INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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Thesis Title: Hydrological Modelling of River Basin and Strategic Management of Watershed under Land use and Climate Change: Case of Genale Catchment, Ethiopia

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SHORT ABSTRACT

It is important to estimate the quantity and quality of water resources in terms of spatial and temporal variability to utilize it sustainably. Change in future climate conditions affects the availability of water resources by modifying the magnitude of precipitation, groundwater recharge, surface runoff, actual evapotranspiration, lateral flow, water yield, the river flows, and provoke water stress in the downstream. Local government authority around the globe is also emphasizing water resources project exploration, design, planning, and management aspect within the river basin.

Erosion of the topsoil is a serious environmental problem worldwide that critically alarms agricultural and upland areas. Most of the wetlands, rivers, and reservoirs are losing their capacity because of sediment deposition into the water body from the upstream of watersheds, as they were not managed.

Land, water and air are the most essential resources blessed by nature to humankind, conserved and maintained with steadfast efforts. This study applies the Modified Universal Soil Loss Equation (MUSLE) to identify critically degraded sub-basins and a non-linear optimization

algorithm to determine the optimal area combination of Ecological Management Practices (EMPs) to control sediment and water yield within permissible limits at a minimum cost.

Change in land use land-cover (LULC) is a paramount dynamic of present-day challenging landscape process and is capable of altering the hydrological responses in the catchment and can bring positive changes on water resources system through watershed management. As the land use planners require updated and high-resolution land resources information, understanding land cover change-induced status due to anthropogenic activities is significant.

Soil and Water Assessment Tool (SWAT) model is used to simulate streamflow, sediment load, & identify spatiotemporal variability of the sediment yield and sediment delivery ratio (SDR), point out erosion-prone area, and prioritize sub-basins/hydrologic response units (HRUs) for management.

The model is implemented by utilizing a digital elevation model, land use, soil type, and slope of the Genale basin; a total of isolated 464 HRUs were created, spreading over 25 sub-basins within the drainage area 54,942Km^2. SUFI 2 algorithm of SWAT Calibration & Uncertainty Programs (SWAT_CUP) is used to calibrate (1990 – 2005) and validated (2006 – 2013) streamflow & sediment on monthly scale and found to show satisfactory performance in both the cases.

Hydrological analysis of the Genale watershed has revealed a high potential value of water yield at the sub-basin-8 and sub-basin-12 under all climate change scenarios. The assessment was done for the whole watershed, and the variation ranges from 7mm to 2124mm. The average value of 421.17 mm, 543.5mm, and 358.1mm under baseline condition, RCP4.5, & RCP8.5 respectively. Under bias-corrected of Regional Climate Model (RCM)-CORDEX data, the result shows there is a decline in precipitation and an increase in future temperature under representative concentration pathways-RCP8.5, and likely to reduce the future production of water yield in the basin, which shows RCP8.5 projection is warmer than RCP4.5.

Among the total 25 sub-basins, three sub-basins produced a very high sediment rate (21-31 ton/ha/year), one produced high (16-20 ton/ha/year), one is moderate (11-15 ton/ha/year), three were low (6-10 ton/ha/year), and the rest 16 sub-basins were under very low categories. In the case of SDR, three sub-basins have very high SDR (>0.452), two sub-basins resulted in high SDR (0.326-0.451), which are located at the upland basin. Based on the model results, sub-basins 6, 8,12, 10, and 7 were identified as sediment-prone areas. Further investigation at the

HRUs scale is taken up to understand critical erosion areas and minimize the cost of management practice, time & human resources. HRU analysis has revealed the immense scope of minimizing cost by concentrating management measures only in the critical HRUs. For example, Sub-basin-6 has 31 HRUs, of which only seven are assessed to have the high rates of sediment yield and thus prioritized as; HRU-159, HRU-160, HRU-161, HRU-168, HRU-170, and HRU-171, which are located on agricultural and arable lands of steep slopes.

The model is practiced for critical sub-basins in the Genale watershed to assess the effectiveness of five EMPs individually and as a combination in controlling sediment yields and peak flow. A relative assessment revealed that terracing as an individual (61.8%) and EMPs combinations (78.5%) are better in reducing sediment yield at the sub-basin scale. Considering the environmental and economic viewpoint, the total cost of EMPs (for five critical sub-basins), applied to reduce sediment yield, is 46.101 million USD or (1.844 billion Ethiopian birr). EMPs are environment-friendly and cost-effective measures to reduce sediment yield.

The analysis of LULC change patterns for the area under study over 24 years showed that most parts of the green forest, barren land, and range shrubs were changed into agriculture, built up, wetlands, and water body with an increase of agriculture by 60%, built up 68%, pasture 37%, range shrubs 9%, and water body 57% during the study period (1990 to 2013), which increased surface runoff, water yield, and sediment yield in the catchment. Significant changes in hydrological elements were observed at the sub-catchment scale, mainly associated with the uneven spatial distribution of LULC changes compared to the whole watershed.

Based on this estimate, the regional governmental authority can prioritize projects to solve water and land degradation related problems of the community.