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SOIL EROSION ASSESSMENT USING REMOTE SENSING AND GIS TECHNIQUE

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ABSTRACT

Soil erosion from a catchment is important factor becuase it creates serious problems in water resources management. Subsequent deposition of the eroded material from catchments causes depletion of reservoir capacity, silting of channels and problems concerning river management.

The geomorphological characteristics of a catchment represent the attributes of the watershed that can be employed in its hydrologic behaviour. The important characteristics from the hydrological studies point of view include the linear,areal and relief aspects of the catchments. Morphometric characterisics of different subcatchments, their interrelationship and regression analysis have been carried out for Jawai dam catchment using GIS techenique. For this purpose Integrated Land and Water Information System (ILWIS) has been used. Soil erosion assessment study was done for determining the level of erosion in the study area.

1.0 INTRODUCTION

Soil erosion is a process of land denundation involving both detachment and transportation of the surface materials. Soil erosion is a complex dynamic process by which productive surface soils are detached, transported and accumulated in a distant place resulting in exposure of subsurface soil and siltation in reservoirs in natural strems elsewhere. It leads to general reduction of raised land. The various important agents of erosion described are running water, ground water, wind, glacier and gravity etc. Excessive erosion from the area may be harmful in the following ways:

(i) It may lead to severe loss of valuable fertile soil which affects the agricultural productivity.

(ii)The loss of the soil cover reduces the water retention capacity of the land and hence may result increased runoff

The sediments eroded from the basins are deposited in the downstream region. This could effect the natural balance in the flood plains and also the projects e.g. resevoirs and canals etc.

1.1 CLASSIFICATION OF EROSION

Soil erosion has been classified by erosive agents (agents causing the occurrence and affecting the course of erosion processes): water, glacier, snow, wind, man, animals, etc.; by form (forms which are derived from the effects of exogenous agents on the soil surface; by intensity (intensity expressed by the extent the soil particles are detached and transported.

Surface Water Erosion

Water erosion is removal of soil from land's surface by running water,including run-off. Water erosion is sub-divided into rain drops,sheet,rill,gully and stream channel erosion.

Factors affecting erosion by water: There is a direct relationship between total run-off and soil loss from agriculture areas, the factors influencing variables affecting soil erosion are climate,soil,vegetation and topography. Of these the vegetation and to some extent the soil may be controlled. The climatic factors and topographic factors except slope,length are beyond the power of man to control.

(1)Climate: Climate factors affecting erosion are precipitation, temperature, wind, humidity and solar radiation. Temperature and wind are the most evident through their effects on evaporation and transpiration. Wind also changes raindrop velocities and angle of impact. Humidity and solar radiation are somewhat less directly involved in that they are associated with temperature.

(2)Soil : Physical properties of soil affected the infiltration capacity and the extent to which it can be dispersed and transposed. These properties which influence erosion include soil structure, texture organic matter, moisture content, and density or compactness, as well as chemical and biological characteristics of the soil. As yet not one soil characteristics or index provides a satisfactory means of predicting erodibility.

(3) Vegetation : The major effects of vegetation in reducing erosion are:

(a) nterception of rainfall by absorbing energy of the raindrops and thus reducing run-off.

(b) retardation of erosion by decreased surface velocity.

(c) physical restraint of soil movement.

(d) improvement of aggregation and porosity of the soil by roots and plant residue.

(e) increased biological activity in the soil and

(f) transpiration which decreases soil moisture,resulting in increased storage capacity. These vegetative influence vary with kind of vegetative material namely roots, plant tops and plant residues.

(4) Topography: Topographic features that influence erosion are degree of slope , length of slope, and size and shape of the watershed. On steep slopes high velocities cause serious erosion by scour and sediment transportation.

Types of water erosion

Sheet erosion: Sheet erosion is the uniform removal of soil in thin layers from sloping surface of soil between rills. Although important, sheet erosion is often unnoticed because it occurs gradually. The rain drop causes the soil particles to be detached and the increased sediment reduces the infiltration rate by sealing the soil pores.

Rill Erosion: When water takes the path of least resistance to flow over the soil surface it forms minute channels. Rill erosion is the removal of soil by water from small but well advanced channels when there is a concentration of overland flow. Detachability and transportability are both greater in Rill erosion than in Sheet erosion because of higher velocity. Rill erosion is of most serious when storm are of high intensity and top soils are loose and shallow.

Gully Erosion: If the channel formed in the land are so deepened and widened by erosion that their size is greater than those of common Rills, the land is no longer readily usable, and the effect is then termed as Gully erosion. These channels carry water during and immediately after rains. Gullies are usually formed by (i) water fall erosion at the gully (ii) channel erosion caused by water flowing through the gully (iii) alternate freezing and thawing of exposed soil banks and (iv) slides and mass movement of soil in the gully. Gullies are often also referred to as ravines.

