PRIORITIZATION OF SIMRAWAL WATERSHED, TONS SUB-BASIN, LOWER GANGA BASIN USING REMOTE SENSING AND GIS TECHNIQUES

[1]Ravi Chaurey, [2]Kutubuddin Beg*
[1]Associate Professor, [2]Research Scholar
Faculty of Physical Geology, Department of Science & Environment
Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalaya, Chitrakoot, District Satna (M.P.) India

Abstract: Watershed is proved to be an ideal unit to study and planning of natural resources as all the resources interact in a watershed. Simrawal watershed comes under Tons sub-basin, Lower Ganga basin and divided into six Sub-watersheds, designated as SW-I to SW-VI for prioritization purpose. The prioritizations of the Sub-watersheds have been done on the basis of Morphometric analysis; Land use/ Land cover classification and Slope. For detailed study, I have taken Resourcesat-2 LISS-IV (100_054_19May2012 & 100_054_27November2012) Satellite Image for updating base & thematic layers while SOI Topo-sheets as reference data and SRTM data for preparing digital elevation model (DEM) and slope using Remote Sensing and GIS techniques. The prioritization results based on weighted overlay analysis with ranking of Drainage morphometric parameters, Land use/ land cover, and Slope reveal that SW-1, SW-3, SW-4, SW-5 and SW-6 falling under high priority zone and SW-2 is moderate priority zone. The stream orders of the sub-watersheds are mainly controlled by physiographic and litho-logical conditions of the area.

IndexTerms **– Simrawal Sub-Watershed boundary, Land use/Land cover, Morphometric analysis, Slope (Degree), GIS technique.**

I. INTRODUCTION

Simrawal watershed area comes under Tons sub-basin, Lower Ganga Basin. It covers total geographical area of Simrawal watershed is 87951.26 Ha. It stretches between Latitude 24°37'25.29"N to 24°55'27.11"N and Longitude 80°39'0.82"E to 81°8'32.48"E. Climate of the area is dry and moist and hot in summer. The study area received Lower rainfall (850.50 mm) during kharif period of 2004 as compared to rainfall of 2013 (1465.9 mm) (Source: http://www.mpwrd.gov.in/). The rainfalls from 2001 to 2017 are showing fluctuation trends. Simrawal River is the main river in the study area and Hathiya Nala, Jhirwah nala, Kothiyar nala, Chauhar nala, Nahar nala, Lagna nala, Magardaha nala and Gorsari nala as its major tributaries. The drainage pattern is mainly dendritic. The present investigation was carried out for prioritization of Simrawal watershed using remote sensing and GIS technique.

The Study area comes under Vindhyan hill range covering Rewa and Bhander Group and located in North-East part of Madhya Pradesh. The Bhander Group constitutes the youngest group of the Vindhyan Basin. The original classification proposed by Auden (1933) and Krishnan (1968) was modified by Sastry & Moitra (1984), Banerjee et al. (2006). With detailed study of literature, published maps, papers and ground survey; we have updated the Litho-stratigraphic sequence of study area showing in Table-1.

