SIMULATION OF RESERVOIR OPERATION IN A MULTI RESERVOIR SYSTEM

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Abstract

The present study aims to apply simulation software MIKE Basin for the operation of reservoirs of Mahanadi Reservoir Project (MRP) Complex. MRP complex is a multipurpose multi-reservoir system. Simulation is a technique by which we emulate the behavior of a system. Simulation is a very powerful technique in analyzing most complex water resource system in detail for performance evaluation. Reservoir operation study has been done for data of 34 years. The results extracted from the study indicated that the performance of simulation model MIKE Basin is satisfactory.

Key words: Reservoir operation, MRP complex, Simulation, MIKE Basin.

Introduction

A Reservoir operation policy is a sequence of release decision in operational periods (such as months), specified as a function of the state of the system. The state of the system in a period is generally defined by the reservoir storage at the beginning of a period and the inflow to the reservoir during the period. Once the operation policy is known, the reservoir operation can be simulated in time with a given inflow sequence. The complexities of a multipurpose multi-reservoir system generally require release decisions to be determined by an optimization or simulation model. Extensive literature review of the subject of optimization of reservoir operations reveals that there is no general algorithm exists for all the systems. The choice of the method depends on the characteristics of the reservoir system being considered, on the availability of data, and on the objectives and constraints specified (Yeh, 1985). A comprehensive study of various simulation models was presented by Wurbs (1993). Models were compared from a general overview perspective, with emphasis on practical application. Labadie (2004) presented a review to assess the state-of-the-art in optimization of reservoir system management and operations and consider future directions for additional research and application. Simulation is a technique by which we imitate the behavior of a system. Simulation is a very powerful technique in analyzing most complex water resource system in detail for performance evaluation. In many situations, however, decision makers would be interested in examining a number of scenarios rather than just looking at one single solution that is optimal. For multi-reservoir operation problem simulation technique is used (Vedula and Mujumdar, 2006). The MRP Complex is a multi-reservoir system, hence it has been decided to use simulation technique for operation of the reservoirs of this system. Simulation software MIKE BASIN has been used for analysis in this work. MIKE BASIN has extensive reservoir modeling capabilities, and accommodate multi-purpose reservoirs and multiple reservoir systems. Application of MIKE BASIN for water management strategies in a watershed of Mun River Basin located in Northeast Thailand was reported by Jha and Gupta (2003). Nishat and Rahman (2009) demonstrated a modeling effort to set up a water resources management model, MIKE BASIN, over the Ganges, Brahmaputra, and Meghna (GBM) river basins, India.

Mahanadi Reservoir Project (MRP) Complex

The Mahanadi Reservoir Project (MRP) Complex is situated in Dhamtari District of Chhattisgarh state in India. MRP Complex consists of Mahanadi basin and Pairi basin. This project comprises of four reservoirs namely Ravishankar Sagar Reservoir, Murumsilli Reservoir and

Dudhawa Reservoir in Mahanadi basin and Sondur Reservoir in Pairi basin. Ravishankar Sagar Reservoir is constructed across Mahanadi river, Dudhawa reservoir is situated on upstream of Ravishankar Sagar Reservoir on Mahanadi river and Murumsilli Reservoir is constructed across Silliyari river a tributary of Mahanadi river on upstream of Ravishankar Sagar Reservoir. Sondur reservoir is situated at the upstream of Dudhawa reservoir and constructed across Sondur river in Pairi basin. Sondur and Dudhawa reservoirs are connected by an interbasin link canal called Sondur Feeder canal. This interbasin link canal transfer water from Sondur reservoir in Pairi basin to Dudhawa reservoir in Mahanadi basin. Sondur feeder canal feed water to Dudhawa reservoir as well as it irrigates some command area. There is no direct irrigation through Dudhawa and Murumsilli reservoirs, they feed water to Ravishankar Sagar reservoir. The MRP Complex is intended to provide irrigation and to meet municipal and industrial demands of Bhilai Steel Plant (BSP) and its township. Thus Mahanadi Reservoir Project Complex is a multipurpose multi-reservoir system. The index map of MRP Complex is shown in Figure 1.

