using Spatial Information Technology.
4. Measurement, micro watershed wise Sediment Yield Index (SYI) for the continuation of flow and maximum carrying capacity of run-off water.

Study Area: This study was undertaken Dangra sub-watersheds its Micro watersheds located respectively in Bankura and Puruliya district of West Bengal state in India. The watershed geographically located between $23^0 20'$ to $23^0 32'$ North latitude and $86^0 45'$ to $86^0 55'$ East longitude on the globe (Figure: 1). The area of Dangra sub-watershed is 210.7 km^2 and elevation varies between 300m to 120m above mean sea level (MSL). The area has a subtropical humid climate with high intensity of rainfall during monsoon (May to October). The sub-watersheds is originated from the Chhotanagpur plateau region therefore the drainage are non perineal.

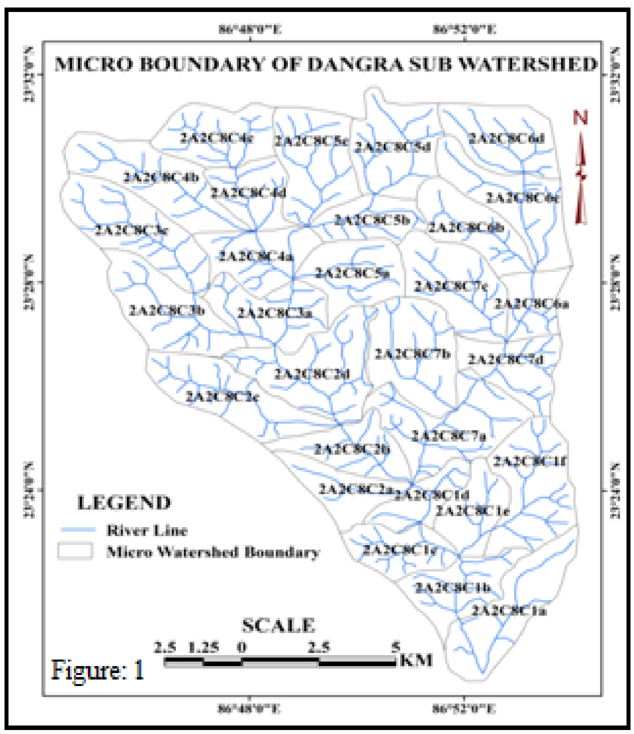


Figure: 1

Materials and Methods: Toposheets on fast publication 1971 ware collect from Survey of India (SOI-Kolkata). The watersheds lie on the SOI toposheet number: 73/I-11, I-14 and I-15 (1:50000 scale), which was used to delineate sub-watershed boundary and topographic parameters.Remote sensing satellite images for the year 2000, 2005, 2010, 2011 (LANDSET-ETM), and Indian remote sensing satellite images 2007, 2008, 2009 and 2010 (IRS-P6-LISS-III) images from National Remote Sensing Center (NRSC-Hydrabad) both Kharif and Rabi session were used for land use land cover classification and updating drainage network. ASTER DEM data collect from GLCF for identify the slope, aspect, detail drainage information. Soil series information collect from NBSS & LUP also samples were collect from field and then analysis in laboratory. Standard survey schedules prepare for collect primary data regarding the research from the field or villagers. The different image processing software and GIS software used in this study are ERDAS/ IMAGINE–9.2, Arc GIS-9.3, PCI-Geomatica-9.1 and ENVI-4.7. And other collateral data was collect from different sources.

Model /formula based analysis

Attributes of the respected themes such as Land use, Geology, Slope, Drainage Density and the field observation of a particular division have been added separately. To demarcate the scarcity and groundwater potential-zones, the weightage of individual theme and future score ware fixed and added to the layer depending upon their suitability to hold water. A probability weightage approach has been applied during overlay analysis in Arc GIS environment (Bera K, 2013). Spatial analysis tool of Arc GIS-9.3 was used for converting the feature to raster and also for final analysis in this method the total weightage of the final map were derived as sum or product of the class assigned to the different layers according to their position.

After identification of the scarcity zones in the sub watershed, all the micro-watersheds have been demarcated by clipping of water scarcity area coverage class in teams of percentage (%) viz. high, moderate and low. The final priority zones have been classified into three classes viz. first order assigned for >66% cover of high