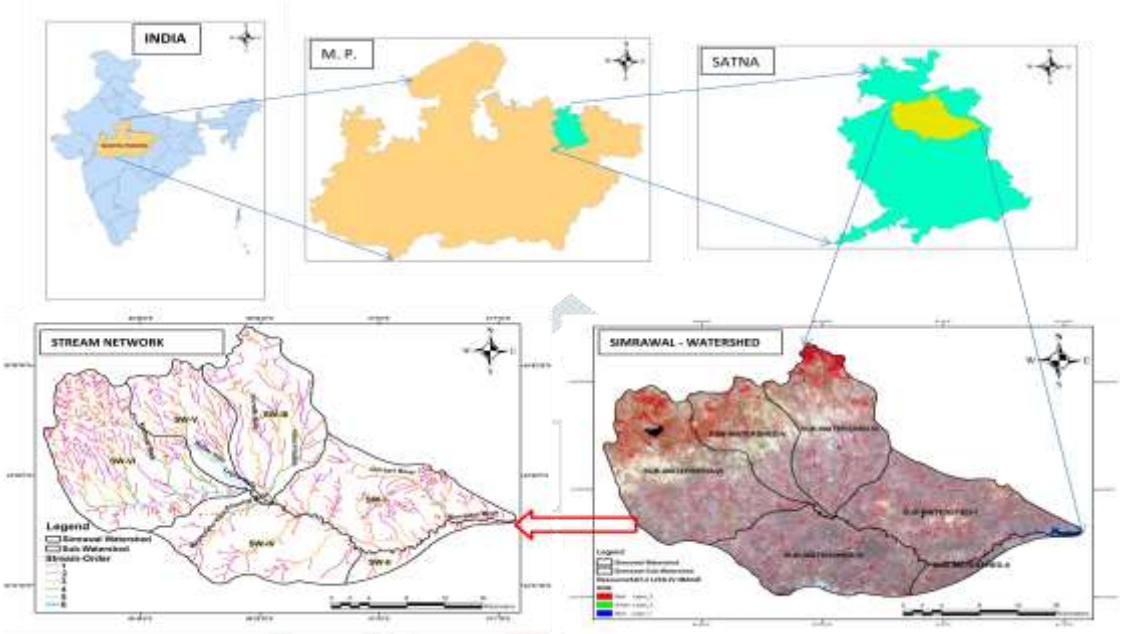
Table-1: Litho-stratigraphic sequence of the study area.

Super-group	Group	Sub-group Formation
		Simrawal Watershed
		Alluvium
Upper Vindhyan	Bhander	Nagod Limestone
		Simrawal Shale
	Rewa	Govindgarh Sandstone (Upper Rewa Sandstone)

Correspondence Author
Kutubuddin Beg
Research Scholar,
Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalaya, Chitrakoot (M.P.)

Lineaments are natural, linear surface elements, interpreted directly from satellite imagery and geophysical map. Major lineaments (>3km) and Minor lineaments (<3km) were identified towards NNW-SSE, NW-SE, NNE-SSW, ENE-SSW and NE-SW direction. The Geomorphic landforms of study area were identified such as plateau highly dissected hills towards N and NE direction. We have identified like i.e. Cuesta, Mesa, Butte, Inselberg, residual hills present in Upper Rewa sandstone formation area while exposed Sheet rock in Nagod limestone area towards South direction.

Figure-1: Location map of study area.

