DEVELOPMENT AND APPLICATION OF A DECISION MODEL FOR RESERVOIR OPERATION

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Reservoir is used to regulate the flow for water resources management to meet the spatial and temporal demand in terms of quantity and quality. A decision-making procedure is needed for reservoir operation and management as it plays an important role in balancing demand and supply for optimal social, economic and environmental benefits.

Several decision-making procedures such as simulation and optimization techniques have been developed to identify optimal operating rules in reservoir systems. Yeh (1985) reviewed the available techniques in general optimization and simulation that can be classified as follows: linear programming (LP), including change-constrained LP, stochastic LP, stochastic programming, and simulation. On the other hand, the intelligent control techniques such as fuzzy logic (FL), artificial neural networks (ANN) and genetic algorithms (GA) can be applied in decision-making model. Some of the relevant literatures can be cited as follow. Russell et al (1996) used fuzzy logic programming to improve existing operating practices in Powell River, Canada. Their results compared with deterministic dynamic programming and fixed rule are shown that fuzzy logic approach is promising, but it suffers from the curse of dimensionality. Fuzzy rule-based models were used to derive operation rule for a multipurpose reservoir in Tenkiller, Oklahoma by Shrestha et al (1996), and compared with actual releases. Dubrovin et al (2002) developed a fuzzy rule-based control for multipurpose real-time reservoir operation in Paijanne Lake, Finland. The results of fuzzy inference and Sugeno-style are the similarly values of monetary flood loss and hydropower revenue which the both of them more than actual operation. Tilmant et al (2002) compared the reservoir operating policies based on fuzzy stochastic dynamic programming (FSDP) with the policies based stochastic dynamic programming (SDP) in Mansour Eddahbi Dam, Morocco. Their study is shown that the reliability in meeting downstream water demand FSDP is less than SDP, but in reliability in meeting end-of-year storage target FSDP is more than SDP, and the annual released FSDP is less than SDP. For hybrid model, Hesebe and Nagayama (2002) used the neural network and fuzzy algorithm for operating of a multipurpose reservoir. They compared the operating policy of the reservoir based on the fuzzy and neural network algorithm with the actual operation using examples of floods during flood and non-flood seasons. Their study indicted that the fuzzy algorithm is an effective operation system when water use is the

main objective, and the neural network-fuzzy algorithm is effective primarily for flood control.

A decision-making model for reservoir releases is developed in this study. The model is composed of three modules: the first module involves a simulation model of physical system based on water balance concept. The second module deals with the decision-making process using neurofuzzy technique for switch control, water supply, and flood control. The third module is for the performance evaluation of water supply and flood control using three indicators such as reliability, vulnerability and resiliency. The hybrid learning algorithms combining the gradient descent and the least-square method is used for training the neural network to generate the fuzzy rule-based and membership functions. The inflows to and storage state of the reservoir are the input for the model and the water releases form the reservoir are the corresponding output.

The decision-making model is applied for reservoir operation study of the Pasak Jolasid Dam, Thailand. The dam situated in the eastern part of the Chao Phraya River Basin. It has an active storage of 782 million cubic meters (MCM) at the normal high water level of 42 m above mean sea level (MSL). The maximum storage volume is 961 MCM (43 m MSL), while the dead storage is 3 MCM (29.5 m MSL). The dam with storage reservoir serves several purposes such as irrigation, flood prevention, water supply for industrial and domestic use, recreation, and ecology, with the main objectives being flood prevention and irrigation. Another objective is to reduce diversion of water from Chao Phraya Dam in dry season and to help divert flood from Chao Phraya River Basin.

From the comparison of the actual operation with the results of the neurofuzzy and simulation using rule curve, the reservoir releases derived based on neurofuzzy model indicate higher reliability for water supply and flood protection. With the simulation using the rule curve, the derived water releases do not exceed the downstream flow capacity of the Pasak River, but releases do not meet the water demand with the level of reliability as can be achieved with neurofuzzy rule based. The appropriate water releases are decided based on neurofuzzy logic developed for reservoir operation and management. All membership functions in neurofuzzy model are expressed in nondimensional form, which provides a generalized model to be used for reservoir operational study.

Keywords: Neurofuzzy; Fuzzy logic; Decision-making modeling; Reservoir operation and management; Pasak River Basin.