CAN BIODIGESTERS IMPROVE WATER QUALITY AND REDUCE GREENHOUSE GAS EMISSIONS?

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Background

Our food system generates a significant amount of waste which contributes to climate change by emitting greenhouse gasses and negatively impacts water quality through nutrient pollution.

Biodigesters are a promising circular waste management solution:

- → Biodigesters facilitate anaerobic digestion to break down organic wastes.
- → The process captures methane, a potent greenhouse gas (GHG) typically emitted during manure and food waste storage, to generate biogas.
- → Nutrients are captured for reuse in a byproduct known as digestate.
- → The market value of biogas can offset the cost of transporting digestate to cropland.

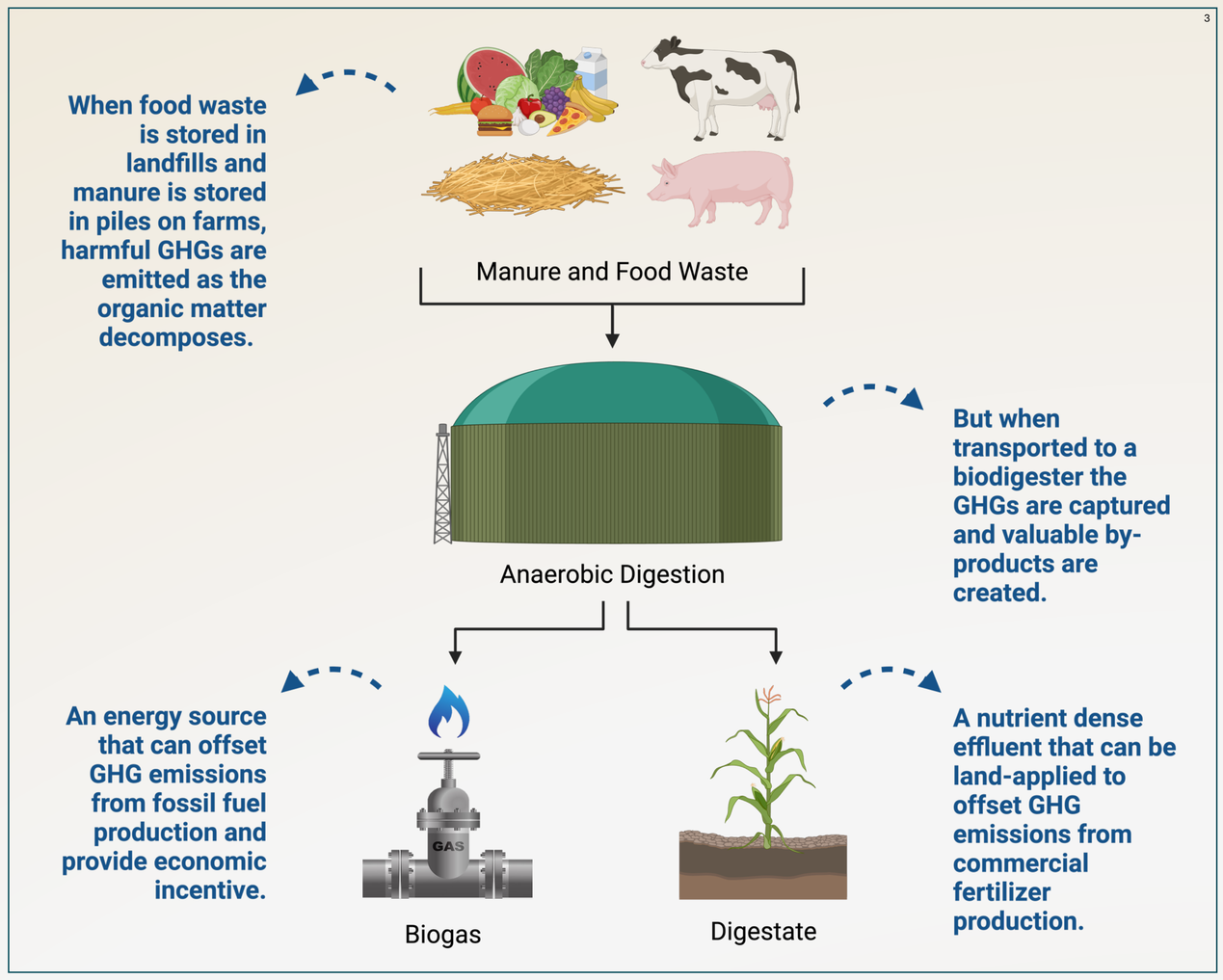
However, there are some concerns surrounding the land-application of digestate:

- → The elevated levels of soluble nitrogen may increase the leaching potential [1].
- → The higher ammonium content and pH may lead to increased ammonia emissions [2].

