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Impact Assessment of the Proposed Water Resources Development Projects in the Blue Nile Basin on Nile Flow at Aswan

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The Eastern Nile Basin contributes about 85% of the Nile inflow arriving annually at Aswan. The Blue Nile (Abbay) is the major sub-basin of the Eastern Nile (Blue Nile, Baro Akobo Sobat, Tekeze Atbara Setit, and Main Nile) that contribute about 62 % of the Nile inflow at Aswan. Recently, the Blue Nile becomes target for large scale unilateral water-based infrastructure development projects (dams, hydropower, and irrigated agriculture) in Ethiopia and Sudan. Even though several studies were carried to assess the impacts of the planned developments on downstream countries, this issue is still questionable and subject to further studies.
The strategic objective of this study is to contribute towards the development of an integrated climate-hydrology-reservoir simulation system for the Nile river. The direct objectives are to provide base line conditions of the water level, flow conditions and hydropower production that can be utilized as reference for future studies in the basin, in addition to investigate the impacts of the proposed water-based development projects in the Blue Nile Basin on the inflow, pool elevation and hydropower generation at High Aswan Dam (HAD).
For this purpose, two models were configured and offline coupled to simulate the system hydrology and the water balance in the basin. The hydrology is simulated using the Soil Water Assessment Tool (SWAT) model and runoff was generated at sub-watershed scale. Then water balance is simulated using the HEC Reservoir Simulation Model (HEC ResSim). Sensitivity analysis was carried out and resulted in the most sensitive parameters that were used to calibrate and validate the model using ground observations of flow discharges and reservoirs water levels. The modelling system is calibrated and validated using observations of flow discharges at Ed-Deim, Khartoum, Dongola stations and the pool elevation at HAD. Model performance is evaluated using the Nash–Sutcliffe parameter and the coefficient of determination. These statistical quantities indicate a good performance of the modelling system in simulating the flow regime in the basin.
The modelling system is employed to simulate the base case scenario that represents the current situation in the basin with the recent Roseires Heightening and Merowe Dam in Sudan. The model is configured to study the impacts of the several development scenarios of hydropower dams and irrigated agriculture development projects. Hydropower dam scenarios include the Renaissance dam, Karadobi dam, Beko Abo dam and Mandaya dam. Dam scenarios resulted in an average reduction of annual inflow at Aswan up to 10.24 BCM and an average reduction of annual power at HAD up to 21.37 % while the combined hydropower and irrigation schemes' scenarios resulted in average reductions up to 14.34 BCM of the annual inflow at Aswan and reduction of 33.29 % in annual hydropower production at HAD. The Renaissance Dam Filling Scenarios were also investigated for FSL 640 and 620 masl for filling periods of 3, 5 and 7 years, and showed that the worst scenario is to fill Ren.640 during 3 years with an average reductions of 10.4 BCM in flow and 21.5 % average reduction in hydropower while the best scenario is to fill Ren.620 during 7 years with average reductions of 5.8 BCM in inflow and 7.7 % reduction in hydropower.