Tunnel Erosion: Tunnel erosion occurs where there is intense penetration of the ground water. This is an underground forms of soil disintegration which occur practically in any thick layer of finely grained sediment. In most cases it develops into intense gully erosion, and therefore tunnel erosion is sometimes referred as a special from of gully erosion. It frequently occurs on forested land causing both soil loss and water losses.

1.2 MORPHOLOGICAL PARAMETERS

Stream channel morphology is the study of stream channel form and structure, but generally it is taken to mean their form and structure regarded as a whole or their collective morphological features. Because these features result from deposition and erosion processes in the channe, which in turn are affected by the available sediment and its movement through the channel system, it is logical that we seek to know the controlling mechanism between stream channel morphology and the associated sediment yield. For the purpose of a quantitative geomorphological appraisal, drainge basin characteristcis have been widely used. In the present work, quantitative analysis of drainage basins is carried out, as the morphometric parameters give a quantitative idea of the geommorpholgical state of the basin, which in turn affects the sediment yield. Quantitative morphometric data could possibly be linked to sediment yield to throw light on the later aspects. First generation of various parameters have been discussed and then their correlation with sediment yield have been described.

Morphometric analysis involves the preparation of a drainage map, designation of stream order, measurement of channel length and catchment area, perimeter etc. and thereafter computing various parameters like the bifurcation ratio, drainage density, frequency, basin configuration and relief aspects etc. Drainage networks exhibit four basic qualities viz. Topology (linkage properties), scale (drainage density, length and area relationships), orientation (direction and shape properties of streams, slopes and divides) and Relief (gradient and hypsometric relationships. Most quantitative studies of drainage networks have considered only one or two of these qualities, although strong interrelationships occur between all aspects of drainage organization (Howard, 1971).

The studies of morphological characteristics of the drainage basins of the Luni-Jawai and west Banas basins to evaluate their surface run-off potentials were done by Singh (1994). Singh et al. (1994) computed sediment yield from the Bandi catchment using morphometric characteristics of different sub-basins.

The quantitative analysis of channel networks begins with Horton's (1945) method of classifying streams by order. Strahler (1957) revised Horton's classification scheme such that the ordering scheme is, unlike Horton's, purely topological, for it refers to only the interconnections and not to the lengths, shapes or orientation of the links comprising a network.

1.3 EFFECT OF LAND USE/COVER

The main role of vegetation cover in the interception of the rain drops is that their kinetic energy is dissipated by the plant rather than imparted to the soil, i.e. vegetation cover protects the soil surface from the direct impact of the falling raindrops. It enhances the degree of infiltration of rainfall into the soil, maintains the roughness of the soil surface, slows down the surface run-off, binds the soil mechanically by root effect, diminishes the micro-climatic fluctuations in the upper most layers of the soil and improves the physical, chemical and biological properties of the soil.

The effectiveness of plant cover in reducing erosion depends upon the height and continuity of the canopy, the density of ground cover and the root density. Mrszek et al., (1975) concluded that the forest with a dense canopy, good undergrowth and undisturbed litter have the most significant effect on the surface run-off and thereby on the intensity and course of erosion. On the other hand,studies have indicated that whilst interception by the canopy reduces the volume of rain reaching the ground surface, it doesn't significantly alter its kinetic energy which may even be increased compared with that in the open ground (Chapman, 1948; Mosely, 1982). This is because of the greater percentage of large drops in the rainfall as a result of the coalescence of the rain drops on the leaves. This condition holds true where there is no appreciable ground cover under the canopy.

Effects of landuse on sediment yield are closely interlinked to those of climate,geology and soil characteristics. However, if effect of landuse is isolated, it becomes clear that major contribution to sediment yield may be attributed to the influence of landuse (Garde., 1987). A table given by Garde et al., 87, indicates that activities of bulding construction and cultivation result in maximum increase in sediment yield.

1.4 GEOGRAPHIC INFORMATION SYSTEM (GIS)

A geographic Information System (GIS) is a computer based system for collecting, storing, retrieving, analysis and displaying of spatial data (Fig.2.1). The increasing volume of available environmental information with all its complexity and subsequent demands for its storage, analysis and display of these large quantities of environmental data, have led in recent years to the rapid development in the application of computers to environmental and natural resources data handling and the creation of sophisticated information system. Effective utilization of large volumes of spatial data depends upon the existence of an efficient data handling and processing systems that will transform these data into usable information.

The GIS is designed to store process and analyze spatial data and their corresponding attributes. Advances in recent technologies have made it possible to integrate a wide range of information. Technological advances have increased input techniques, storage and retrieval capabilities. GISs have renewed spatial data collection and analytical procedures.

Employing manual techniques to integrate the vast amount of data from a variety of sources for the purpose of obtaining the desired logical results for use in the watershed management aspects is both time consuming and expensive. On the other hand the present advance of technology made it possible to easily handle and analyse large volumes of data using computer based system. A GIS in particular provide enormous potential for effectively storing, handling, manipulating, and analysing multiple spatial data sets in a single analysis at a high speed unmatched by any other method.

