Journal of Multidisciplinary Engineering Science and Technology (JMEST)
ISSN: 2458-9403
Vol. 3 Issue 12, December - 2016

Micro Watershed Prioritization Based on Two Differentiate Models

V S S Kiran
GIS Speicalist, Willis Towers Watson
Thane, India – 400601
vsskiran_rsgis@rediffmail.com

Y K Srivastava
Scientist, RRSC (East) - ISRO
Kolkata, India – 700156
srivastava_yk@yahoo.com

G Jai Sankar & M Jagannadhha Rao
Professor, Andhra Univeristy
Visakhapatnam, India – 400601
mjrao.geology@gmail.com
jaisankar.gummapu@yahoo.com

G T Vijaya Kumar
Subject Matter Expert, IIC Technologies Ltd
Hyderabad, India – 400601
gtvijaya@yahoo.com

***Abstract*—Generally development programs are applied on land resources as watershed basis. Delineation of watersheds within a large drainage basin and their prioritization is required for proper planning and management of natural resources for sustainable crop production. In India, every year we are facing the problem with less crop production due to irregularity in rainfall, leads to lack of agriculture activity. Similarly, few places get heavy rainfall, since there is no proper facility to harvest rainwater and topographic condition most of rain water goes into waste by runoff and soil loss. In this study, we attempt to prioritize micro watershed with two differential parameters soil conservation runoff and universal soil loss model. Results based on these two models used to identify the highly potential area to either store the water or to construct the check dam for irrigation purpose to increase the agricultural activities.**

Keywords— GIS, Remote Sensing, Rainfall, Soil and Geography

I. INTRODUCTION :

Our Earth is covered by 29 % land and 71 % water and these are the two very valuable and most vital resources. These resources essentially required not only for the sustenance of life but also need for the economic and social progress of a region. However, increasing population, biotic pressure and over exploitation of land for agricultural and industrial uses lead to accelerated soil erosion and conservation of fertile agricultural land into unproductive land, thereby causing large scale degradation of natural resources. The development of natural resources on a sustainable bases without dissipate its productivity for future generation is the needed.

Maximum area of geography is covered by water. Most of the Earth's water, about 96.5 percent, is saline water exists in the oceans, which is not used for drinking purpose. More than 68 percent of the planet's fresh water is largely inaccessible, in the form of glaciers, ice caps and permanent snow. Another 30 percent of the planet's fresh water is in the ground as we called ground water, which is available within a half mile of the Earth's surface.

For, Watershed management and development a several pragmatic models and equation are used, extensively,silt yield prediction equation for computation of runoff, universal soil loss equation and silt yield equation are used by few researches and soil workers (Wischmeir and smith, 1978). Flaxman (1971) developed a sediment yield predictive equation for computing actual rate of sediment yield index factor. The Soil and Land use Survey of India has developed Sediment Yield Index model for prioritizing watersheds. J. Adinarayana (1996) and Nooka Ratnam et.al (2008) studied the prioritization of basinn using SYI and V S S Kiran and Y K Srivastava (2014) using prioritizing water using Universal Soil Loss Equation.

II. STUDY AREA:

The Silabati river which is also known as Silai river is one of the major river in West Bengal. River Silai originates in the terrain of the Chhota Nagpur Plateau in the Purulia district of the state of West Bengal in eastern India. It flows in an almost southeasterly direction through the districts of Bankura and West

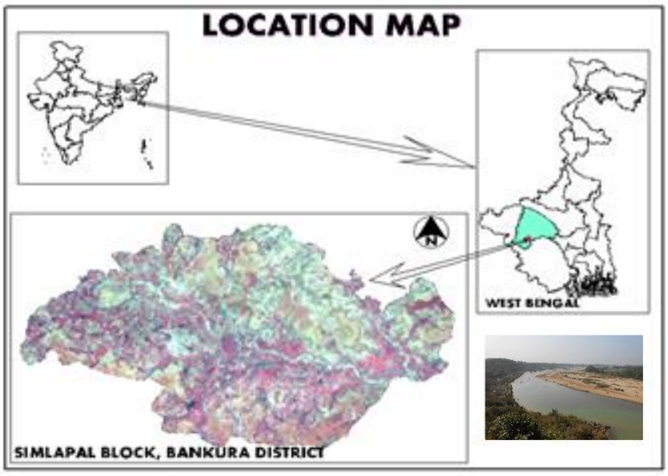

Figure 1: Study Area

Midnapore. The Silabati joins the Dwarakeswar near Ghatal and afterwards is known as Rupnarayan.

It finally joins the Hooghly River, which empties into the Bay of Bengal. The study area is selected the part of Silai river which crossed the Simlapal community development block of Bankura District, West Bengal. 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 Km2. (Figure – 1).

