Evaluation of Stakeholder Utility Risk Caused by the Objective Functions in Multipurpose Multireservoir Systems

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Abstract: Optimal operation of reservoir systems is a challenging task in water resource management, involving stakeholders with different utilities. These utilities are conflicting, especially in a multireservoir system when the number of stakeholders increases compared to a single-reservoir system. A reservoir system with hydropower energy generation and supplying downstream demands is an example of these challenges. An appropriate objective framework can improve mitigation of stakeholder conflicts. This paper considers a 1-year optimal operation of a multireservoir system, with two parallel upstream reservoirs and a downstream reservoir in series. System objectives are hydropower energy generation as well as supplying downstream demands. Existing conflicts of this system are determined in single-objective reservoir operation models. The mathematical form of objective functions can limit utility risk in multiobjective problems. To overcome impacts of existing conflicts, a simulation model has been coupled with the weighting method and Nash equilibrium in multiobjective models. Results show that although the calculated objectives using the Nash equilibrium are less (worse) than the maximum (best) values of the objective function with the largest weight for the first (highest) objective priority using the weighting method, in two parallel reservoirs the values of the objective function are larger (better), about 70.83 and 54.17%, respectively, for hydropower energy generation and supplying downstream demands objectives. Moreover, these objectives calculated by the Nash equilibrium are 58.33 and 50% better, respectively, than same values by the weighting method in series reservoirs. Thus, utilities were significantly balanced and increased from the worst (minimum) utility values by the Nash equilibrium. The Nash equilibrium increases considerably the reliability value for all stakeholders at the same time. **DOI: 10.1061/(ASCE)IR.1943-4774.0000785.**

Author keywords: Multipurpose operation; Reservoir systems; Conflict; Nash equilibrium.

Introduction

Operation and management of existing water facilities should be conducted in the best manner. The latter can be achieved when many groups are involved in a project to satisfy their possible desired utilities, including public and private, consumer and manufacturer, investor and exploiter, and stakeholder and beneficiary. The mentioned groups follow their objectives, which are conflicting in most existing systems.

Recently, many studies have been conducted in various aspects of water resources systems such as reservoir operation (Afshar et al. 2010; Bozorg Haddad et al. 2008b, c, 2009, 2011a; Fallah-Mehdipour et al. 2011b, 2012), cultivation rules (Moradi-Jalal et al. 2007; Noory et al. 2012), pumping scheduling (Bozorg Haddad and Mariño 2007; Bozorg Haddad et al. 2011b; Rasoulzadeh-Gharibdousti et al. 2011), water distribution networks (Bozorg Haddad et al. 2008a; Soltanjalili et al. 2011; Fallah-Mehdipour et al. 2011a; Seifollahi-Aghmiuni et al. 2011; Ghajarnia et al. 2011; Sabbaghpour et al. 2012), operation of aquifer systems (Bozorg Haddad and Mariño 2011), and site selection of infrastructures (Karimi-Hosseini et al. 2011). Although mathematical formulations have been widely used in water resource problems, especially in single/multipurpose reservoir systems, only a few of these works dealt with the stakeholders' utility risk specially in multireservoir systems.

Cai et al. (2004) categorized conflict cases in water resource management in different parts, such as multidisciplinary-complexity, domain-dependent knowledge, social value oriented, institutional constraints, and cultural dimensions. For instance, considering the optimal operation of a reservoir system for satisfying different objectives, different stakeholders should compromise to gather a balanced decision. The conflicts between different stakeholders appear more in multireservoir systems. In other words, conflicts between different reservoir stakeholders add to existing conflicts between stakeholders of each reservoir. In reservoir systems, integrated management of reservoirs as a management strategy is needed for adjusting existing disagreements. This strategy helps decision makers to establish a negotiation between the involved parties.

The appropriate formulation of a problem can overcome existing conflicts by balancing various parameters that are directly/indirectly related to stakeholders. Mathematical formulations have been widely used in water resource problems, especially in single/multipurpose reservoir systems. Yeh (1985) and Labadie (2004) presented state-of-the-art reviews in operation of reservoir systems, especially using mathematical methods in optimization problems.

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