Besides the other applications of GIS, the major applications related to hydrology of GIS includes:

i) Land use planning and management
ii) Natural resources mapping and management
iii) Land information systems
iv) Urban and regional planning
v) Management of well log data

2.0 REVIEW OF LITERATUTE

The soil erosion from the draiange basin is a result of complex processes which is controlled by the various climatic, topographic, geologic, geomorphic and landuse charactericts. A number of studies have been carried out to investigate the erosion rate and the governing physical factors and based on these studies several models have been proposed. Most conservation planning for erosion control however use empirical model to estimate average annual soil loss. Investigations into much models reveals that most of these models require input parameters in terms of spatial information of landuse, morphological characteristics.

Zingg (1940) was among the first few workers who tried to relate quantitively, soil erosion and topography. A large number of subsequent workers have correlated sediment yield with various meterological, hydrological, geomorphological, geological and landuse parameters. Schumm (1954) demonstrated an inverse correlation between sediment yield per unit area and the area. Anderson (1954) carried out study in selected mountainous watersheds of western Oregon and has shown that suspended sediment load is propotional to the area. Several other workers (Roehl,1962, Wilson, 1973, Jansen, 1974, Martz, 1978, Taylor, 1983) have also shown similar type of effects. Though most of the investigators describe this effect by the following argument : The small upstream basins are generally steep and have limited flood plains on which sediments can be stored; with an increase in catchment area storage space relatively increases with sediment yield slightly reduces. Hence sediment yield per unit area somewhat decreases with increase in area.

Regarding the ersion rates from Indian catchments not too much informations are available. Khosla (1953) expressed the sediment yield from catchments in terms of catchment area. Sharma and Chaterji (1982) carried out study in selected nadis (embankmnet ponds) in Rajasthan and has shown that sediment yield is propotional to mean annual rainfall and basin slope. Using data from some river catchements and some reservoirs in Indi, Dhurva Narayan et al. (1983) gave seperate relationships fro sediment yield in terms of annual runoff, annula rainfall, catchment area and erosion index. Subramanian (1982) carried out sytudy in Krishna basin of India and has shown that the sediment yield is proportional to annual runoff and inversly propotional to the area of the basin. Garde et al. (1983) analysed data from 31 large and small reservoirs in India. The absolute volume eroded material was expressed in terms of hydrometeorogic landuse and catchment variables. Abbas and Subramanian (1985) correlated the sediment yield with the basin area after carrying a study on Ganga basin. Garde and Kothyari (1986)

Garde and Kothyari (1986, 1987) analysed erosion data alongwith other data charecterising 50 Indian catchments to obtain a relationship for anual sediment yield use of data from 104 other catchments spread evenly over India has been made for the estimetion of erosion rates from the catchments. Based on these values an isoerosion map of India has been prepaired on the basis of this study they concluded that the land use variable has been found to be the most influencial factor affecting, the sediment yield followed by catchment slope,rainfall variables and drainage density.

Chakraborti (1991) evolved a methodology to predict subwatershed wise sediment yield rate and to prioritise these watershed based on frequancy distribution of data renges.He councluded that in the absence of measured sediment yield is an small watershed, this method will be inmensely usefull for conservation planning purposes.

The regression equation which retake the sediment yield to the catchment and hydrometerorological condition, are usefuly used for pridection of sediment yield from ungauged catchments.

Spanner (1982;1983) combined Landsat MSS data and a digital elevation model (DEM) in a GIS context. A stratification of the landscape according to relief (elevation,steepness) allowed accurate discrimination between orchards and natural vegetation that had not been possible using Landsat data processing alone. The DEM helped to quantify three of six coefficients of the USLE (slope gradient and length, and cover).

Morgan et al. (1990) developed a process based soil erosion prediction model In this attention is given to the dynamic nature of soil erodibility, tillage and crop cover. The model calculates the volume of rainfall reaching the ground surface as direct through fall, leaf drainage and stemflow: the volume of surface depression storage in relation to microtopographic roughness: the rate of detachment of soil particles by raindrop impact as a function of the energy of the direct material that is splashed into the flow and thereby made available for transport: the rate of detachment of soil particles by surface flow; the transport capacity of the runoff.

McCool et al. (1990) revised the universal soil lodd equation to more accurately estimate soil loss from both crop and rangeland areas. All factors R,K,LS,C and P have recieved attention. R-values for the western United States were developed from hourly precipitation data. A time variant K factor was included. New length and steepness (LS) factor relationships were developed. C factors are now computed by a subsurface approach, and P factors were developed using CREAMS model.

Subramaniyan et al. (1990) has given soil loss for the catchments of river valley projects in India. In this study soil loss for 27 catchments have been gievn with the geograhical setting of each catchment. These 27 catchments have varying size, physiographic characteristics and socio-economic conditions and are spread over different river systems of India such as the Ganga, Yamuna, Brahmputra, Indus, Krishna, Cauvery, Godaveri and other small rivers of the country. Further the authors suggested that for selecting excessively eroding catchments and for locating the highly degraded watersheds within these catchments appropriate information on rate of erosion of Sediment Production Rate (SPR) is essential.

