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Conceptualizing green water within the planetary boundary for freshwater use

Transformations of land cover from natural vegetation to anthropogenic land use have far-reaching implications on the terrestrial water stock and vapor flow, thus green water. Since green water plays a vital role in biophysical processes, vegetation CO_2 sequestration, moisture recycling and regional tipping points in the Earth system, it is imperative to account for anthropogenic perturbations of the green water fraction. However, an explicit representation of green water within the Planetary Boundary concept is still missing which is seen as a major drawback of the framework.

By employing the process-based dynamic global vegetation model LPJmL4, human-induced changes in the terrestrial water balance as compared to an undisturbed scenario were simulated on a global scale.

The results suggest that humanity is a main driver of change in the terrestrial water balance in general and green water in particular. Most striking is the shift from productive biophysical plant transpiration to purely physical soil evaporation caused by deforestation. However, these changes are showing a strong spatial heterogeneity and are partly balanced out by an increase in water vapor flow due to redirected runoff in the form of irrigation water.

This extensive intervention with the terrestrial water vapor flux has strong implications for regional and continental moisture recycling and can contribute towards reaching potential tipping points in the Earth system. All things considered, this study evaluates a qualitative and quantitative fundament of accounting for green water within the Planetary Boundary for Freshwater use to help preventing detrimental and unacceptable human interferences with the terrestrial water cycle.

Keywords: Physical Geography · Ecosystem Analysis · Green water · Planetary boundary · Water stress · Land-use · Moisture recycling · Land use modelling · Evapotranspiration · Earth system · Potential natural vegetation

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