Assessing Catchment Sediment Yield and Siltation Impacts on Reservoir Capacity under Land Cover/Use Changes: the Case Study of the Fincha Dam, Ethiopia

Generally, the water stored by hydraulic infrastructures constructed on natural rivers is used for water supply, hydropower, irrigation, recreation and navigation. Such volume can be affected by sedimentation, which is caused by sediments detached by the watershed hillslopes and carried into the reservoir by flowing water. This sedimentation causes major problems for reservoir and dam management, correlated to environmental and economic consequences. In fact, the decrease in the storage capacity of the reservoir hampers the purpose for which it was constructed, given that the usable storage volume will reduce, interfering with the normal dam operation. Depending on the amount of material deposited, the shortening of the hydropower reservoir lifetime will bring several consequences on the local economy, mostly related to drinking water supply, irrigation and hydropower generation in low-income countries. The land cover/land use (LCLU) changes are fundamental variables that can have a great impact in influencing many environmental aspects. LULC changes coupled with erroneous management may result in a high rate of soil erosion and increased sediment transport by changing the magnitude and pattern of runoff, peak flow, sediment yield and groundwater levels, adversely affecting the useful life of reservoirs.

Bare land expansion, increased surface runoff production and soil erosion are major environmental damages attributed to LULC in the Fincha River basin, Ethiopia. These degradation processes have adverse impacts on local agricultural productivity, water resource availability and food security. In addition, heavy rains cause severe erosion and sediment transport, which ultimately leads to the degradation of soil and contributes to negative impacts on downstream flooding, pollution and siltation of water bodies and reservoirs. In the country, several factors are involved in accelerating soil erosion such as urbanization, deforestation, overgrazing, improper tillage practices, leaving the land fallow resulting in low organic matter, land-tenure system, small and fragmented land holdings, and overall poverty. Therefore, a proper estimate of the future capacity of the reservoir created by the Fincha Dam is a difficult task for water managers dealing with the design, maintenance and operation of a reservoir, given the multiple forcing involved. However, reservoir sedimentation can be managed by controlling the rates of sediment loss across a watershed, which could be eventually estimated by using proper modelling tools.

The proposed study will assess the catchment sediment yield and siltation impacts on the Fincha reservoir under LULC changes by combining spatially integrated hydrological parameters, digital elevation models, land use and soil map with the ArcGIS interface Soil and Water Assessment Tool (ArcSWAT). The study will primarily emphasize on how land cover changes affect the sediment yield and its consequences on the reservoir capacity. Secondly, by means of multiple simulations, the research will provide water managers and policymakers with multiple scenarios forced by different LULC, and associated management strategies and mitigation measures for reducing the siltation in the Fincha Dam reservoir.

In order to achieve the main objectives of the project, the following research questions will be tackled:

a) What is the sediment yield of the mainland cover/use classes in the selected river basin?
b) How sediment yield correlates with topography, flow discharge, channel geometry, and land cover and drainage characteristics?
c) What is the impact of land cover/use changes on the sediment yield of the catchment and do these effects vary seasonally?
d) Are the sediments (bed loads and suspended load) affecting the useful life of the reservoir?
e) What are the possible management strategies and mitigations measures that can be applied for reducing the sediment load coming from the basin hillslopes and the siltation in the Fincha Dam reservoir?

The combination of field information and remote sensing data will be used for simulating future LCLU changes scenarios, also by applying an integrated Markov Chain and Cellular Automata (CA-Markov) dynamic model.