S K Saha,J Bhattacharjee, C Lalengguwa & U M Pande (1992), In this study was undertaken to determine priority classes of subwatersheds of part of song river watershed, esteren doon valley, based on spatial erosional soil loss estimates using IRS- IA- LISS II data using USLE, The results indicated that out of total fifteen subwatersheds,nine subwatersheds belongs to high to very high priority classes (over estimated soil loss between 50.5 to 225.4 t/ha/yr.) covering 36.2% area of the watershed. Rest subwatersheds covering 63.8% area of the watershed were classified as low to moderate priority categories(average estimated soil loss between 7 to 17.7t/ha/yr.).

Singh et al.(1994) computed the parameters of Bandi catchment situated also in the arid zone. For this catchment the drainage density, bifurcation ratio and circulatory ratio etc. for fifth order basin was computed as 1.53 to 2.83, 2.89 to 4.25 and 0.18 to 0.60 respectively. In the computation made above all these parameters are almost in these ranges.

Dutta et al. (1995) carried out soil erosion studies in a eastern most part of Rajasthan using USLE. The different parameters required such as soil, landuse/cover and geomorphic characteristics etc. were derived using remote sensing and GIS . Soil loss predicted using above equation was less and ranging between 1 to 14 t/ha/year.

3.0 STATEMENT OF THE PROBLEM

In th present study, quantitive analysis of drainage basins is carried out with the following objectives :

1. As the morphometric parameters give a quantitive idea of the geomorphological state of a basin which in terms effect the sediment yield. Quantitive morphological data could possibly be linked to sediment yield. As such there was a need to compute the morpometric data.
2. Generation of morphological data using GIS technique as this is very tedious and time consuming using manual tech.
3. Mapping of landuse pattern from satellite data
4. Analysis of correlation coefficient amont the various parameters.
5. Computation of sediment yield usning standard empirical model
6. Identification of priority of watersheds using indexing approach of the most influential parameters.

4.0 THE STUDY AREA AND DATA USED

For the present study Jawai dam catchment has been chosen for morphometric analysis. The Jawai dam was constructed across the river Jawai, a tributary of river Luni which flows in Rajasthan state. The dam is situated near village Bhinga in Pali district. The location of the dam is Longitude 73° 9' 40" and Latitude 25° 6' 10" and the catchment area is 720 sq.km. The river rises in the Aravali Range and travelling for a length of about 250 km in the west direction joins the Luni river near Gandap village. The Jawai river is joined by its important tributaries, such as, Sela Nadi and Tarawari Nadi. The topography of the river basin is undulating with altitude varying between 1100m and 300 m. The Jawai basin is fan-shaped. The catchment area plan upto the dam site is

Its climate is semi-arid with large variations in temperature. During the summer, the mean monthly maximum temperature varies between 40 c and 25 c . During the winter, the mean monthly minimum temperature ranges from 10 c to 27 c with the minimum temperature louching ranges 10 c. The region is influenced by south-west monsoon. The rainfall is received by dissipation of the remnants of the Bay of Bangal cyclones and occasional Arabian Sea rainstorms passing over the region. The mean annual rainfall is about 500.0 mm, 90% of which occurs in the months of June to September. The annual rainfall varies widely from year to year. Even though thr region is located in semi-arid region for away from the Bay of Bangal, the region has experienced a few major rainstorms.

5.0 METHODOLOGY

As mentioned earlier that the objective of the present study is to generate data on morphometric parameters which could be used to relate quantitively understand the process of sediment yield in the catchment. For such an analysis, fourteen subbasin of the Jawai dam catchment has been made. The different variables computed and measured are the stream numbers, stream length, basin area, drainage frequency, drainage density, elongation ratio, relief ratio etc. representing various linear, areal and relief aspects of the subbasins. The description of measurement of various variables from topogrpahical maps are given below.

5.1 GIS SOFTWARE USED

The GIS software used in this study is ILWIS (Integrated Land and Water . Information System). It was developed at the Computer Centre of International Institute of Aerospace Survey and earth sciences (ITC) Enschede, The Netherlands. ILWIS provides user with state of art of data gathering, data input, data storage, data manipulation and analysis and data output capabilities, merging and integrating conventional GIS procedures with image processing use with microcomputers and uses both vector and roster graphics data (Valenznela 1988).

A conversion program attains the importation of remote sensing data, tabular data raster maps, and vector files in several other formats. Analog data can be transferred into vector format by means of digitizing program.

Complex modelling of features can be executed by the map calculation. Map calculation includes an easy to use modelling language and the possibility of using mathematical functions and macros. It integrates tabular and spatial data bases. Tabular and spatial data bases can be used independently and on an integrated bases. Calculation, queries and simple statistical analysis can be performed by table calculator.

