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Block Level Micro Watershed Prioritization Based on Morphometric and Runoff Parameters

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Abstract Water is one of the most and essential natural resource in the globe, without which our life cannot exist. The demand of water is increasing with the increase of population day by day. We need water for regular activities, drinking, industry, agriculture, human and cattle consumption. Therefore, it is very important to manage with this resource as a sustainable manner. However, we need proper development and management planning to restore or recharge water where highly runoff exists due to various topographical conditions. In this paper we concern the block based micro watershed study with the help of morphometric and Runoff estimation method. Remote sensing and GIS tools very significant for prioritization of micro watershed studies. NRSC Runoff Curve Number method is a quantitative descriptor of the land use and land cover, soil characteristics of watershed and its computed, runoff through an empirical relation that requires the rainfall and watershed co-efficient namely runoff curve number. These Curve Number approach to runoff volume is typically thought of as a method for generating the storm runoff. Where we also applied the common morphometric analysis method which has been commonly applied to the prioritization of watersheds and sub watersheds. Hence we applied the morphometric parameters where linear and aerial shape have been determined for each micro watershed and assigned rank on the basis of value or relationship with erodibility so as to arrive at a compound value for final ranking of the sub-watersheds. The runoff and morphometric parameters were obtained with the help of Remote Sensing and GIS tools. Based on output results of both parameters the final results revealed of micro watershed priorities are shown into five categorizes very high, high, medium, low and very low priority.
Keywords *Morphometric Parameters; Watershed Prioritization; Runoff Estimation; Land Use/Land Cover; Remote Sensing and GIS*

1. Introduction

A watershed is an ideal unit for natural resources management system that also support in water and land for mitigation of the impact of natural disaster for achieving sustainable development. The significant factor for planning and development of a micro watershed are its physiography, drainage, geomorphology, soil, land use/land cover, surface runoff and available water resources. Remote

Sensing and GIS technology both are the most effective tools for watershed development, watershed management, and studies on prioritization of micro-watersheds.

Morphometric Analysis could be used for prioritization of micro-watersheds by studying different linear and aerial parameters of the watershed even without the availability of soil maps (Biswas et al., 1999). Remote Sensing and GIS tools have become proven tools for the management and development of water resources on block level micro watershed system (Kiran and Srivastava, 2010). Several studies have been carried out worldwide and they have shown excellent results. Due to advancement in satellites and sensing technology, it is possible to map clear details of the earth surface and provide scope for micro watersheds level management and planning.

The study area that is taken has severe water crises during the summer season. The terrain is highly undulated with very high runoff which causes minimum recharge of ground water in spite of 1750 mm average annual rainfall. This high runoff also causes very fertile soil erosion. The present study aims to prioritize micro watersheds based on Morphometric analysis and surface runoff analysis. In this study we attempt to increase the water potential for irrigation and drinking purpose.

2. Study Area

The study area Simlapal block, Bankura district, which is part of Silai River basin in West Bengal State is considered for the analysis. It is located on 22˚ 59' 38.84" North to 22˚ 50' 34.42" North latitude and 86˚ 55' 20.15" to 87˚ 13' 06.10" East longitudes. It has an average elevation of 57mtr (187 feet's) and area of this block is 309.20 Km^2 (Figure 1).

