Optimization management of multi-purpose reservoir in the dry season
Case study of Hoa Binh reservoir, Viet Nam

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INTRODUCTION

Hoa Binh reservoir (Fig.1) is the first hydroelectric reservoir on the Da river, upstream of the Red river delta (RRD) and the second largest reservoir in Viet Nam. It has a central role in power generation and water regulation downstream. The main parameters of the reservoir are summarized in Table 1.

Table 1: Reservoir parameters

Normal water level	117 m
Dead water level	80 m
Total capacity	9862 Mm³
Effective capacity	6062 Mm³
Number of turbines	08
One turbine capacity	240 MW

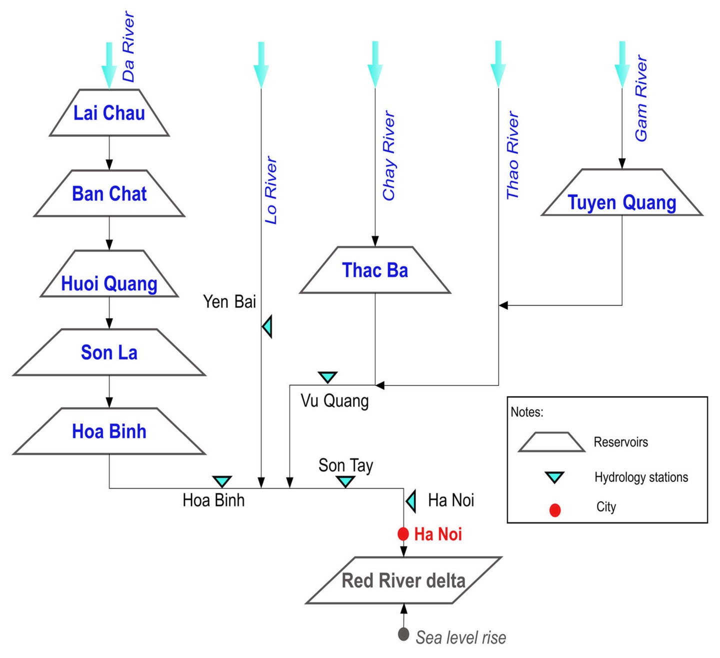


Figure 1: Schematization of reservoir network upstream of the Red River (RR)

MATERIALS AND METHODS

This study concerns the dry season (institutional define from 16/09 to 14/06 of the following year), since many issues due to water scarcity have arisen in the past 20 years, and there are still few associated studies. The year of 2019-2020 is selected for the input data since it is the most recently critical dry year.

The two main objectives are *Hydropower generation* and *Irrigation demand* in the dry season. In addition, another environmental objective under consideration for the dry season is the discharge needed to limit the salinity level in the Red river at KM30 equal to 1‰. Figure 2 shows the water discharge from Son Tay station to satisfy 1‰ threshold based on results of [1].

Genetic Algorithm (GAs) is applied in the study to find a good feasible solution that is significantly close to optimal, it enables the operator to be flexible in making decisions by offering multiple Pareto optimal solutions to a problem.

Minimization of the Water Deficit (1)

$$WD = \sum_{t=1}^{T}\left[w_{ir}\left(D_t^{ir} - R_t^{tu}\right)^2 + w_s\left(D_t^{s} - R_t^{tu}\right)^2 \right]$$

Maximize the Energy production (2)