Errors involved in digitization and editing the error :

Manual cartographic digitizing, due to its tedious process often involves errors. Therefore before any further step is taken after digitization the segments should be checked for errors. The most common possible errors that are likely to occur during digitization are over and under shooting of the lines, failure to snap lines together at nodes, omission of lines and points incorrect feature coding, incorrect location of features etc. The errors were checked and corrected by the facilities available in ILWIS under VECTOR-digitize module.

Polygonization :

After each segment file was checked and corrected, polygon files for soil and landuse were created by the polygon generator program. The polygons for any given polygon file were assigned identification name and color values. It is worth to note that polygon features attributes labels are normally entered only after the topology of the digitized data has been checked and corrected if necessary. In the GIS package used program facilities are also available to automatically create polygon information file containing the areas and parameters of different polygons. Area and perimeter calculations are performed by an interactive in-built program.

Vector to Raster Conversion :

Because high spatial variability and overlay operations are easily and efficiently implemented in a raster model, all maps encoded in vector structures (both in polygon and segment) were converted into raster structure. Soil and landuse maps which were rasterised through polygon to raster mode in the vector to raster module.

5.2 DERIVATION OF MODEL INPUT PARAMETERS

The process of data base creation for the basin in ILWIS involved collection of relevant available data, including these data into digital format, digitization error checking and correction, polygonization of segment files and finally conversion of data acquired in vector structure to roster format.

Computation of the parameters required for morphometric analysis using manual methods like area measurement using dot grid method or using planimeter and length measurement using curvimeter are very tedious and time consuming. It is more difficult if the map is on higher scale like 1:50,000 and 1:25,000. In the present work ordering, calculation of various inputs which are required for calculating drainage parameters are estimated using Geographic Information System (GIS) technique. Use of GIS can not only make this task relatively easy but accurate as well.

The boundary of drainage catchment, all streams have been mapped at a scale of 1:50,000 from Survey of India toposheets (Fig.5.1). The entire study area was divided into 14 subcatchments as shown in Fig.5.2. Also a contour map at the same scale was prepared. Both These maps were then converted to digital form using digitization and stored in ILWIS. Digitization which is the most time consuming part of the analysis, was carried into parts to minimise the digitization errors. Then the digitized map was corrected for any type of error such as proper joining of the streams, proper overlaying of the segments etc. The system then autoedits the coverage and splits the stream of the higher order at the point where they meet. Individual stream (segment) lengths are computed by default and stored in the order table alongwith the order of each stream. The area and perimeter of the basin can be computed after converting segment (boundary) map to polygon map. After converting the contour map into digital form, it was rasterised. Then interpolation from isolines was carried out on this map. This interpolated map gives the elevation at each point(pixel) in the basin. This map was reclassified into a interval of 100 m and shown in figure 5.3. Using the above GIS data base, additional physical characteristics of the basin like the bifurcation ratio, elongation ratio, drainage density, stream frequency, basin relief aspects etc. are evaluated and detailed description is given below.

For stream order, Strahler's system, which is in fact slightly modified Horton's method, has been followed here. When this order system is applied through ILWIS over the entire drainage network of the study area it is found that this is seventh order basin.

In ILWIS length of each stream is stored in a table. Then after adding length of each stream for a order we can get lengths of each order. The cumulative stream length divided by the number of stream segment (N_u) of that order give mean stream length L_u

The area and perimeter of the basin were computed after converting the basin map in polygon form in ILWIS. The area and perimeter are 325 and 93 km respectively. The area of each order streams can not be estimated directly using ILWIS. These values were computed with the help of area and length relationship (Strahler, P4-49). According to this, area and length in terms of Horton's law of drainage network composition, is given as below :

$A_u = A_1 R_b^{u-1} (R_b^u-1)/(R_b-1)$

Where A_1 is the mean area of first order basin and R_b is the bifurcation ration and R_{lb} is Harden's term for the ratio of length ratio to bifurcation ratio. In this relationship only A_1 is unknown, so A_1 can be calculated.

The land use map of the study area was prepared using IRS data. The IRS LISS II data in the form of FCC of bands 2,3 4 in the scale of 1:250,000 were used. Using the visual interpretation technique in which tone, texure, pattern etc. forms the basis of classification, a landuse map was prepared and shown in Fig.5.4.

A number of sediment yeild equations for Indian catchment are given below (Garde & Kothyari, et al.,1987)

1. Khosla (1953)

$$V_s = 3.23 * 10^{-3} A^{0.72}$$

Where V_s = Annual sediment yield in Mm^3

A = Catchment area in sq. km.

2. Dhurva Narayan et al, (1983)

$$T_1 = 5.5 + 11.1\ Q$$

$$T_1 = 5.3 + 12.7\ Q.W$$

Where T_1= Annual sedimentation rate in mt/year

Q = Annual runoff in M ha m.

