Land Use and Water Efficiency in Current and Potential Future U.S. Corn and Brazilian Sugarcane Ethanol Systems
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Background
Domestic biofuel production from renewable energy sources could potentially yield environmental and social benefits such as reducing greenhouse gas (GHG) emissions and promoting rural development. But as biofuel production continues to increase worldwide, concerns about land competition between food and fuel, excessive demand for water by competing users, and other un anticipated environmental consequences have grown.

Biofuels’ water, energy, and land footprints are context-dependent. Footprints are very reliant on the types of crops used, crop yield, inputs required by crops, efficiency of biofuel conversion process, sources of process energy, and co-products generated.

Goal
1. Assess the current and potential future land use efficiency and water use of U.S. corn ethanol and Brazilian sugarcane ethanol—the two largest ethanol production systems in the world.
2. Examine tradeoffs between land and water use among potential future ethanol systems.

Methods
Primary method: Literature review and meta-analysis (i.e., recalculating from reported results).
Corn and sugarcane systems searched for:
- Current and historical commercial industry averages
- Advanced, current commercial systems
- Parallel future systems between corn and sugarcane
- Future systems with CCS.

Abstract
Biofuels represent an opportunity for improved sustainability of transportation fuels, promotion of rural development, and reduction of GHG emissions. But the potential for unintended consequences, such as competition for land and water, necessitates biofuel expansion that considers the complexities of resource requirements within specific contexts (e.g., technology, feedstock, supply chain, local resource availability).

Through technological learning, sugarcane and corn ethanol industries have achieved steady improvements in resource use efficiency and environmental performance. Even greater improvements could be realized in future systems through a combination of continuous technological learning and better utilization of crop residues.

Conclusions
- The GHG savings and land energy productivity of both ethanol systems have improved significantly due to continued adoption of more efficient technologies over time.
- Advanced future systems are expected to continue to improve their environmental performance. However, how far these improvements reach depends on factors such as the assumed technologies, agricultural practices, technological learning, and how the crops and associated residues will be used to produce different combinations of products.
- The water impacts of biofuel systems are largely determined within the local contexts (e.g., water availability, the land-water nexus, and other ecosystem constraints). As such, biofuel water and land use footprints can only be understood within these contexts.

References

Results

![Graph showing GGH emissions savings (Mg CO₂ eq/ha harvested) from 2005 to 2010.](image)

- With GHG emissions from LUC

**Average consumptive water footprints (all in m³/GJ):**
- U.S. corn ethanol: 110 (43 green and 67 blue water)
- Brazilian sugarcane ethanol: 108 (58 green and 49 blue water).

**Potential site-specific (e.g., soil and climate) variation:**
- U.S. corn ethanol
  - Consumption (including green and blue): 50 – 385 m³/GJ
  - ET: 73 – 346 m³/GJ
- Brazilian sugarcane ethanol
  - Consumption (including green and blue): 50 – 250 m³/GJ
  - ET: 37 – 155 m³/GJ

NREL and other DOE laboratories are researching water supply and demand at the watershed scale for current and future biomass production to understand the tradeoffs of agricultural intensification and biofuel expansion.

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