GOLDSHI-PSO: Governance-Oriented Learning for Dynamic and Sustainable Hydropower–Irrigation using Particle Swarm Optimization

Program Riset Dosen Muda

Faizal Immaddudin Wira Rohmat, S.T., M.T., Ph.D [1,2], Hadi Kardhana, S.T, M.T, Ph.D[1,2], Pascalis Dwi Rosario Deno, S.T., M.T[2]

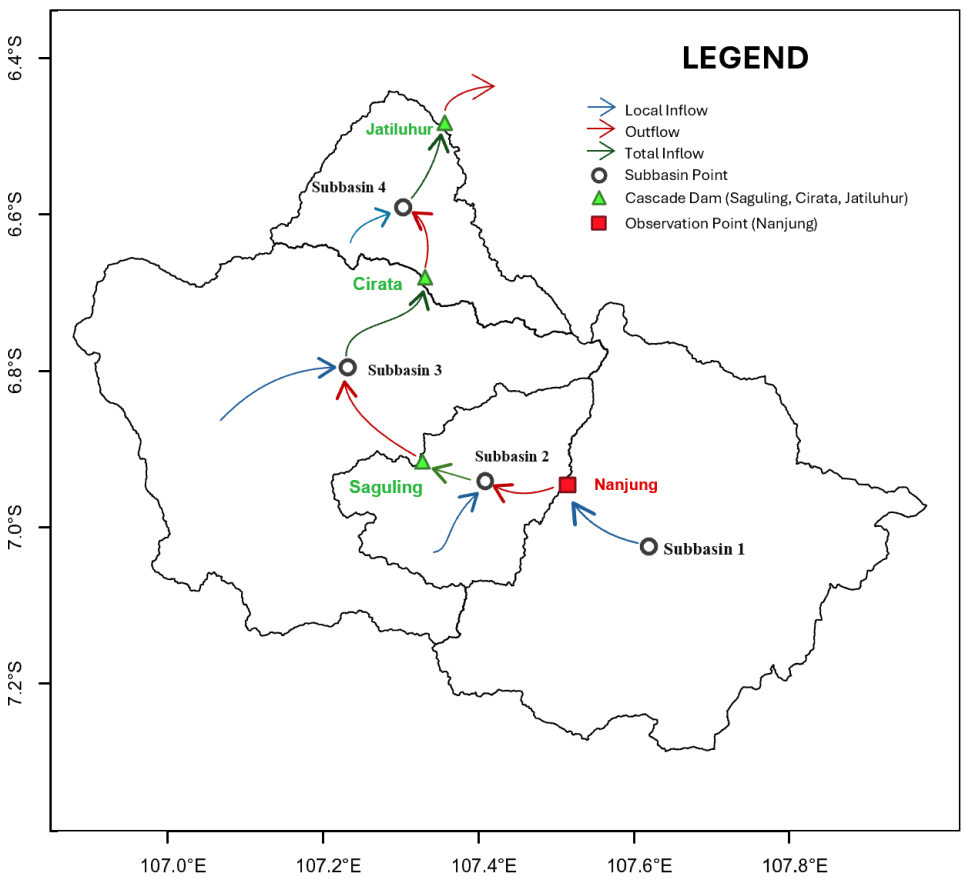
[1] Fakultas Teknik Sipil dan Lingkungan
[2] Pusat Pengembangan Sumber Daya Air

Introduction

Water management and the operation of the Saguling, Cirata, and Jatiluhur reservoir cascade in the Citarum watershed depend on continuous discharge records. But, several observation points have gaps in their records. This limitation can be solved using HEC-HMS rainfall-runoff simulation model with satellite rainfall data as the model inputs. One type of satellite rainfall data that can be obtained is GSMaP, produced by JAXA and NASA. The spatial and temporal coverage of GSMaP makes it possible to represent rainfall distribution across the watershed and provide continuous rainfall inputs for hydrological simulation.

This study aims to calibrate HEC-HMS model and obtain optimal parameters value for each subbasin parameter by gradually calibrated it. The results expected to provide a better understanding of the hydrological response of each subbasin and the performance of satellite rainfall data in rainfall-runoff simulation.

Keyword: HEC-HMS, model calibration, Citarum watershed, reservoir Cascade, GSMaP



Picture 1. basin model schematic for Nanjung and Citarum cascade system

Method

This study employs the lumped hydrological model HEC-HMS with continuous simulation to represent the Upper Citarum Watershed and its three-reservoir cascade system. The model consists of four subbasins corresponding to the observation points at Nanjung, Saguling, Cirata, and Jatiluhur, with upstream reservoir outflows serving as inflows to downstream reservoirs. The workflow includes watershed delineation, meteorological data preprocessing, and continuous simulation using evapotranspiration and GSMaP rainfall datasets.

