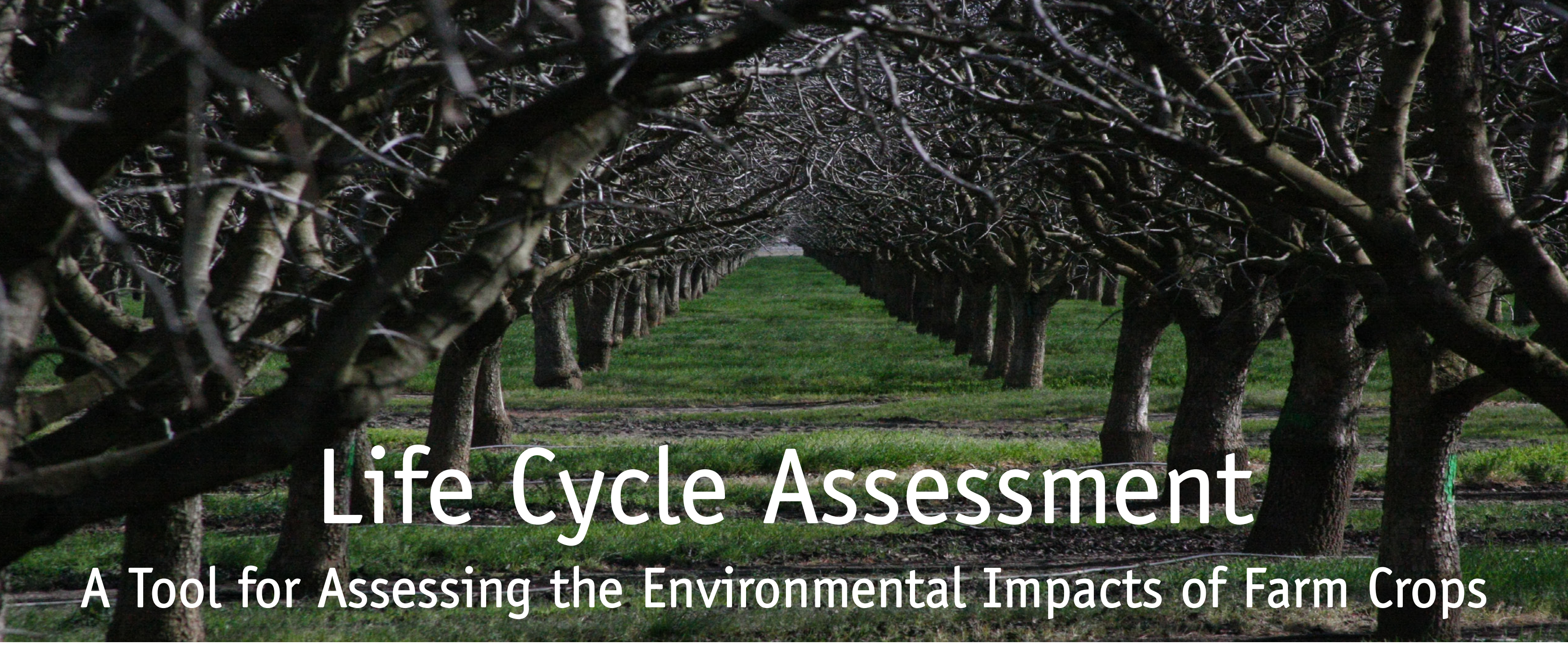

Life Cycle Assessment

A Tool for Assessing the Environmental Impacts of Farm Crops

What is an LCA?

Life Cycle Assessment (LCA) is a comprehensive tool for assessing the environmental impacts and resources used throughout the full life cycle of a system or a product, such as a food crop.

LCAs typically account for the energy and environmental impacts of all stages of a product's life cycle, such as acquisition of raw materials, the production process, handling of waste byproducts, and more. For example, a life cycle model of peach production might consider the amount of irrigation water used, energy required for pumping water, energy required to produce, transport, and apply fertilizers and pesticides, energy needed for harvesting, transporting, and processing the peaches, and impacts of waste disposal methods.