W = T_1/A

A = Catchment area

3. Garde et al. (1983)

$$V_s = 1.182 * 10^{-6} P^{1.29} A^{1.03} D_d^{.40} S^{0.08} F_c 2.42$$

Where A : Catchment area, Sq. Km., L : Strem Length, km.

S : Catchment slope, D_d : Drainge density

F_c : Vegetation Cover factor,

P : Annual mean precipitation, mm.

V : Sediment yield rate m^3/100 km./year

$$V_s = 1.067 * 10^{-6} P^{1.38} A^{1.29} D_d^{.40} S^{0.130} F_c 2.51$$

Where A : Catchment area, Sq. Km., L : Strem Length, km.

S : Catchment slope, D_d : Drainge density

F_c : Vegetation Cover factor,

P : Annual mean precipitation, mm.

V : Sediment yield rate Mm^3

FIG. 5.1

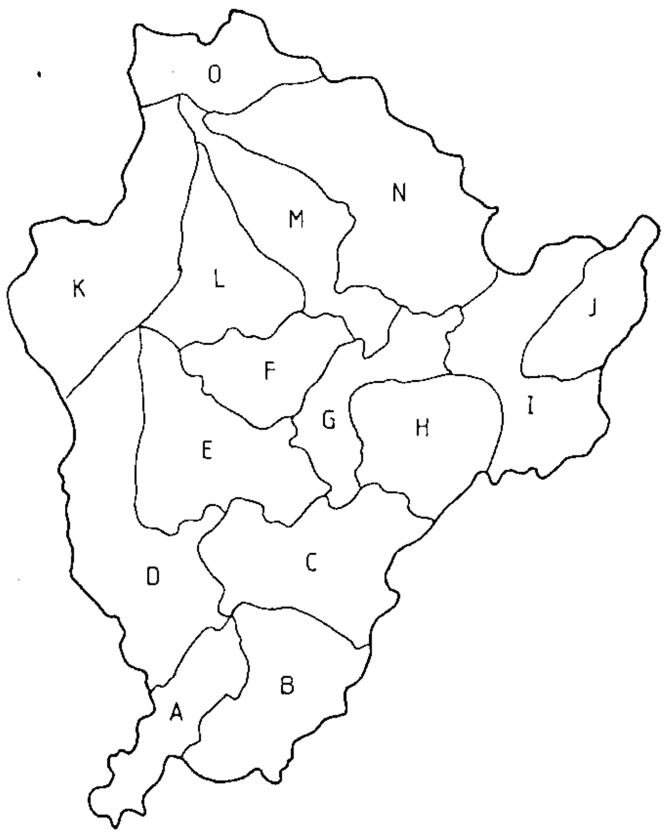

FIG. 5·2 SUB CATCHMENTS OF JAWAI DAM CATCHMENT

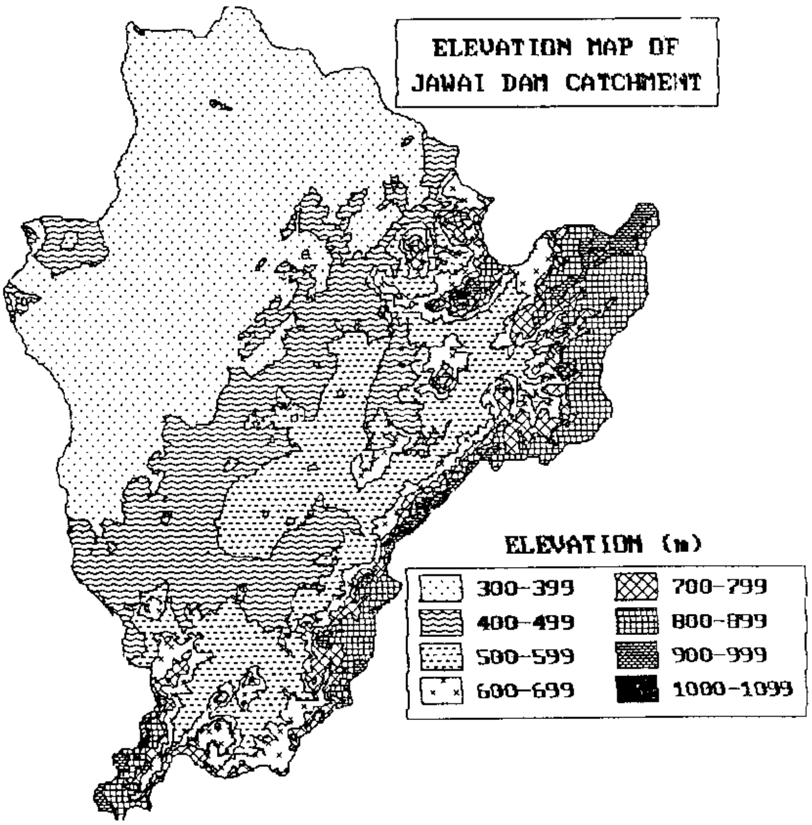
ELEVATION MAP OF
JAWAI DAM CATCHMENT
ELEVATION (m)
300-399
400-499
500-599
600-699
700-799
800-899
900-999
1000-1099