Table 1	**Scarcity Zone & Priority Class**			
MWC	**High (%)**	**Moderate %)**	**Low (%)**	**Priority**
2A2C8C1a	73.2	26	.8	**1**
2A2C8C1b	91.3	8	.7	**1**
2A2C8C1c	8	84	8	**3**
2A2C8C1d	80.4	17.6	2	**1**
2A2C8C1e	96	4	0	**1**
2A2C8C1f	96	4	0	**1**
2A2C8C2a	30	67	3	**3**
2A2C8C2b	51	45	4	**2**
2A2C8C2c	24	76	0	**3**
2A2C8C2d	61.6	36	2.4	**2**
2A2C8C3a	61	39	0	**2**
2A2C8C3b	20.7	78	1.3	**3**
2A2C8C3c	53	47	0	**2**
2A2C8C4a	50	50	0	**2**
2A2C8C4b	55	45	0	**2**
2A2C8C4c	66.2	33.8	0	**1**
2A2C8C4d	88	12	0	**1**
2A2C8C5a	93	7	0	**1**
2A2C8C5b	90.3	9.7	0	**1**
2A2C8C5c	87	13	0	**1**
2A2C8C5d	96	4	0	**1**
2A2C8C6a	86.2	13.8	0	**1**
2A2C8C6b	24	76	0	**3**
2A2C8C6c	29	71	0	**3**
2A2C8C6d	87	13	0	**1**
2A2C8C7a	89.7	10.3	0	**1**
2A2C8C7b	82	18	0	**1**
2A2C8C7c	74	26	0	**1**
2A2C8C7d	86	14	0	**1**

scarcity zone, second order assigned for 33 to 66 % high scarcity zone and third priority order <33% of high scarcity zone cover (Table 1).

Watershed characteristics were extracted by using GIS and Remote Sensing Satellite Data. For purpose of the watershed characterization of Dangra sub-watershed under study, a drainage extract from ASTER data by using Arc GIS-9.3 and then update with the help of IRS P6 LISS-III image. The detail information of the watershed is measured with the help of Arc GIS (9.3) software up to micro watershed level. Morphometric parameters namely Linear, Relief and Areal of the watershed are calculated based on selected formula in table 2. The Survey of India toposheets covering the study area were scanned, rectified and digitized for elevation contours, drainage network, and prominent land character using Arc GIS software (Bera & Bandyopadhyay, 2013 and Mishra et al, 2010). Then GIS analysis was made to convert the whole sub-watersheds into 29 micro watershed wise slope, aspect, slope shape factor, soil characteristics etc. were find out. All drainage basin and morphometric parameters viz. stream order, area, perimeter, basin length, form factor, circulatory ratio, elongation ratio, basin shape factor, unit shape factor, basin relief, relief ratio, relative ratio, ruggedness number, drainage density, constant of channel maintenance, fineness ratio, stream frequency, basin slope, hypsometry analysis, stream ordering, number of stream, bifurcation ratio, stream lengths, length of main stream, stream length ratio, length of overland flow, main channel slope etc. were extracted from GIS analysis (Kumar et al, 2010) and then calculated (Table 3).

Table 2 Methods of calculating morphometric parameters

	Morphometric Parameters	Methods	References
LINEAR	Stream order (U)	Hierarchical order	Strahler, 1964
	Stream length (Lu)	Length of the stream	Horton, 1945
	Mean stream length (Lsm)	Lsm = Lu/Nu where, Lu=Stream length of order 'U' Nu=Total number of stream segments of order 'U'	Horton, 1945
	Stream length ratio (Rl)	Rl=Lu/Lu-1; where Lu=Total stream length of order 'U', Lu-1=Stream length of next lower order.	Horton, 1945
	Bifurcation ratio (Rb)	Rb = Nu/ Nu+1; where, Nu=Total number of stream segment of order'u'; Nu+1=Number of segment of next higher order	Schumm,1956
RELIEF	Basin relief (Bh)	Vertical distance between the lowest and highest points of watershed.	Schumm, 1956
	Relief ratio (Rh)	Rh=Bh/Lb; Where, Bh=Basin relief;Lb=Basin length	Schumm, 1956
	Ruggedness number (Rn)	Rn = Bh × Dd Where, Bh =Basin relief; Dd=Drainage density	Schumm, 1956
AREAL	Drainage density (Dd)	Dd = L/A where, L=Total length of streams;A=Area of watershed	Horton, 1945
	Stream frequency (Fs)	Fs = N/A where, N=Total number of streams; A=Area of watershed	Horton, 1945
	Texture ratio (T)	T = N1/P where,N1=Total number of first order streams; P=Perimeter of watershed	Horton, 1945
	Form factor (Rf)	$Rf=A/(Lb)^2$;where, A=Area of watershed, Lb=Basin length	Horton, 1932
	Circulatory ratio (Rc)	$Rc=4\pi A/P^2$;where, A=Area of watershed, π=3.14, P=Perimeter of watershed	Miller, 1953
	Elongation ratio (Re)	$Re=2\sqrt{(A/\pi)}/Lb$;where, A=Area of watershed, π=3.14, Lb=Basin length	Schumm,1956
	Length of overland flow (Lof)	Lof = 1/2 × Dd where, Dd=Drainage density	Horton, 1945

