Modeling the land-water-climate nexus - what are links to energy?

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The most recent global framework for sustainable development, the Sustainable Development Goals (SDGs), addresses – among other goals - energy (goal 7), climate (goal 13), water (goal 6), and land (terrestrial ecosystems – goal 15 and agriculture – goal 2). While the need for an integrated or “nexus” approach across all of these resources, for improving human food-, energy- and water-securities while reducing environmental pressure, is stressed in the latest SDG draft and in any green economy strategy, it is by no means clear how to operationalize and implement such an approach.

Science can inform the required integration by quantifying the interlinkages and feedbacks between different resources such as water, land and energy in space and time, including the effects of climate and land use change. That way, science can support the identification of potential synergies and tradeoffs between sectors, which need to be managed and governed. While the current resource situation in terms of resource availabilities, demands and use efficiencies can be derived from statistical data analysis (and is often presented in Sankey diagrams), integrated models such as the LPJmL biosphere model are required to simulate future resource use and scarcities and cross-resource inter-dependencies.

LPJmL has frequently been used to simulate biophysical and biogeochemical processes consistently across land and water systems, including productivities and yields of food, feed, and biofuels crops, as well as other ecosystem services. Crops are represented globally uniformly as crop functional types, other vegetation as plant functional types. Agricultural management (irrigation, treatment of residues, intercropping) are considered through their effect on productivity, on soil organic carbon and on carbon extracted from the ecosystem. LPJmL simulates at 0.5° resolution carbon and water fluxes and stores, and accordingly water availability, terrestrial carbon storage and crop water requirements, productivity and production, for current and future climate and land use. With that LPJmL is able to dynamically assess the impacts of global change (and the effects of adaptation measures) in agricultural and other ecosystems.

By linking LPJmL to an energy model, the interlinkages between energy-, food- and eco-systems as mitigated through land and water, and with that opportunities for improved (and climate friendly) production could in principle be simulated. Water and land requirement for additional energy demands, power generation and different mitigation pathways and associated renewable energy options could be assessed, and their compatibility with requirements for food and other biomass could be tested. Similarly, the energy requirements (and climate effects) of future food and other biomass demands and associated agricultural intensification options, such as additional irrigation and fertilizer use could be assessed.

We propose to link LPJml to an energy model and are very open for collaboration with interested partners.

Figure: Integrated approach across water, land and energy resources for ensuring food, energy and water security (BMZ 2014)