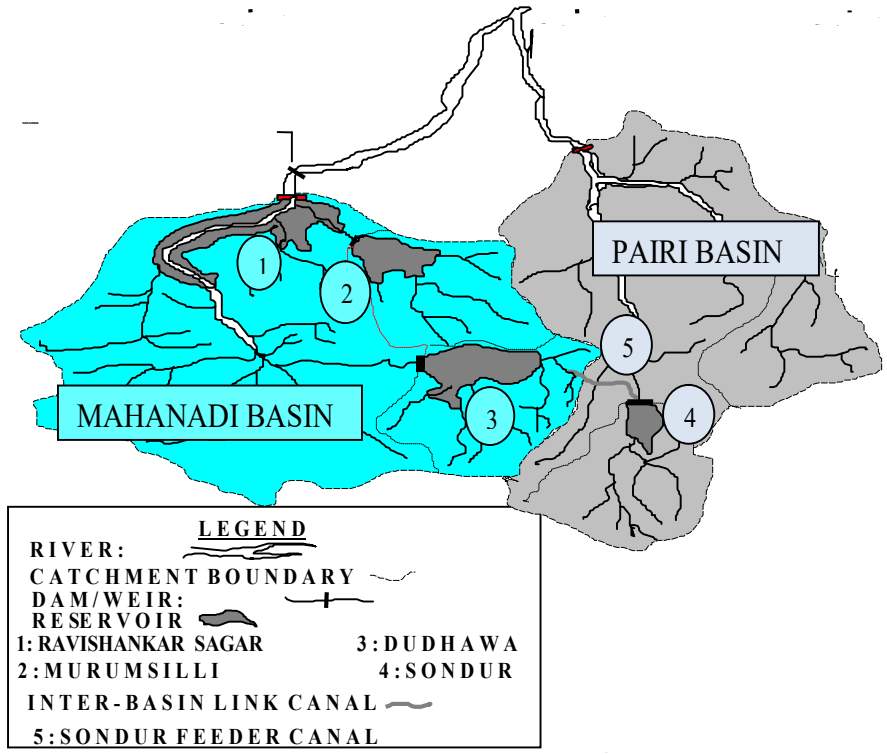


Fig. 1: Index Map of Mahanadi Reservoir Project (MRP) complex.

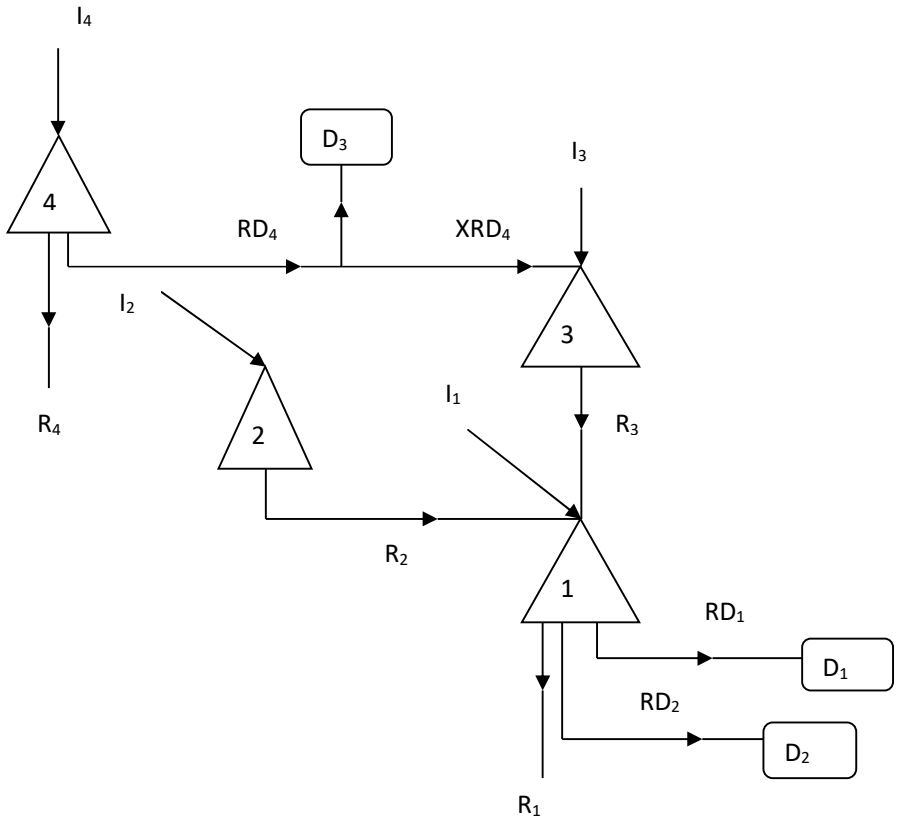
Methodology

This paper deals with the application of simulation software "MIKE BASIN" for operation of reservoirs of MRP complex. The following priority order on the utilization of storage of MRP system has been used in the model as per the recommendation of Government-

(i) First priority has been given to municipal and industrial use.

(ii) Second priority has been given to Irrigation demand for Kharif and Rabi season.

In MRP complex, Ravishankar reservoir is connected with two upstream reservoirs Murumsilli and Dudhawa and there is inter basin transfer of water from Sondur reservoir to Dudhawa reservoir. The schematic diagram of MRP complex has been shown in Figure 2. For different need water is supplied through Ravishankar reservoir only, hence Dudhawa and Murumsilli reservoirs are feeder reservoirs. Sondur reservoir feed water to Dudhawa reservoir as well as it irrigates some command area.



