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Effects of dams on downstream rivers: the case of Ribb River, Ethiopia

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Abstract

Dam construction affects the discharge and sediment transport regime of the river system by reducing and shifting the annual peaks and storing incoming sediments. Without new sediment replacing the bed material entrained and transported away by the flow, the river deprived of sediment presents channel bed and bank erosion and adjusts its morphology. Dam construction thus results in changes of river planform, slope, width, depth and sediment characteristics through time, which depend on released discharge and geological formation. This means that the generalized prediction of dam induced impacts is inappropriate as the drivers and process are site specific (Graf, 2006). This study attempts to anticipate the effects of dam construction on the morphology of low land meandering rivers combining analytical and numerical investigations.

The Ribb River, located in the North Western part of Ethiopia, is selected as base-case for the investigation. The river flows with a meandering pattern to Lake Tana, the source of Blue Nile River. A large dam for purposes of irrigation is in construction 75 km from the mouth (BRLi and MCE, 2010). The operation of the dam will affect the downstream river reaches. To assess the effects which will be foreseen in future, an Equilibrium Theory (Jansen et al., 1979), which compares the reach-scale morphodynamic equilibrium conditions of the system before and a long time after interventions and a 1D SOBEK-RE mathematical model were used. Equilibrium coincides with the condition in which the sediment transport capacity is equal to sediment input and output. The application of a 1D morphodynamic model which simulate the non-steady river flow, sediment transport and morphological changes, allows to assess the river bed slope change through time associated with different dam operation schedules. The model is then used as a tool for the study of different scenarios, represented by different river characteristics, different dam operations, etc. The application of numerical models is vital to observe rate and magnitude of river bed slope changes through time, in which it cannot be done using empirical equations. In addition, it will help to estimate the time span required to attain the long term morphological equilibrium after interventions. The analysis and combination of Equilibrium Theory and numerical results allows for some generalization and distinctions regarding the effects of dam construction on low-land rivers.

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