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

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The world's agricultural and food systems vary by climate, geographic region, and local economic development conditions, but trade is making food products global in many cases, which is then followed by global interest in the efficiencies of production, water consumption, energy use, and emissions. Consumers want to know and consider in their decisions the environmental implications of the food they eat, and want to see profound reductions. Farmers and agricultural and food companies want to react positively and make changes, which is a challenge in the face of changing economic, climatic, labor, water, dietary, energy, labor, and emissions considerations and conditions.

Food, energy, and water systems are individually complex and inherently interdependent. Their joint study is both a necessity and a challenge. We have developed an integrated model of food, energy, and water systems to employ all three models simultaneously to tackle complex questions that span all three systems, but also problems that one would only see once the components and parameters of the three systems are in the same framework.

Our model accounts for the various inputs of agricultural production, food processing, and food distribution, from farm to consumer, including water, energy, biocides, labor, capital equipment, productivity, supply chains, transportation, retail and distribution, cooling, food processing, and food and packaging waste. The methodological basis for our model includes life-cycle assessment, life-cycle cost analysis, and a dynamic Bayesian network that allows us to propose optimal solutions in the face of changing conditions.

Through case studies we show what environmental and economic costs are expected to be when evolving water treatment technologies and sources (especially wastewater recycling, stormwater capture, and desalination) and water-saving technologies are deployed in most agricultural production areas of the world to maintain production in the face of climate change and disruptions. Packaging of products holds a key to reducing the environmental impacts of fruits and vegetables. Changing the electricity and energy supply has become an economically feasible opportunity. We incorporate into our model the enormous inefficiencies food waste represents.

The target audience for our model and results includes farmers and agricultural planners in the private and public sectors, individual consumers, water and wastewater agencies and companies, energy companies, food processors, and retail and distribution companies. Our model is globally

applicable and scalable.