ABSTRACT

The present study aims at assessing groundwater scenarios at different scales. Three different scales (basin, regional and local) were considered for assessment of groundwater variation. Basin scale study was carried out at Indo-Gangetic basin. Space-time cokriging was carried out using GRACE (Gravity Recovery And Climate Experiment; spatial resolution : $1^\circ \times 1^\circ$) and TRMM (Tropical Rainfall Measuring Mission; spatial resolution: $0.25^\circ \times 0.25^\circ$) data as secondary variables for generating groundwater scenario at basin scale ($0.25^\circ \times 0.25^\circ$). Scenarios were predicted for pre-monsoon 2005 and 2008. However, post-monsoon study produced inferior quality results. Regional scale study at GRACE pixel level ($1^\circ \times 1^\circ$) was undertaken to capture the temporal (including seasonal) variation at individual well level. GRACE, precipitation ($1^\circ \times 1^\circ$) and soil moisture ($0.5^\circ \times 0.5^\circ$) data were utilized as predictor variables. Predictor variables at different monthly lags (zero to 3-months' lag) were correlated to groundwater level data at individual wells. Three machine learning techniques - Support Vector Regression (SVR), Random Forest Method (RFM) and Gradient Boosting Mechanism (GBM) were used in the temporal analysis. SVR models outperformed other models for most of the cases. Temporal prediction was also carried out for wells at local scale, i.e., wells within a city (Kanpur city) within one GRACE pixel. Efficacy of remotely-sensed data was evident from the results obtained at both regional and local scales. Groundwater level variation alone cannot ascertain the groundwater potential/vulnerability zones. Therefore potential zone and vulnerability zone identification studies were taken up at local scale (Kanpur city). Potential zone identification considered both quantitative and qualitative aspects. Land Use/Land Cover (LULC), soil, geology, recharge rate, drainage density, rainfall, slope, elevation, normalized difference vegetation index (NDVI), depth to groundwater table were considered as quantitative influencing features and alkalinity, total dissolved solids, magnesium and fluoride were taken as qualitative influencing features. Groundwater Potential Index (GWPI) and Water Quality Index (WQI) maps were prepared using AHP (Analytic Hierarchy Process). The

maps were used together to identify potential zones. Sensitivity analysis of the influencing features was conducted to identify most sensitive features in potential zone mapping. DRASTIC (Depth to water table, Recharge rate, Aquifer media, Soil media, Topography, Impact of vadose zone and hydraulic Conductivity) was used for vulnerability zone assessment in the city. DRASTIC weights required modification to consider variations at local scale. Entropy information method, Fuzzy pattern recognition method and Single parameter sensitivity analysis were used to modify DRASTIC weights. Effectiveness of the weight modification methods were judged by conducting grey incidence analysis between DRASTIC outputs and water quality parameters, (i.e., alkalinity, TDS and magnesium). The method which got the highest incidence value was considered as the most effective method in assessing vulnerable zones within the city. The present Thesis developed a methodology which used space-time geostatistics with satellite-derived data to assess groundwater variation scenario in a data scarce basin. Machine-learning techniques were used to identify the efficacy of GRACE data at sub-basin scale. Unique attempt to identify groundwater potential zones based on both quality and quantity aspects was made. Grey incidence analysis was used for effectiveness evaluation of subjective and objective weighting DRASTIC methods. The present study developed different generic methodologies which can be used *a priori* taking up any specific groundwater research.

Keywords: *Space-time cokriging, multi-resolution data, machine learning algorithms, multi-scale groundwater scenarios, potential zone, vulnerability zone, grey incidence analysis.*