FIG. 5·3

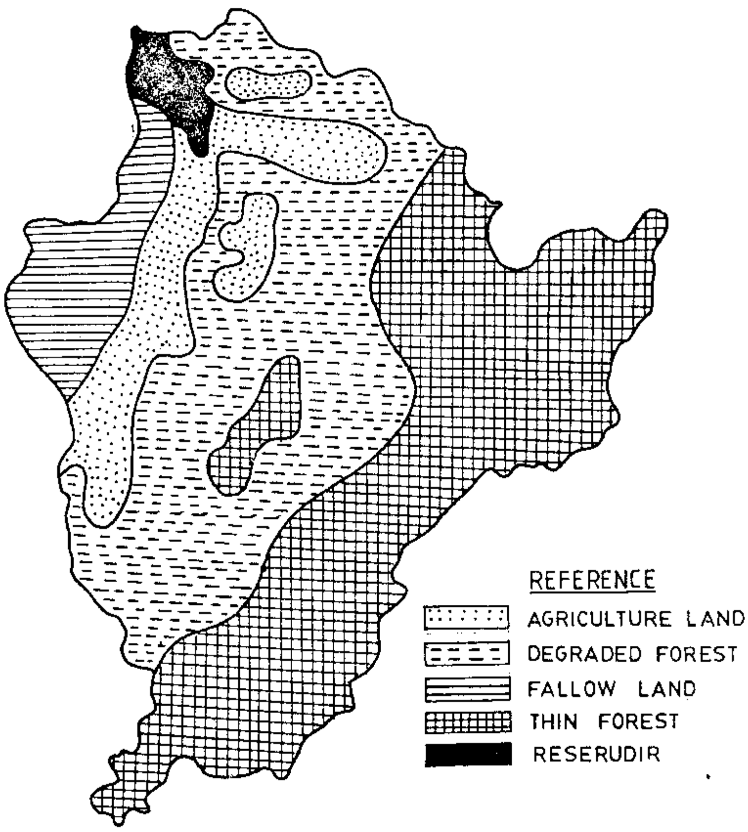

FIG. 5.4 LANDUSE MAP OF JAWAI DAM CATCHMENT

6.0 ANALYSIS AND RESULTS

Landuse and morphological charcteristics are the important parameters influencing the sediment from catchments. Variation in these factors in different catchments permit evaluation of their individual influence on sediment yield. As a first step, morphological analysis and landuse analysis have been carried.

6.1 Morphological analysis

The values of range,average and standard deviation of the morphometric charcteristics like basin area,length, drainage frequency, draiange density, bifurcation rartio, elongation ratio, relief ratio, circulatory ratio etc. of different basin orders were computed and are presented in table 1.

After estimation of different parameters, regression analysis have been carried out and the simple correlation among all the variables shown in the table given below.

Landuse map of the study area has already been prepared. Now on the basis of landuse categories, landcover index has been estimated using equation
The soil erosion was estimated using the relationship given by Garde et al. and given as :

$V_s = 1.067 * 10^{-6} P^{1.384} A^{1.292} D_d^{.397} S^{0.129} F_c 2.51$

Where A : Catchment area, Sq. Km., L : Strem Length, km.

S : Catchment slope, D_d: Drainge density

F_c : Vegetation Cover factor,

P : Annual mean precipitation, mm.

V : Sediment yield rate m^3/100 km./year

The soil erosion estimated using above equation for each catchment is given below in table no.

From the table 2 above it can be seen that the factors drainge density, Slope, Landcover index are not coorelatd with other parameters. This indicates that the affect of these factors are more influential.

From table 3 it is clear that the erosion is very high in catchment no. K and L.

due to the fact that landcover index is high for these catchments. It means that the landcover is having a major impact on the soil erosion. On the basis of above it can be concluded that the catchments with high erosion can be treated on priority.

Table 1: Geomorphological parameters of the sub-catchments of Jawai dam catchment

Catchment	Order	Area(sq.km.)	Length(KM.)	Max. basin lenth	Peri. m.	Elevetion (m)	Dra. density	Bifur.ratio
A	4	29.17	14.59	12.20	31.72	932 -509	3.12	4.92
B	5	46.94	12.37	11.25	33.37	800 - 509	3.27	3.76
C	5	55.40	13.35	11.90	38.33	1100- 464	3.79	3.85
D	4	75.55	27.69	18.00	52.19	464 - 359	2.50	5.21
E	5	55.16	18.34	12.50	39.53	600 - 343	3.03	3.64
F	4	28.39	10.47	9.25	25.17	500 - 345	2.98	4.18
G	4	30.83	11.58	11.85	37.08	1000- 400	3.94	4.95
H	5	42.19	12.90	08.60	26.65	1042- 564	4.35	3.89
I	5	51.88	13.45	13.00	45.01	825 - 540	3.94	3.89
J	4	28.00	11.83	10.15	24.93	902 - 591	3.40	4.98
K	4	70.63	17.49	16.00	41.63	412 - 325	1.64	4.34
L	4	38.55	14.10	10.00	42.57	405 - 321	1.59	3.72
M	5	41.46	22.56	16.25	42.57	699 - 325	2.39	3.35
N	5	87.96	20.69	17.00	47.34	830 - 321	3.09	3.16
O	4	30.52	10.83	10.00	27.79	321 - 300	1.96	3.93

