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"Reconcile land system changes
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Adaptation of the lucia model to simulate maize-legume intercropping systems in sub-saharan Africa

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Abstract

There is an increasing demand for process-based crop models with intercropping capabilities to support the global transition toward sustainable and climate-friendly food systems. Here, we adapted the Land Use Change Impact Assessment (LUCIA) intercropping module to simulate cereal-legume intercropping systems in a low-input environment of Sub-Saharan Africa. LUCIA is an integrated, spatially explicit, and dynamic model that evaluates the effects of land cover change on agricultural productivity across landscapes of approximately 30 km^2. Notably, the intercropping sub-module in LUCIA has already been tested in agroforestry systems across diverse environments.

The dataset used for this study comes from two season experiments conducted in northern Ghana across constating agroecological zones namely Northern Guinea Savannah (NGS) and Southern Guinea Savannah (SGS). Two grain legumes cowpea and soybean were intercropped with maize in different spatial arrangements: (i) maize-legume intercropped within-row, (ii) one row of maize alternated with one row of legume, and (iii) two rows of maize alternated with two rows of legume. The LUCIA model was parametrized and calibrated using sole crop data on phenology, canopy light interception, aboveground biomass, grain yield, and nitrogen uptake. Then, we evaluated its capabilities using an intercrop design.

The adapted model produced good simulations of species light interception, aboveground biomass, and yield compared to the measured data across growing seasons and sites, with less than 15 % normalised root mean square error (nRMSE). Future studies will explore how model uncertainty is affected after calibration with intercrop data in addition to sole crop data. This is key to ensuring the model is not used 'off the shelf,' especially under low-input conditions where both water and nutrients are limiting.

Keywords: Agroecology, landscape model, low input cropping systems, multispecies systems

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