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Watershed planning and development plan by using RS and GIS of Sangharinala watershed arang

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■ **ABSTRACT :** The aim of the project is to develop an action plan for watershed management. Watershed management is the process of creating and implementing plans, programmes and projects to sustain and increase watershed functions that affect the plants, animal and human communities inside watershed boundary (Wikipedia). The recent technologies like remote sensing and GIS support use to giving a quicker and cost effective analysis of various applications with accuracy for planning. It also gives a better perspective for understanding the problems and, therefore, helps planners to evolve a better solution for sustainable development. From the final output of these themes generate~ pond, grassed waterways, percolation tank and check dams are recommended for the study area, mainly to control sedimentation from the catchments. To increase the groundwater recharge and vegetative cover to control soil erosion, various action plans like construction of recharge structures, afforestation etc. have been proposed. This project describes in brief the work carried out for the study area using remote sensing and GIS.

■ **KEY WORDS :** : Watershed, Watershed development, ArcInfo, IRDAS imagine, DEM, Drainage map, Sangharinala

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Water resources are increasingly in demand in order to help agricultural and industrial development, to create incomes and wealth in rural areas, to reduce poverty among rural people, and to contribute to the sustainability of natural resources and the environment. Reliable and timely information on the available natural resources is very much essential to formulate a comprehensive land use plan for sustainable development. The land, water, minerals and biomass resources are currently under tremendous pressure in the context of highly competing and often conflicting demands of an ever expanding population. Consequently over exploitation and mismanagement of resources are exerting detrimental impact on environment. In India more than 75 per cent of population depends on agriculture for their livelihood. Agriculture plays a vital role in our country economy. In order to mitigate droughts which occur frequently in several parts of the country especially in dry land areas the Ministry of Agriculture and co-operation has launched. An integrated watershed concept using easy, simple and affordable local technologies. Watershed approach has been the single most important landmark in the direction of bringing in visible benefits in rural areas and attracting people's participation in watershed programmes. The basic objective is to increase production and availability of food, fodder and fuel; restore ecological balance. Watershed management is an iterative process of integrated decision making regarding uses and modification of lands and waters within a watershed. Development of the watershed needs better understanding about the various natural resources their relations with each other and their relations with livelihood of the stakeholders. The present study was an attempt using Remote Sensing and GIS techniques to propose various water harvesting and soil conservation measures in order to suggest integrated land and water resource development plan for Sangharinala watershed covering 54.50 km^2 at Raipur district in Chhattisgarh.

Location and extent:

The study area is bounded by North latitudes $21^{0}20'$ to $21^{0}26'$ and East longitudes $81^{0}90'$ to 82^{0} falls in the Arang Block of Raipur district in Chhattisgarh and covered by Survey of India toposheet no. (No. 64 CT/15 and 64 CT/16) with scale of 1: 50,000. The area experiences average annual rainfall of the area is about 1420 mm, out of which the monsoon season contributes more than 80 per cent rainfall. About 80-90 per cent of total rainfall occurs between June to September, most of which goes as runoff resulting continuous depletion and poor recharge of ground water due to high infiltration rate, poor moisture retention capacity and low irrigation potentials a majority cultivated area is rain-fed. The mean maximum and minimum temperatures recorded in the area 41ºC and 10ºC, respectively. Location of study area is shown in Fig. A.

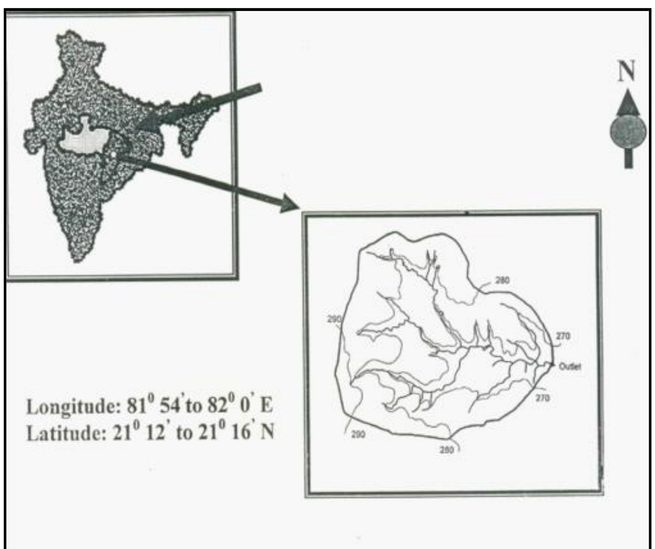

Fig. A : Study area map

Scope of the present study:

