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Groundwater recharge estimation through unsaturated zone modelling

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Abstract: Globally, groundwater is an important source of freshwater, especially for those areas which suffer from poor quality or a scarcity of surface water. The southern part of Bangladesh, adjacent to the Bay of Bengal, faces water quality issues for irrigation. Around 30% of the country's population lives in the area; many of whom have difficulty accessing fresh water for irrigation resulting in lower cropping intensity than elsewhere in the country. With the rapid growth of population and expansion of agriculture with different cropping patterns, groundwater withdrawals are exceeding recharge which is highly unsustainable. Less recharge will reduce fresh groundwater availability in the future which eventually will affect water quality. Along with human interference, rainfall variability and change in daily weather pattern changes recharge which is a concern for the future sustainability of existing groundwater resources.

Several studies have examined water resource management issues in the coastal zone of Bangladesh. However, recharge estimation is very limited in the southwest coastal region. This study considers land use, cropping pattern and climatic variability to estimate groundwater recharge for the southwest part (Satkhira) of Bangladesh. In this area, irrigated agriculture is the dominant land use and rice-based crop patterns are practiced by farmers. The most widely used pattern – Boro rice-Fallow-Aman rice is considered for this research.

We hypothesis that estimation of recharge using modelling techniques with the physical representation of the system will help in effective groundwater management. Water movement in the vadose zone is primarily vertical (i.e., one-dimensional). The one-dimensional Hydrus-1D software package (Simunek 2008) was used for unsaturated zone modelling. This model has been used in many countries, including Bangladesh (e.g., Roy et al. 2020), with researchers considering it an effective tool to assess potential groundwater recharge. Daily weather data have been used to estimate reference crop evapotranspiration and irrigation water requirement using FAO CROPWAT 8.0 (FAO, 2009); then crop ET was used as input for HYDRUS-1D.

Estimated groundwater recharge rates range from 73.7 to 537.1 mm/yr (average 370.9 mm/yr) which is 3-24% of total rainfall plus irrigation, and 4-29% of total rainfall. This variable recharge rate is due to rainfall variability and amount of seasonal rainfall. Rainfall is the main source of groundwater recharge simulated during monsoon and post-monsoon periods whereas some recharge from the Boro season might result from irrigation. The fallow season (modelled as a small grass in the field) results in more recharge than crop (Boro and Aman rice) seasons because it covers the full monsoon period and that crops return more water to the atmosphere via more transpiration than no crop/small grass during the monsoon period. The results of this study will help to investigate groundwater level changes and future scenarios development for saturated zone modelling and would contribute to planning groundwater management in other areas with similar climate and agriculture pattern.

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