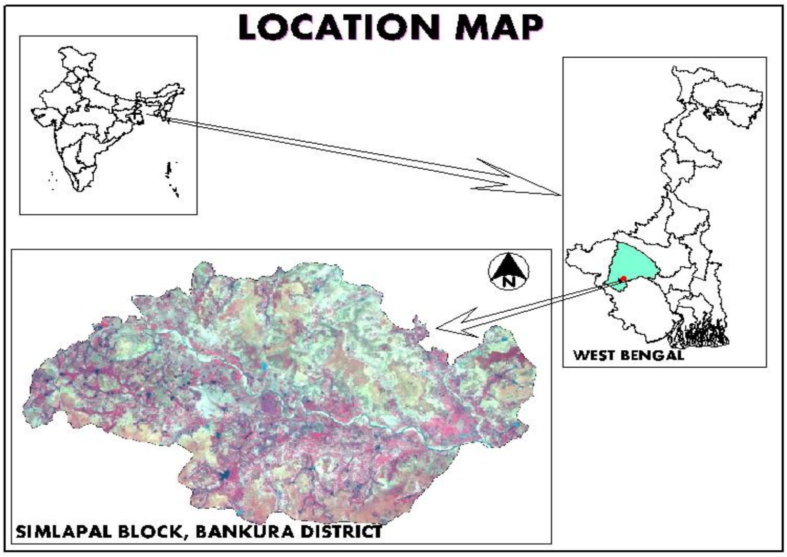

Figure 1: *Location Map of Simlapal Region, West Bengal*

3. Methodology

Remote Sensing and GIS tools have been used for the processing of satellite data and deriving of thematic maps and vector layers. Extracted thematic maps from the satellite images using remote sensing techniques and applied GIS tools for detailed analysis. Performed Morphometric analysis and Surface runoff for prioritization of micro-watersheds using GIS tools. The datasets used for study are Survey of India toposheets on 1:50,000 scale and IRS LISS I IV satellite imagery with 23.5 and 5 meter resolutions, NBSS soil data. SRTM digital elevation datasets and Seasonal rainfall data.

3.1. Morphometric Analysis

The morphometric analysis is one of the significant RSGIS tool for prioritization of micro-watershed even without soil map and land use/land cover map. This model is depends on the behaviour of total drainage system and its pattern (Nookaratanam et al., 2005). The drainage pattern refers to spatial relationship among area streams, which could be influenced in erosion by inequalities of soils rock resistance, slope, geologic history and structure of a region (Nag S.K., 1998). Prioritization of micro-watershed in a morphometric analysis uses, crucial linear morphometric parameters like Drainage density (Dd), Stream frequency (Fu), Texture ratio(T), Bifurcation ratio (Rb) Length of overland flow (Lo) and shape morphometric parameters are Form factor (Rf), Shape factor (Bs), Circularity Ratio (Rc), Elongated ratio (Re), Compactness coefficient (Cc). While computing morphometric parameters we also considered linear and aerial aspects. All these parameters were obtained with the help of GIS Software. The highest value of the linear parameters was priority rated rank 1 and next highest value was rated rank 2 and so on, similarly lowest value of aerial or shape factor was rated rank 1 and next lowest value a rating of rank 2. After rating of all parameter, the rating value for every micro-watershed was averaged to arrive at a compound value (Cp). The Compound value is based on the average of all parameters in single micro-watershed (Kiran and Srivastava, 2012).

Then priority fixation of all micro-watersheds were categorized into five equal groups based on range of compound value, these are very high (≤30), high (>30≤37), medium (>37≤43), low (>43≤50), very low (>50). Thus, 14 micro watersheds out of 77, were given as very high priority since they have very low compound values, 19 micro watersheds were given high priority, with low Cp values. 15 micro watersheds were given medium priority having moderate compound values, 23 micro watersheds fall under low priority with high compound values and the remaining 6 micro watersheds are given very low priorities which have very high compounds values (Figure 2).

