An Integrated Food-Energy-Water Systems Model for Tackling Questions Related to Agricultural Produce and Food Supply Chains

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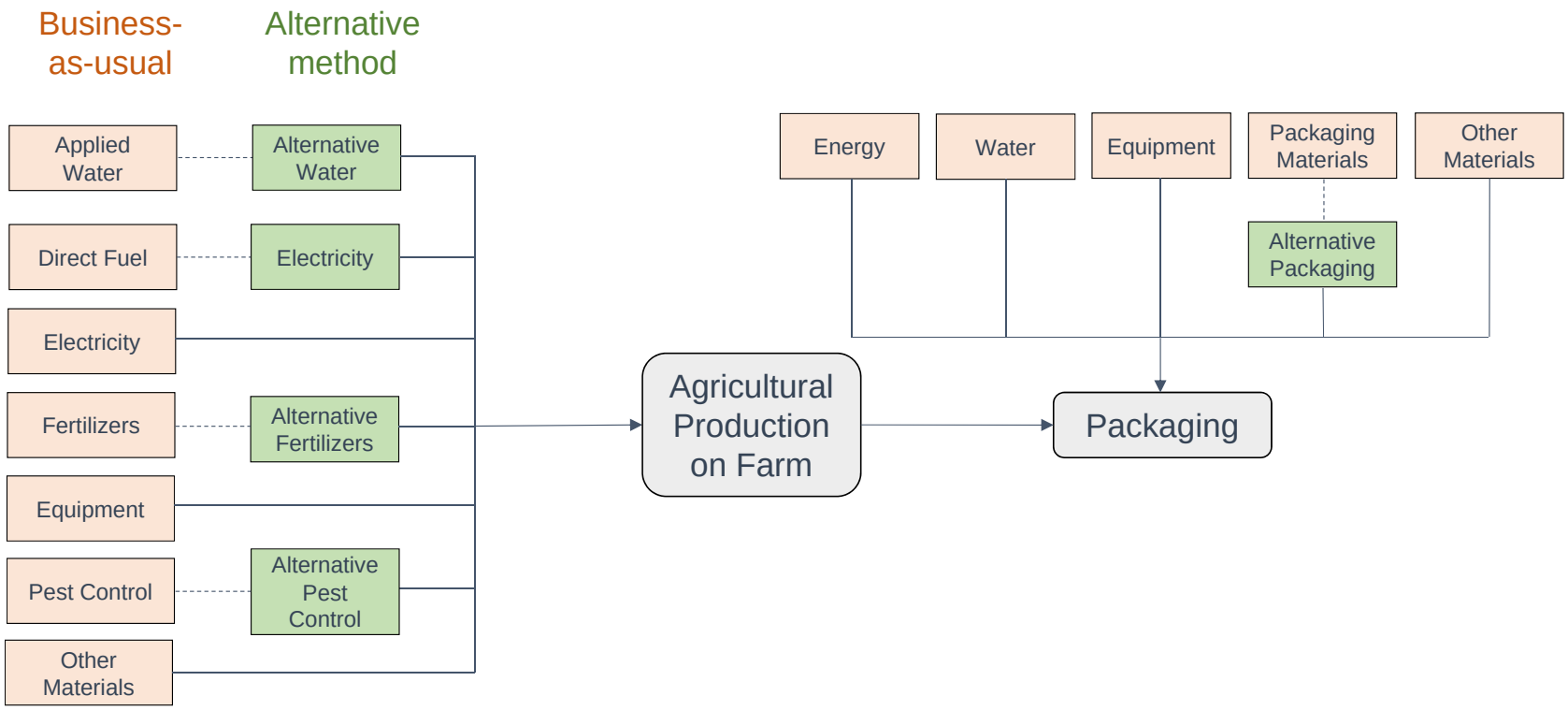
May 7, 2020

What Do We Study?

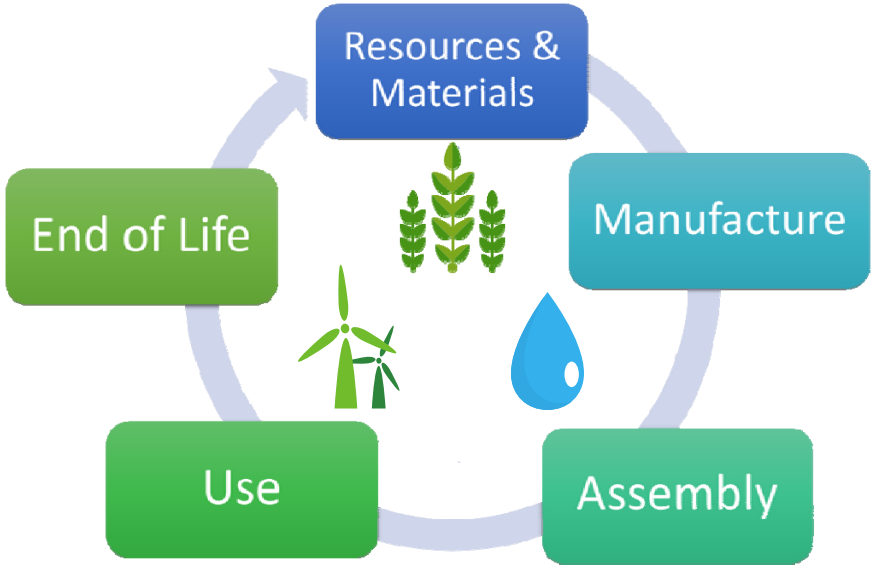
- Develop an integrated model of food, energy, and water (FEW) systems that accounts for the various inputs of agricultural production and food waste from farm to table.
- Focus on FEW systems that interface around and in cities.
- Analyze life-cycle economic costs, energy consumption, water use, and greenhouse gas (GHG) emissions.
- Focus on high-value produce (vegetables and fruits) in California and year-round supply of oranges in four large U.S. cities.
- Explore potential uses of alternative water sources in California for agricultural and landscape irrigation and food processing.
  - Recycled water, desalinated brackish water, desalinated seawater, and stormwater.