$$E = \sum_{t=1}^{T} \eta\gamma R_t^{tu}(H_t^r - H_0)$$

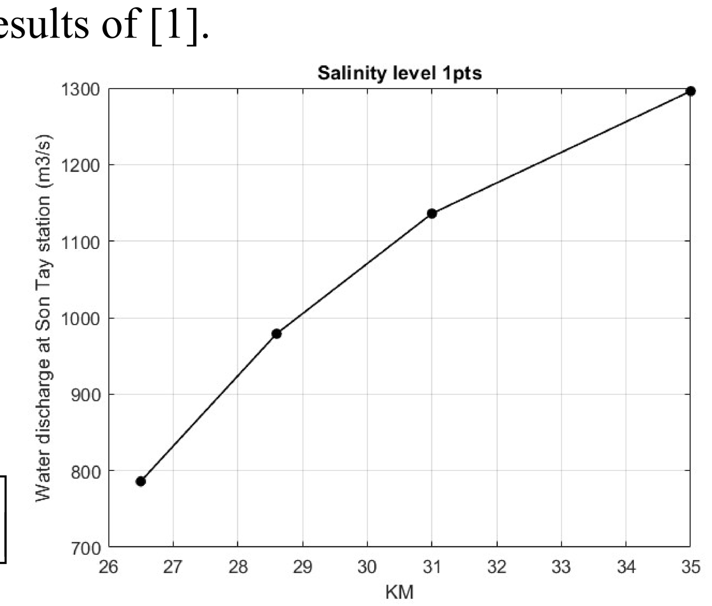


Figure 2: Water discharge to keep salinity level 1‰ at different point on RR under the climate change scenario RCP8.5-2050

D^{ir}, D^s (m^3/s) are demands for irrigation and salinization prevention respectively; R^{tu} (m^3/s) is water release from Hoa Binh reservoir; w_{ir}, w_s are the weights assigned to irrigation demand and salinization prevention respectively. η is the hydropower efficiency; γ (KN/m^3) is specific weight of water; H^r (m) is the reservoir water level; H_0 = 10 m is water level downstream.

RESULTS

The optimization model is applied in two different scenarios of the demand downstream:

Scenario 1: Only consider to assure the irrigation demand ($w_{ir} = 1$; $w_s = 0$),

Scenario 2: Consider to assure the irrigation demand and salinization prevention ($w_{ir} = 1$, $w_s = 0.6$)

