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# Modeling the hydrologic effects of land and water development interventions: a case study of the upper Blue Nile river basin

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Abstract:
Over 67% of the Ethiopian landmass has been identified as very vulnerable to climate variability and land degradation. These problems are more prevalent in the Upper Blue Nile (UBN, often called Abay) river basin covering a drainage area of about 199,800 km2. The UBN River runs from Lake Tana (NW Ethiopia) to the Ethiopia-Sudan border.
To enhance the adaptive capacity to the high climate variability and land degradation in the basin, different land and water management measures (stone/soil bunds, runoff collector trenches, exclosures) have been extensively implemented, especially since recent years. Moreover, multipurpose water harvesting schemes including the Grand Ethiopian Renaissance Dam (GERD, reservoir area of ca. 4000 km2) and 17 other similar projects are being or to be implemented by 2025.
However, impact studies on land and water management aspects rarely include detailed hydrological components especially at river basin scale, although it is generally regarded as a major determinant of hydrological processes. The main aim of this study is therefore to model the significance of land and water management interventions in surface runoff response at scale of UBN river basin and to suggest some recommendations.
Spatially-distributed annual surface runoff was simulated for both present-day and future (2025) land and water management conditions using calibrated values of the proportional loss model in ArcGIS environment. Average annual rainfall map (1998-2012) was produced from calibrated TRMM satellite source and shows high spatial variability of rainfall ranging between ca. 1000 mm in the Eastern part of the basin to ca. 2000 mm in the southern part of the basin. Present-day land use day condition was obtained from Abay Basin Master Plan study. The future land use map was created taking into account the land and water development interventions to be implemented by 2025.
Under present-day conditions, high spatial variability of annual runoff depth was observed in the basin ranging from 80 mm in the central part of the basin to over 1700 mm in water bodies. This variation is mainly controlled by variation in surface conditions and areal-extent of each land use type, and rainfall depth. For a specific land use type, runoff depth is found to increase with elevation as this in turn directly influences the rainfall distribution. By 2025, due to the land and water management interventions, total runoff depth in the basin could decrease by up to 40%. Following the conversion of other land use types to water bodies due to the medium to large-scale water harvesting schemes such as GERD reservoir, runoff response in those specific parts of the basin could increase by over 200%. Sub-basins have been prioritized for future land and water management interventions. Further study remains necessary to understand the downstream impacts of those interventions on runoff and sediment discharges.

Keywords: Land and water management; Upper Blue Nile; Grand Ethiopian Renaissance Dam; Spatial variability of runoff; Downstream impact.