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# Small scale eco-hydrological regime shifts and impacts on regional changes in the Sahel

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The West African Sahel experienced a long drought from the 1970s to the 1990s during which runoff has paradoxically increased, as a response to human and climate-induced changes in surface conditions. Despite the vegetation recovery (re-greening) observed at regional scale over the past 30 years, surface runoff is still increasing, suggesting that the Sahelian eco-hydrological system passed a tipping point and is now trapped in a « high runoff » state. To study this hypothesis, we developed a system dynamics model incorporating vegetation-hydrology interactions at annual time scale. The model successfully reproduced the vegetation collapse and the increase of runoff-prone bare soil areas monitored over 65 years on a pilot site in Northern Mali. Our results confirmed the existence of a tipping point between alternative high/low runoff states at the small catchment scale. According to the model, a reverse shift to the pre-drought low runoff state is possible, but the conditions in which this shift would occur remain uncertain. The system trajectory presents a strong sensitivity to annual rainfall variability (amplitude and temporal structure). This study suggests that the increasing runoff in a re-greening environment is caused by the tipping of some areas to a high runoff/low vegetation state, illustrating how a regime shift in sub-systems can result in eco-hydrological changes at larger scale. The associated large-scale changes of the rainfall partitioning may alter evapo-transpiration and thus the surface-atmosphere feed-back. Those changes also bear strong environmental and socio-economic consequences, either adverse (increase of degraded areas to the detriment of agriculture, and increased flood risk) or beneficial (increased water resource in ponds and water tables).