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Integrating land-atmosphere interactions in the water footprint indicator

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Green water (i.e., precipitation water that infiltrates into the soil and becomes available for plants' root uptake) is the pillar for food production and biosphere sustainment. However, food production can also compromise the resilience of green water and thus, its potential to sustain the land-water-food-human system.

Despite a large number of scholars having quantified the spatio-temporal evolution of the green water, so far the critical role of local green water resilience to sustain the ecosystem has not been quantified adequately. This means that green water overexploitation due to local factors (which is other than measuring a high green WF) went undetected, whereas omitting moisture recycling implies that the land-use-induced gains and losses of moisture supply to downwind rainfall are ignored that is significant, as around 60-70% of mean global evapotranspiration returns as precipitation over land. Indeed, due to land cover changes in a precipitationshed (i.e., the area supplying evaporation to a downwind location's rainfall), gains and losses in precipitation may occur in the evaporationshed (i.e, the downwind region where evaporation from upwind areas precipitates as rainfall).

The aim of this study is to redefine the green water footprint, which can be used for assessing the resilience and sustainability of green water use for food production addressing feedbacks between upwind land cover changes and downwind changes in precipitation, which can subsequently lead to changes in actual crop evapotranspiration, yields and the relative associated irrigation water demand.

Therefore, we define green water use as a function of the change in evapotranspiration patterns in downwind areas in the emblematic case of deforestation in upwind areas.

By coupling the STEAM water balance model with atmospheric moisture tracking model, we simulate the impact of land cover changes on downwind precipitation. These simulated changes in downwind precipitation allow then the evaluation on crop evapotranspiration in the agricultural hubs in the affected downwind areas, by means of the crop-hydrological model WaterCrop.

Our results shed light on the feedback between perturbation on potential vegetation evapotranspiration, downwind precipitation, actual crop evapotranspiration, crop yield and associated irrigation water demand changes in the downwind regions to better frame the sustainability and resilience of land-water-human systems for food production in the context of land-atmosphere interactions.