# Methodologies in Assessing Sustainability of Swine-Crop Systems

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## Purpose

To explain how LCA and related soil and crop evaluation tools are applied in swine production and manure management research.

## Importance

Understanding the environmental impact of swine production requires looking at the entire production system rather than individual parts. One of the most effective ways to evaluate this is through a "whole systems" approach that considers each stage of production. Starting with growing crops for feed production, to caring for animals, to handling the manure they produce. This method allows us to see how decisions in one area, such as fertilizer use or manure application, can affect soil quality, water resources, and greenhouse gas emissions.

By studying production in this way, we can identify both the benefits and risks of different practices. For example, applying manure to fields can reduce reliance on chemical fertilizers and build healthier soils, but poor management may increase air and water pollution. Using structured evaluation methods gives farmers, industry leaders, and policymakers a clearer picture of how to balance productivity with environmental responsibility.

## Key Concepts

Life Cycle Assessments (LCA) measures the environmental impact of a system from start to finish. It includes four stages: setting goals and scope, building an inventory of inputs, assessing impacts, and interpreting results. In swine production, inputs include feed sources (i.e., corn and soybean meal), housing energy, and manure management. Outputs involve greenhouse gas emissions, nutrient losses, and resource use. This framework helps compare practices and identify both the costs and benefits of different production systems.


## System Boundaries in LCA

A critical step in conducting an LCA is deciding where the boundaries of the system begin and end. For swine production, this usually includes crop production (corn and soybean), feed used by pigs, manure handling, and how manure is applied to fields. Clearly defining these boundaries ensures that important connections between soil and crops are captured. For example, manure applied to a field can reduce chemical fertilizer use, but if applied in excess, it can increase nutrient runoff. Proper boundaries help highlight such trade-offs.

## Soil Health Frameworks

Soil health is a key factor in evaluating sustainable practices. It is measured by chemical indicators like pH, soil organic carbon, and nutrient levels; physical indicators such as bulk density and water retention; and biological indicators like biomass and enzyme activity. Manure can play a dual role by enhancing soil organic matter and microbial activity when applied carefully, but has potential to degrade soil quality if applied improperly. By linking soil health indicators to farm practices, producers can better understand how their decisions affect long-term productivity.

## Nutrient Cycling Tools

Nutrient cycling tools help keep tract of the movement of nitrogen, phosphorus, and potassium between animals, manure, and crops. These tools can identify where nutrients are being used efficiently and where losses may occur. New technologies, like remote sensing, can further guide fertilizer application by showing where crops are healthy and where they may need support. This helps reduce over-application of fertilizers, saving money while protecting the environment.

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**Practical Applications**

LCA's provide a practical way to compare farming systems. For example, a farm using synthetic fertilizer may have lower nitrous oxide emissions, but contribute less to soil organic carbon storage than a farm applying manure. Manure can enrich soils but also carries risk if not managed properly. By integrating soil health metrics into farm planning and sustainability reporting, farmers and industry leaders can better weigh these trade-offs. Ultimately, applying LCA alongside soil health frameworks offers a clear pathway to make swine production more efficient and environmentally responsible.

**Key Takeaways**

- Life Cycle Assessment (LCA) tracks environmental impacts across feed, housing, and manure management
- Inputs: Diet components (i.e., corn and soybean meal), energy, and manure
- Outputs: Greenhouse gas emissions, nutrient losses, and resource use
- Clear system boundaries (crop production → swine feed → manure handling → soil application) ensure soil-crop interactions are captured into the circulatory assessment
- Soil health is measured with chemical, physical, and biological indicators; manure can improve or degrade these depending on application/use
- Nutrient cycling tools track nitrogen, phosphorus, and potassium flows
- Remote sensing and new technology guides more precise fertilizer use
- LCA helps compare practices and weigh trade-offs, supporting developing sustainability plans for pork producers

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