Table 3, Morphometric Calculation of Dangra Sub-Watershed

MWC	Linear					Relief			Arial							
	U	Lu (m)	Lsm (m)	Rl	Rb	Bh	Rh	Rn	Dd	Fs	T	Rf	Rc	Re	Lof
2A2C8C1a	9	18095	10893.8	0.37	3	38	0.003	0.076	0.002	0.0007	0.0018	0.0658	0.48527	0.28933	0.001
2A2C8C1b	11	17582	10291.2	0.28	4	22	0.002	0.062	0.003	0.0007	0.0026	0.0693	0.462309	0.29688	0.00142
2A2C8C1c	16	17742	10614.1	1.41	3.33	20	0.002	0.07	0.003	0.0010	0.0007	0.0711	0.681636	0.3009	0.00175
2A2C8C1d	6	13349	10295	0.22	4	22	0.003	0.074	0.003	0.0008	0.0039	0.0737	0.519238	0.30625	0.0017
2A2C8C1e	8	7651	3621.9	2.05	5.5	26	0.003	0.04	0.001	0.0003	0.0001	0.0713	0.68085	0.30132	0.00077
2A2C8C1f	24	17630	2135.4	0.87	4.33	22	0.001	0.04	0.002	0.0004	0.0005	0.0651	0.600859	0.28782	0.0009
2A2C8C2a	6	19325	14989	2.23	4	28	0.003	0.109	0.004	0.0010	0.0004	0.0713	0.476939	0.30133	0.00194
2A2C8C2b	24	21253	3736.7	0.61	3.2	28	0.008	0.581	0.021	0.0065	0.0106	0.0885	0.040115	0.33552	0.01037
2A2C8C2c	11	13184	4374.5	0.18	3.5	28	0.003	0.064	0.002	0.0006	0.0036	0.0699	0.478096	0.29821	0.00114
2A2C8C2d	15	19106	11376.1	0.76	13	32	0.002	0.067	0.002	0.0002	0.0002	0.0658	0.508842	0.28933	0.00106
2A2C8C3a	23	31134	7652	10.53	8.5	30	0.009	0.877	0.029	0.0034	0.0003	0.088	0.053879	0.33463	0.01461
2A2C8C3b	15	16620	6239.9	4.98	5.17	16	0.002	0.044	0.003	0.0005	0.0001	0.0695	0.571114	0.29749	0.00138
2A2C8C3c	12	11657	3691.6	1.34	5.75	34	0.003	0.041	0.001	0.0002	0.0001	0.0653	0.656993	0.28823	0.00061
2A2C8C4a	12	16516	5934.8	2.91	5	26	0.002	0.048	0.026	0.0004	0.0001	0.0659	0.609898	0.28971	0.00093
2A2C8C4b	8	6974	4242.5	0.27	2.5	14	0.002	0.024	0.002	0.0007	0.0025	0.0735	0.608405	0.30591	0.00087
2A2C8C4c	18	16346	5639.0	2.55	6.83	34	0.003	0.064	0.002	0.0003	0.0001	0.0661	0.695639	0.29002	0.00094
2A2C8C4d	13	17865	8425.2	3.62	10.5	20	0.002	0.051	0.002	0.0002	0.0001	0.0681	0.606383	0.29431	0.00127
2A2C8C5a	12	16419	6499.8	3.12	5	28	0.003	0.067	0.002	0.0005	0.0001	0.0684	0.66735	0.29499	0.00121
2A2C8C5b	14	20644	7196.2	3.13	5.7	22	0.002	0.071	0.003	0.0006	0.0002	0.069	0.560421	0.29624	0.00161
2A2C8C5c	16	17020	6428.0	1.95	8.5	32	0.003	0.056	0.002	0.0002	0.0001	0.0652	0.60545	0.28809	0.00088
2A2C8C5d	16	12021	5100.4	3.51	6.1	26	0.003	0.048	0.002	0.0003	0.0001	0.0688	0.614672	0.29601	0.00093
2A2C8C6a	13	13585	3958	1.62	4.67	28	0.002	0.045	0.002	0.0003	0.0002	0.0664	0.474174	0.29062	0.0008
2A2C8C6b	14	13426	5033.8	2.87	8	22	0.003	0.064	0.003	0.0004	0.0001	0.0721	0.623313	0.30294	0.00146
2A2C8C6c	11	13865	6674.9	0.73	10	40	0.003	0.057	0.001	0.0001	0.0002	0.0652	0.495325	0.2881	0.00072
2A2C8C6d	10	13121	5283.5	1.68	5	22	0.003	0.059	0.003	0.0005	0.0003	0.0715	0.654196	0.30165	0.00134
2A2C8C7a	16	16777	6072.3	2.53	7.67	34	0.003	0.066	0.002	0.0002	0.0001	0.0661	0.707077	0.29015	0.00097
2A2C8C7b	17	14428	2606.1	1.42	3.83	32	0.003	0.053	0.002	0.0004	0.0003	0.0662	0.656153	0.29025	0.00084
2A2C8C7c	12	11780	2842.4	0.55	5	18	0.002	0.030	0.002	0.0003	0.0006	0.0681	0.718895	0.29451	0.00085
2A2C8C7d	12	12670	2638.6	1.08	3.83	26	0.002	0.044	0.002	0.0004	0.0004	0.0675	0.732926	0.2931	0.00085