In large number of cases the failure of watershed development is largely due to adjustments with diverse facets of nature, caused by lack of awareness of the natural resources. In order to generate optimum utilization of existing natural resources like land, vegetation and water in watershed proper scientific surveys should be conducted. Geo-scientific studies of the terrain, socio-economic appraisal of the stake holders and the use of Remote Sensing data for faster assessment of natural resources such as soil, geology, drainage etc. as well as assessment of economic activities through land use and infrastructure of the watershed area is well known. This is also used for monitoring of watershed development at later years. GIS is a very powerful tool for development of the watershed area with all natural and socio-economic facets for better planning, execution and monitoring of the project.

Objectives:

The main objective of the present study was to generate information/databases on 1:50,000 scale pertaining to hydro geomorphology, drainage, surface water bodies, watershed, transport network etc. using multi-temporal satellite data. Conversion of these databases into digital form for future analysis and utilization and to prepare location specific land, water resources development plans, by integrating these databases with socio-economic data and contemporary technology in the GIS environment such that control of soil and moisture conservation and land degradation, optimal management of croplands and conservation and management of water resources can be achieved.

■ METHODOLOGY

To achieve the above objectives, the following methodology and procedure was adopted in the present study. Collection of satellite data and survey of India topographical maps, collection of rainfall and temperature data and other collateral data covering the study area, preparation of base map on 1:50,000 scale using survey of India topographical maps, preparation of drainage, watershed/sub watershed, preparation of DEM (Digital Elevation Model) from contour map, DEM was prepared by considering 24 m by 24 m resolution, preparation of drainage maps, land use/cover, sub-watershed, soil texture maps, preliminary pre-field interpretation of hydro geomorphology using satellite data on 1:50,000 Scale, calculation of curve number, recommendation of land and water resources development plan.

Geomorphology:

Geomorphology is the study of forms and process of landforms, which are the products of various exogenetic and endogenetic forces. Landforms play a significant role in land resource mapping, watershed studies, terrain evaluation and soil classification in addition to ground water studies. The ground water conditions vary from terrain to terrain.

For the present study ERDAS Imagine software, ArcInfo GIS software and SOI Toposheet 1: 50,000 scale have been used to map various geomorphic features in order to delineate ground water potential zones in the area. Based on the interpretation of the satellite imagery and SOI toposheet the following hydro-geomorphic units have been delineated on 1:50,000 scale.

■ RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Remote sensing and GIS:

The success of planning for developmental activities depends on the quality and quantity of information available on both natural and socio-economic resources. It is, therefore, essential to devise the ways and means of organizing computerized information system. Remote Sensing (RS) data and Geographical Information System (GIS) play a rapidly increasing role in the field of land and water resources development. One of the greatest advantages of using Remote Sensing data for natural resource management is its ability to generate information in spatial and temporal domain, which is very crucial for successful model analysis, prediction and validation. Examples from recent literature spotlight several uses of GIS as applied to land use classification. Ghosh *et al.* (1996) used GIS for land use/land cover change analysis in a mountainous terrain. Agrawal and Mishra (1992) made an attempt to delineate different hydro geomorphological units in and around the immediate environs of Jhansi city in Uttar Pradesh State of India.Tim *et al.* (1992) in their study identified the critical areas from the land resources prospective an average soil loss tolerance value of 9.0 t/ha/yr. was used for Nomini Creek watershed located in Westmoreland Country, Virginia. Similarly Nayak and Jaiswal (2003) observed that conventional hydrologic data are inadequate for the purpose of design and operation of water resources systems.

The DEM generated by the GIS using topographic map of the study watershed is shown in Fig.1. The colored area represents the zone of interpolation between two colour lines. Different colors show different zones of interpolation. The accuracy of results obtained from a DEM depends on the recent topography or contours and resolution.

