Sediment transport modelling

Determination of the main areas contributing to the suspended sediment load in the Mara River, Kenya

MSc Thesis

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Summary

The Serengeti is a vast ecosystem of about 30,000 km$^2$ located in southwest Kenya and northern Tanzania. This region encompasses, among other areas, the Serengeti National Park in Tanzania and the Masai Mara National Reserve in Kenya. Through both reserves flows the Mara River that originates in Kenya in the Mau Escarpment and flows into Lake Victoria in Tanzania. In its catchment, human interventions have led to deforestation and the increase of agricultural areas. This conversion to cultivation, combined with the application of non-optimal agricultural practices, has resulted in increased soil compaction. As a result, less rainwater infiltrates the soil and more water flows as rapid surface runoff towards the river. With the increased fast runoff, more topsoil is expected to erode and to be transported to the river, thus polluting it. This research focuses on the modelling of the hydrology and soil loss from the catchment to locate the main sources of transported suspended sediment in the Mara River Basin.

The suspended load in the Mara River consists of coarse sediments in the river bed and fine sediments in the wash load originating from the top soil in the entire catchment. The main sources of the coarse sediments are assessed hydraulically whereas for the fine sediments a hydrological model is combined with an empirical sediment yield model.

The coarse sediments in the Mara River are mainly found in the bed and can originate from gullies or the river itself as high flow velocities are needed for their transport. To determine the main source, the sediment transport capacity of the river was compared with the one of a typical gully observed locally and the occurrence of river meandering was analysed.

The fine sediments in the Mara River are mainly found in the wash load and are assumed to originate from eroded topsoil. To assess the main sources, a semi-distributed hydrological model based on the concept of FLEX-Topo was created and combined with the empirical model MUSLE (Modified Universal Soil Loss Equation). With this hydrological and sediment transport model, the soil loss was calculated on daily time-scale. It is assumed that this soil loss is equal to wash load in the river. In the hydrological model five sub-catchments and four hydrological response units (HRUs) were defined; the sub-catchments are: North, Middle, Talek, Sand, Lower and the HRUs are: forested hill slopes, shrubs on hill slopes, agriculture and grasslands. Only for croplands and grasslands, the MUSLE model were applied to calculate the soil loss as no significant erosion was observed in forests and shrub lands.

This model simulated the hydrology well and also captured the order of magnitude of the soil loss; however not the exact patterns. The largest soil losses were found in the Sand and Lower sub-catchment: the soil loss is 0.30 mm/yr in the grasslands in the Sand and 0.2 mm/yr in the cultivated areas in the Lower sub-catchment. It is recommended to increase the model accuracy by using additional field measurements at multiple locations in the catchment, for example precipitation, temperature and discharge to improve the hydrological part and turbidity data to improve the sediment part of the model.

This means that the main sources for the fine suspended sediments are the grasslands in the Sand and the crop lands in the Lower sub-catchment. It is recommended to focus on these areas for decreasing the fine suspended sediment load most efficiently. However, currently most studies seem to focus on the cultivated areas in the North where local people have observed decreased crop yields in the past 20 years and suspect it is a result of eroded fertile top soil. The coarse sediments are found to originate from the river itself which has caused and still causes meandering.