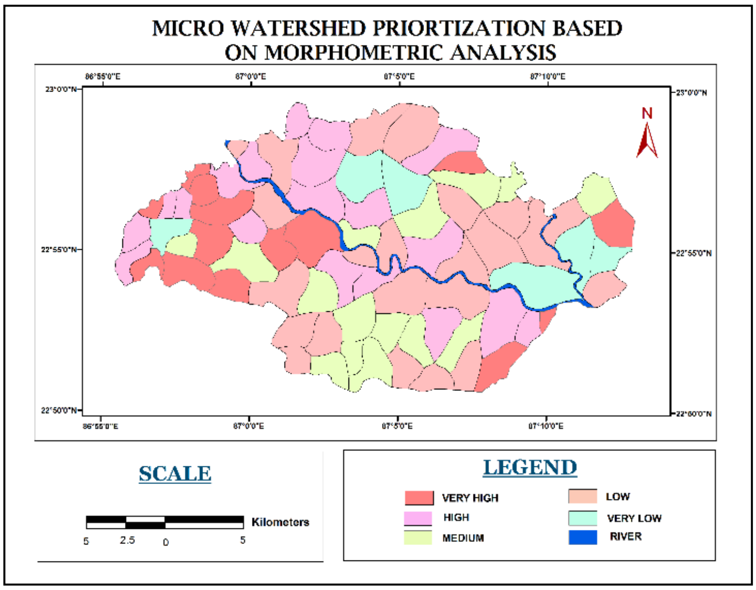

Figure 2: *Morphometric Analysis Output Results*

3.2. Runoff Calculation and Analysis

The SCS curve number approach to runoff volume is typically thought as a method for generating storm runoff and not for water quality design. Typically utilized with the assumption of average Anti Moisture Condition that will be appropriately analysed to study the moisture condition of every single micro-watershed. Soil Conservation Service is to be used with RSGIS tools to estimate the runoff from each Micro-Watershed. Curve Number model carried on hydrological soil groups, land use and land cover features and daily rainfall data parameters. Soil Conservation Service Curve Number (USDA, 1985) method is a well accept tool in hydrology, which uses a land condition factor called the Curve Number.

This curve number is taken based on some important properties of catchments namely soil type, land use, surface condition, and antecedent moisture conditions, and also some desirable curve number in suitable land use/land cover features of Indian conditions (Kiran and Srivastava, 2014).

Soil Conservation Service Runoff Curve Number is a quantitative identification of the land use and land cover, soil characteristics of micro watershed and its computed direct runoff through an empirical relation that requires the rainfall and watershed co-efficient namely runoff curve number (Pramod Kumar et al., 1991). The SCS Curve Number approach to runoff volume is typically thought of as a method for generating storm runoff for rare events. The volume of runoff is expressed as:

$$VQ = (P-0.3S)^2 / (P+0.7S)$$ ---- Runoff Hydrological Equation

Where, VQ is volume of runoff and P is Accumulated rainfall and S is potential maximum relation of water by the soil.

To calculate the runoff of each micro watershed of study area analysed the study area soil and classified into three different hydrological soil groups based on antecedent moisture conditions of soil. It is very important in runoff estimation for prioritization of micro watershed. Soil properties influence the relationship between rainfall and runoff by affecting the rate of infiltration. Based on infiltration rates, soil texture and soil taxonomic conditions, soils in the study are divided into four hydrologic soil groups i.e. Well drained (Group-A), Moderate to well drain (Group-B), Poor to Moderate drained (Group-C) and Poorly drained (Group-D), However the study area classified only three categories based on geographic condition and soil factors i.e. Group A, B and D (Kiran and Srivastava, 2014), (Figure 3).

