تحقیقات منابع آب ایران
Iran-Water Resources Research

سال ششم، شماره ۲، تابستان ۱۳۸۹
Volume 6, No. 2, Summer 2010 (IR-WRR)
4-5

Extended Abstract

A Model for Reservoir Operation Based on the Game Theory

H. Homayoun-far [1], A. Ganji [2], D. Khalili [3] and A.A. Mousavi [3]*

Introduction

Challenges and conflicts over limited water resources have come up due to the increase in water demands that cannot be resolved by the existing optimization models. In recent years a few discrete stochastic dynamic models have attempted to solve cases of water use (conflicts) so that more efficient water distribution management can be achieved (Ganji et al., 2007, 2008). These models have to some extent addressed the conflict issues of water resources. However, they still cease to accommodate certain needed constraints and they also involve complicated procedures and massive computational efforts. The discrete nature of these models seems to have been the limiting factor.

Objectives

In order to resolve the shortcomings in conflict resolution modeling, in this research a continuous dynamic stochastic game model is proposed to manage water consumption under challenging conditions. Value functions (long term), utility functions (short terms), and equation of motion in the proposed model are in the continuous form and their mathematical equations are intended to decrease computational volume and save time.

Methodology

In this study, a new method (the Ricatti equations method) is presented to solve a dynamic game of reservoir system. The state variables and transition equation are considered to be continuous variables. The game problem is mathematically solved by Ricatti equations. This approach is able to generate operating policies for dynamic reservoir operation. As compared to discrete models (e.g., dynamic programming, DP), state variables, inflow, and release are not discretized in the Ricatti equations method. The Ricatti equations method is a closed form solution based on a linear quadratic value function and requires less computational efforts when compared with discrete models. The proposed continuous model is applied to the Zayandeh-rud river basin in Iran.

Discussion and Results

The results of the Ricatti equations method are presented for both one and two player game. Considering these results, policy functions are derived. In order to evaluate the reservoir operating rules, annual reservoir storage and release were simulated for 300 years of synthetic inflow time series.

Then, the concept of reliability is used in this research to compare the overall performance of the developed model and the DP model for water allocation based on the decisions made by the reservoir operator as well as the water users (Table 1). The second column in this Table shows the occurrence and volumetric reliabilities of water users. The reliability values of the reservoir operator are also presented in the third column. It is indicated that the allocation reliability indices have increased for two player games.

This is due to the additional individual Bellman equation for a consumer (as a new player) that guarantees supplying higher levels of consumer demands.

1-Graduate student, Water Engineering Dep., College of Agriculture, Shiraz University, Iran.
2-Assistant Professor, Dep. of Desert Region Management, College of Agriculture, Shiraz University, Shiraz, Iran, Corresponding author Email: ganji@shirazu.ac.ir
3-Associate Professor, Water Engineering Dep., College of Agriculture, Shiraz University, Shiraz, Iran
*- Corresponding Author

Table 1-Reliability indices as result from Ricatti equation and DP models

The volumetric reliabilities of reservoir	The occurrence reliabilities of reservoir	The volumetric reliability of reservoir system for water allocation	The occurrence reliability of reservoir system for water allocation	Model
0.041	84.33	84.54	59.33	Ricatti (one player)
0.064	75.3	94.6	69.7	Ricatti (two player)
0.001	76.33	99.74	56.67	DP

Furthermore, the DP and the proposed model presented the same reliability values. As a result, it seems that the proposed solution method generates appropriate operating policy rules for reservoir operation.

Conclusion

In this research a continuous solution method was developed for the dynamic game models in reservoir operation and water allocation problems with conflicting objectives. As a comparison with alternative discrete solution methods, i.e., DP, the proposed solution method generates appropriate operating policy rules for reservoir operation using water users' preferences. Furthermore, the method proposed in this paper is more efficient and needs less computation time. This is due to the continuous formulation of the state variable and the value function.

Keywords: Game theory, Optimization, Reservoir, Continuous Dynamic Models

References

Ganji, A., Khalili, D. and Karamouz, M. (2007). "Development of stochastic conflict resolution models for reservoir operation. I. The perfect symmetric stochastic model. " *Advances in Water Resources.* Vol. 30, pp. 528-542.

Ganji, A., Khalili, D., Karamouz, M., Ponnambalam, K. and Javan, M. (2008). A fuzzy stochastic dynamic Nash game analysis of policies for managing water allocation in a reservoir system. *Water Resources Management.* Vol. 22(1), pp. 51-66.