The IRS satellite images both monsoon (Kharif) and winter (Rabi) seasons were classified using supervised classification (after several ground truth verifications) with maximum likelihood classification algorithm in Erdas Imagine 9.2 software. The classification overall accuracy found to be acceptable ranging from 90.1% to 91.7% for all the classifications. The curve numbers coverage for the watershed land use was prepared based on hydrological soil groups, hydrologic condition and Antecedent Moisture Conditions (AMC). The CN coverage was generated by converting the classified image in raster form to polygons and intersecting with the micro watershed. If more than one land use was found in a micro watershed wetted CN was calculated for individual.

For the traditional composited CN approach, an average CN value is calculated for the entire simulated watershed, and the runoff depth (Mockus, 1949) for this average CN is determined using the following equations.

Where P is total precipitation (mm), I_a is initial abstraction (mm), Q is direct runoff (mm), and S is potential maximum retention or infiltration (mm).

$$Q = \frac{(P - I_a)^2}{P - I_a + S} \qquad S = \frac{25400}{CN} - 254$$

Where CN is the curve number which depends upon land use, hydrologic soil group and antecedent soil moisture condition (Narayana et al, 1993) had recommended I_a equal to 0.3S for most of the regions in India except for the regions having black clay soils where I_a is 0.1S. But in USA and other countries I_a equal to 0.2S has been found suitable. So in this study both initial abstraction value of 0.2S and 0.3S were attempted along with composite and distributed approach to find its relative importance (Rallison et al, 1980).

In a distributed approach, runoff volume is calculated for each individual micro watershed or polygon in the sub watershed, based on the land use and soil conditions at that location. There is no CN averaging, rather separate CN values are determined for each micro watershed or polygon and runoff values are calculated for each micro watershed or polygon. These runoff values are then averaged to find the total runoff or composite runoff depth for the watershed at the outlet (Table 4).

Table 4,	MICRO WATERSHED WISE RUN-OFF CALCULATION			
M.W Code	**2007**	**2008**	**2009**	**2010**
2A2C8C1a	2745.23	2379.323064	2007.248229	2287.67962
2A2C8C1b	3266,13	2826.62527	2375.607774	2852.42508
2A2C8C1c	4637.48	4487.960839	3753.496775	4714.60123
2A2C8C1d	3266.13	2936.612137	2464.700973	2981.08552
2A2C8C1e	3521.86	3063.827359	1365.821553	1345.68865
2A2C8C1f	3521.86	2722.797754	2375.607774	2730.03137
2A2C8C2a	2663.84	1965.132689	1833.6138	2287.67962
2A2C8C2b	2091.36	1965.132689	1660.658796	2287.67962
2A2C8C2c	1746.07	1396.007591	1261.820516	1175.39481
2A2C8C2d	3897.89	3764.659735	3753.496775	1674.27932
2A2C8C3a	4308.93	3928.496823	3286.285439	4495.50167
2A2C8C3b	2208.49	2341.894835	1980.056699	2185.46768
2A2C8C3c	4423.65	1608.513718	1388.570725	1469.27865
2A2C8C4a	2280.46	1912.405713	1617.941211	1674.27932
2A2C8C4b	1883.28	1467.100115	1388.570725	1401.74578
2A2C8C4c	1746.07	1331.743407	1177.477313	1605.21255
2A2C8C4d	2132.8	1608.513718	1438.949185	1605.21255
2A2C8C5a	2474.73	2106.9505	1660.658796	1674.27932
2A2C8C5b	1940.06	1467.100115	1276.158308	1674.27932
2A2C8C5c	10353.8	1467.100115	1365.821553	1345.68865
2A2C8C5d	2091.36	1823.477985	1557.57397	1674.27932
2A2C8C6a	1978.92	1573.446474	1660.658796	1830.26098
2A2C8C6b	2132.8	1774.111508	1557.57397	1469.27865
2A2C8C6c	1978.92	1774.111508	1521.888861	1469.27865
2A2C8C6d	1914.72	1573.446474	1388.570725	1401.74578
2A2C8C7a	3266.13	2826.62527	2375.607774	2852.42508
2A2C8C7b	5523.03	5401.609642	4742.353167	5724.67877
2A2C8C7c	2428.35	2175.606058	1844.288026	2093.25708
2A2C8C7d	2566,41	2175.606058	1844.288026	2093.25708

The quantitative assessment of soil erosion is a basic aspect of watershed management and therefore using SYI model one can predict the rate of soil loss by using empirical formulas for Watershed Prioritization based on the Sediment Yield Estimation (Table 5).