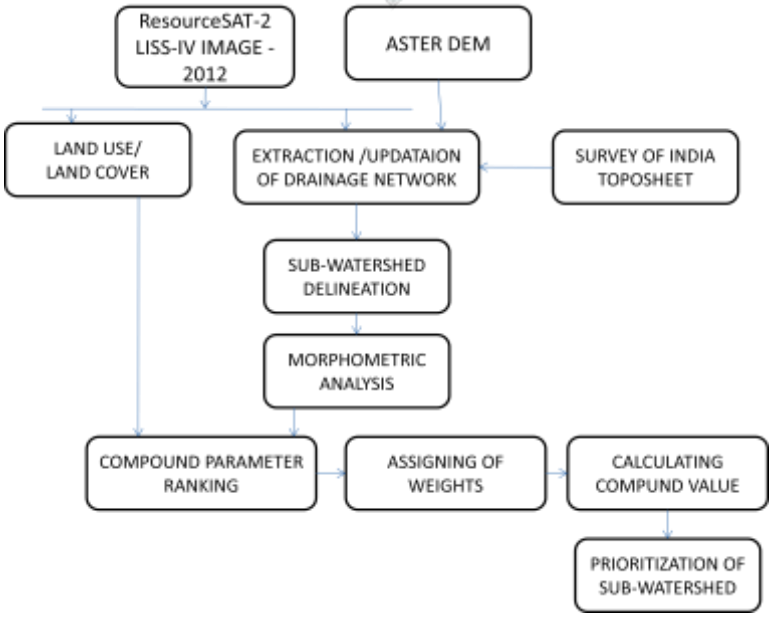


Most of these landforms covered by vegetation and carry a thinner soil cover. These zones provide a moderate to poor groundwater potential. Stripped Plain with shallow basement area identified in between and along the river channel of study area. Moderate and shallow pediplain areas were identified in Simrawal shale area and Nagod limestone area. The Soil of Study area comes under ITMA series. The taxonomy of soils, as per NBSS&LUP (USDA) system of soil classification of study area are Typic Ustorthents, Typic Ustorchrepts, Typic Ustochrepts (Cal.), Typic Haplustalfs, Lithic Ustorthents, Lithic Ustorchrepts, Vertic Ustochrepts and chromic Haplusterts (Cal.). Table-2 is showing detailed soil properties of study area.

II. METHODOLOGY

We have taken ResourceSAT-2 LISS-IV (2012) satellite images procured from NDC-NRSC Hyderabad and SOI Toposheet, Datum-WGS84 (Part Sheet) G44U09, G44U10, G44U13, G44U14, G44V01 and G44V02 (download from SOINAKSHE portal) for updating Base, thematic layer (LU/LC) and Simrawal watershed. SRTM (Earth Explorer) DEM was used to map slope of study area. The stream ordering was carried out using the Horton's law (modified by Strahler). According to Strahler stream ordering process, Numbering begins at the top of a stream with headwater flow paths being assigned the number 1.

Figure-2: Methodology of Simrawal Sub-watersheds area.



Where two flow paths of order 1 join, the section downstream of the junction is referred to as a second order stream. Where two second order streams join, the waterway downstream of the junction is referred to as a third order stream, and so on. Where a lower order stream joins a higher order stream (e.g. third order), the area downstream of the junction will retain the higher number. In general the entire sub watersheds are selected for the morphometric analysis in following heads: Linear aspects and Aerial aspect are computed using standard methods and formulae (Horton 1932, 1945, Smith 1954, Strahler 1964). Further we have prepared and ranked Land use/ Land cover and slope data of each sub-watershed for prioritization. After the ranking has been done based on every single parameter, the ranking values for all parameters of each sub-watershed were added up for each of the six sub-watersheds to arrive at compound value (Cp). Based on average value of these parameters, the sub-watersheds having the least rating value was assigned highest priority, next higher value was assigned second priority and so on.

III. RESULTS AND DISCUSSION

3.1-Drainage Morphometric Analysis:

Drainage morphometric studies are very important to study the behavior of a river/stream, its aggradations/degradation, shifting of the river course, erosion of river/stream bank etc. and to plan remedial measure for erosion and other related problems. We have taken Linear (Mean bifurcation ratio) and Areal (Drainage density, Stream Frequency, Texture ratio, Circulatory ratio, Length of overland ratio and Constant channel of maintenance) for prioritization study.

Table-2: Morphometric parameters of Simrawal Sub-watersheds area.

Sub-Watershed	Mean bifurcation Ratio (Rbm)	Drainage Density (Dd)	Stream Frequency (Fs)	Texture Ratio (Rt)	Form Factor (Rf)	Circulatory Ratio (Rc)	Elongation Ratio (Re)	Compactness Constant (Cc)	Basin Shape (Bs)	Length of Overland Flow (Lg)
SW-1	5.11	1.28	1.32	3.37	0.29	0.44	0.60	0.18	3.50	1.57
SW-2	3.57	1.41	1.18	0.71	0.37	0.16	0.69	0.37	2.71	1.42
SW-3	4.41	1.31	0.65	1.80	0.29	0.57	0.61	0.17	3.45	1.52
SW-4	3.45	0.91	0.61	1.63	0.29	0.53	0.61	0.17	3.45	2.19
SW-5	2.96	1.48	0.95	1.70	0.31	0.39	0.63	0.22	3.24	1.36
SW-6	5.21	1.87	2.10	6.86	0.28	0.58	0.59	0.16	3.61	1.07

Table-3: Morphometric parameter ranking and prioritization of Simrawal Sub-watersheds area.