This research explores the environmental implications of digestate use across Ontario to understand if biodigesters can reduce the water quality impacts and GHG emissions associated with agricultural wastes at the system scale. To do this:

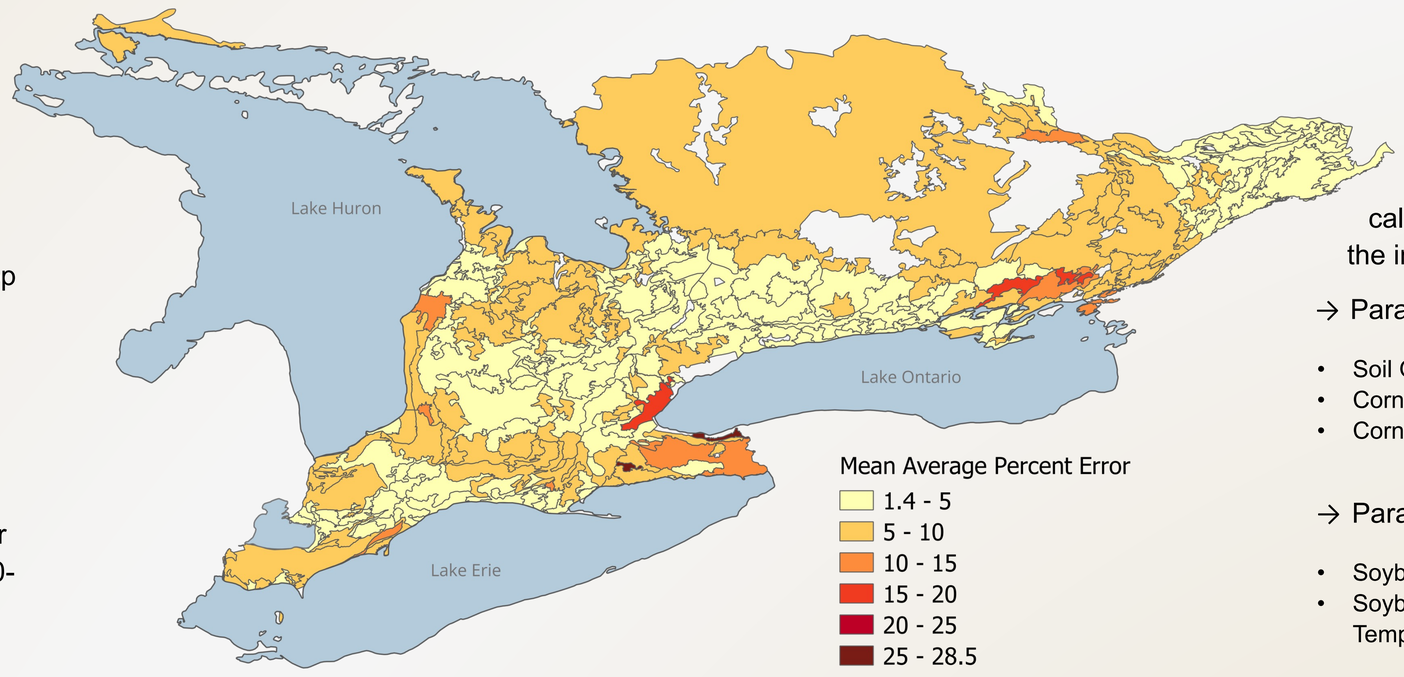
- → The DeNitrification and DeComposition (DNDC) model will be used to model the application of digestate, manure, and commercial fertilizer across Ontario.
- → The procedure used to calibrate the DNDC model to observed crop yield data for 267 regions in Ontario is presented here.

Can the DNDC model be calibrated to match crop yields across Ontario's agricultural regions?



Model Calibration

- → The DNDC model was calibrated for 267 polygons in Ontario, as delineated by the Soil Landscapes of Canada 3.2 (SLC) dataset [4].
- → The model was calibrated to observed crop yield data aggregated to the SLC scale.
- → Optimal values for 24 soil, crop, and field management parameters were identified using the OSTRICH calibration and optimization tool [6].
- → The calibration was done using an 11-year corn-soybean rotation which included a 10-year spin-up stabilization period.



