Towards an improved assessment of indirect land-use change

Evaluating common narratives, approaches, and tools

J.W.A. Langeveld, M. Chordia, G.A. Oladosu, M. Brandão, V.H. Dale, K.L. Kline, A. Cowie

Introduction

The debate surrounding the impact of biofuel production on food availability and land use is characterized by a lack of consensus and critiques of existing approaches, and varying estimates of Indirect Land-use Change (iLUC). To address the uncertainty around iLUC, IEA Bioenergy Task 43 and Task 38 conducted a comprehensive study to examine the interrelations between biofuel production, agricultural biomass, food and feed markets, trade flows, and land use. This study aims to get a deeper understanding of the potential implications of biofuel production on food systems and land use dynamics.

Analytical framework

An analytical framework was developed (Figure 1) that examines crop, food, and ethanol production, as well as trade activities in the U.S. (biofuel production) and countries where indirect effects may be observed, such as Brazil. Direct effects in the U.S. involve changes in corn production and crop prices, while indirect effects include changes in livestock production, crop production, and agricultural commodity trade. In Brazil, indirect effects may relate to corn production, crop exports, and changes in land use.

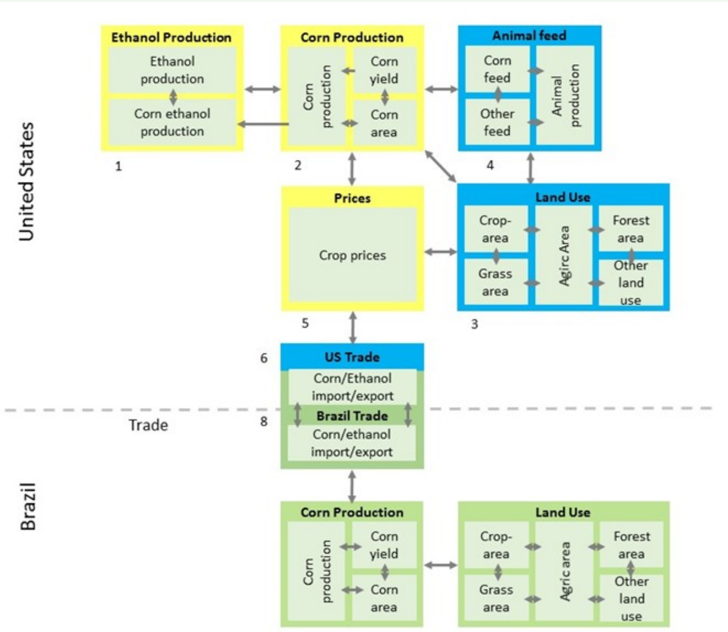

Figure 1. Analytical framework that links developments in US ethanol production to domestic and distant changes in corn markets, production, land use and trade. Domestic activities that are directly affected are depicted in yellow; activities that are indirectly affected are in blue. Activities in distant economies are presented in green.

Narratives

The report introduces two narratives that predict and explain possible indirect impacts of biofuel production: 'trade and market response', and 'internal adjustment'.

The trade and market response narrative focuses on the impact of biofuel on food markets, where the increased demand is projected to lead to higher corn prices and reduced U.S. corn and meat exports affecting distant economies, like Brazil, where farmers adjust their crop areas, including through deforestation, to supply the diverted feedstocks. Trade flows are significantly affected on both domestic and international levels, as prices and market shares respond to the diversion of corn to biofuel production.

The internal adjustment narrative projects changing demands, including biofuel production, to be met with diverse strategies including increasing cropping intensity, investing in farm machinery, adjusting crop rotations, and improving agricultural efficiency. Increased biofuel production is expected to have limited effects on international food and land markets, as the U.S. agricultural system adapts internally to meet demand.

Modelling approach

Food and Agricultural Policy Research Institute model (FAPRI-MU)

An example of advanced biofuel feedstock production modelling is presented by FAPRI-MU. Implications of increased U.S. ethanol production from corn were projected in 2009. Half of the additional corn demand was expected to be met through yield increase and area expansion, the remainder to be covered by animal feed, trade plus some alternative sources. No significant changes were projected in corn stocks or exports. FAPRI focused on commodity markets and farm incomes, with limited consideration of land cover changes.

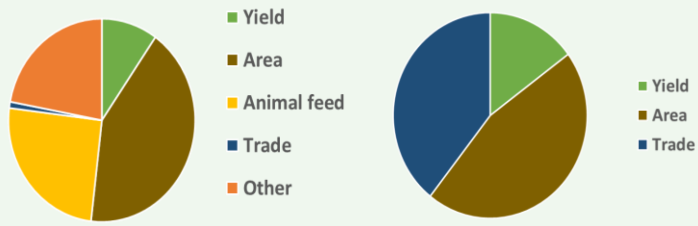

Figure 2. Sources of additional corn for ethanol production in the U.S., according to FAPRI-MU (2009, left) and Searchinger et al. (2008, right)

Searchinger et al. (2008)

Searchinger et al. (2008) compared two policy scenarios for 2004-2016: a base scenario and a high bioethanol policy scenario with an additional demand of corn ethanol. The high bioethanol scenario was projected to lead to increased corn demand and peaking crop prices, affecting U.S. livestock production and export. Farmers in distant economies including Brazil were expected to compensate for reduced U.S. exports by increasing crop production based on land conversion. Using a global equilibrium model, the paper projected significant GHG emissions due to land-use change. It has been criticized for overestimating GHG impacts compared to other studies.

