

DELINEATION OF ECO WATERSHEDS BY INTEGRATION OF REMOTE SENSING AND GIS TECHNIQUES FOR MANAGEMENT OF WATER AND LAND RESOURCES

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ABSTRACT

Present study describes the concept of eco-watersheds. Eco watershed is described as the homogenous watershed which have similar characteristics for natural resources development and management practices. Study was carried out for the Erau watershed of Bajaj Sagar sub catchment in Mahi basin having geographical area of 736 sq. kms. Remote Sensing and GIS techniques were used in analysing the 135 micro-watersheds of the study area. The watershed characterisation parameters viz. landuse/landcover, geomorphic units, morphological parameters etc. were standardised using Z score and then were subjected to Principal Component analysis for removing data redundancy. Out of total 12 components extracted, first 6 components accounted for 69.3% of variance in the data. Hierarchical Clustering analysis was applied to group the micro watersheds in natural groups. The natural groups were further grouped to find the eco watersheds in the area. The study revealed 9 eco regions from the analysis and 50 eco watersheds out of 135 micro watersheds .

INTRODUCTION

The water and land management on watershed basis has a scientific proven basis which helps in increasing the productivity, along with sustainable utilisation of resources. Watersheds are natural hydrologic entity where water flows in a definite path. Development and management needs of watersheds with similar characteristics are also similar. Eco watersheds describe the homogenous watersheds which have similar characteristics for natural resources development and management.

Eco watersheds can be defined based on many parameters like geology, climate, landuse, soils, vegetation etc. but to study the hydrologic response, other affecting factors like morphometric characteristics must be included in the analysis. Analysis of large watersheds is quite tedious and time consuming. Remote Sensing data provides a fast and economic way to analyse large watersheds by virtue of synoptic and repetitive coverages. GIS is a tool which helps in analysing multi layer data. The present study aims at delineation of eco watersheds by considering different variables e.g. morphometric characteristics, landuse/landcover, hydrogeomorphology, elevation and slope in Erau watershed of Bajaj Sagar sub-catchment in Mahi basin in India by integration of Remote Sensing and GIS.

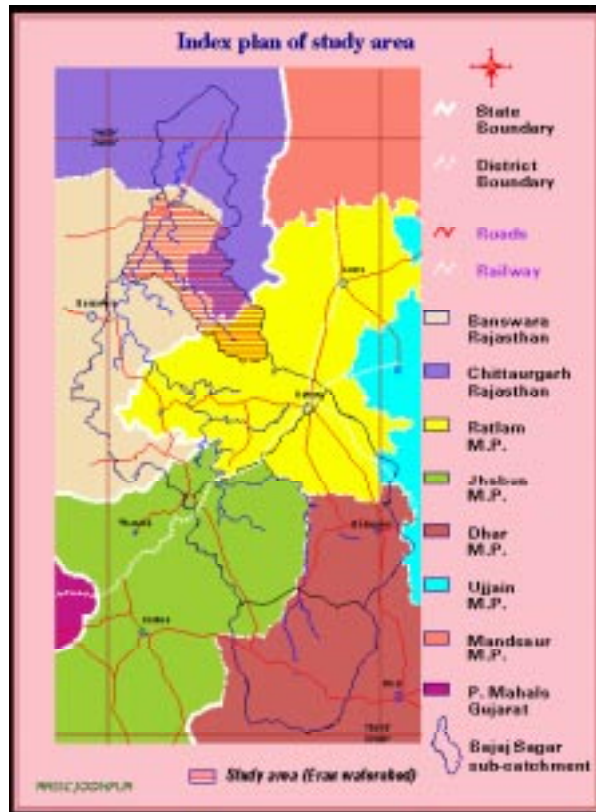
STUDY AREA

Study area is the Erau watershed of Bajaj Sagar sub-catchment of Mahi basin. Mahi is the perennial river arising from the Northern sides of Vindhyan ranges. Erau is the major tributary which flows through the watershed and originates from the hills of tehsil Pratapgarh in Rajasthan and joins Mahi. Erau watershed is one of the seven watersheds of sub-catchment. It is located between 23d25' - 23d50' latitude and 74d51' - 74d55' longitudes and covers an area of 736 sq. kms. Figure 1 shows the location map of study area. The study area is mostly hilly with small patches of agriculture and also cultivation on gentle slopes. Area receives rainfall during south-west monsoon and the average annual rainfall is around 920 mm.

