ABSTRACT

Most of the major irrigation projects in developing countries, including India, operate at a low overall efficiency, and thus, are unable to achieve their design targets. In India, though irrigation sector has remained the single largest user of water, with increasing municipal and industrial needs, its share of water use is likely to go down. Thus, in future, irrigation has to become efficient and produce more per unit volume of water. This realization has forced the policy makers and researchers to devote their efforts on improving performance of complex irrigation systems. In India, lack of financial resources and infrastructure are a major obstacle for physical/structural development, thus, efficient operation and management of the system is the only feasible alternative. Further, it has also been realized that the operation and management of the main system is vital compared to tertiary level management.

In recent years, several canal hydraulic models have been developed. However, most of these models stress on the solution approach, user friendliness and graphical features but fail to address the problem of decision making regarding optimal canal release. Moreover, these models concentrate exclusively on the hydraulic aspect of the canal system and do not take the hydrology of the irrigated command into account. This study, therefore, focuses on developing an integrated opti-simulation model consisting of an optimisation module to optimise the canal release, a hydraulic module to simulate the flow in the canal system and a hydrological module to simulate the command hydrology. A nonlinear, constrained multivariable optimisation routine is developed and linked to the canal hydraulic model (MIKE 11) and command hydrological model (MIKE SHE). Optimisation routine is solved using the Sequential Quadratic Programming (SQP) algorithm. Effort is also made to develop an improved rotational delivery schedule based on the analysis of long-term field data.

The integrated opti-simulation model is applied to the Right Bank Main Canal System of Kangsabati Irrigation Project, West Bengal, India. Simulations are performed for Kharif irrigation periods of three different years (1995-1997). Three-simulation scenarios are considered here. These are (i) MIKE 11 and MIKE SHE Simulation (MMS), (ii) Integrated Opti-Simulation (IOS), and (iii) Integrated Opti-Simulation with Improved Schedule (IOS_IS). Five inline structures, including the head regulator at the system source, are selected as the time controlled structures, i.e., the optimisation routine optimises the canal releases at these structures.

The hydraulic and hydrological models are calibrated and validated independently, and the results are found to be satisfactory. Several alternative varied rate rotation schedules are compared and the one having three irrigations of 20 to 21 days each, followed by 20 days of canal closure, with irrigation start date of 11th July, is found to be the best.

The inter-comparison of the three simulation scenarios showed that the application of the integrated opti-simulation model reduced the gap between supply and demand and improved the spatial distribution of supply, thereby, minimizing the tail-end deprivation. Application of the integrated opti-simulation model reduced the average deficit volume at the system source by 36.1%. Similarly, application of the opti-simulation model in conjunction with improved schedule reduced the average deficit volume at the system source by 36.8%. Further, the values of the three performance indicators, i.e., adequacy, equity and dependability improved significantly with the application of integrated opti-simulation model and the improved delivery schedule. Encouraging results of integrated opti-simulation model and improved delivery schedule, therefore, show the potential for their implementation as a cost effective tool for improved performance of the large irrigation systems, within the existing infrastructure.

KEY WORDS

Large Irrigation System, Opti-Simulation Model, Hydraulic Model, Hydrological Model, Nonlinear Optimisation, Calibration, Validation, Delivery Schedule, Performance Evaluation