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## Impacts of Biofuel Production on the Food-Energy-Water Nexus in Malawi

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### Abstract

The growing pressure on natural resources worldwide requires a profound understanding of the intrinsic links between food, energy, and water and the conflicting impacts of development policies on all three sectors. While the expansion of biofuels is promoted to reduce poverty and enhance energy security, tradeoffs regarding water through irrigation or food security through land displacement could outweigh the benefits. This paper is the first to simultaneously assess the effects of biofuel production on food, energy and water security through the implementation of a comprehensive modelling framework. Sugarcane and ethanol sectors are integrated into a recursive-dynamic computable general equilibrium (CGE) model of Malawi. Different sugarcane production technologies concerning farm size and irrigation intensity are simulated to measure changes in energy and food security. To evaluate effects on water, the CGE model is linked to a new crop model that calculates water requirements of crops based on historic climate data. A micro-simulation module analyses policy effects on poverty. Higher availability of ethanol from sugarcane undoubtedly enhances energy security. Due to extreme land scarcity in Malawi, land displacement for sugarcane production leads to crowding out of other crops. Contrary to findings of many other studies at the global level, we find that not food crops but traditional export crops are displaced due to an appreciation of the exchange rate from increased ethanol exports. Food security increases through higher food availability, lower food prices, and higher incomes. Positive effects on food security are highest if sugarcane is produced by smallholder farmers under irrigation. Even without irrigation, smallholder farmers realise income gains and reductions in poverty. Since sugarcane is a very water-intensive crop, both rainfed and irrigated sugarcane production for ethanol lead to an enormous rise of exports of virtual water from Malawi. As irrigation water is exclusively taken from surface water, an expansion of irrigated sugarcane is likely to decrease water levels of rivers and thus water security in Malawi. These complex effects stress the importance of an integrated assessment of food, energy, and water security to identify both synergies and tradeoffs of development policies.

**Keywords:** Biofuels, food security, Malawi, poverty, water