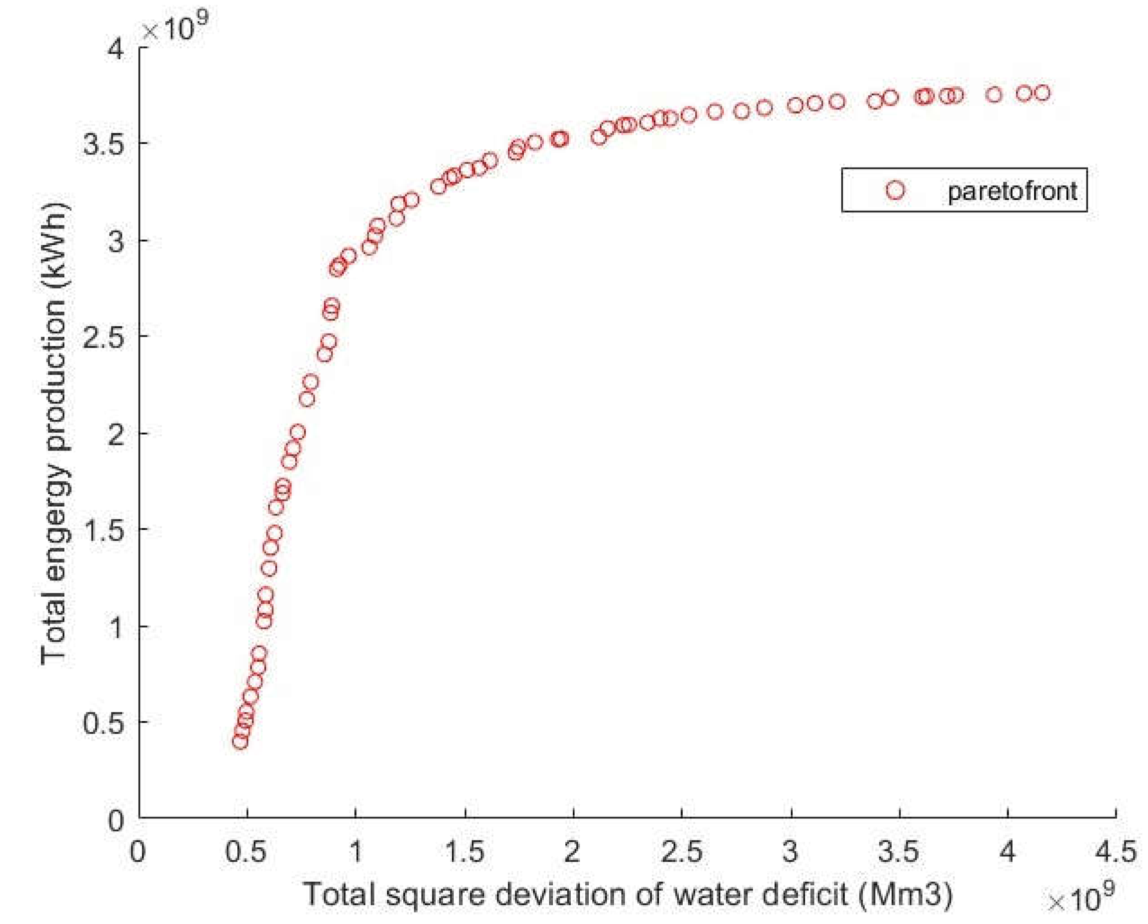
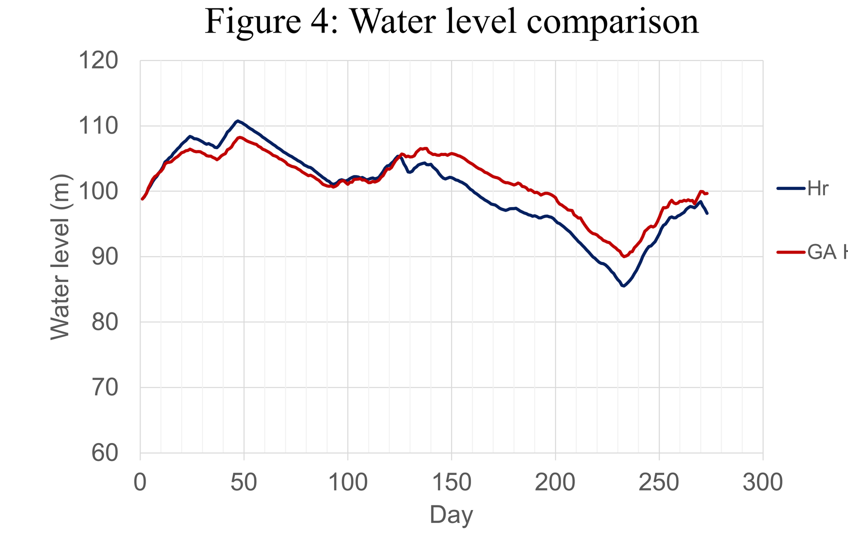
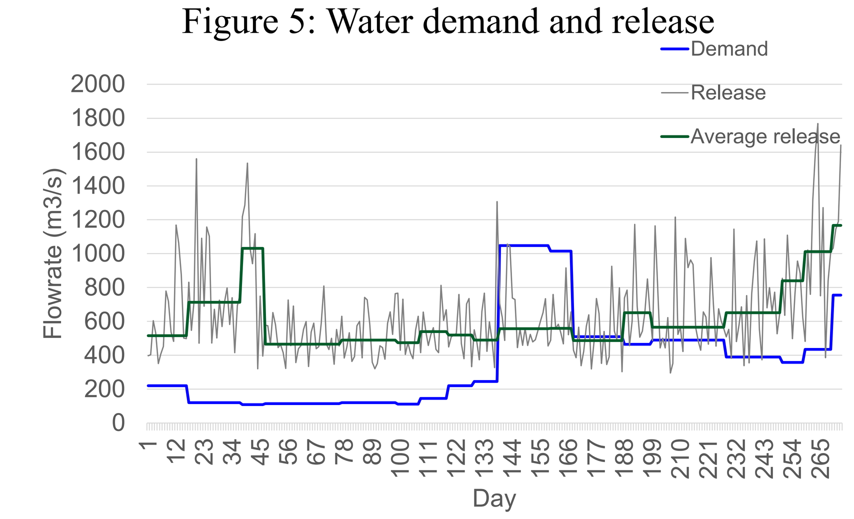


Figure 3: Pareto optimal front, showing the trade-off between irrigation and hydropower for scenario 1





