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Application of GIS in Watershed Management and Soil-Water Conservation

*Jogeswor Sing[1], Rajib Lochan Panigrahy[1] and Argha Ghosh[2]
[1]PG Scholar, Department of Natural Resource Management, College of Forestry, OUAT, Bhubaneswar-751003, Odisha, India
[2]Assistant Professor, Department of Agricultural Meteorology, OUAT, Bhubaneswar-751003, Odisha, India
*Corresponding Author's email: jogesworsing@gmail.com

Geographic Information System (GIS) is a significant resource for managing watersheds and conserving soil-water resources due to the integration and analysis of spatial information provided through it. The combination of GIS with remote sensing data, DEMs, hydrological models, and multi-criteria decision-making leads to effective ways for watershed delineation, evaluation of soil erosion, analysis of land-use changes, and conservation strategies. Recent studies prove that GIS-based approaches can be used to locate vulnerable areas, prioritize sub-watersheds, calculate soil loss, and determine appropriate soil and water conservation structures. Hence, GIS helps achieve sustainable watershed planning and management of natural resources.

Keywords: GIS, watershed management, soil conservation, water conservation, remote sensing, soil erosion, RUSLE, spatial analysis.

Introduction

Management of the watershed refers to the holistic management of soil, water, vegetation, and land resources in a catchment area. With an increase in land use change, deforestation, intensification of agriculture, soil erosion, and climate change, there is a great need for scientific watershed planning. The GIS can serve as an efficient tool for combining information on topography, climate, soils, hydrology, and land use. The advancements in remote sensing technology and GIS have enhanced the spatial and temporal analysis of precipitation, runoff, evaporation-transpiration, erosion, groundwater, and water quality. (Patel et al., 2026)

GIS Applications in Watershed Management

GIS has been widely employed in the delineation and morphometric analysis of watersheds using DEMs. Variables such as elevation, slope, aspect, drainage density, stream order, basin morphology, relief, and hypsometry can be estimated using GIS. The identification of regions with high erosion risk and prioritization of sub-watersheds for intervention can be achieved using these variables. It was shown by Sharma and Mahajan (2020) that morphometric and hypsometric analysis of Himalayan sub-watersheds using GIS and remote sensing can effectively prioritize sub-watersheds for soil and water conservation. Likewise, GIS-based multi-criteria analysis can help identify crucial sub-watersheds that require priority treatment. (Sharma & Mahajan, 2020). Another significant application is that of soil erosion evaluation and prioritizing watersheds. GIS can be used to analyze rain erosion capacity, soil erodibility, slope length and gradient, vegetative cover, and other aspects of land management to predict soil erosion loss spatially. The Revised Universal Soil Loss Equation (RUSLE) in combination with GIS and remote sensing is extensively applied for identifying erosion-

prone areas. Using GIS, remote sensing, and RUSLE, Ghosh et al. (2022) studied the Mayurakshi River Basin of eastern India to generate spatial classes of soil erosion risk. The same approach was adopted by Singh et al. (2023) for evaluating watershed erosion under varying rainfall and land-cover scenarios.

GIS for Soil and Water Conservation

Site selection and prioritization of soil and water conservation techniques such as contour bunds, terraces, check dams, farm ponds, gully plugs, vegetative barriers, and afforestation are among the many applications of GIS. Analysis for suitability involves slope, soil type, drainage, rainfall, land use, runoff probability, and erodibility among other factors. According to recent studies, spatially oriented planning for conservation has been found effective in identifying critical source areas and increasing the efficiency of watershed management (Singh et al., 2023). GIS has the ability to use satellites for assessing the effectiveness of the measures using vegetation cover and soil moisture. (Ali et al., 2020). It is also now common to combine GIS with hydrological models, machine learning tools, cloud computing, and high-resolution satellite imagery. Current GIS-supported research into watersheds makes use of systems like Google Earth Engine, and hydrological models such as SWAT and HEC-HMS in order to conduct assessments on runoff, sedimentation, groundwater, flooding, and the effects of land use. While the combination of multiple remote-sensing datasets with GIS and hydrological models has enhanced the assessment of watersheds, uncertainties, data quality issues, calibration, and scaling have remained relevant challenges. (Patel et al., 2026)

Conclusion

GIS is now considered a crucial decision-support tool in the sustainable management of watersheds and soil-water conservation. It is possible to delineate watersheds accurately, identify erosion risks, prioritize sub-watersheds, analyze land uses, and select conservation sites due to its ability to integrate spatial data. Incorporating GIS with remote sensing, RUSLE, digital elevation models, hydrological modeling, and artificial intelligence techniques will further enhance the process of managing watersheds and monitoring them. Future applications should focus on high-resolution data, field verification, uncertainty analysis, participatory GIS, and climate change scenarios. (Patel et al., 2026)

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