Sub-Watershed	Rbm	Dd	Fs	Rt	Rf	Rc	Re	Cc	Bs	Lg	CP	Priority
SW-1	3	2	3	3	3	2	2	2	2	2	2.4	High Priority
SW-2	2	2	2	1	1	3	1	3	2	2	1.9	Moderate Priority
SW-3	3	2	2	2	3	2	2	2	2	2	2.2	High Priority
SW-4	2	2	2	2	3	2	2	2	2	3	2.2	High Priority
SW-5	2	2	2	2	2	2	2	2	2	2	2.0	High Priority
SW-6	3	3	3	3	3	2	3	2	2	1	2.5	High Priority

3.2-Land use/ Land Cover:

The land is one of the prime land resources. The term land use refers to how the land is being used by human beings, while land cover refers to biophysical materials found on the land. The land use and land cover inventories are very important for many planning and management activities. Land use and Land cover (LULC) data provides useful information regarding developmental, environmental and resource planning applications at regional as well as global scale (Ramachandra et al., 2012). The growing population and increasing socio-economic necessities creates a pressure on land use/land cover. This pressure results in unplanned and uncontrolled changes in LULC (Seto, K.C, et al; 2002). Satellite Remote Sensing data, which are a useful source of information and provides timely and complete coverage of any specific area, have proven useful in assessing the natural resources and monitoring the land use or land cover changes (Satyanarayana et al., 2001). Various land use /land cover categories were delineated on the basis of spectral signatures and terrain characteristics which were later supplemented by limited ground truth verification, the thematic maps derived through satellite data was imported to Arc GIS 10.4 software for further analysis.

Table-4: Land use /Land cover mapping of Simrawal Sub-watersheds area.

Sub-Watershed	Built-up (Ha)	Agriculture (Ha)	Ag. Plantation (Ha)	Forest (Ha)	Land with Scrub (Ha)	Land without Scrub (Ha)	Mining (Ha)	Barren Rocky (Ha)	Waters bodies (Ha)	Water-logged (Ha)
SW-1	502.43	16773.20	50.01	-	88.81	680.51	-	-	433.72	6.94
SW-2	94.41	2481.54	13.85	-	10.82	43.76	-		144.75	-
SW-3	427.039	10013.4	175.51	3682.16	313.61	1644.12	-	-	272.68	-
SW-4	574.71	14810.14	37.12	-	125.54	362.02	407.71	19.20	291.25	21.21
SW-5	191.93	4318.42	56.98	3485.15	303.90	1414.95		450.41	237.43	-
SW-6	578.58	13698.93	166.85	5958.36	246.38	1846.92	-	4.18	489.71	-

Table-5: Land use /Land cover ranking and prioritization of Simrawal Sub-watersheds area.

Sub-Watershed	Built-up	Agriculture	Agriculture Plantation	Forest	Land with Scrub	Land without Scrub	Mining	Barren Rocky	Water-bodies	Water-logged	CP	Priority
SW-1	3	1	2	-	2	3	-	-	1	3	15	High Priority
SW-2	1	2	2	-	1	1	-		3	-	10	Moderate Priority
SW-3	3	1	1	2	3	3	-	-	2	-	15	High Priority
SW-4	3	1	2	-	3	2	3	2	2	2	21	High Priority
SW-5	2	2	2	2	3	3		3	2	-	19	High Priority
SW-6	3	1	1	1	3	3	-	2	1	-	15	High Priority

