MODELLING IMPACTS OF LAND USE LAND COVER AND CLIMATE CHANGES ON RUNOFF AND SEDIMENTATION IN THE UPPER JHELUM BASIN

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Abstract

Changes in Land Use Land Cover (LULC) patterns and climate variability significantly impact the hydrological processes and sediment dynamics within river basins. In the Himalayan region, the Upper Jhelum Basin has experienced rapid LULC modifications due to urbanization and deforestation, highlighting the need for an integrated analysis of hydrology and sedimentation. The Indicators of Hydrologic Alteration (IHA) framework was applied in this study to evaluate flow pattern variations from 1960 to 2022. The Soil and Water Assessment Tool (SWAT) was utilized to model the impacts of LULC changes and climate variability on runoff and sediment yield. Historical and projected LULC datasets were analyzed to evaluate their influence on runoff coefficients and hydrological responses. Rainfall erosivity (R) was evaluated using outputs from six General Circulation Models (GCMs) within the (Coupled Model Intercomparison Project) CMIP6 framework under two Shared Socioeconomic Pathways: SSP245 and SSP585. GIS-based modeling techniques and the Revised Universal Soil Loss Equation (RUSLE) were employed to estimate soil erosion patterns and specific sediment yield (SSY). Spatial and temporal variations of RUSLE parameters were analyzed alongside climate projections, and the sediment delivery ratio (SDR) was calculated to evaluate sediment transport dynamics across the watershed. Additionally, SWAT modeling was used to simulate hydrological processes, providing a comprehensive assessment of runoff and sedimentation patterns under future climate and LULC scenarios. The findings indicate a significant increase in soil loss from 2020 to 2090, with peak erosion rates reaching 71.67

t/ha/yr under the SSP585 scenario. SWAT simulations demonstrate that rapid urbanization has led to increased runoff and altered hydrological flow regimes, intensifying flood risks and sediment deposition. The estimated sediment yield trends suggest a progressive increase in sedimentation, significantly affecting water resource management and reservoir storage capacity. Both mid-term (2050) and long-term (2100) projections highlight escalating erosion risks, pointing out the urgent need for sustainable watershed management strategies. This study introduces a comprehensive framework that combines climate variability, LULC transitions, and hydrological modeling to generate critical insights for managing flood risks and controlling sedimentation in the Upper Jhelum Basin. The results provide a scientific foundation for policymakers and water resource planners to develop adaptive strategies to address the effects of climate change and LULC changes on regional hydrology. This study is the first in-depth investigation focused on the Jhelum Catchment.