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Simulation of land use change impacts on hydrological processes in a tropical catchment

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Impacts of land use change on the water balance of a catchment are still not fully understood due to climatic interferences. For tropical regions, only few studies have attempted to attribute changes in the water balance to land use change, where some of the results are contradictory and inconsistent, in particular for large catchments (> 100 km^2). In this study, we assessed the impacts of land use change on the water balance of the Samin catchment (277.9 km^2) on Java, Indonesia using the Soil Water Assessment Tool (SWAT) model and the baseline-altered method. We divided the simulation period 1990 – 2013 into four equal periods to represent baseline conditions (1990 – 1995) and altered land use conditions (1996 – 2001, 2002 – 2007, and 2008 – 2013). Land use maps for 1994, 2000, 2006 and 2013 were acquired from LANDSAT and ASTER satellite imageries to represent land use cover for each period. A SWAT model was calibrated for the baseline period using land use of the year 1994 and then applied to the altered periods with and without land use change to investigate the contribution of land use change to changes in stream flow. The results show that incorporating land use change in the model simulations resulted in a Nash Sutcliffe Efficiency (NSE) of 0.7 compared to 0.6 when land use change is ignored. In addition, the error in the simulations without land use change was increasing with time and thus resulted in a deteriorating model performance. Land use change appeared to be the important driver for changes in stream flow and thus allowed to attribute changes in the water balance to land use change. The main land use changes during 1994 – 2013 are a decrease in forest area from 48.7% to 16.9%, an increase in agriculture area from 39.2% to 45.4% and an increase in settlement area from 9.8% to 34.3%. For the catchment, this resulted in an increase of the runoff coefficient from 35.7% to 44.6% and a decrease in the ratio of evapotranspiration to rainfall from 60% to 54.8%. More pronounced changes can be observed for the ratio of surface runoff to stream flow (increase from 26.6% to 37.5%) and the ratio of base flow to stream flow (decrease from 40% to 31.1%). At sub-catchment level, the effect of land use changes on the water balance varied in different sub-catchments depending on the scale of changes in forest and settlement area. A reduction in the forest area significantly contributed to a higher runoff coefficient and lower ratios of evapotranspiration to rainfall and lateral flow to stream flow, whereas an increase in the settlement area significantly contributed to a higher runoff coefficient and ratio of surface runoff to stream flow and a lower ratio of base flow to stream flow.

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