

# Groundwater simulation and recharge impact on availability in the Yamuna-Krishni interfluve region

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Groundwater serves as a critical source of water for agricultural, domestic, and industrial purposes in the western part of Uttar Pradesh, India. In recent decades, rapid population growth has led to a significant increase in groundwater extraction, causing aquifers to suffer due to inadequate water resource management practices. Understanding groundwater recharge, flow behaviour, and yearly variations in recharge is essential to assess groundwater potential. The present study employs the hydrological Soil and Water Assessment Tool (SWAT) model to estimate recharge in the Yamuna-Krishni interfluve region. The SWAT model was calibrated and validated using evapotranspiration (ET) data, achieving coefficient of determination ( $R^2$ ), Nash-Sutcliffe efficiency coefficient (NSE), percent bias ( $P$ -bias), and root mean standard deviation ratio (RSR) values of 0.75, 0.61, 7.0, and 0.52 during the calibration period, and 0.62, 0.53, 6.8, and 0.49 during the validation period, indicating satisfactory model performance. Groundwater flow modelling was carried out using Visual MODFLOW, based on the estimated recharge and geological data of the present study area. This model was also calibrated and validated with observation well head data, yielding correlation coefficients of 0.98 for the calibration period and 0.97 for the validation period. Additionally, the study examined the impact of a 20% uncertainty in recharge under different scenarios to predict aquifer responses. The recharge was estimated at approximately 170 mm/year, and the projected drawdown in the study region could reach approximately 13.42 m by 2027 under a scenario. The findings of the present study provide valuable insights for developing sustainable water resource management strategies to optimise groundwater use for agricultural, domestic, and industrial purposes.

**Keywords:** ArcSWAT model, groundwater, recharge, sustainability, Visual MODFLOW.

published report by the Department of Drinking Water and Sanitation, 'ensuring drinking water security in rural India', Ministry of Rural Development, GoI (2009), it is stated that 85% of potable water provision is sourced from groundwater reservoirs. The pressing issue of ensuring access to drinking water during periods of scarcity arises from several factors, including the excessive extraction of groundwater for agricultural and industrial use, which depletes available drinking water resources. The depletion of groundwater has presented a challenging task in the current scenario, requiring effective measures for its management and conservation. To address this, several models have been established to simulate groundwater flow and serve as a decision support framework<sup>1</sup>. Groundwater management involves quality and quantity considerations in addition to effective resource management<sup>2</sup>. A hydrogeological model functions as an accurate representation of the real groundwater system, depicting specific conditions. Groundwater models can predict the system's future behaviour under steady conditions or in the event of changes<sup>3</sup>. They can be simple, using one-dimensional analytical approaches, or advanced and complicated, using a three-dimensional multi-layer model.

Groundwater levels are declining as a result of fast population growth and subsequent overexploitation. Traditionally, groundwater and surface water were managed independently<sup>4</sup>. However, it has become a rising tendency to study the engagement of surface water factors such as lakes, streams, and rivers with groundwater<sup>5</sup>. It is imperative to look into the groundwater system's modelling, storage capacity, recharge, and withdrawal rates in light of the current reduction in groundwater levels. Developing strategies requires an awareness of the connection between surface water bodies and the aquifer. The reliability of models can be assessed through the evaluation of recharge patterns over space and time. A study employed an optimisation method within a calibrated simulation model to analyse the pattern of groundwater flow<sup>6</sup>. Furthermore, another study carried out an optimised management of groundwater extraction in Lucknow city<sup>7</sup>.

Abdulla *et al.*<sup>8</sup> conducted groundwater system modelling for the Arwa basin, Palma and Bentley<sup>9</sup>