III. Data Used & Methodology:

The various data used in this research study. To prioritizing the watershed with two differential models one is USLE and another one is Surface Runoff estimation we are collecting the various datasets and information. Collected data sets are:

a. India Remote Sensing Satellite Images
b. Survey of India reference maps
c. National Bureau of Soil Survey Soil Maps
d. State Government weather and rainfall data

Universal Soil loss equation (USLE) was calculated using following experimental formula suggested by Soil survey:

$$A=R*K*LS*C*P$$ --- Equation 1.

Where, A is the average annual soil loss in tons. /ha, R is a rainfall factor, K is a Soil erodibility factor, LS is a slope length and steepness factor, C is a cropping factor and P is a conservation practice factor. Computation of these factors can be done easily and efficiently using geographic information system with various data layers representing watershed boundary, slope, rainfall distribution, land use and management practices and soils.

Runoff estimation was calculated using soil conservation curve number method suggested by Soil survey:

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

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

IV. Analysis:

As per above mentioned methodology we have analyzed the data in different stages and prepare the different input layers, those are applicable to do the runoff and soil erosion estimation. Analysis follows:

A. Delineate Drainage layer
B. Delineate Micro-watershed
C. Prepare Land use/Land cover
D. Classify Soil Datasets
E. Prepare and Classify slope map
F. Apply USLE Equation
G. Apply SCS CN Equation for Runoff Estimation

A. *Delineate Drainage Layer:*

The drainage layers were digitized using GIS tools from FCC of LISS-III data and then updated using the Resource-sat (LISS-IV) data because of the high spatial resolution data with multispectral bands, and on substantial increase in the number of drainages observed to the LISS-III data. All drainage layers mainly 1st order streams are also validated to the SRTM DEM data. (Figure -2)

B. *Delineate Microwatershed:*

The drainage pattern formed, the basis for division into river basins, sub-watershed and micro-watershed. Pattern of a drainage basin are dependent upon a number of classes i.e. nature, distribution, features. The quantitative features of the drainage basin and its stream channel can be divided into linear aspect, aerial aspect and shape parameters. On the basis of drainage pattern and texture of Simlapal block was divided into 22 sub watersheds having an area of 30 to 50 sq. km and each sub watershed is further divided into micro-watershed having an area of 5 to 10 sq. km or less the 5-sq. km. (Figure -2)

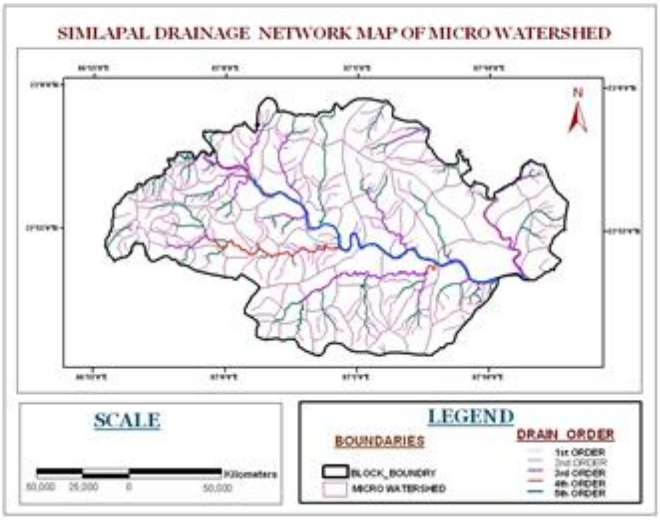

Figure 2:Drainage Layer & Micro watersheds

C. *Prepare Land use/ Land Cover:*

To prepare land use and land cover layer, supervised classification technique was adopted with maximum likelihood algorithm. Prepared land use and land cover layer was classified into 13 classes i.e. Agriculture, Plantation, Fallow land, Scrub land, Waster land, Water bodies, Open forest, Blank Forest, Degraded Forest, Dense Forest, Rivers, Sand Depositions and Settlement etc. (Figure -3)

D. *Classification of Soil Datasets:*

Simlapal land is covered with the thick forest and undulating terrain the soil type varies from fine loamy too sandy. The total area is covered with six types of soils i.e. fine loamy, coarse loamy, fine loamy sandy, gravelly loamy, fine and loamy soil.

E. *Classification of Slope Conditions:*

The slope layer prepared using SRTM DEM data. Extraction of the study area from DEM image has been done by using GIS software generating the slope map by applying grid format. Study area slope is categorized into four categories i.e. Nearly level is 0-1%, very gently sloping 1-3%, gently sloping is 3-5%, moderate sloping is more than 5%.