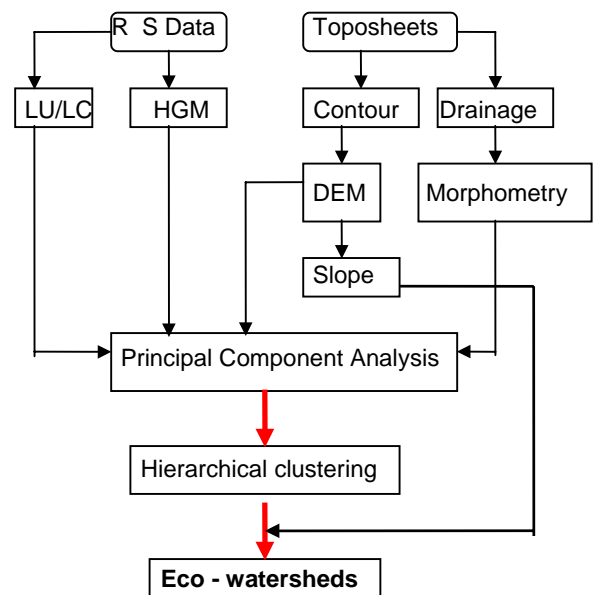
The area has undulating topography with assemblage of different rock types in the area. The top of the ridges are flat and are composed of Deccan trap basalts. The valleys and depressions have been formed into deeply weathered granite, gneisses and schists.

DATA SET

IRS - 1B LISS II data of path 30 and row 51 with 36 m resolution was used for the analysis. The date of pass of satellite data was October 1994 and March 1993. Survey of India toposheets at 1:50,000 scale were also used.



Flowchart for methodology



DEM generation - For the generation of DEM, contour lines were scanned from 1:50,000 scale toposheets having contour interval of 20 m. The scanned and corrected contours were labeled with elevation values using a labeling package called ICOLA developed indigenously. Drainage lines were also scanned and corrected. DEM and drainage lines were given as input for generation of DEM of the study area. Slope map was calculated from DEM and

METHODOLOGY

Methodology consisted of major two parts

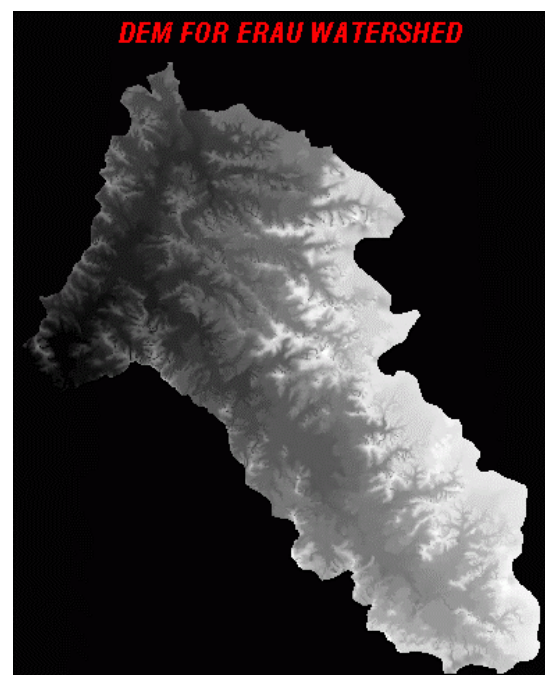
- Preparation of data base
- Analysis of database

Flowchart of methodology is given here.

Preparation of database - For the preparation of database following steps were carried out

Extraction of study area - Study area mask was prepared and after downloading the LISS II bands, data pertaining to study area was extracted using the mask.

Landuse/landcover classification - Supervised classification techniques with Maximum Likelihood algorithm were used for the classification. A total 9 categories were identified. Areal statistics for cropland, four categories in forest land, two categories in wasteland and waterbodies along with settlement was calculated.



was given as additional input while defining eco regions. Figure 2 shows the DEM for Erau watershed.

Extraction of micro watersheds - DEM of the watershed area was given as input to automated extraction of micro watersheds. Total area was divided into 135 micro watersheds. The average area of watershed was around 5 sq. kms.

Preparation of hydrogeomorphology map - Hydrogeomorphological units play a vital role in analysis of any watershed. Hydrogeomorphological map was prepared for entire area. Eight units of hydrogeomorphology were identified and their extent was found out for each micro-watershed.

Analysis of database

Calculation of morphometric parameters - Morphometric parameters are of utmost important to understand the behaviour of any watershed. A total of 6 parameters were calculated for all 135 micro-watersheds. Bifurcation ratio, total stream length, circularity, drainage density, total number of streams are the morphometric parameters calculated in the study.

Univariate statistics - Statistical parameters viz. minimum, maximum, mean and standard deviation were calculated using data from all the 135 watersheds and are tabulated in table 1.

Calculation of Z scores - The variable used in the analysis are of different nature and with different units of measurement. To get a standardised data, Z score was calculated for each parameters.

Principal Component Analysis - To understand the behaviour of all the parameters pertaining to study area, and to reduce the dimensionality of database, the data pertaining to 22 variables of 135 micro-watersheds were submitted for Principal Component Analysis. The Principal Component Analysis reduced the dimensionality of data. Table 2 shows the results of PC analysis in the form of percent variance and the component loading done in Erau watershed. PC extracted 12 components, accounting for a total variance of 92.7 %. The first component correlated the area of watershed with landuse/cover category, length of stream and total length of streams accounting for 22.3 % variance. Second component highlighted relation of elevation with good and moderate forest and the geomorphological category structural hill with 17.0 % variance. The third component has high loading from buried plain accounting for 11 % of variance and fourth component has high loading from water and pediments. Pediplain and degraded forest have high loading on fifth component accounting for 6.1 % of variance. Other components highlighted the other parameters.