AIS and LUS (1991) proposed equation has been applied for Sediment Yield Estimation. The formulas as follows--- SYI = $\{\sum(Ai*Wi*Di)/AW)*100\}$

Here, Ai = Area of with mapping unit. Wi = Weightage value of with mapping unit.
Di = Delivery Ratio assigned to with mapping unit. AW = total area of watershed.

Table 5, Micro Watershed wise SYI (Sediment Yield Index) calculation													
Micro Watershed Code	Area Sq/mile	2007			2008			2009			2010		
		Weightage (Wi)	Delivery Ratio	SYI	Weightage (Wi)	Delivery Ratio	SYI	Weightage (Wi)	Delivery Ratio	SYI	Weightage (Wi)	Delivery Ratio	SYI
2A2C8C1a	3.493	0.71	0.353	32.558	0.71	0.353	32.558	0.71	0.353	32.558	0.8	0.353	27.752
2A2C8C1b	2.391	0.71	0.422	26.644	0.59	0.422	22.141	0.71	0.422	26.644	0.8	0.422	22.711
2A2C8C1c	1.962	0.71	0.458	23.728	0.71	0.458	23.728	0.71	0.458	23.728	0.8	0.458	20.225
2A2C8C1d	1.514	0.71	0.505	20.193	0.71	0.505	20.193	0.83	0.505	23.606	0.9	0.505	19.507
2A2C8C1e	1.923	0.71	0.462	23.436	0.71	0.462	23.436	0.83	0.462	27.397	0.9	0.462	22.640
2A2C8C1f	3.773	0.71	0.339	33.774	0.71	0.339	33.774	0.71	0.339	33.774	0.8	0.339	28.788
2A2C8C2a	1.921	0.71	0.462	23.424	0.71	0.462	23.424	0.83	0.462	27.383	0.9	0.462	22.629
2A2C8C2b	3.955	0.83	0.331	40.34	0.83	0.331	40.340	0.83	0.331	40.340	0.9	0.331	33.336
2A2C8C2c	2.239	0.71	0.434	25.653	0.71	0.434	25.653	0.71	0.434	25.653	0.8	0.434	21.866
2A2C8C2d	3.493	0.95	0.353	43.566	0.95	0.353	43.566	0.95	0.353	43.566	1	0.353	35.155
2A2C8C3a	4.113	0.95	0.323	46.982	0.95	0.323	46.982	0.95	0.323	46.982	1	0.323	37.911
2A2C8C3b	2.321	0.71	0.428	26.189	0.71	0.428	26.189	0.83	0.428	30.616	0.9	0.428	25.300
2A2C8C3c	3.693	0.59	0.343	27.787	0.59	0.343	27.787	0.71	0.343	33.438	0.8	0.343	28.502
2A2C8C4a	3.425	0.71	0.357	32.252	0.71	0.357	32.252	0.83	0.357	37.703	0.9	0.357	31.157
2A2C8C4b	1.540	0.71	0.502	20.409	0.71	0.502	20.409	0.71	0.502	20.409	0.9	0.502	19.716
2A2C8C4c	3.373	0.71	0.360	32.009	0.71	0.360	32.009	0.71	0.360	32.009	0.8	0.360	27.284
2A2C8C4d	2.717	0.59	0.399	23.772	0.59	0.399	23.772	0.71	0.399	28.607	0.8	0.399	24.384
2A2C8C5a	2.627	0.59	0.405	23.338	0.59	0.405	23.338	0.71	0.405	28.085	0.8	0.405	23.939
2A2C8C5b	2.468	0.59	0.416	22.54	0.47	0.416	17.956	0.59	0.416	22.540	0.7	0.416	20.038
2A2C8C5c	3.720	0.71	0.342	33.551	0.71	0.342	33.551	0.71	0.342	33.551	0.8	0.342	28.599
2A2C8C5d	2.497	0.71	0.414	27.3	0.71	0.414	27.300	0.83	0.414	31.914	0.9	0.414	26.373
2A2C8C6a	3.272	0.47	0.365	20.87	0.47	0.365	20.870	0.59	0.365	26.199	0.5	0.365	16.124
2A2C8C6b	1.776	0.47	0.476	14.781	0.47	0.476	14.781	0.47	0.476	14.781	0.6	0.476	13.957
2A2C8C6c	3.718	0.47	0.342	22.205	0.47	0.342	22.205	0.71	0.342	33.544	0.8	0.342	28.593
2A2C8C6d	1.892	0.71	0.465	23.206	0.71	0.465	23.206	0.71	0.465	23.206	0.8	0.465	19.780
2A2C8C7a	3.351	0.71	0.361	31.905	0.71	0.361	31.905	0.59	0.361	26.512	0.7	0.361	23.569
2A2C8C7b	3.334	0.83	0.362	37.205	0.83	0.362	37.205	0.83	0.362	37.205	0.9	0.362	30.745
2A2C8C7c	2.691	0.59	0.401	23.644	0.59	0.401	23.644	0.47	0.401	18.835	0.6	0.401	17.786
2A2C8C7d	2.887	0.59	0.388	24.559	0.59	0.388	24.559	0.59	0.388	24.559	0.7	0.388	21.833