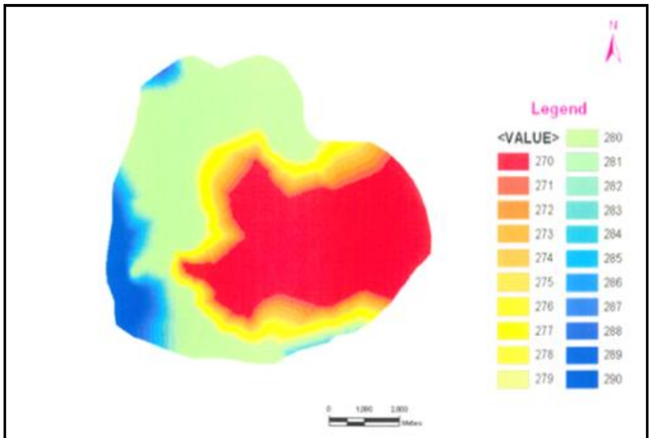

Fig. 1 : Digital elevation model of the Sanghari Nala watershed

The drainage network gives an idea about the location of streams of various orders and density of streams. The drainage map was generated with the help of GIS by digitization the drainage network from the

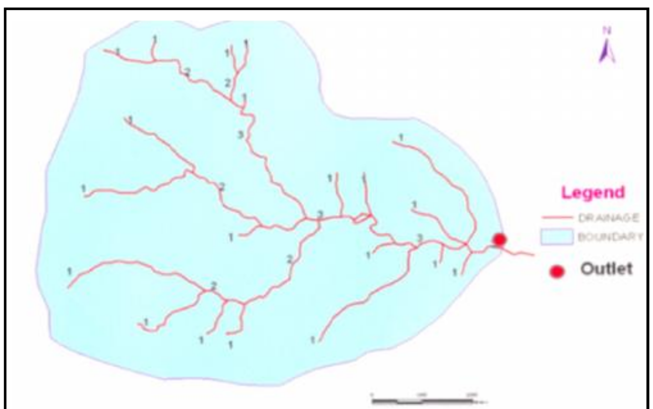

Fig. 2 : Drainage map of the Sanghari Nala Watershed

toposheet for determining the various watershed parameters including drainage density, channel length and depth (Fig. 2). Similar results were reported byWang and Yin (1997).

The watershed and sub watershed boundaries were delineated manually by digitized using GIS for further use watershed area of manually delineated boundary was found to be 54.50 KM^2. Hydrological data observed at the outlet of the watershed were calculated using manually delineated area of the watershed.

The land use/cover map was generated through image processing software using satellite image. Area under different land use classes obtained after classification, land use classes include deep water, shallow water upland paddy, lowland paddy, barren land, fallow land, shrubs and settlement. Land use cover number of pixels, per cent of image occupied by each land use classes are given in Table 1 which shows the land use/cover map of the study watershed for the monsoon season of the year 2009. Similar results were reported by Tripathi *et al.* (2001).

Table 1: Area under different land use classes in Sangharinala watershed

Land use class	No. of pixels	Area(ha)	% Image
Deep water	390	5.616	0.10
Shallow water	8404	121.08	2.23
Upland paddy	152742	2199.48	40.58
Low land paddy	150504	2167.26	39.98
Barren land	19371	278.94	5.15
Fallow land	20	0.288	0.005
Shrubs	30993	446.30	8.25
Settlement	13945	200.81	3.71

Table indicates the maximum area (4366.74 ha.) was under paddy, therefore, watershed was considered as agricultural watershed.

Accuracy of image classification was judged after performing the land use/cover classification. A high value of overall accuracy (89.6%) and Kappa co-efficient (Khat) of 0.95 indicated that the land use/cover classification was appropriate for the study watershed. Land use/cover classification was matched well with the land use/ cover actually prevailing in the ground. In many previous studies similar range of classification accuracy and Kappa co-efficient were observed and accepted.

Hydrologic condition of the watershed based on the drainage network. Hydrological soil groups based on the soil properties and antecedent moisture condition (AMC-II) as described by Singh (1994) were considered in the study. This information was then used to get the weighted average curve number for each sub watershed. Weighted average value of curve number for the Sangharinala watershed is found to be 89. The weighted average values of curve number for each sub watersheds are given in Table 2.

