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REAL-TIME RESERVOIR OPTIMIZATION FOR LONG-TERM OPERATION CONSIDERING SEASONAL ENSEMBLE PRECIPITATION FORECASTS: A CASE STUDY OF THE SIRIKIT DAM IN 2019

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Introduction

The Sirikit reservoir—one of the two large reservoirs in the Chao Phraya River Basin (CPRB)—has a primary role in effectively managing the water resources of the basin. However, the reservoir is located in a tropical climate with significant seasonal differences and uncertainty regarding the basin's hydrological condition. These conditions cause both floods and droughts which proved to be very challenging for reservoir operation. Furthermore, the Sirikit dam has frequently faced drought conditions since 2011 massive flooding occurred in the basin which the mean annual inflow of the reservoir from 2012 to 2021 is lower than the historical 30-year average. Regarding the downstream water requirement, this resulted in a low storage volume of the reservoirs as a result of the imbalance between inflows and outflows. The events resulted in difficulties in water management for the coming years as a result of insufficient reservoir water storage. In addition, climate change complicates future water resource management in CPRB because of increasing extreme weather fluctuations (Wichakul *et al*., 2015).

Recently, Meema *et al*. (2021) indicated potential advantages of considering medium-range ensemble precipitation forecasts (EPF) for real-time reservoir operation using dynamic programming (DP). However, the study presented significant differences in reservoir operation results driven by future long-term inflow assumptions (for determining storage penalty in DP). For more robust decision-making during real-time reservoir operation, this study aims to introduce the seasonal forecast information for long-term reservoir operation to improve the real-time optimization scheme for mitigating drought conditions. Thus, the main objective is to utilize the seasonal river flow prediction for real-time reservoir optimization using DP for a case study of the drought event in 2019.

Methodology

Fig. 1 illustrated the real-time reservoir optimization scheme for 1-week in advance release strategy. The 2-week inflow forecast (Q_t and Q_{t+1}) obtained from the hydrological model (simulated with 2-week advanced medium-range EPF) was input into the DP to optimize the 1-week advanced release strategy (R_t) at any storage level. To optimize the release strategy using the DP algorithm, the potential future droughts damage at the end of the target period (F_{t+2}) is required to associate the penalties to the lower storage levels of the reservoir to avoid the reservoir drawdown to low storage levels by releasing excess water to generate quantified benefits during the optimization period. For this purpose, the seasonal ensemble precipitation forecast conducted by the European Centre for Medium-Range Weather Forecasts (ECMWF) was employed with the improved 1K-DHM (Meema and Tachikawa, 2020) for seasonal ensemble inflow predictions of the reservoir. To determine the initial conditions of the model, a cost-effective approach—empirical data assimilation (Collischonn *et al*., 2005)—was applied. The seasonal ensemble inflow predictions extended seven months in the future were performed once a month regarding the updated ECMWF seasonal forecast.

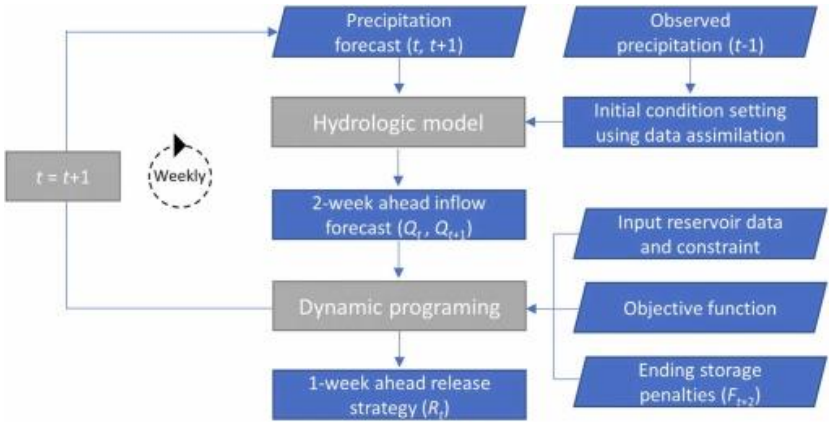

Fig. 1 Real-time reservoir optimization scheme for 1-week in advance dam release strategy for long-term reservoir operation considering medium-range and seasonal EPF.

Result and discussions

Regarding the previous study, there are advantages when associating forecast information with real-time optimization for decision-making in reservoir operation and providing more efficient operating decisions than employing historical data. However, the future long-term inflow assumption (for ending storage penalty determination) has a significant effect on the results of the reservoir operation. To improve optimization process efficiency, utilizing seasonal reservoir inflow forecasts may improve the real-time optimization scheme for the long-term reservoir operation by minimizing the future drought damage and increasing the potential of hydropower generation. The results of this study may be useful for long-term reservoir operation. This achievement would be practical and provide benefits to society in terms of water resources management.

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