Geophysical Research Abstracts
Vol. 14, EGU2012-9048, 2012
EGU General Assembly 2012

Quantification of changes in water balance and sediment transport due to recent and future land use change in the Xiangxi Catchment (Three Gorges Region)

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The construction of the Three Gorges Dam on the Yangtze River induced a large-scale land use change in the Three Gorges Region in Central China. The relocation of towns, villages and agricultural areas is assumed to impact the water balance and increase erosion rates as well as sediment yields in the affected catchments. At the same time, an increasing risk of reservoir eutrophication can be expected because of higher inputs of nutrients, especially phosphorus, adsorbed to sediment and due to reduced flow velocities and prolonged residence times of water in the reservoir.

As field experiments are often labor- and time-intensive and do not provide the possibility to analyze the effect of management decisions prior to their implementation, hydrologic and water quality models are frequently used to assess the impact of land use changes on water resources. In this study, the eco-hydrological model SWAT was applied to the Xiangxi Catchment in the Three Gorges Region in order to simulate stream flow and sediment loads at Xingshan gauging station under changing land use conditions.

For the baseline scenario, a land use map for the year 1987 was used. The calibration of stream flow resulted in a good fit of simulated and observed data, which is indicated by NSE values of 0.69 and 0.67 for the calibration and validation periods, respectively. In contrast, the model was not able to simulate the monthly average sediment loads correctly as indicated by very low NSE values of 0.42 (calibration) and 0.07 (validation). This is mainly due to insufficient input data because of a very low density of rain gauges in the Xiangxi Catchment. Also, there is very high uncertainty in the observed sediment data. Nevertheless, the modeling results prove the general applicability of SWAT to the Xiangxi Catchment and provide a sufficient basis for the simulation of land use scenarios.

Land use maps for the years 1999 and 2007 were used to quantify the changes in water balance and sediment inputs in the past 20 years. Additionally, three land use scenarios were developed in order to simulate the impacts of possible future land use changes. Results indicated that surface runoff and sediment inputs decreased on catchment average, but strongly increased on slopes directly adjacent to the Three Gorges Reservoir. The simulated future land use scenarios showed that an expansion of agricultural areas especially on slopes with a high connectivity to rivers and the reservoir would lead to a considerable increase of sediment inputs and thus has to be prevented or at least managed in a sustainable manner.