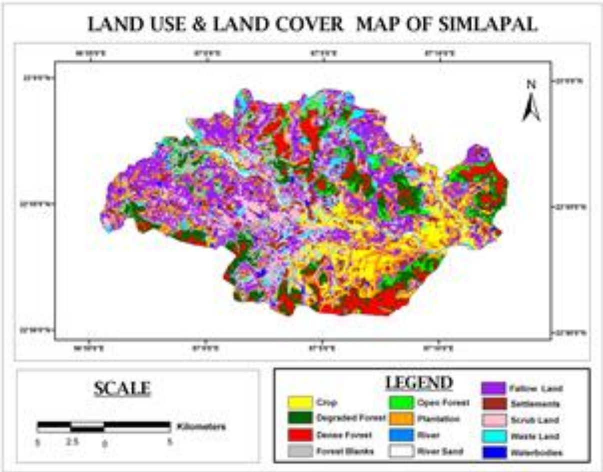

Figure 3: Land Use and Land Cover Map

F. *USLE (Universal Soil Loss Equation):*

The universal soil loss equation has been used to estimate the average rate of soil erosion for each feasible alternative combination of crop system and management practices in association with a specified soil type, rainfall pattern, and topography (Smith in 1965 and Kiran in 2014). The average annual soil loss is tons/ hectare (A) is calculated using.

$$A=R*K*LS*C*P \quad \text{----------} \ (1)$$

Where, A is the average annual soil loss in tons/ha, R is a rainfall factor, K is a Soil erodibility factor, LS is a slope length and steepness factor, C is a cropping factor and P is a conservation practice factor. Computation of these factors can be done easily and efficiently using geographic information system with various data layers representing watershed boundary, slope, rainfall distribution, land use and management practices and soils.

The calculated results of micro-watershed areas were computed using slope, soil erodibility, runoff, crop obtained by overlaying the output values. These all factors were used in estimating the average annual soil loss for each micro-watershed. Incorporation of USLE values of a micro-watershed would determine quantitative priority value of that micro-watershed. The micro-watershed would arrange in the descending order of the USLE, and all values and graded in order of priority into five categories, as Very High, High, Medium, Low and Very Low. (Figure -4)

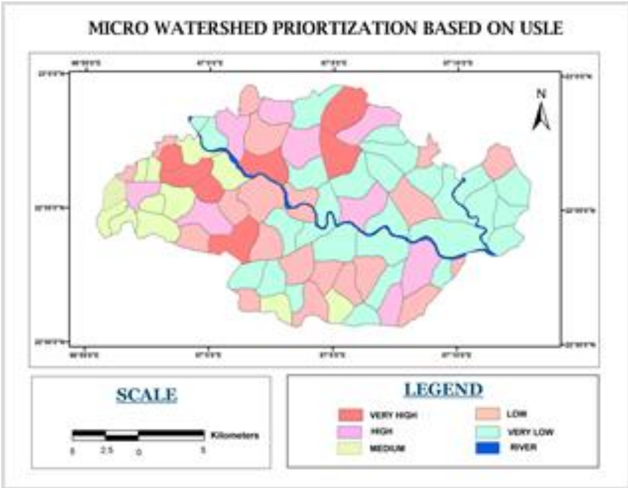

Figure 4: Prioritization Based on USLE

G. *Soil Conservation Service Curve Number Model for Runoff Estimation: :*

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. 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:

$$VQ = (P-0.3S)2/\ (P+0.7S) \ \text{-----------} \ (II)$$

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

Based on hydrological calculation of VQ values are arranged in order of priority into five categories, as

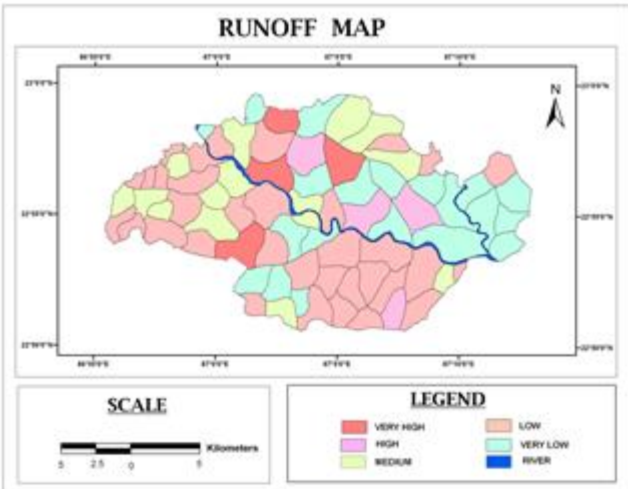

Figure 5: Prioritization Based on SCS-CN

Very High, High, Medium, Low and Very Low. (Figure – 5)

