Assessing the impact of land use changes on runoff in the upper Danube River Using the SWAT Model

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# Abstract

Based on the SWAT (Soil and Water Assessment Tool) distributed hydrological model, this study quantitatively assesses the impacts of land use change on runoff in the Upper Danube River Basin, aiming to reveal the human-water relationship in a typical watershed of the climatic transition zone in Central Europe and to simulate hydrological responses to different environmental changes by means of a scenario analysis approach. Taking the upper Danube as a case study area, the study proposes the following core research questions for the evolution of land use pattern caused by rapid urbanization, agricultural expansion and ecological protection policies in the basin: (1) validation of the adaptability of the SWAT model for runoff simulation in watersheds with complex topography; (2) impacts of land use changes on runoff spatial-temporal heterogeneity; and (3) patterns of variability of hydrological responses at different time scales. The study will integrate 30m resolution DEM, FAO soil database, daily meteorological data (temperature, precipitation, wind speed) from 1990 to 2020, and measured runoff data from hydrological stations. SWAT-CUP and SUFI-2 algorithms will handle sensitivity analysis, calibration, and validation, with accuracy evaluated using R², NSE, and PBIAS. The study hypothesizes that land use change dominates runoff change by changing infiltration rate and evapotranspiration process. Based on the historical land use evolution trend and future prediction, three scenarios of natural vegetation restoration, agricultural intensification and urban expansion are set to simulate the runoff response of the upper Danube River. ArcGIS maps will visualize runoff change hotspots and thresholds across scenarios. This study deepens the multi-scale land use-hydrology coupling mechanism and can be used to optimize land use planning.

# Keywords

Hydrologic modeling, runoff simulation, Water resources management, ArcGIS