ABSTRACT

The prevailing rice-dominated cropping system in the Hirakud canal command (eastern India) is under severe threat due to imbalance between irrigation water supply and demand. The canal water supply, which is the only source of irrigation, is just adequate to meet the irrigation requirement of non-monsoon crops only at 10% probability of exceedance (PE) of rainfall and canal water availability, whereas irrigation requirement exceeds the canal water availability by around 700 million m^3 at 90% PE level. On annual basis, the canal water supply is able to meet only 54% of the irrigation demand at 90% PE level. Hence, in order to mitigate the irrigation water deficit, groundwater is considered as a supplemental source. Quasi-three-dimensional groundwater flow simulation modelling by the Visual MODFLOW was undertaken to detect the change in hydraulic head due to transient pumping stresses. The simulation model was calibrated and validated satisfactorily. Sensitivity analysis indicated that the groundwater recharge is most sensitive to the model solution followed by the aquifer hydraulic conductivity. Enhanced pumping scenarios showed that groundwater extraction can be increased up to 50 times of the existing pumping, without causing any adverse effect to the aquifer but still it is not sufficient to supplement the irrigation water deficit. Hence, combined simulation-optimization modelling was undertaken to determine the maximum permissible groundwater pumpage. An optimal land and water resources allocation model was then developed to determine the optimal cropping pattern realizing the maximum net annual return. The modelling results suggested that the net annual returns from the area can be increased by 51.3 and 12.5% at 10 and 90% PE levels, respectively, by adopting optimal cropping patterns and optimal pumping strategies. The sensitivity analysis of the model indicated that the variation in the market price of crops has a great influence on the optimal solution followed by the cost of cultivation and cultivable area. Finally, different future scenarios of land and water use were formulated for the command area. The adoption of optimal cropping patterns and optimal pumping strategies is strongly recommended for sustainable management of available land and water resources of the canal command.

Keywords: eastern India, LINGO, optimal land and water resources allocation, optimal pumpage, probability of exceedance, sensitivity analysis, simulation-optimization modelling, Visual MODFLOW