V. Results & Discussion:

Prioritization of Micro-Watershed has been done by using two different values, one is by runoff estimated value and other is by soil loss estimated values. These two modelled values are integrated as two different prioritized attributes. Attributes of USLE analysis is based on soil erodibility, slope condition, slope steepness, crop type and crop practice factor. By multiplying of these factor we arrived a value, i.e the average annual soil loss factor values. According to these values the micro-watershed priorities have been prepared; and differentiate into five levels i.e. 7 micro-watersheds out of 77, were given very high priority, as they have very high soil loss values, 9 micro-watersheds were given high priority, with high soil loss values, 12 micro-watersheds fall under medium priority having moderate soil loss, 21 micro-watersheds fall under low with low soil loss and the remaining 28 micro watersheds were given very low soil loss values.Attributes of SCS analysis is based on seasonal runoff estimation of daily rainfall data. According to these estimated runoff weightage values the micro-watershed priorities have been done, were 4 micro-watersheds (MWS) 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.

With the Integration of both the model of runoff priority values and soil loss priority values the micro watershed prioritization is done for each micro watershed based. Out of 77 micro-watersheds 16 were given very high priority with very high runoff and very

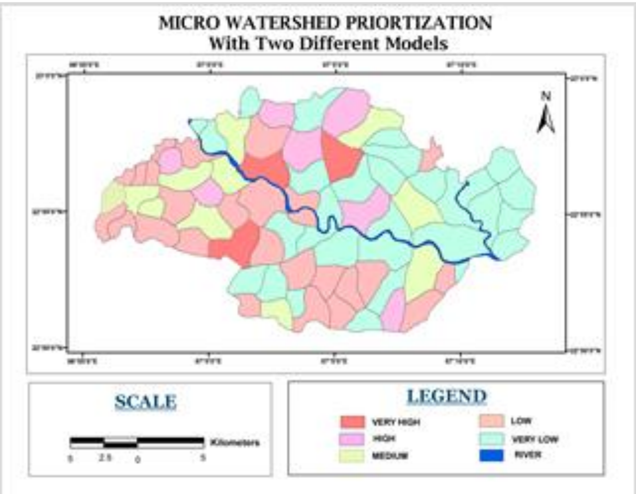

Figure 6: Micro watershed Prioritization Results

high soil losses values and good drainage pattern and drainage density, 12 falls under high with high runoff and high soil erosion values, 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. (Figure -6)

Reference:

[1] V S S KIRAN AND Y K Srivastava, Bonfring International Journal of Industrial Engineering and Management Science, Vol. 2, Special Issue 1, July 2012.

[2] V S S KIRAN AND Y K Srivastava, International Journal of Earth Science and Engineering, Volume 07, No. 01, February 2014.

[3] Biswas, S., Sudhakar, S., and Desai, V.R, Prioritization of Sub-watershed based on Morphometric Analysis of Drainage Basin: A remote sensing and GIS approach, Journal of the Indian Society of Remote Sensing, 155-166, 1999..

[4] USDA, SOIL CONSERVATION SERVICE(1985), National Engineering Hand book, USA

[5] Sachin, 2005, Prioritization of Micro-Watershed of Upper Bhama Basin on the Basis of Soil Erosion Risk Using Remote Sensing and GIS technology. Ph.D. Thesis, University of Pune, Department of Geography.

[6] K. Nookaratnam, Y.K. Srivastava, V. Venkateswara Rao, E. Amminedu and K.S.R.Murthy, 2005. Check Dam positioning by prioritization of micro-watershed using SYI models and Morphometric Aanalysis : A remote sensing and GIS approach journal of Indian society of Remote Sensing, Vol 33, No.1

[7] Chandramohan .T &Dilip G Durbude 2002. Estimation of soil erosion potential using universal soil loss equation journal of Indian society of remote sensing , vol 30 , No-4

[8] S. K. Nag, 1998. Morphometric Analysis using Remote Sensing techniques in the Chakra sub-basin Purulia district,- journal of Indian Society of remote-sensing ,vol.26, no.1&2

[9] Pramod Kumar et.al, K.N.Tiwari, D.K.Pal, 1991. Established SCS Runoff curve number from IRS digital data base, journal of Indian Society of Remote Sensing ,vol.19,No.4,

[10] Samah Al_Jabari et.al & Majed Abu Sharkh et.al, Ziad Al-Mimi,2009. Estimation of Runoff for agricultural watershed using SCS curve number and GIS, A remote sensing and GIS approach thirteenth International Water Technology Conference, IWTC 13,2009, Hurghada, Egypt,1213-1229.

[11] [12] US department of Agricultural ,1981. Predicting rainfall erosion losses, A guide to conservation planning, handbook no 537

[14] Suresh. R, 1997. Soil and Water Conservation Engineering. Standard published distr., Delhi. 48-51