

REVIEW ARTICLE

Application of Remote Sensing and GIS Techniques in Watershed Management

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ABSTRACT

Watershed is a natural hydrological unit with a definite area and common drainage point. Watershed management is a holistic approach for sustainable management and conservation of natural resources like soil, water and plant, since these resources are under tremendous stress due to ever increasing biotic pressure. Remote sensing (RS) is a science of deriving information about an object from measurements of electromagnetic radiation reflected or emitted from that object. Geographic information system (GIS) is a computer hardware and software system designed to collect, manage, analyze and display geographically (spatially) referenced data. RS & GIS has become an indispensable scientific tool for mapping and monitoring of natural resources, and frequently used in the delineation, characterization and prioritization of watershed for planning.

Key words: Remote Sensing, GIS and watershed

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INTRODUCTION

Satellite remote sensing provides an excellent source of data from which updated land use / land cover (LULC) changes can be extracted and analyzed in an efficient way. In addition, effective monitoring and simulating of the urban sprawl phenomenon and its effects on land-use patterns and hydrological processes within the spatial limits of a watershed are essential for effective land-use and water resource planning and management. Farmers in many areas are using groundwater faster than nature is replenishing it, causing continuous declines in the water levels. In India, as in other developing countries, agriculture accounts for most water use, accounting for as much as 85% of total annual draft. Projections for the year 2025 indicate that all of northwestern India, the southern plateau and south-eastern coastal regions will run into water deficit.

Timely and reliable information on soils with respect to their nature, extent, spatial distribution, potentials and limitations is very crucial for optimal utilization of natural resources on a sustainable basis. Soil surveys provide such information. Remote sensing enables faster and accurate land-use mapping and has proved to be the most efficient and reliable technique to prepare a comprehensive inventory of soil resources and land-use pattern of an area [6].

Remote sensing and GIS, with the integration of socio-economic data is very useful for watershed planning and management, Combined GIS and RS technology is an excellent tool for monitoring land degradation, land use change as well as soil and water resources changes over a space and time. Remote sensing is used for data acquisition on the earth resource whereas GIS is used for data analysis. When these two tools are integrated in the research on watershed management an effective solution is arrived at to solve any complex problem.

Watershed

Watershed is a physical unit in which water from all over the area flows under gravity to a common drainage channel **OR** watershed is defined as a geo-hydrological unit draining to a common point by a system of drains.

Types of watershed

- Macro watershed (> 50,000 ha)
- Sub-watershed (10,000 to 50,000 ha)

- Milli-watershed (1000 to 10,000 ha)
- Micro watershed (100 to 1000 ha)
- Mini watershed (1-100 ha)

WATERSHED MANAGEMENT

Watershed management is a term used to describe the process of implementing land use practices and water management practices to protect and improve the quality of the water and other natural resources within a watershed by managing the use of those land and water resources in a comprehensive manner.

Components of watershed management

- Soil and water conservation
- Water resource improvement
- Alternate land use system

Impact assessment of watershed program through remote sensing and GIS

- [8] Reported that the temporal land use / land cover map of 1997 and 2004 clearly demonstrate that land under cultivation has increased substantially. While there is an upward increase by 5.41% under double cropping, fallow lands have increased marginally by 0.13% as evidenced by both satellite imageries and ground verifications made during the study period. The fallow land in the watershed has increased during the period from 1.08 ha to 3.35 ha. Area under land with scrub and land without scrub have decreased by 4.96 ha and 30.81 ha, respectively during the project period. Whereas *Prosopis juliflora* and sparse *Acacia* spp. Plantation has decreased to the extent of 0.29 ha during the project period.
- These wastelands were reclaimed for productive use by adopting suitable treatment measures like better soil and water conservation practices. Similar results of decreased wastelands were observed. Information on water bodies show that nearly 1.62 ha area (which includes lakes and tanks) has been decreased during the project duration. This is because of underwater harvesting and runoff retention programmes, nala bunds, boulder checks and gully checks have been constructed in the depression.

Geographic information technologies in watershed management

• Remote Sensing (RS)

Remote sensing tool is used for mapping and planning of natural resources.

These techniques have been extensively applicable in nearly all fields of watershed aspects like estimation soil of erosion, rainfall runoff modelling, flood management and irrigation water management.

• Geographic Information Systems (GIS)

The database available in GIS environment facilitates assimilation of different thematic datasets to understand interrelationships

GIS plays an important role in information management, analysis and providing solutions to the planning of natural resources

It is also useful in delineating hydro-morphological units in the area

Need of RS and GIS

- Design and estimate of water harvesting structure
- Location of water harvesting structure
- For watershed delineation
- To improve the socio economic condition through RS and GIS techniques
- Timely and accurate information on spatial distribution

Detailed LRI for crop suitability and land capability classification using RS and GIS

[5] Worked on Lingera-2 micro watershed Yadgir district and traversing were done using cadastral map, SOI toposheet, and IRS LISS IV (5.8 m) merged/Cartosat imagery (2.5 m). Total six soil series and four LCC were derived *viz.*, IIs, Iles, IIles and IVes. The crop suitability for horticulture crops *viz.*, Mango, Sapota, Gauva, Jamun and Custard Apple were derived based on the soil fertility, climatic regime and land quality.

Steps involved in watershed development

• Watershed Delineation

The 8-stage delineation is as follows:

Stage 1

Water Resource Regions (WRR): In all, there are 6 WRRs in India (Watershed Atlas AIS&LUS, 1990), out of which Karnataka is covered by two regions. All drainages flowing into the Bay of Bengal accept the Ganges and the Brahmaputra (4). All drainages flowing into the Arabian Sea accept the Indus drainage (5). Average size of a Water Resource Region is 270-1130 Lakh ha.