Table 2: Sub watershed wise areas and curve no. (CN) value

Sub watershed	Area (ha)	% area	CN value
SW1	345.14	6.33	91.91
SW2	148.67	2.73	87.98
SW3	355.17	6.52	83.40
SW4	934.78	17.15	89.00
SW5	838.88	15.39	89.74
SW6	577.55	10.60	90.00
SW7	385.30	7.08	86.91
SW8	674.36	12.37	90.64
SW9	634.48	11.64	89.60
SW10	555.67	10.19	90.77
Total watershed	5450.00	100.00	89.29

Soil texture map of the Sangharinala watershed was prepared using soil resource data through GISas shown in Fig. 3. Areas under different soil texture were found to be 174.62, 520.20, 711.78 and 4043.40 ha for sandy loam (Bhata), sandy clay loam (Matasi), loam (Dorsa) and clay (Kanhar), respectively.

Water resource development plan was prepared on the basis of integration of information on hydro

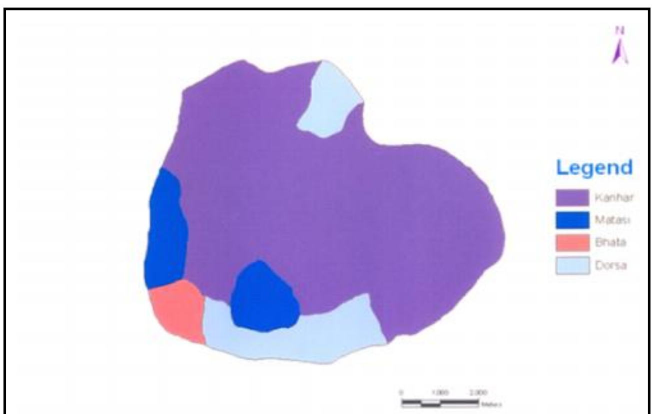

Fig. 3 : Soil texture map of the Sanghari Nala watershed

geomorphological characteristics, surface water availability, land use land cover, drainage present status of ground water utilization and considering the present and long term needs of water in the study area. Conservation management and development of water resources from integral component of the development plant. Suitable conservation measures suggested were farm pond, grassed water way, contour furrow, check dam, rock fill dam, percolation tank, staggered trenching, nalabunding, pasture development and tree plantation. The action plan map of Sangharinala Watershed is shown in Fig. 4. Similar results were reported by Rao *et al.* (1997) and Krishna Murthy *et al.* (2000).

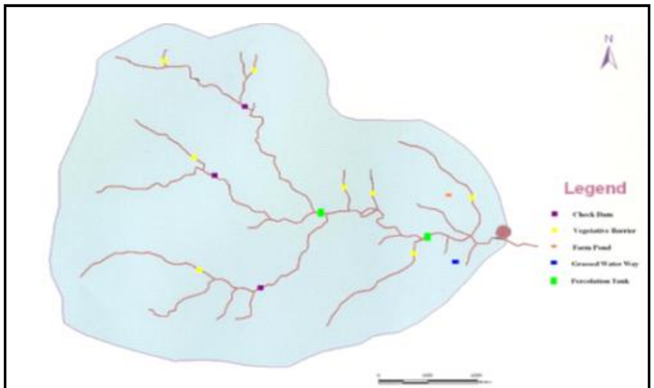

Fig. 4 : Action plan map of the Sanghari Nala watershed

Conclusion:

The elevation of the study area ranged from 270 to 290 m above mean sea level (MSL). The topography of the watershed is almost flat. The average slope of the watershed is 1.5 per cent. Thus, from the study generated various maps including watershed, sub-watershed, boundaries, drainage map,soil map, land use/land cover map, Digital Elevation Model (DEM) of Sangharinala Watershed in GIS environment. It is recommended that water resource development was farmpond, water harvesting techniques, grassed water way, contour furrow, check dam, percolation tank, pasture development and tree plantation.This will also increase the groundwater recharge besides providing supplementary irrigation during *Rabi* season. Farmers should be encouraged with regard to making of farm ponds and soil conservation measures.

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