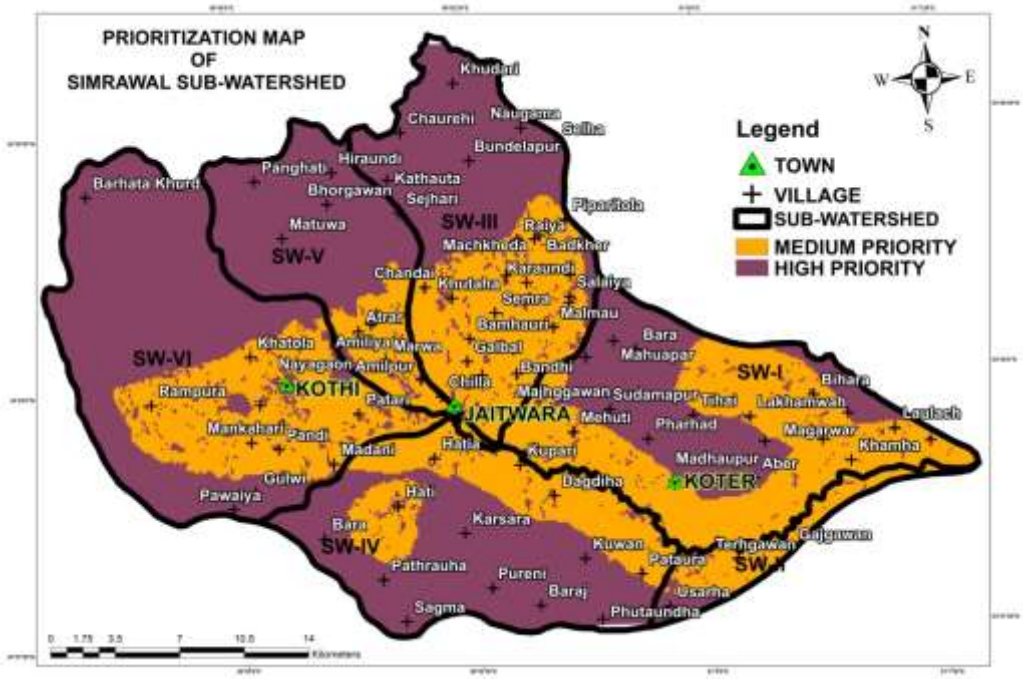
3.3-SLOPE:

The SRTM DEM data was used to derive an elevation (m) and slope (in Degree) map. Slope and elevation are one of the factors that directly influence the infiltration of rainfall in that steeper slopes generate large runoff during rainfall events, whereas gentle slopes allow sufficient time to infiltrate the surface. Weights and ranking were assigned according to the slope and elevation for prioritizations of Simrawal sub-watershed.

Table-6: Elevation and Slope (Degree) ranking and prioritization of Simrawal Sub-watersheds area.

Sub-watershed	Elevation (m)	Priority	Slope (Degree)	Rank	Priority
SW-1	258 - 423	High Priority	1 - 28	3	High priority
SW-2	262 - 320	Moderate Priority	1 - 19	2	Moderate priority
SW-3	274 - 487	High Priority	1 - 38	3	High priority
SW-4	258 - 359	High Priority	1 - 28	3	High priority
SW-5	272 - 478	High Priority	1 - 31	3	High priority
SW-6	274 - 488	High Priority	1 - 49	3	High priority

Figure-3: Prioritization map of Simrawal Sub-watershed area.



IV. Conclusion

Watershed prioritization is one of the most important aspects of planning for implementation of its development and management programmes. The present study demonstrates the usefulness of GIS for morphometric analysis, Land use /land cover and Slope study for prioritization of the six sub-watersheds of Simrawal watershed of Tons Sub-basin, Ganga basin. The morphometric parameters are termed as erosion risk assessment parameters and are used for prioritizing sub-watersheds (Biswas et al., 1999). The linear parameters are a direct relationship with erodibility, whereas shape parameters have inverse relationship with erodibility (Nooka et al., 2005). However on the superimposition of the thematic layers of land use/land cover, morphometric and slope analysis in GIS environment, only SW-2 has indicated a Moderate priority zone is showing less susceptible to soil erosion whereas the rest of the sub-watersheds SW-1, SW-3, SW-4, SW-5 and SWS6 are falling under high priority zone are showing more susceptible to soil erosion. Therefore, immediate attention towards soil conservation measures is required in these sub-watersheds to preserve the land from further erosion and to alleviate natural hazards.

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