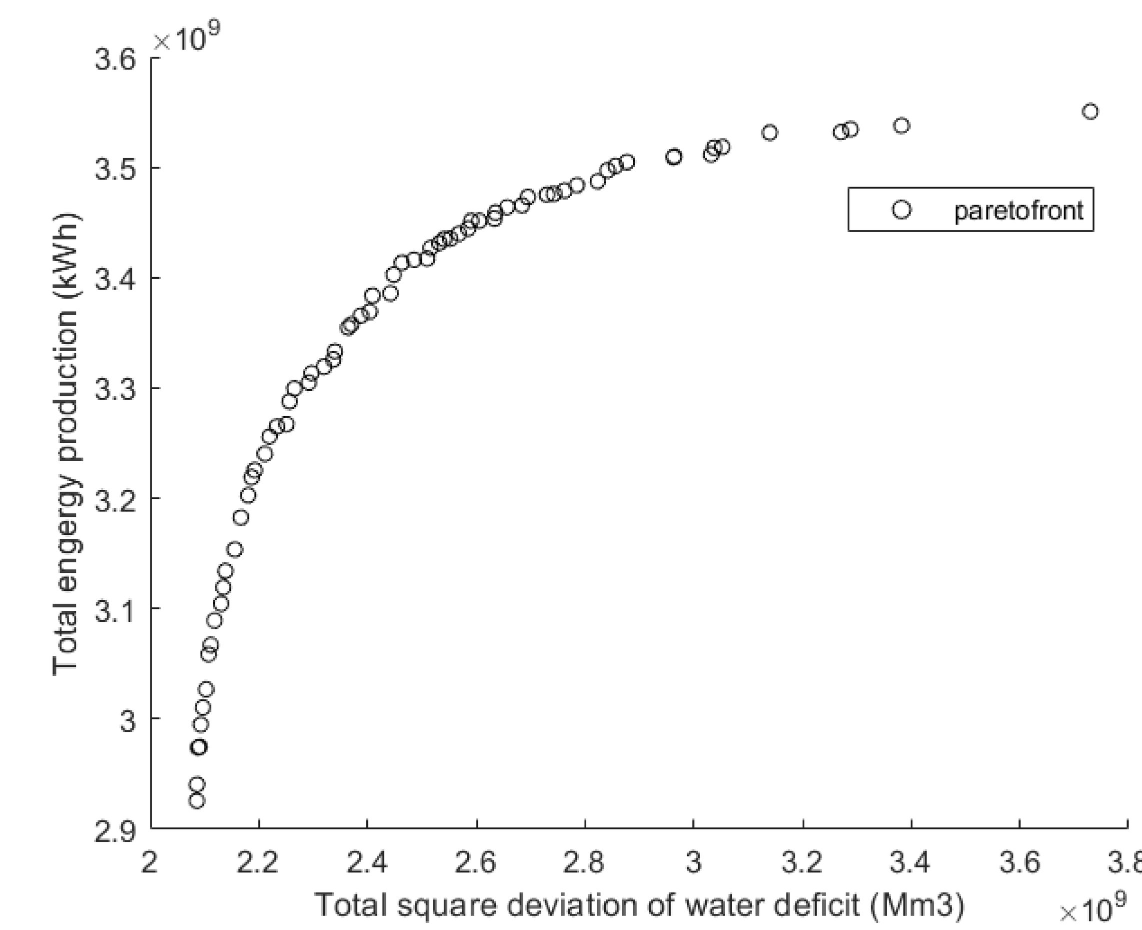
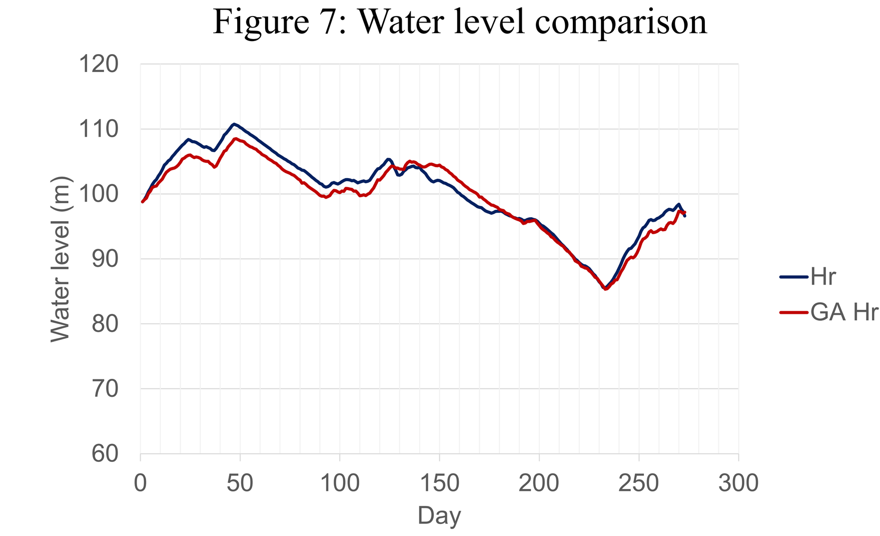
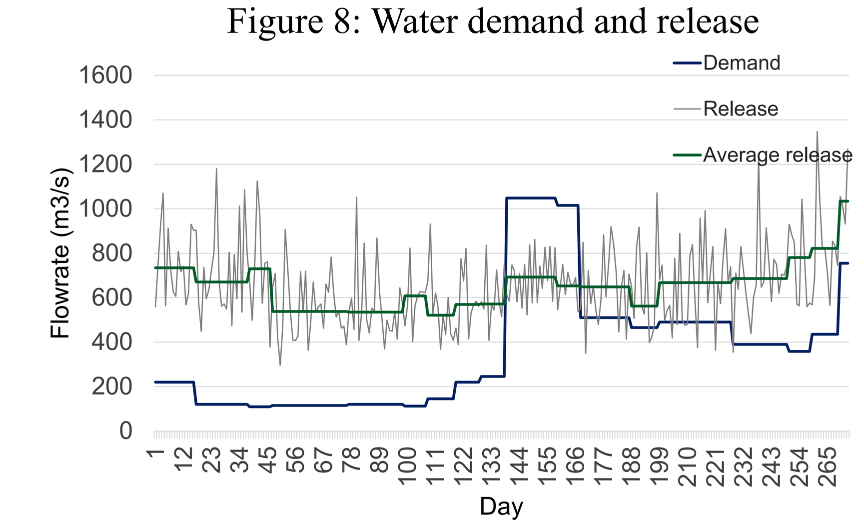