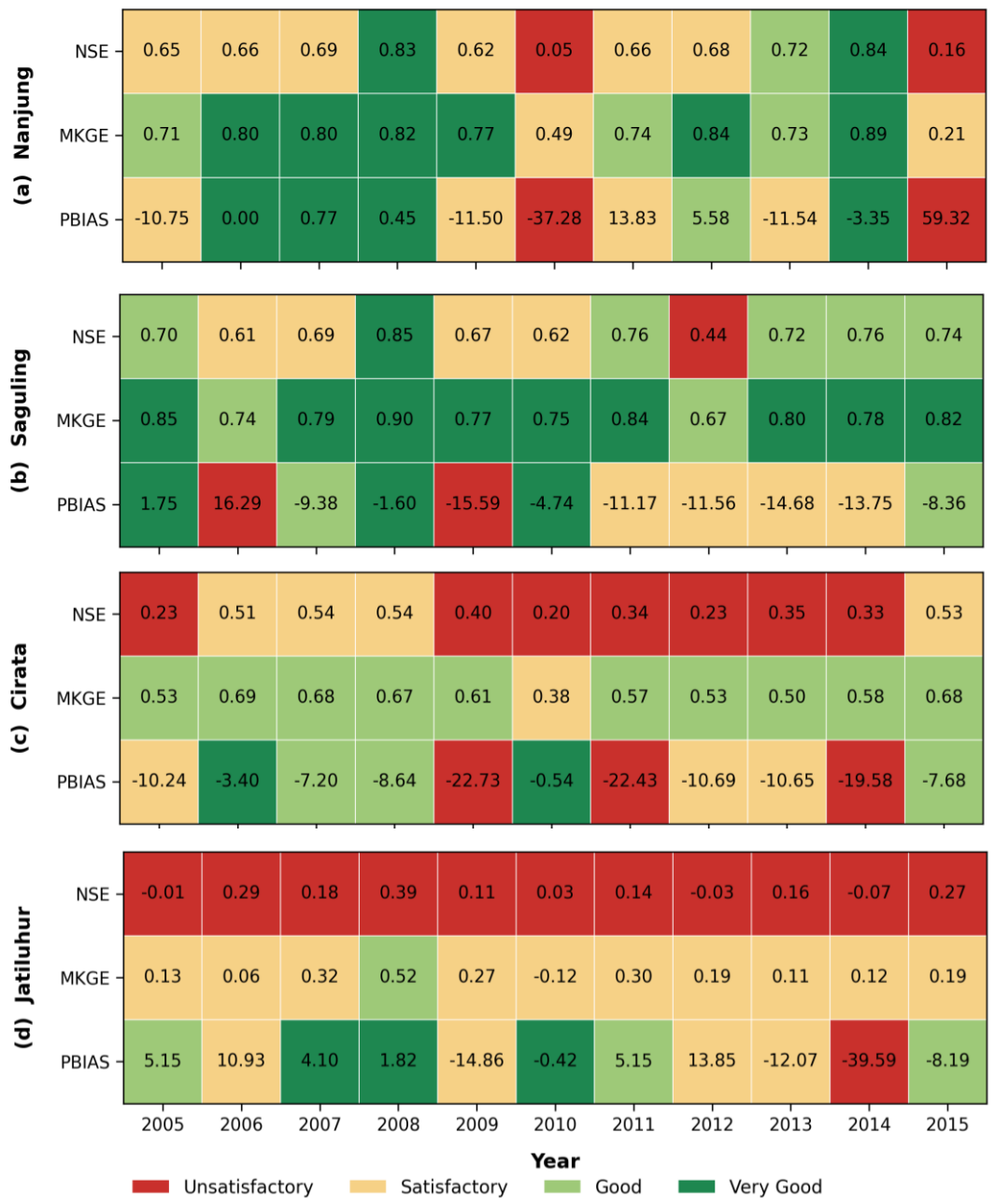
Model calibration was conducted sequentially from upstream to downstream over the 2005–2015 period. The calibrated parameters were subsequently evaluated through annual simulations to assess model performance, identify potential overfitting or data quality issues, and examine the consistency of model performance across different years.

Sequential calibration in three steps (volume, transform and lag, baseflow) combined with the Optimization Trial feature and the use of local inflow data in the reservoir subbasins reproduces the natural watershed response in the upstream part of the cascade system at satisfactory to good accuracy.

Result & Discussion

The model produces satisfactory to good performance at the Nanjung point (NSE 0.632, MKGE 0.709) and Saguling point (NSE 0.730, MKGE 0.853). Both PBIAS values (-3.48 and -4.30) fall into the very good category. Conversely, NSE at Cirata (0.442) and Jatiluhur (0.192) stays unsatisfactory despite small volume bias (PBIAS -2.08 and -6.70). Cirata has an NSE just below the satisfactory class and a good MKGE (0.647), whereas Jatiluhur has the lowest values for both metrics (NSE 0.192, MKGE 0.358).

The model is not yet able to reliably reproduce local inflow dynamics at each observation point. This difference in performance is most likely due to local inflow data that do not reflect actual hydrological conditions, the model's coarse spatial resolution and zonal precipitation data, as well as the limitations of the HEC-HMS conceptual framework in capturing complex processes.



Picture 2. Annual evaluation of the final calibrated parameters at (a) Nanjung; (b) Saguling; (c) Cirata; (d) Jatiluhur

Conclusion

The combination of HEC-HMS and GSMaP can therefore fill missing discharge data and support water resource management and reservoir cascade operations at points with reliable observation data (Nanjung and Saguling). Cirata suits data filling that prioritizes water volume over peak magnitude and timing. Its NSE below 0.50 means simulated peaks and timing at Cirata still need caution. Jatiluhur needs further improvement before it can serve this purpose.

Acknowledgement

This study was financially supported by ITB Early Career Research Program (Riset Dosen Muda) 2026 with contract number 2235/IT1.B07.1/TA.00/2026.