Table 1 (Contd.): **Geomorphological parameters of the sub-catchments of Jawai dam catchment**

Catchment	Shape Factor	Elong. Ratio	Circul Ratio	Dra. Freq.	Const. of ch. Main.	Relief Ratio	Ruggd. number
A	0.364	0.195	0.249	4.04	0.32	423	1.32
B	0.529	0.370	0.343	4.69	0.31	291	0.95
C	0.473	0.391	0.352	5.49	0.26	636	2.41
D	0.348	0.233	0.272	2.46	0.40	105	0.26
E	0.443	0.353	0.335	3.66	0.33	257	0.78
F	0.563	0.331	0.324	3.09	0.34	155	0.46
G	0.281	0.219	0.264	5.58	0.25	600	2.36
H	0.746	0.570	0.426	2.13	0.23	478	2.08
I	0.321	0.306	0.312	6.07	0.25	285	1.12
J	0.566	0.271	0.294	5.43	0.29	311	1.05
K	0.512	0.275	0.296	1.69	0.61	87	0.14
L	0.267	0.385	0.350	1.58	0.63	84	0.13
M	0.287	0.157	0.223	3.62	0.42	374	0.89
N	0.493	0.304	0.311	4.69	0.32	509	1.57
O	0.496	0.305	0.311	2.49	0.51	21	0.41

Table 2: Relationship between different morphometric characteristics

	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11
V1	1.0	.67	-.9	.84	.83	.08	-.1	.35	.29	.33	.30
V2	.67	1.0	-.7	.49	.61	.05	-.07	.36	-.16	-.23	-.20
V3	-.96	-.73	1.0	-.77	-.76	-.10	.10	-.31	-.25	-.17	-.14
V4	.84	.49	-.77	1.0	.87	.04	-.23	.25	.28	.29	.24
V5	.83	.61	-.76	.87	1.0	-.01	-.07	.58	.15	.23	.19
V6	.89	.05	-.01	.04	-.01	1.0	-.26	-.10	-.10	-.36	-
V7	-.13	-.07	.10	-.23	-.07	-.26	1.0	.08	.00	.02	..3604
V8	.35	.36	-.31	.25	.58	-.10	.08	1.0	.08	.24	.25
V9	.29	-.16	-.25	.28	.15	-.10	.00	.08	1.0	.65	.65
V10	.33	-.23	-.17	.29	.23	-.36	.02	.24	.65	1.0	.99
V11	.30	-.20	-.14	.24	.19	-.36	.04	.25	.65	.99	1.0

V1 Drainage density
V2 Drainage Frequency
V3 Const. of Channel Maint.
V4 Relief Ratio
V5 Ruggedness Number
V6 Bifurcation Number
V7 Area
V8 Slope
V9 Shape Fatcor
V10 Elongation Ratio
V11 Circulatory Ratio

Table 3: Estimation of sediment yield using seddiment yield model

catch ment	A	L	S	D	F	V ($*10^{-4}$)
A	29.17	90.88	.0348	3.12	0.21	14.14
B	46.94	153.33	.0258	3.27	0.21	25.66
C	55.40	209.92	.053	3.79	0.21	14.96
D	75.55	188.9	.0058	2.50	0.32	101.2
E	55.16	167.35	.0250	3.03	0.14	10.73
F	28.39	84.65	.0167	2.98	0.20	12.11
G	30.83	121.39	.0506	3.94	0.20	17.39
H	42.19	183.44	.0555	4.35	0.21	27.43
I	51.88	204.65	.0219	3.94	0.21	30.57
J	28.00	95.22	.0306	3.40	0.21	15.18
K	70.63	115.8	.0054	1.64	0.50	237
L	38.55	61.33	.0084	1.59	0.52	113.5
M	41.46	99.16	.0230	2.39	0.20	22.32
N	87.96	271.74	.02999	3.09	0.52	60.77
O	30.52	59.82	.0021	1.96	0.20	8.22

6.0 CONCLUSION

The manual estimation of geomorphological parameters is tedious and time consuming process which may lead to some time erroneous estimates. GIS which is becoming very efficient tool for storage and retrieval of large amount of data, can give better results in time and cost effective manner. A database once created and stored in a GIS system can be updated whenever needed). Effect of landuse changes can be easily incorporated in the estimation of soil erosion. On the basis of analysis of erosion data, the variables which are more ifluential affecting the sediment yield are landuse,drainage density and slope .

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