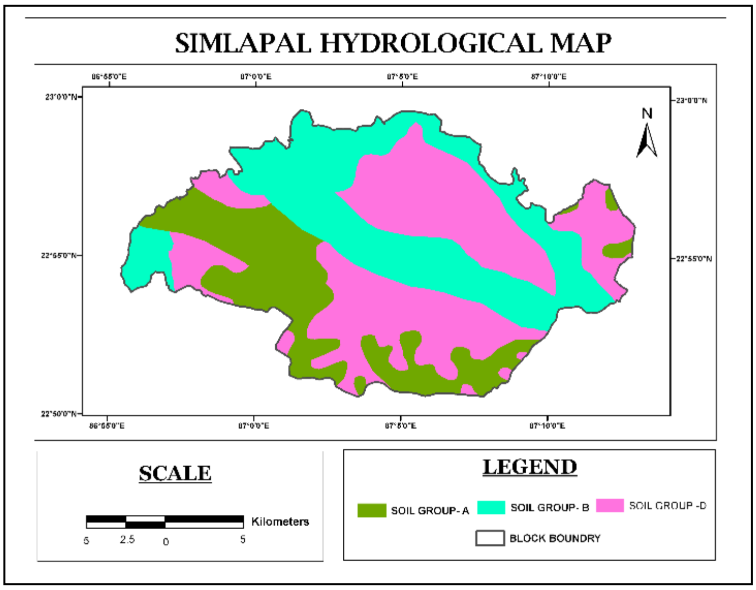

Figure 3: *Hydrological Soil Groups of Study Area*

As land use and land cover also important parameter for curve number, we classified the LISS IV data and prepared the land use and land cover map using supervised and hybrid classification techniques to overlay the vectorised data (Figure 4). With the help of hydrological groups and land use land cover curve number we calculated the ground Anti Moisture Condition, which is indicator of watershed wetness and availability of soil moisture storage during the rain (Samah Al Jabari et al., 2009). The soil conservation service developed three antecedent soil-moisture conditions and named as AMC-I, AMC-II, AMC-III. The AMC condition I curve number is dry condition it can be denoted as CN-I, AMC condition II curve number is normal condition it can be denoted as CN-II, AMC condition III curve number is dry condition it can be denoted as CN-III. Using these curve number, we could estimate the soil vegetation land complex and antecedent soil moisture condition in a watershed. Using the hydrological Soil Groups (A, B and D), land use classes to create the curve number. The values of curve number for the all three antecedent moisture condition are listed in Table 1. To calculate the runoff estimation of each micro watershed by applying the above mentioned Runoff hydrological equation.

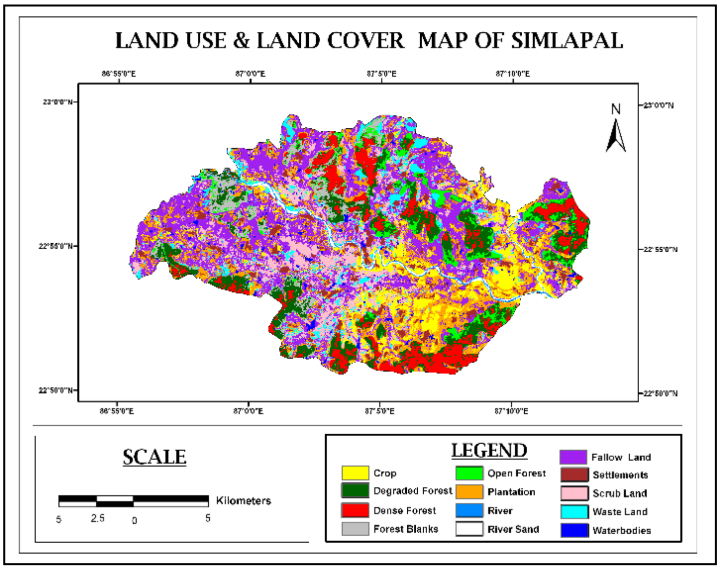

Figure 4: *Land Use and Land Cover Map of Study Area*

Based on rainfall and hydrological calculation of VQ values are arranged in order of priority into five categories. The final prioritize results are 4 micro-watersheds out of 77, were given very high priority, 4 MWS were given high priority, 14 MWS fall under medium priority, 32 MWS fall under low priority and remaining 23 MWS falling very low priorities (Figure 5).

Table 1: *Hydrological Soil Group Curve Numbers*

LU/LC Classes	Curve Number(CN)		
	HSG - A	HSG -B	HSG - D
Agriculture	55	69	83
Plantation	39	61	83
Fallow	59	70	81
Scrub land	77	86	94
Wasteland	45	66	83
Water bodies	94	94	94
Open Forest	19	40	63
Forests Blank	64	71	85
Degraded Forest	15	30	48
Dense Forest	36	58	80
River	94	94	94
Sand Deposition	96	96	96
Settlement's	59	74	86