Product Systems



Method: Life-cycle Assessment (LCA)

Quantify
INPUTS
(materials, energy, water, etc.)



Estimate
OUTPUTS
(products, byproducts, emissions, wastes, etc.)

To help us:

Target improvements Benchmark utility performance Educate consumers Set design goals Evaluate technology performance
Identify tradeoffs Prioritize investments Enable more sustainable solutions Inform planning and policy

Data Sources

- Literature on the most recent studies of alternative water sources and agricultural production.
- “Cost and return” studies for agricultural produce by the University of California Cooperative Extension.
- Electricity profile reports from U.S. Energy Information Administration and California Energy Commission.

Analysis and Sample Results

Energy consumption of food production using conventional water, recycled water, and stormwater

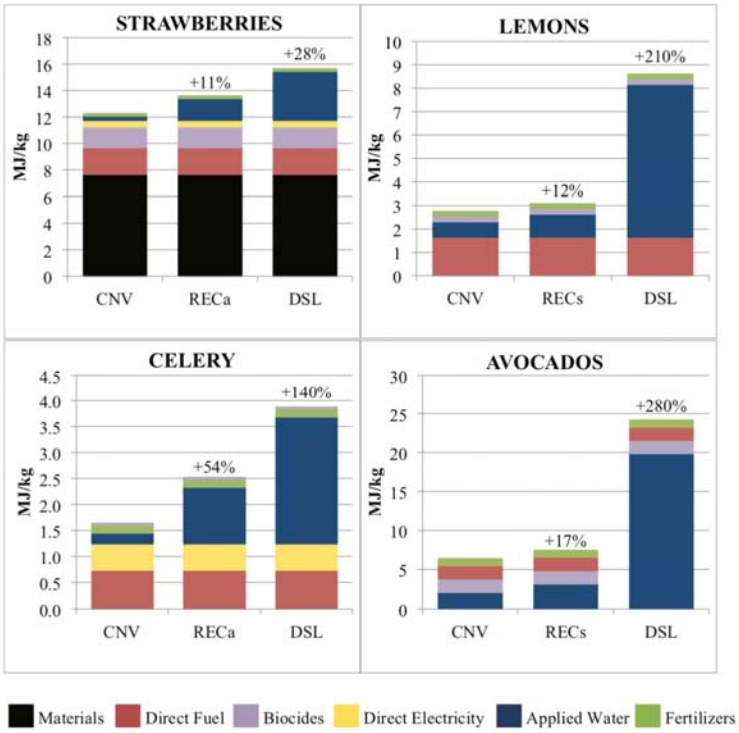


Figure 8. Life-cycle energy for conventional irrigation (CNV), recycled secondary water (RECs), recycled advanced water (RECa), and desalinated water (DSL).

- Updating with more recent studies.
- Including two additional alternative water sources: stormwater and desalinated brackish water.

Bell, E. M., Stokes-Draut, J. R., and Horvath, A. (2018). Environmental evaluation of high-value agricultural produce with diverse water sources: case study from Southern California. *Environmental Research Letters*, *13*(2), 025007.

Sample Results

Carbon footprint of supply of oranges

Figure 5. Carbon footprint of fresh oranges supplied to four US cities by production region ($kgCO_2e/kg$ of oranges). Key: AU = Australia, CA = California, CL = Chile, FL(T) = Florida by truck, FL(R) = Florida by rail, MX = Mexico, ZA = South Africa, TX = Texas. Note: Error bars represent 10/90 uncertainty interval.

Bell, E. M., and Horvath, A. (2020). Modeling the carbon footprint of fresh produce: effects of transportation, localness, and seasonality on US orange markets. Environmental Research Letters, 15(3), 034040.

Future Research

- Updates on alternative water and packaging options in food production.
  - Soon to publish: Qin, Y. and Horvath, A. (2020). Use of Alternative Water Sources in Irrigation: Potential Scales, Costs, and Environmental Impacts in California. *Environmental Research Communications*.
- Future study includes life-cycle assessment of energy use, water use, and emissions associated with food waste.

Acknowledgment:

- This material is based upon work supported by the National Science Foundation under Grant No. 1739676, INFEWS/T1, “Reducing the Environmental Impacts of FEW Systems In and Around Cities”. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.