Figure 6: Pareto optimal front, showing the trade-off between irrigation and hydropower for scenario 2





D_s = 1136 m^3/s from Figure 2, this value is substituted to equation (1) to calculate the total squared deviations of water deficit, ws = 0.6 since water release from Hoa Binh reservoir only distribute around 60% to the total downstream inflow at Son Tay station.

RESULTS AND DISCUSSION

The optimal point of this two objectives optimization is WD = 1.36x10^9 Mm^3 and E = 3.27x10^9 kWh in scenario 1 where, and is WD = 2.18x10^9 Mm^3 and E =3.2x10^9 kWh in scenario 2.

It should be noticed that at the beginning of the dry season 2019-2020 the water level could not satisfy the minimum water level as in Reservoir regulation 740/QD-TTg [2] even if no release was implemented. However, we can improve the performance of the reservoir in the peak time of demand, the water elevation are higher (Figure 4) while the demands are still satisfied (figure 5). One other noticeable point is, during the Spring crops season in February the water demand are not satisfied, but this is the demand at Son Tay where the river has inflow also from Thac Ba and Tuyen reservoirs. The same thing can be seen in water level in scenario 2 (Figure 7), but in this case, the water demand in March and April are also satisfied.

CONCLUSION

This study uses GAs optimization to generate the optimal Pareto front for the two conflict objectives: Water demand downstream and Hydropower production. In addition, salinization prevention is also considered under the climate change scenario RCP8.5 2050. From the results, we can see that reservoir operation can still be improved. It is interesting that even when water is released more for downstream needs, the energy production decreases slightly by 0.07 billion kWh.

However, this study is only the preliminary work since it only calculated the Pareto front for one year. In the future, further research should be done to take into account more precise demand to prevent saltwater intrusion, and applied for longer time period. Additionally, the research can be broadened to forecast the optimization in the upcoming years, and to the multi-reservoir system.

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