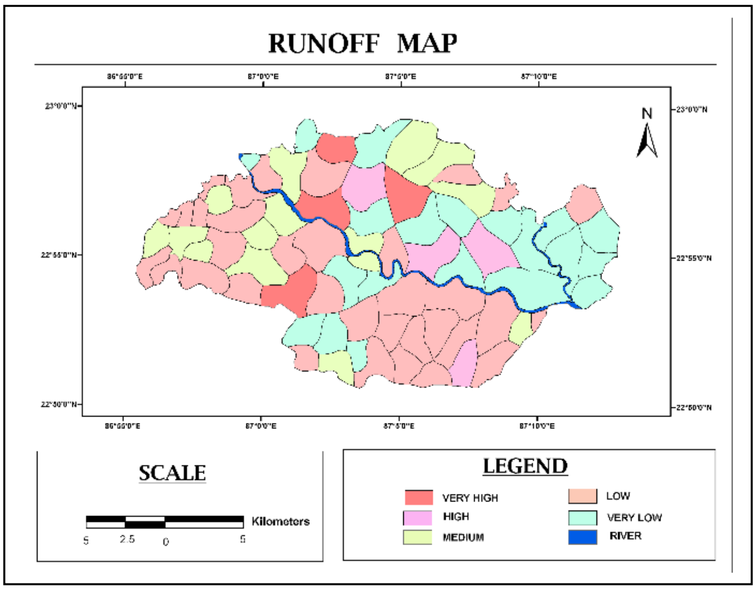

Figure 5: *Runoff Results*

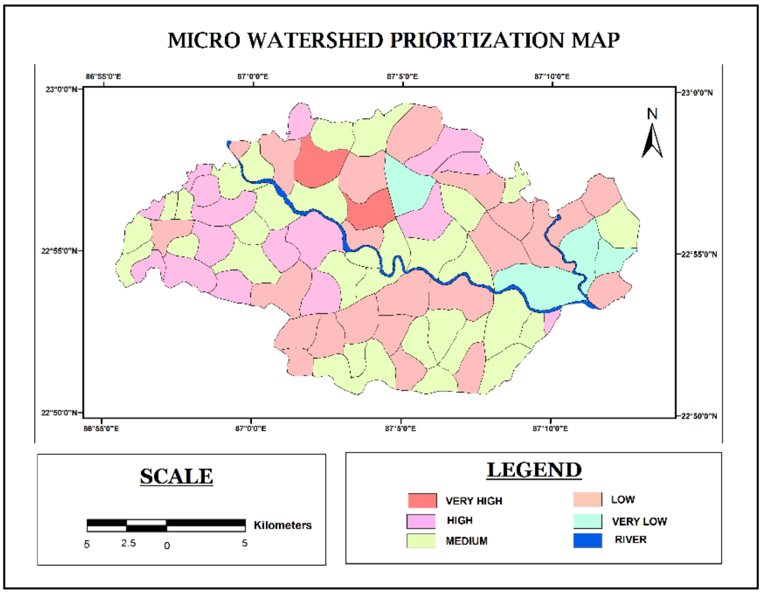

Figure 6: *Final Results*

4. Results and Discussion

Prioritization of Micro-Watershed has been done by using compound values by morphometric analysis and volume of runoff values by soil conservation service curve number method these are then integrated with two different prioritized attributes. Attributes of morphometric analysis is based on three aspects namely linear, aerial and shape. These three aspects are given ten parameters and computed the compound parameter values. According to these values the micro-watershed priorities are 14 micro-watersheds were found very high category, 19 micro-watersheds were found high priority, 15 micro-watersheds were found medium priority, 23 micro-watersheds were found low category and 6 micro watersheds were found very low priority (Figure 2). Based on SCS-CN method, the attributes of SCS are given in the seasonal runoff estimation of daily rainfall data we used it for the estimation of the runoff to prioritize. Estimated runoff weightage were 4 micro-watersheds out of 77, were given very high priority, 4 MWS were given high priority, 14 MWS fall under medium priority, 32 MWS fall under low category and 23 MWS falling very low priorities (Figure 5). From the integrated study of SCS-CN method and Morphometric analysis, Out of 77 micro-watersheds 2 were identified as very high prioritized micro-watersheds. These have very high soil loss values and have excellent drainage density, highly runoff. Texture ratio values of these basins are also indicating the high. Out of 77 micro-watersheds 16 were given high priority with high runoff and good drainage pattern and drainage density, 32 fall under the medium priority with moderately drainage pattern and medium soil erosion, 23 micro-watersheds were given low priority and remaining 4 micro-watersheds were found very low priority, probably because of the area in plains. The prioritization of Micro-watershed decreasing from western side to eastern side because of the slope (Figure 6).

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