POTENTIAL SITE SELECTION FOR WATER HARVESTING IN A MICRO WATERSHED WITH FUTURE WATER BALANCE PERSPECTIVES

By

ARAVIND P

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ABSTRACT

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ABSTRACT

World is facing acute water scarcity owing to growing freshwater demand, rainfall aberrations and miserable management of water resources. Rapid urbanization, climate change and unplanned land use have significantly altered the hydrological cycle, leading to unpredictable rainfall, declining groundwater levels, and hydrological extremes. Valanchery micro-watershed of Bharathapuzha river basin faces acute seasonal water scarcity due to its abrupt topography and higher runoff. In this regard, the study was carried out to identify the potential water harvesting sites with the scientific integration of future LULC, climatic projections, hydrological modeling and machine learning for the Valanchery micro watershed in Bharathapuzha river basin of Kerala.

LULC classification was carried out for the years 2015, 2020 and 2023 using Google Earth Engine and Random Forest classification techniques. Overall accuracy of 0.84-0.89 and Kappa coefficient of 0.79 to 0.87 showed a satisfactory classification. LULC analysis revealed an increase in the urban and plantation and a decrease in waterbody, paddy and barren land. The land use of 2025 and 2030 was predicted using MOLUSCE plugin of QGIS software after validation of 2023 predicted land use with the actual land use map of 2023. Kappa coefficient of 0.79 was achieved during the land use prediction process and the percent of correctness was around 78.65 %. Future LULC predictions showed an increase of 1.18 km^2 in urban and a reduction in paddy and plantation land use.

SWAT hydrological modeling was carried out, for the present period and after satisfactory calibration (2021-2024) and validation (2024-2025), it was used for simulating the future water balance. Water balance analysis indicated that around 40% of rainfall exits as surface runoff, while groundwater recharge contribution was around 15%, which may be due to limited infiltration which emphasize the need for improved groundwater recharge structures. Results of future hydrological simulations revealed increasing monsoon intensities, rising temperatures (up to +1.5°C), and altered surface runoff–baseflow dynamics, particularly under SSP585 scenario.

Compromise programming (CP) technique was used to identify the best model based on the observed rainfall and temperature data. Based on the CP results, it was found that the CESM2-WACCM was the best model for rainfall and the EARTH model was identified as the best model for the maximum and minimum temperature. Bias correction was carried out using the linear

scaling method for the temperature and power transformation method for the precipitation data. Bias corrected rainfall and temperature data was incorporated into the calibrated SWAT model, which successfully simulated the water balance components for the present as well as for the near future (2025 and 2030). Future water balance, shows an increased rainfall and temperatures, leading to the hydrological shifts from infiltration-driven to runoff-dominated by 2030.

Machine Learning models were applied based on IMSD guidelines to identify potential sites for water harvesting based on the future water demand of 2025 and 2030. Machine learning algorithms combined with IMSD criteria were evaluated using ROC-AUC metrics. The XG Boost achieved the highest accuracy with an AUC value of 0.92 followed by random forest with an AUC value of 0.75 and so XG Boost method was used to locate suitable sites farm ponds, percolation ponds, and check dams. Results indicated that larger structure density and spatially distributed water harvesting sites under SSP126, while SSP585 required higher density and strategically placed structures to mitigate intensified surface flow and seasonal droughts.

The study establishes a practical framework that couples remote sensing, hydrological modelling, climate science, and ML-based site suitability, offering a robust decision-support tool for policy makers and watershed development agencies. This research contributes a scientifically validated and operationally feasible approach for climate-resilient watershed planning. Implementing the conservation measures in the identified sites will support water security, reduce flood risk in downstream areas and would enhance agricultural water availability in dry seasons, and will help to improve the long-term hydrological balance of the micro-watershed.