Reservoir △	**Release in canal**	**Demand** ▭
1. Ravishankar	RD_1- Mahanadi feeder canal	D_1- Mahanadi feeder
2. Murumsilli	RD_2- Mahanadi main canal	canal demand
3. Dudhawa	RD_4- Sondur feeder canal	D_2- Mahanadi main
4. Sondur	**Release from reservoirs**	canal demand
Inflow to reservoir	R_1- from Ravishankar	D_3- Sondur feeder
I_1- Ravishankar	R_2- from Murumsilli	canal demand
I_2-Murumsilli	R_3- from Dudhawa	
I_3-Dudhawa	R_4- from Sondur	
I_4-Sondur		

Figure 2: Schematic representation of MRP-Complex

By observing the Figure 2, it is clear that there is only one way of supplying water from Sondur to Dudhawa but there are three possible ways of supplying water from Murumsilli and Dudhawa reservoirs to Ravishankar Sagar reservoir. These three ways of supplying water has been simulated in MIKE BASIN software and designated as three models. These three models are:

(i) **Model-I:** In this model Murumsilli reservoir has been given first priority and Dudhawa has been given 2nd priority to feed water to Ravishankar reservoir.

(ii) **Model-II:** In this model Dudhawa reservoir has been given first priority and Murumsilli has been given 2nd priority to feed water to Ravishankar reservoir.

(iii) **Model-III:** In this model Murumsilli and Dudhawa have been given equal priority to feed water to Ravishankar reservoir.

To make the models more efficient the following additional conditions have been incorporated in the models.

(a) At Ravishankar reservoir the priority of downstream users have been fixed as follows:
   (i) M & I demand have been given first priority.
   (ii) The irrigation demand of Mahanadi feeder canal (MFC) has been given second priority.
   (iii) The irrigation demand of Mahanadi Main Canal (MMC) has been given third priority.

(b) At Sondur reservoir the first priority has been given to supply water for irrigation and second priority to supply water to the Dudhawa reservoir.

The above three models have been simulated in MIKE BASIN. To find the optimum model, the annual deficit between demand and supply for different users has been computed for each model. The model having least value of deficit for a specified duration will be the optimum model. Annual deficit was found minimum in model-I, hence this is the optimum model.

Results and Analysis

The Model-I (optimum model) has been used for operation of reservoirs of MRP Complex. For starting period of operation the initial storage in the reservoirs is taken as their corresponding dead storages. Model-I is applied to MRP system with data of 34 years (1975 – 2008). The monthly operation policy for individual year is determined using the simulation model-I. The reservoirs were considered at the dead storage level at the beginning of June in the year 1975. The monthly deficit between demand and supply have been computed and summed up for each year to determine the total yearly deficit. The results have been shown in Table 1. It is observed from Table 1 that for most of the year the deficit is less than 10%. In water resources less than 10% deficit is not considered as deficit (Verma, 2000). Out of the 34 years only 4 years have the deficit more than 10%, hence the performance of simulation Model-I for operation of reservoirs of MRP complex is satisfactory.

Table 1: Yearly Deficit in Model-I

SN.	Year	% Yearly deficit
1	1975	1.54
2	1976	0
3	1977	0
4	1978	0
5	1979	7.23
6	1980	1.36
7	1981	0
8	1982	0
9	1983	1.28
10	1984	0
11	1985	0
12	1986	0
13	1987	0
14	1988	15.78
15	1989	12.85
16	1990	2.70
17	1991	0
18	1992	0
19	1993	7.33
20	1994	1.55
21	1995	1.85
22	1996	3.42
23	1997	0
24	1998	1.26
25	1999	7.93
26	2000	1.64
27	2001	10.64
28	2002	0.43
29	2003	11.29
30	2004	4.33
31	2005	0
32	2006	0
33	2007	0
34	2008	0

Conclusions

In this paper simulation software "MIKE BASIN" has been used for operation of reservoirs of MRP complex. For operation of reservoirs of MRP Complex three Models have been identified. In Model-I, Murumsilli reservoir has been given first priority and Dudhawa has been given second priority to feed water to Ravishankar reservoir. In this work for reservoir operation Model-I has been selected because it is the optimum model. From the analysis of the results of reservoir operation it is found that for most of the year the deficit is less than 10%, hence the performance of simulation Model-I for operation of reservoirs of MRP complex is satisfactory.

References

1. Jha, M. K. and Gupta, A. D. (2003), "Application of MIKE BASIN for Water Management Strategies in a Watershed", Water International, Vol. 28., No.1, 27-35.
2. Labadie, John W. (2004), "Optimal Operation of Multireservoir System: State-of-the-Art Review", Journal of Water Resources Planning and Management, Vol.130, No.2, 93-111.

3. Nishat, B., and Rahman, S .M., 2009, "Water Resources Modeling of the Ganges-Brahmaputra-Meghna River Basins Using Satellite Remote Sensing Data", Journal of the American Water Resources Association, Vol. 45, No. 6, pp 1313-1327.

4. Vedula S. and Mujumdar P.P. (2006), "Water Resources System", Tata McGraw-Hill Publishing Company Limited, New Delhi.

5. Verma M. K. (2000) *Ph. D. Dissertation,* Devi Ahilyabai University, INDORE (M.P).

7. Wurb, R. A. (1993), "Reservoir-System Simulation and Optimization Models", Journal of Water Resources Planning and Management, Vol. 119, No. 4, 455-472.

8. Yeh William W-G (1985), "Reservoir Management and Operation Models : A State –of- the-Art Review", Water Resources Research, Vol.21, No.12, 1797-1818.