Life cycle assessment (LCA)

Brandão (2022) conducted a consequential LCA on U.S. corn-based ethanol production following the trade and market response narrative. It relies on a market balance approach, quantifying corn diversion from food, feed, and export markets and assuming adjustments by marginal suppliers to maintain demand. A substantial amount of corn for ethanol production

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comes from expanding corn area on U.S. agricultural land, with smaller proportions diverted from feed, food, or export. Changes in livestock product demand, price, and cropping practices were not included.

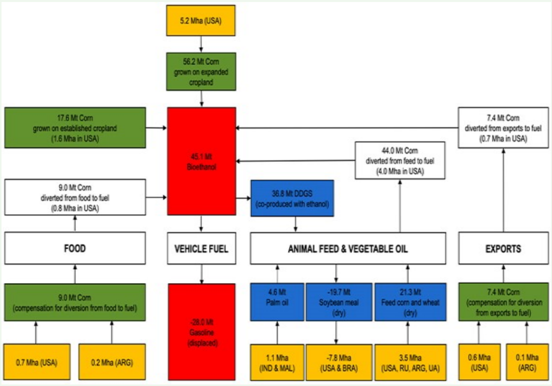

Figure 3. Implications of increasing production of corn for ethanol in the USA, including balancing of vehicle fuel, food, feed, and vegetable oil markets (Brandão, 2022)

Extended LCA studies

Flugge et al. (2017) analysed corn-based ethanol's greenhouse gas emissions using life cycle analysis encompassing various categories like domestic and international land use change and nine other scenarios. The study compared emissions from a state-of-the-art natural gas-powered refinery and business-as-usual conditions with or without GHG reduction measures. International land use change was the main contributor to GHG emissions in all scenarios. Overall, corn ethanol consistently had lower GHG emissions than gasoline, but the extent varied across scenarios.

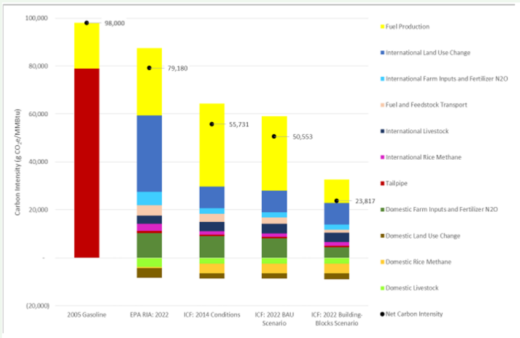

Figure 4. Full Life-Cycle Corn Ethanol GHG Results for the ICF: 2014 Current Conditions, ICF: 2022 BAU, and ICF: 2022 Building-Blocks Scenarios (Flugge et al., 2017)

Causality analysis studies

Oladosu et al. (2021) analysed the causal relationships between U.S. ethanol production and corn and oil markets. They found that high ethanol production is linked to increased corn supply and exports, but not to higher crop prices. The link between ethanol production and corn use in animal feed exists but is not as strong as expected. The study challenges common narratives about biofuel effects on exports and crop prices.

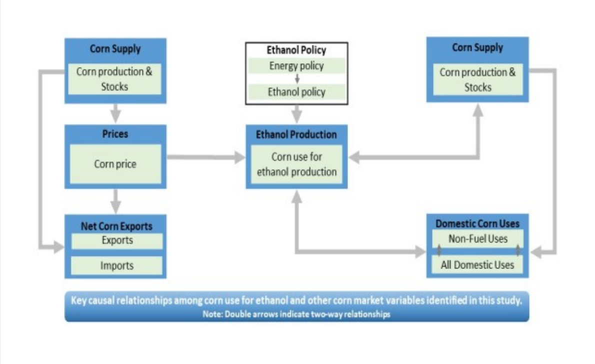

Figure 5. Causal analysis evaluation based on Oladosu et al. (2021)

Analysis: the impacts of expanding U.S. corn ethanol production

From 2005 to 2015, U.S. corn ethanol production increased, but corn demand couldn't be fully met. Land use for corn didn't significantly expand, and livestock feed used alternatives like distillers dried grains and solubles. Crop prices fluctuated due to droughts in 2008 and 2012. Corn exports remained stable. In Brazil, corn production and exports rose due to improved yields and double cropping with soybeans, but the overall impact of U.S. biofuel production on land use and trade was less severe than projected, and links to land-use changes in other countries were inconclusive in formal statistical analysis.

Conclusion

The analysis of biofuel production from 2005 to 2015 highlighted strengths and weaknesses in two narratives. The trade response narrative correctly predicted rising corn prices but missed changes in crop production systems. The internal adjustment response narrative accurately foresaw ethanol output expansion without compromising food or feed markets. Conflicting conclusions on land-use change call for further research, using a comprehensive approach to understand the climate effects of biofuel policies.

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