5) Validation Results: The results demonstrated that the WEAP model could reliably simulate the water dynamics of the Middle Nzoia Catchment. The consistency of model performance across both calibration and validation periods affirmed its suitability for future scenario analysis and water resource planning.

3.1.9 Model performance metrics

Model performance was thoroughly assessed using key statistical metrics during the calibration phase. The Nash-Sutcliffe Efficiency (NSE) was employed to evaluate how well the WEAP model simulations matched observed data, with values nearing 1 indicating a good fit between simulated and real water dynamics. Additionally, the Mean Absolute Error (MAE) and Root Mean Square Error (RMSE) were calculated to measure average deviations and squared differences between observed and simulated values, providing insight into the model's accuracy and precision in predicting river flow and water quality. During the validation phase, these metrics were recalculated using independent datasets not used in calibration, testing the model's robustness and ability to generalize to new data. The consistency of NSE, MAE, and RMSE across various time periods and scenarios was evaluated to confirm the model's reliability, ensuring that the WEAP model continued to provide accurate predictions and remained a trustworthy tool for future analysis. The mathematical expressions to compute the parameters mentioned above are:

Mean Absolute Error (MAE)……(i)

Root Mean Square Error (RMSE) ……(ii)

NB: The mean absolute error (MAE) and root mean square error (RMSE) are used to measure the deviation between the model outputs and the observed flows. Values tend to be zero for perfect agreement between observed and simulated values.

Error in Volume (VE in %)……(iii)

Nash-Sutcliffe Coefficient(R)……(iv)

Index of Agreement (IA)……(v)

The Index of Agreement =1 indicates the best (perfect) performance of the model.

Where:

Qoi is the observed streamflow at time (m^3/s)

Qsi is the simulated streamflow at time (m^3/s)

Vo is the observed streamflow volume (million m^3/month)

Vo is the simulated streamflow volume (million m^3/month)

Q is the average streamflow (m^3/s)

3.2 Scenario analysis

3.2.1 Sensitivity analysis

The scenario analysis involved a comprehensive sensitivity analysis to examine how changes in model parameters influenced the simulation results. rates were adjusted to assess their impact on the model's predictions.

3.2.2 Scenario comparisons

Statistical methods were utilized to conduct a comparative analysis of outcomes across various scenarios, focusing on the effects of altered land use, climate conditions, and water management strategies. This analysis quantitatively assessed the impact of each scenario on water supply and demand, facilitating the evaluation of the effectiveness of different water management strategies. The results of this comprehensive analysis formed the basis for developing evidence-based recommendations for sustainable water resource management.