A standardized questionnaire was prepared to collect Socio-economic information for the watershed management ware clotted by using matrix based sampling. The village were selected based required information in each village i.e. river distribution. Everything was taken to give proper representation in the sample by making use of Block Development Office (B.D.O). After the data collections all the data generated from the field and sorted by data entry process in the software. Finally prioritized the villages for tacking action compare with natural (micro watershed) boundary.
In order to understand the present position of study area based on the primary and secondary data base. For human social and infrastructural aspects, a baseline survey based on questionnaire is carried out (Chakrabarti et al. 1996). This exercise was done with the objective of collecting information on developments/ changes that have taken place in the study area.
The primary database has been collected through questionnaire survey and instrument based field measurement. The survey related to water scarcity period, irrigation facility and personal implementation for both domestic and agriculture purposes.

Result and Discussions

All reclassify them maps are overlay analysis for the scarcity identification. Finally, the scarcity zone is classified into three classes' i.e high, moderate and low. From the output it is observed that the maximum area is under high scarcity zone. The high scarcity zone occurs not only for high altitude but also low precipitation. Low and medium scarcity zone is scattered around the low elevation area i.e riverside.
From the final output (Figure 2) sandy color indicates the high scarcity, light green color represent moderate and light blue represent low priority. In the sub-watershed seventeen micro-watersheds under high, six under low and six under moderate priority is assigned out of 29 micro watersheds.

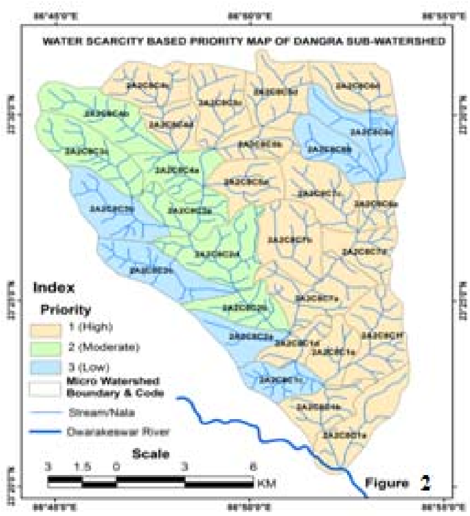


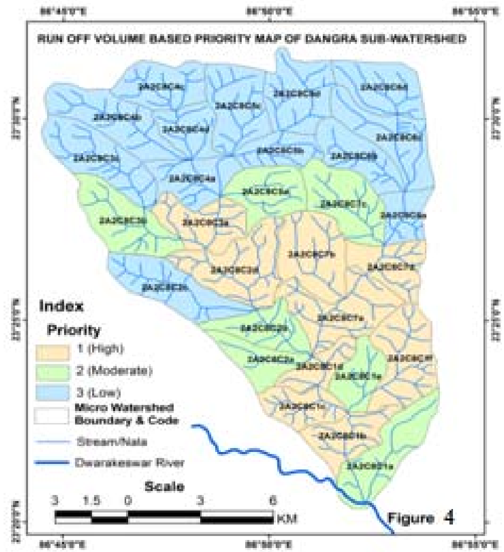
Figure 2

Final morphometric calculation is done by the computing of compound value of Linear Relief and Areal Parameters. Weightage values are assigned to each such parameter. Weightage values are summarized up for each micro watershed. Compound value for each micro watershed is ascertained using the formula ∑All value / Parameters *100. Final priority for each micro watershed is calculated on the following basis. Final Priority class 1=Compound value <196, 2 priority 197-217 and 3 above 217 respectively (Figure: 3).