Sensitivity Analysis

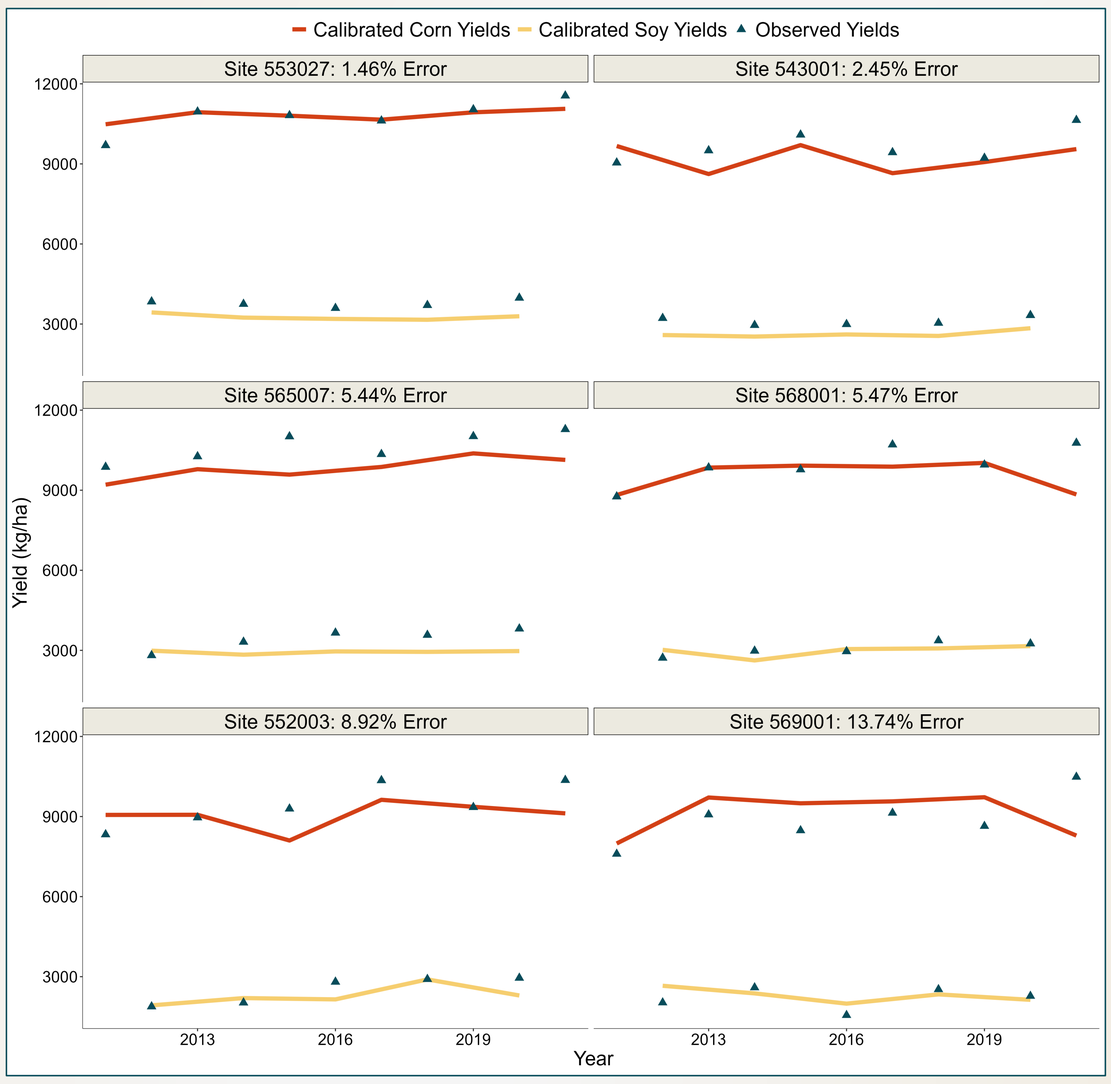
A sensitivity analysis was conducted for 9 SLC polygons using the Efficient Elementary Effects method [5]. The sensitivities of the 24 calibrated parameters were evaluated based on the influence they exhibited on crop yield outputs.