Stage 2

Basins: Each WRR is divided into Basins which consists of individual big rivers like Krishna (4D), Cauvery (4B), Godavari(4E) and a combination of smaller ones which are contiguous to each other such as the Basin between the Krishna and the Cauvery(Pennar and Palar-4C), Southern (5A) and North Western Ghats (5B) etc.. Average size of a Basin is 30-300 Lakh ha.

Stage 3

Catchments: Each basin is divided into a number of catchments which mainly pertains to the main tributaries or a group of contiguous small tributaries or individual major streams. For instance, the main tributaries of river Tungabhadra are rivers Tunga and Bhadra and Varada – the confluence of all these three beyond the Tungabhadra reservoir has been considered as Upper Tungabhadra catchment. Average size of a catchment is 10-15(Lakh ha).

Stage 4

Sub-catchment: The catchments are further divided into a number of sub-catchments consisting mainly smaller tributaries and streams and cover an area 2-10 lakh ha

Stage 5

Watershed: Each sub-catchment is divided into a number of watersheds to cover an area of 0.2 - 3 lakh ha.

Stage 6

Sub-watershed: Each watershed is further divided into a number of sub-watersheds having an area in the range of 3000 – 5000 ha.

Stage 7

Mini-watershed: Each sub-watershed is further divided into a number of mini-watersheds ranging in size from 1000 to 3000 ha.

Stage 8

Micro-watershed: Each mini-watershed is further divided into number of micro-watersheds ranging in size from 500 to 1000 ha.

- **Watershed Characterization**

Each watershed shows distinct characteristics, which are so variable that no two watersheds are identical. All the characteristics affect directly or indirectly the disposal of water. Some of the important characteristics include size, shape, slope, drainage, vegetation, geology, soil, climate and land use

- **Prioritization**

Prioritization is a process of identifying areas of main concern based on single or many parameters. Selection of one or few watersheds out of many watersheds by using predefined set of criteria

- **Participatory action plan preparation**

- **Implementation**

- **Address the overall impact on natural resources & socio-economic aspects**

Remote sensing based agricultural drought assessment

- [3] indicated that remote sensing based agricultural drought assessment in Palar basin of Tamil Nadu state, India, showing the distribution of NDVI for paddy, for the years 1998 and 1999, clearly indicated that the vegetal cover in the year 1999 is much less compared to 1998.

- **Synthetic Aperture Radar**

- **Normalized Difference Vegetation Index (NDVI)**

The normalized difference vegetation index (NDVI) is a simple graphical indicator that can be used to analyze remote sensing measurements, and assess whether the target being observed contains live green vegetation or not. $NDVI = (NIR - Red) / (NIR + Red)$

Vegetated areas have a relatively high reflection in the near-infrared and a low reflection in the visible range of the spectrum. Clouds, water and snow have larger visual than near-infrared reflectance. Theoretically, NDVI value ranges from -1.0 to +1.0, in which the maximum value +1.0 suggests the greenest vegetation (Sabins, 2000 and Lillesand and Keifer, 2000).

- **DEM**

Digital elevation model (DEM) is digital representation 3 dimensional information (X, Y, Z) of the continuous topography of the bare earth surface in a particular reference coordinate system.

Characterization and evaluation of soil resources of microwatershed for sustainable land use planning

[2] In Manvi taluk, Raichur district, Karnataka, were studied for their properties and evaluation of soil. The land capability classes and sub classes were arrived at as per the guidelines in Soil Survey Manual (AISLUS, 1971). The criteria used for land capability classification based on soil properties, the soils of Patapur micro-watershed of Manvi taluk have been classified into two land capability classes viz., III and IV. The upland and lowland were grouped under land capability sub-class IVe and IVs, respectively. These

soils were marginally cultivable lands due to severe limitations of erosion limitations. Whereas, midland was classified into two classes III and IV, which are marginally cultivable lands with severe limitations of coarse fragments, moderate drainage, soil characteristic and fertility factor limitations. Majority of the crops were moderately to marginally suitable and few were currently and potentially unsuitable.

Land evaluation of Bhanapur micro-watershed in northern dry zone

A study was undertaken to evaluate five soil series belonging to Bhanapur micro watershed (Koppal district) in northern dry zone of Karnataka for sustainable land use planning. Soil-site suitability evaluation for wheat, cotton, sorghum, sunflower, maize, chilli, pigeonpea, and pearl millet showed that red soils were moderately suitable (S2) for groundnut, marginally suitable (S3) for other crops and not suitable for wheat. The black soils were moderately suitable (S2) for pearl millet and sunflower [4] in Cd contaminated soil samples. Cadmium concentration was significantly reduced from 38.45 mg/kg to 9.16 mg/kg which was 76.2% reduction.

CONCLUSION

- Through remote sensing we get synoptic view, multi-resolution, multi-spectral, repetitive images which offer appropriate method for quick, unbiased mapping and monitoring of natural resources both in space and time domain
- We get timely and accurate information on spatial distribution – land-use, soil, vegetation density, forest, geology, water resources
- GIS and remote sensing technique can be used in watershed management right from delineation, characterization, prioritization, action plan preparation, treatment monitoring and impact assessment
- GIS can be effectively utilized for LCC and soil site suitability mapping. Remote sensing and GIS techniques are the quick, accurate and low cost technologies for watershed planning.

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