Hierarchical Cluster Analysis - The PCA scores on the components were submitted for grouping analysis. The average linkage method was used for analysis.

All the watersheds were initially grouped into 100 groups. These were further grouped in 79 and finally 50 eco watersheds were developed. The grouping and regrouping can be done as per the planning requirement. Finally all the 135 micro watersheds were grouped in 9 eco regions. Fig 3 shows the eco watersheds of the study area.

PLANNING THE WATERSHED

Water resources planning in any watershed calls for characterisation of watersheds. Response of the watersheds vary as per physiographical and landuse/cover conditions. The grouping of micro-watershed resulted in 9 eco regions. The planning needs of each eco region defer as characteristics of each region is given here.

Region 1 - Agricultural land, irregular plains, good drainage, low elevation, less slope

Region 2 - Waste land, irregular plains, medium elevation, moderate drainage, medium slope

Region 3 - High elevation, hills and undulating plain with agriculture, medium to high slope

Region 4 - High elevation, plateau, agriculture, plain

Region 5 - Low elevation, plains, cropland, wasteland, medium slope

Region 6 - Moderate to high elevation, open forest, medium to high slope

Region 7 - Medium elevation, scrub land, pediplains

Region 8 - High elevation, steep slope, hills, good forest

Region 9 - Areas around reservoir

Figure 3 : Eco watersheds for Erau watershed



These regions are categorised by taking all the possible inputs for water resources development and management, hence a specific development plan was attached to each region. This level is suitable for suggesting broad level management practices viz. soil erosion, protection against entry of silt in reservoir etc. Eco watersheds shown in figure 3 are good indicator of hydrologic response. Shape of watershed affects time of concentration of flow. Run off hydrograph is also affected by shape. Considering this, the different techniques will be applied to eco-watershed 1 and 4 and so on. These group help in better management of watershed.

RESULT AND DISCUSSION

PCA helps us to reduce the data dimension. Hierarchical clustering groups the watersheds bringing out the similarity in the characteristics. The grouping can be done at different levels depending upon requirement of planning. In the present study total 59 eco watershed generated from 135 micro-watersheds serves the planning requirement. Broad level planning need can be fulfilled by 9 eco regions.

These regions and eco watersheds are important elements while deciding the management activity. Management on watershed basis has a scientific base and this study helps in characterising the watersheds in an integrated way.

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Table 1 : Statistical summary of data for 135 micro-watersheds of Erau watershed

Parameter	Units	Minimum	Maximum	Mean	Standard Deviation
Area	sq. km	1.08	16.27	5.45	2.06
Elevation	meters	255	543	406.86	76.83
Total streams		12	298	57.29	31.29
Stream length	meters	4009	84100	20965.6	9282.25
Bifurcation ratio		.65	9.76	2.43	1.28
Circularity		.23	.76	.53	.12
Drainage Density	meter/ sq. km	.01	1.92	.45	.35
Stream frequency	number/ sq. km	4.22	20.72	10.55	3.05
Settlement	sq. km	0	.22	.02	.04
Crop land	sq. km	0	5.29	1.36	.82
Good forest	sq. km	0	3.670	.62	.71
Moderate forest	sq. km	0	1.50	.34	.30
Degraded forest	sq. km	0	3.39	.92	.78
Forest blank	sq. km	0	1.96	.1	.24
Scrub land	sq. km	0	5.70	1.70	1.12
Sandy area	sq. km	0	1.20	.13	.16
Water bodies	sq. km	0	4.110	.26	.69
Hills	sq. km	0	4.89	.69	.88
Pediment	sq. km	0	3.62	.36	.70
Buried pediment	sq. km	0	2.43	.3	.44
Pediplain	sq. km	0	6.22	1.42	1.56
Buried pediplain	sq. km	0	7.87	1.29	1.67

Table 2 : Principal Component Analysis of Erau watershed

Component Variables	1	2	3	4	5	6 - 10
Area	.85915					
Elevation		.32247				
Total streams	.66461					
Stream length	.76735					
Bifurcation ratio						.99245
Circularity						.96261
Drainage Density			.08281			
Stream frequency						
Settlement						.92314
Crop land	.83342					
Good forest		.92374				
Moderate forest		.88499				
Degraded forest					.52890	
Forest blank						.95183
Scrub land	.89401					
Sandy area	.68554					
Water bodies				.83386		
Hills		.73848				
Pediment				.71147		
Buried pediment						.93351
Pediplain					.87361	
Buried pediplain			.87417			