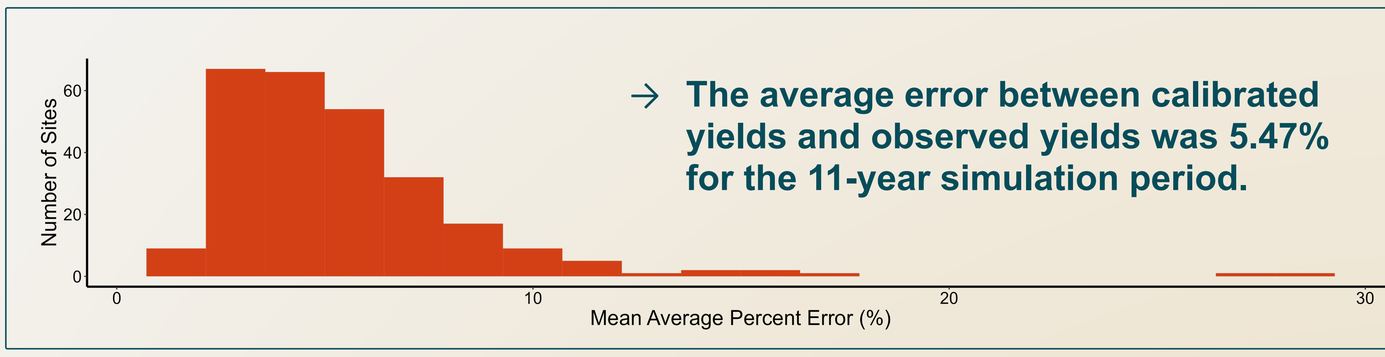
→ Parameters found to be informative at all sites:

- Soil Organic Carbon Fraction
- Soil Clay Fraction
- Corn Plant Date
- Corn Accumulative Temperature
- Corn Harvest Date

→ Parameters found to be uninformative at all sites:

- Soybean Water Requirement
- Soybean Harvest Date
- Soybean Accumulative Temperature
- Tile Drain Radius

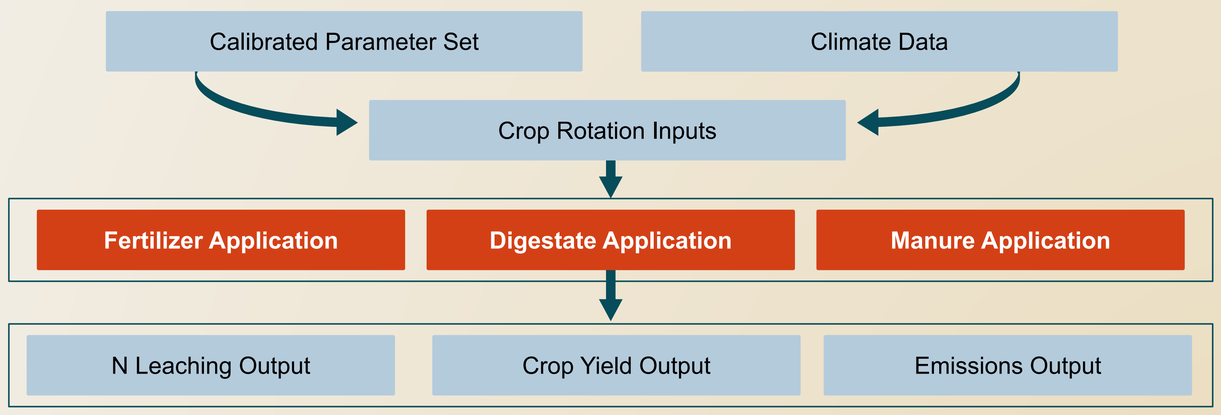




→ **The average error between calibrated yields and observed yields was 5.47% for the 11-year simulation period.**

Future Work: Scenario Modeling Approach

Using the calibrated parameter sets, a scenario modeling approach will be used to evaluate the influence that climate, soil, and field conditions have on the environmental implications of digestate use in place of, or in tandem with, commercial fertilizer and manure.



References:
[1] Schwager, E. A., VanderZaag, A. C., Wagner-Riddle, C., Crolla, A., Kinsley, C., & Gregorich, E. (2016). Field Nitrogen Losses Induced by Application Timing of Digestate from Dairy Manure Biogas Production. Journal of Environmental Quality, 45(6), 1829–1837.
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[3] Image Created with BioRender.com
[4] Soil Landscapes of Canada Working Group, 2010. Soil Landscapes of Canada version 3.2. Agriculture and Agri-Food Canada. (digital map and database at 1:1 million scale)
[5] Cuntz, Matthias, Juliane Mai, Matthias Zink, Stephan Thober, Rohini Kumar, David Schäfer, Martin Schrön, et al. 2015. "Computationally Inexpensive Identification of Noninformative Model Parameters by Sequential Screening." Water Resources Research 51 (8): 6417–41.
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