Figure 3

After the generation of individual year wise runoff for 2007, 2008, 2009 and 2010 an effort was made to prepare an average run-off for four years collectively. Thus for this reason look up table 4 were prepared and prioritized on a knowledge based approach.
To prepare a final priority map, the weightage value was given for all micro watersheds based on runoff priority

for four years. For example in micro watershed 1c, 2d, 3a, 7b, 1b, 1d, 1f and 7a were assigned as very high priority. Falling under medium class 1a, 1e, 2a, 2b, 7d, 3b, 7c, 5a and all remain falling micro watershed low class because they are commonly falling under high class in four years 2007, 2008, 2009 and 2010.The study attempt has been made to estimate the run-off volume in response to the aggregate rainfall occurred in the un-gauged watershed area. The work is primarily based on the integration of data on various watershed characteristics viz, drainage, surface water, land use, forest, hydrological soil group etc. This has led to the preparation of maps (Figure: 4) estimation the run-off.



On the basis of four year SYI calculation final priority has been done. The final priority is classified in three class's i.e high, medium and low. The 16 micro watersheds fall under highest priority class, 10 micro watersheds fall under medium priority class and 3 micro watersheds fall under low priority class respectively (Figure 5). The immediate action plan is required in high priority class than other priority class to protect top soil nutrient

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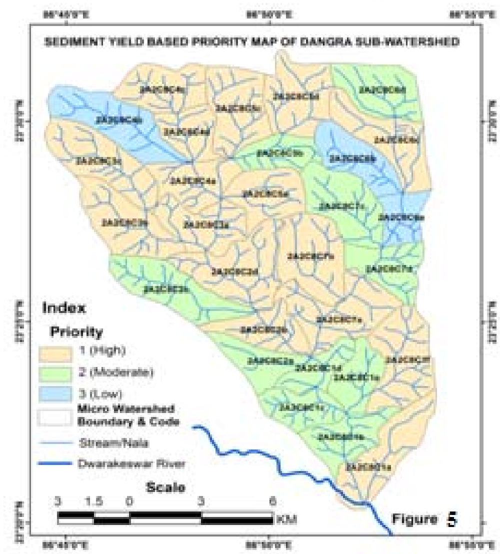
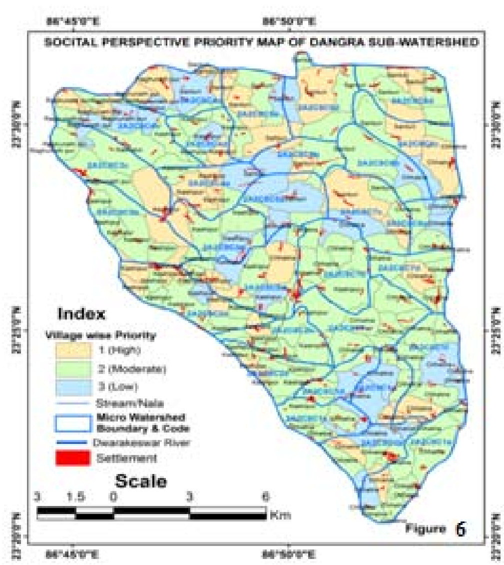


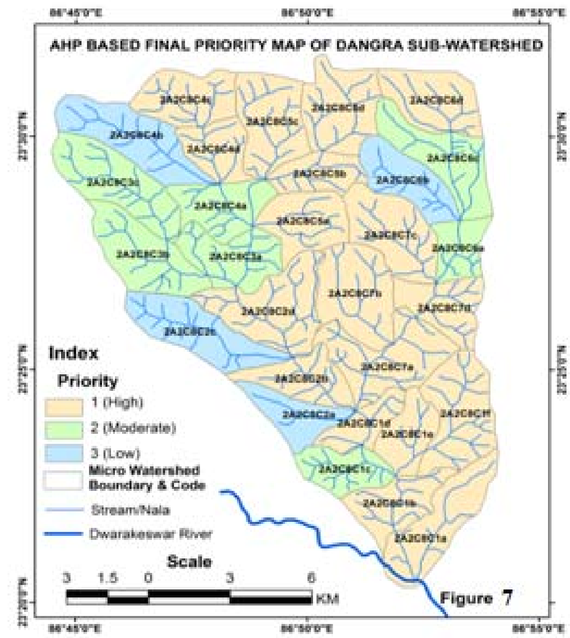
Inter-sectoral allocation of cultural and Socio economic factors should be based on the marginal value of the water resource for the society. The marginal value of water is higher in the residential sector than the agricultural sector at current use levels. This implies that policy should be directed towards reducing the appropriation of water resources by agriculture upstream and increasing the water provided to the residential and SCP areas.

This study looks at the issues particular to optimal management of surface/ sub-surface water and the allocation between competing agricultural and residential demands. Optimal allocation of the water is a multistage decision process. At each stage, e.g. each year, a decision must be made regarding the volume of perception, which will maximize the present value of economic returns to the basin. The initial conditions for each stage may be different due to changes in either the economic or hydrologic parameters of the basin under consideration (Figure 6).



