ABSTRACT

Overdraft disturbs the natural recharge-discharge equilibrium and thereby produces declining groundwater levels leading to freshwater crisis, land subsidence and saltwater intrusion worldwide. In developing countries like India, such problems remain silent until they have large impacts. Consequently, these problems are gradually becoming severe. The Balasore coastal groundwater basin in Orissa, India is no exception and is plagued with overdraft problems. The overexploitation resulted in abandoning many shallow tubewells in the basin. Thus, the sustainability of the groundwater resources in this basin is questionable. The present study deals with the detailed hydrologic and hydrogeologic analyses of the coastal basin, development of an integrated simulation optimization model for the basin and the formulation of management strategies using the developed simulation-optimization model. The integrated simulation-optimization model includes a two-dimensional groundwater flow and transport simulation model, a hydraulic management model for optimizing the pumping schedule, and a land and groundwater allocation model for determining optimal cropping patterns, corresponding gross irrigation requirements and the net annual return. The hydrologic and hydrogeologic analyses indicated that for normal and dry years, the gross annual irrigation requirements for the existing cropping pattern are 32% and 178% greater than the safe yield of the second aquifer, respectively, while the present groundwater withdrawal for irrigation is 71% more than the safe yield. The regression analysis of monthly rainfall, river stage and the corresponding groundwater levels revealed that though the river seepage and rainfall are two major sources of recharge to the basin, the first source is more significant. The second aquifer is severely contaminated by seawater intrusion within a 4-5 km wide tract along the cost, leaving groundwater unfit for drinking and irrigation purposes. The second part of the study focused on the development of a 2-D groundwater flow and transport model of the basin using the Visual MODFLOW package for analyzing the aquifer response to various pumping strategies. The simulation model was calibrated and validated satisfactorily. Using the validated model, the groundwater response to five pumping scenarios under existing cropping conditions was simulated. The results of the sensitivity analysis indicated that the Balasore aquifer system is more susceptible to the river seepage, recharge from rainfall and interflow than the horizontal and vertical hydraulic conductivities and specific storage. A hydraulic management, and a land-cum-groundwater allocation model were developed, which were integrated with the simulation model to obtain optimal cropping patterns and optimal pumping schedules for normal, wet and dry years. The modelling results suggested that by maintaining the groundwater level within desired limits and by adopting optimal cropping patterns and optimal pumping schedules, the net annual returns from the basin can be increased to 257, 167 and 112% during wet, normal and dry years, respectively. The sensitivity analysis of the land-cum-groundwater allocation model shows that the price of products, availability of water and land, and the cost of cultivation are the most sensitive parameters affecting cropping pattern and the net return from the basin. Finally, based on the modeling results, salient management strategies have been formulated for the Balasore basin to ensure sustainability of vital groundwater resources. The adoption of optimal cropping patterns and optimal pumping schedules, coupled with on-farm rainwater harvesting is strongly recommended for the basin for the sustainable management of groundwater resources. Encouraging results of this study show their implementation as an effective tool for the Balasore basin.

Keywords: *Coastal basin, Eastern India, LINGO, optimal cropping pattern, optimal pumpage, overdraft, seawater intrusion, simulation-optimization modeling, Visual MODFLOW.*