**The Future of Sustainable Food:**

**Evaluating the Effect of Dynamic Life Cycle Assessment Methods on Agricultural Environmental Outcomes**

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**Abstract.** In the coming decades, agricultural systems will face rapid and profound change. Responding to emissions targets and net-zero initiatives, new methods and technologies will emerge to reduce the sector’s greenhouse gas (GHG) emissions. At the same time, already locked-in global warming will transform the climate, altering weather patterns and influencing outcomes like yield and irrigation demand. To prepare for this evolving future, stakeholders will need tools to understand not only how systems perform now, but how they will perform over many years. One such systems-modeling tool, life cycle assessment (LCA), calculates environmental impacts like GHG emissions and water footprint; however, standard LCA is static, capturing a “snapshot” that reflects the current data available. Dynamic LCA (DLCA) addresses this shortcoming by incorporating temporal resolution into different aspects of the changing natural and technological systems that underly production.

This study expands on previous LCA work with outdoor lettuce crop modeling by incorporating two DLCA methods: dynamic inventory modeling and dynamic process modeling. Dynamic inventory modeling considers the mix of energy and chemical resources that support a production system: in this study, a decarbonizing electrical grid, renewable resources replacing diesel, and green ammonia-based fertilizers are considered. Meanwhile, this study’s dynamic process model considers how warmer weather under climate change scenarios may affect crop yield and irrigation demands, changing the associated environmental impacts.

Preliminary results for dynamic inventory modeling suggests that the deployment of renewable energy in heavy machinery can have a significant impact on global warming outcome (up to 20% reduction), particularly if electrification is combined with renewable generation. Green ammonia fertilizer also enables a reduction in GHG emissions, but to a lesser extent (12% reduction). Additionally, ongoing dynamic process modeling will examine expected climate change effects in 2050 on conventional lettuce cultivation sites in California and Arizona, including a consideration of how higher temperatures and changing precipitation may affect irrigation demand. The effects of this dynamic process model on LCA results will then be compared to the different dynamic inventory effects, providing food-energy-water system stakeholders with insights into what technologies and strategies will have the greatest future impact.