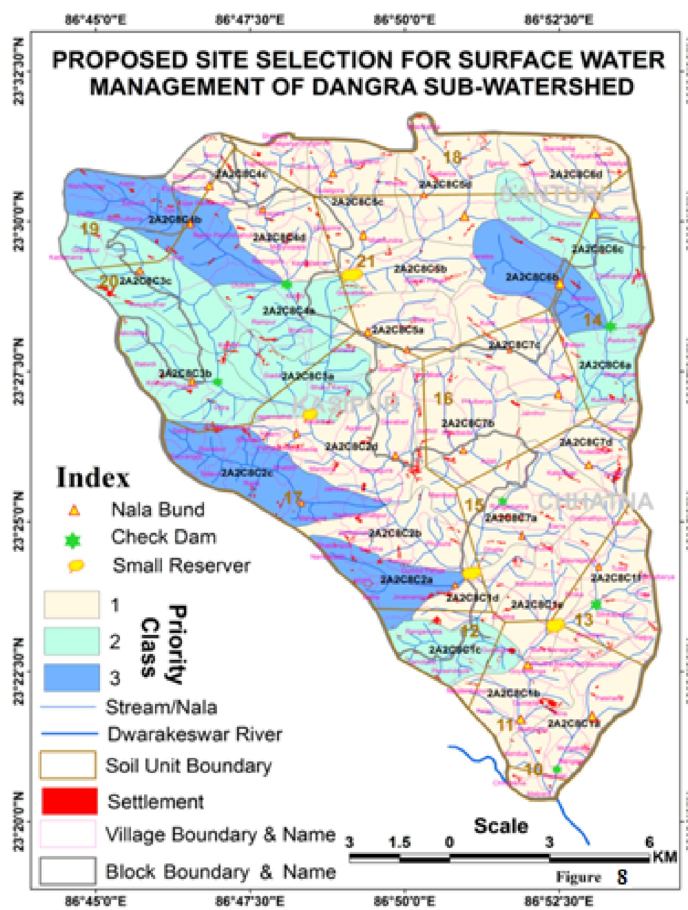
Final Priority by MCE (AHP)

More than one parameter is equally importance for watershed management, as these are very much interrelated. In the present study, 5 standard methods were used and studied briefly to calculate individual parameters of the study area. One of the Multi-Criteria Evaluation techniques is Analytical Hierarchy Process (AHP) proposed by Saaty's-1980. It is increasingly used as decision support method along with multiple parameters. AHP is welcomed for supporting procedural justice that regards clearness and equality of decisions. This is useful for water resource management, with diverse parameters, for prioritization questions with diverse criteria or for allocation of scarce resources.



However, AHP's promises for procedural justice are partly grounded in its supposed numerical accuracy. The numerical basis of AHP is not as unequivocal as current 'AHP standard practice' suggests. By contrast, AHP can contribute to the multiple criteria for procedural justice, which may explain AHP's continuing and growing popularity. Final priority has been evaluated through AHP method.

All the parameters are integrated in the GIS environment to decide the soil conservation measures at the appropriate site in the watershed (Figure 7).



Management Plan

For the purpose of water resources (surface and sub-surface water) management, methodology has been sub-categorized by different methods. The methods are also used by researcher or scientist for different place to water harvesting / recharge (Roy S, 2003). The methods are as follows;

1. Obstruction methods for **Check dam, nala bund**, gully plugs and contour bunds.

2. Storing method used for **percolation tanks, farm ponds**, K.T Weirs and recharge pits.
3. Spreading methods for recharge basins and flooding.
4. Injection methods applied for Inverted or recharge wells.

The above four methods are applied (Figure 8) based on some analysis of the flowing parameters: Extraction of watershed boundary and other parameters from DEM, Textural analysis of the Soil Sample, analysis of rainfall data, Preparation of runoff potential zone, sediment yield, Preparation of land use/ land cover generation of aspect, slope and pour point table etc. Other techniques may be applied to solve the scarcity problem at local level in the area.

Conclusion

Water resources development needs very careful analysis of the upper catchments to the lower stretch of a watershed otherwise scattered local level surface/ ground water management in the upstream is likely to affect negatively the recharge in the downstream of a river.

It is observed form the study that the study areas only major sources of all purpose use is rainfall. Due to vigorous monsoon and non Perennial river the villager's alleys suffer. Side by side watersheds where as permanently no roof top harvesting is suggested, due to short period of rainy secession, so surface sub-surface water storage is only responsible for human use.

Small size nala bundh and dam are suggested for temporary storage for life save irrigation based on the physical and anthropogenic practices.

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