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Quantifying synergies and trade-offs in the water-land-energy-food-climate nexus using a multi-model scenario approach

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The human population has substantially grown and become wealthier over the last decades. These developments have led to major increases in the use of key natural resources such as food, energy and water causing increased pressure on the environment throughout the world. As these trends are projected to continue into the foreseeable future, a crucial question is how the provision of resources as well as the quality of the environment can be managed sustainably.

Environmental quality and resource provision are intricately linked. For example, food production depends on availability of water, land suitable for agriculture, and favourable climatic circumstances. In turn, food production causes climate change due to greenhouse gas emissions, and affects biodiversity through conversion of natural vegetation to agriculture and through the effects of excessive fertilizer and use of pesticides. There are many examples of the complex interlinkages between different production systems and environmental issues. To handle this complexity the nexus concept has been introduced which recognizes that different sectors are inherently interconnected and must be investigated in an integrated, holistic manner.

Until now, the nexus literature predominantly exists of local studies or qualitative descriptions. This study present the first qualitative, multi-model nexus study at the global scale, based on scenarios simultaneously developed with the MAgPIE land use model and the IMAGE integrated assessment model. The goal is to quantify synergies and trade-offs between different sectors of the water-land-energy-food-climate nexus in the context of sustainable development goals (SDGs). Each scenario is designed to substantially improve one of the nexus sectors water, land, energy, food or climate. A number of indicators that capture important aspects of both the nexus sectors and related SDGs is selected to assess whether these scenarios provide synergies or trade-offs with other nexus sectors, and to quantify the effects. Additionally a scenario is developed that aims to optimize policy action across nexus sectors providing an example of a holistic approach that achieves multiple sustainable development goals.

The results of this study highlight many synergies and trade-offs. For example, an important trade-off exists between climate change policy and food security targets: large-scale implementation of bio-energy and afforestation to achieve stringent climate targets negatively impacts food security. An interesting synergy exists between the food, water and climate sectors: promoting healthy diets reduces water use, improves water quality and increases the uptake of carbon by forests.

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