Stochastic projection of the effects of an increased biofuel demand on direct and indirect land use change in Brazil

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Governments throughout the world have set mandatory biofuel targets for the transport sector. However, large scale biofuel production can have negative environmental and socio-economic impacts. Many of these impacts occur because allocation of the biofuel feedstock causes land use to change from some previous use to the feedstock, direct land use change (dLUC). But it can also cause change of land use outside the biofuel feedstock cultivation area, indirect land use change (iLUC), resulting from expansion of this previous use in order to compensate for the supply shortfall due to its displacement. The magnitude of the impacts of both dLUC and iLUC are steered by the location and spatial pattern of the feedstock and the other land uses. Our aim is to assess the locations and spatial pattern of sugar cane expansion in Brazil as a result of an increased demand for biofuels due to the mandates for a period up to 2030, using a scenario approach to explore different potential developments in policies and markets.

For this assessment we use a coupled model approach. The Modular Applied GeNeral Equilibrium Toolbox (MAGNET), a global Computable General Equilibrium (CGE) model, is linked to the PCRaster Land Use Change model (PLUC), a spatially explicit land use change cellular automaton. MAGNET, simulating the global policy and market related processes, is used project production quantities and cultivation areas of all agricultural commodities, including sugar cane, in the 37 regions MAGNET is divided into. One of these regions is Brazil. The location and spatial pattern of the land use areas within Brazil over time depends on spatial factors such as proximity to hubs, potential yield through biophysical factors like soil type and slope, and neighbourhood effects. We simulate these using PLUC, which spatially allocates the areas of all land uses projected by MAGNET at a 5 km resolution grid.

Acknowledging that scenario assumptions, models, input data, and calibration data contain uncertainties, we apply a stochastic modelling approach to quantify the propagation of these uncertainties through the two models to the output. As a result, an ensemble of time series of land use maps is obtained from which the probability on dLUC and iLUC per grid cell can be derived. In our future analyses, the spatially explicit land use change results will be used to assess impacts on water, carbon stocks, biodiversity and socio-economics, to provide a complete overview of the sustainability sugar cane ethanol.