LCA explicitly requires a broad set of impacts to be considered, including air and water pollutants, energy use, and others, because the goal of an LCA is not just to understand all the life cycle stages associated with a product, but also differences or trade-offs among different environmental impacts. However, over the last decade life cycle greenhouse gas (GHGs) assessments, or carbon footprints, have grown in popularity. Carbon footprints apply the principles and methods of LCA, but track only GHG emissions.

By characterizing, quantifying, and interpreting the environmental flows from "cradle-to-grave," LCAs can play an important role in assessing the GHG emissions associated with agricultural products, which tend to be more dependent on regionally specific conditions and factors than industrial products. Importantly, LCAs can also identify "hot-spots"—opportunities along the production chain for mitigating energy consumption and reducing emissions.

The life cycle perspective is useful in avoiding problem shifting from one phase of the life cycle to another or from one environmental issue to another. For example, the use of synthetic nitrogen fertilizer accounts for a relatively modest portion of the total GHG emissions of field production for many crops when only considering on-farm operations and soil emissions of nitrous oxide (caused by adding nitrogen to the soil). However, when the energy-intensive manufacturing of the fertilizer is included as a stage in the analysis, the portion of GHG emissions attributable to synthetic nitrogen use can increase by 30-150%, typically making it one of the largest sources of total GHG emissions in the carbon footprint of many crops, and warranting much more attention in GHG reduction efforts.

Drip irrigation in a Sacramento Valley organic orchard. A LCA model could evaluate the environmental impacts of drip irrigation versus flood, furrow, sprinkler, or center-pivot systems.

Source: Sunny Slope Orchard, 2012

Limitations and Challenges

Although LCA models strive for a holistic evaluation, it is challenging to include every relevant input within the system boundary. Results can differ immensely depending on where the LCA model defines the beginning and end of the product's life cycle. Furthermore, some factors are complex and difficult to quantify. For example, it is challenging to define parameters for measuring impacts on land use, biodiversity, human health, and a variety of other factors.

The validity of an LCA depends on the integrity of its underlying data and on adequate calibration. In biological systems such as agriculture that are inherently dynamic and variable, it can be challenging to obtain data that characterize the many possibilities and interactions in the system.

Of critical importance to the credibility and application of any LCA model is the transparent communication of its underlying assumptions, boundaries and data sets.

LCA: A Decision Making Tool in Agriculture

Carbon footprint LCAs have applications for growers, food manufacturers, and retailers interested in reducing the GHG emissions of their products. Growers may use LCA models to estimate total emissions and understand where their greatest emissions are occurring, as well as to test the effects of different farming practices. They may also be used in the future as publicly funded GHG emissions reductions incentive programs such as farm bill conservation programs or California's cap-and-trade Greenhouse Gas Reduction Fund, or as market-based carbon offsets become available. Manufacturers, retailers, and commodity organizations can use LCAs on a farm-level or industry-wide basis for marketing or certification purposes. Policymakers and regulators could use LCAs on a crop or industry-wide basis to help focus policy options for reducing impacts, establish regulations, and develop voluntary programs to promote the use of practices that reduce GHGs or other environmental impacts.
LCA models can be coupled with life cycle cost modeling to provide both environmental and economic insights for decision-making. One valuable outcome from such a combination is that LCAs can provide the data required to estimate external costs associated with pollutant emissions and other environmental impacts, costs to society that are not captured in traditional economic analyses.

Life Cycle Assessment Case Study: California Orchards

The Agricultural Sustainability Institute at UC Davis developed an LCA model to evaluate the GHG emissions and opportunities for reducing GHGs in the production of California almonds, peaches, pistachios, prunes, and walnuts. Some examples of what is included in the model include:

- Fertilizer and pesticide production and application
- Fuel production and use
- Surface and ground water use
- Direct on-farm GHG emissions & carbon sequestration
- The handling of biomass byproducts (e.g., tree prunings, removed trees and processing waste such as shells, hulls, fruit pits) by burning, chipping for use as compost or mulch, or as a feedstock for renewable energy generation

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Produced by:
UC Sustainable Agriculture Research and Education Program • http://asi.ucdavis.edu/sarep
California Climate and Agriculture Network (CalCAN) • www.calclimateag.org

Funding provided by the
California Department of Food and Agriculture's Specialty Crop Block Grant Program

March 2015