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# Assessing planetary and regional nitrogen boundaries related to food security and adverse environmental impacts

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In this presentation, we first discuss the concept of -, governance interest in- and criticism on planetary boundaries, specifically with respect to the nitrogen (N) cycle. We then systematically evaluate the criticism and argue that planetary N boundaries need to include both the benefits and adverse impacts of reactive N (Nr) and the spatial variability of Nr impacts, in terms of shortage and surplus, being main arguments for not deriving such boundaries.

Next, we present an holistic approach for an updated planetary N boundary by considering the need to: (i) avoid adverse impacts of elevated Nr emissions to water, air and soils, and (ii) feed the world population in an adequate way. The derivation of a planetary N boundary, in terms of anthropogenic fixation of di-nitrogen (N2) by growing legumes and production of N fertilizer, is illustrated by (i) identification of multiple threat N indicators and setting critical limits for them, (ii) back calculating critical N losses from critical limits for N indicators, while accounting for the spatial variability of indicators and their exceedance and (iii) back calculating critical N fixation rates from critical N losses.

The derivation of the needed planetary N fixation is assessed from the global population, the recommended dietary N consumption per capita and the N use efficiency in the complete chain from N fixation to N consumption. Results of example applications show that the previously suggested planetary N boundary of 25% of the current value is too low in view of needed N fixation and also unnecessary in view of most environmental impacts. We also illustrate the impacts of changes in the N use efficiency on planetary boundaries in terms of critical N fixation rates.