

# Agent Based Modeling for Sustainable Urban Farming Incorporating Renewable Solar Energy and Impact on Food Security

**Marwen Elkamel and Luis C. Rabelo**

Industrial Engineering & Management Systems Department, University of Central Florida,  
Orlando, FL, USA

[melkamel@knights.ucf.edu](mailto:melkamel@knights.ucf.edu), [rabelo@ucf.edu](mailto:rabelo@ucf.edu)

## Abstract

The world environment is continuously changing due to various factors that include technological advancements, climate change, economic growth, and population increases. These factors contribute to greater demand for food, energy, and water resources. Policymakers need to strategize and plan accordingly to determine how to preserve the environment due to rising temperatures, water scarcity and increased demand for food resources while also efficiently managing these resources in order to meet sustainable goals. Policymakers are tasked with reducing carbon emissions, as well as increasing resource utilization efficiently all while keeping costs down. An approach known as food-energy-water (FEW) nexus is developed in order to promote sustainable development and synergy between resources in the nexus. The adoption of this FEW nexus framework can contribute to a greater understanding between the resources and their connections and thus allow us the evaluation of tradeoffs that exist between the resources and optimize the framework where informed decisions that will aid in achieving sustainability goals (societal, economic, and environmental) can be achieved. In this paper, we apply and study the impact of the FEW on a case study in Florida that includes a number of urban farms. The urban farms were developed with the objective of contributing fresh food supply to the local community. The inhabitants of the local community belong to food deserts, where inhabitants are low-income, low-mobility, and do not have access to fresh food within ten miles. Each of the urban farms belongs to a community-scale microgrid (MG) which provides electricity for the local community and the electricity is generated from solar energy. The MG's objective is to meet environmental sustainability goals by contributing fewer carbon emissions compared to traditional energy sources such as coal, crude oil, or natural gas. In addition, solar energy is a viable option due to the amount of solar radiation in the state of Florida. In this paper, the impacts of the proposed framework (urban farms & microgrids) through an analysis of societal, economic, and environmental sustainability measures are investigated. For societal sustainability measurements, the impact of the framework on food security of the local inhabitants are studied. For environmental sustainability, the impact of carbon emissions and the carbon emissions that are avoided due to the use of solar energy are analyzed. Finally, in terms of economic sustainability, the costs of the solar energy infrastructure, as well as possible costs or profits due to lack of electricity production or excess production are estimated. The paper employs an agent-based modeling (ABM) approach to study the interactions between agents in the framework (consumers, urban farms, microgrids) and this will allow to gain a greater understanding of the synergies and tradeoffs that occur in a FEW nexus for the case study considered.

## Keywords

Agent-based modeling, Food-Energy-Water nexus, Food deserts, GIS, Simulation, Renewable Energy

## Biographies

**Marwen Elkamel** is a graduate student currently pursuing his PhD in the Department of Industrial Engineering & Management Systems at the University of Central Florida. He obtained a Bachelor degree with distinction in Economics with a minor in Management Studies from the University of Waterloo, Ontario, Canada and a Master of Science degree in Management (Business Analytics track) from the University of Central Florida. Before starting his PhD, he worked as a data analyst for WeCare tlc. During his undergraduate studies, he served as a Research Assistant at the Waterloo Institute for Sustainable Energy (WISE). He was involved in two different projects that encompassed the acquisition and summary of data and preparation of computer programs to simulate processes and to make appropriate conclusions. During his PhD studies, he has been preparing machine learning models for electricity consumption with the consideration of socio-economic factors. He was also involved in a project that dealt with power

resources scheduling and planning. He is currently focusing on modeling and optimizing the Urban Food-Energy-Water Nexus in order to find more efficient ways to supply water, energy and food and manage natural resources that can aid in sustainable energy development and improved water and food security. He is a member of IEOM, IFORMS, and the Institute of Industrial & Systems Engineering. He has published several journal and conference papers in the areas of modeling, simulation, optimization, and big data analytics.

**Dr. Luis C. Rabelo** is a Professor of Industrial Engineering & Management Systems at the University of Central Florida. He was the NASA EPSCoR Agency Project Manager (2009-2011). He received dual degrees in Electrical and Mechanical Engineering from the Technological University of Panama and Master's degrees from the Florida Institute of Technology in Electrical Engineering (1987) and the University of Missouri-Rolla in Engineering Management (1988). He received a Ph.D. in Engineering Management from the University of Missouri-Rolla in 1990, where he also did Post-Doctoral work in Nuclear Engineering in 1990-1991. In addition, he holds a dual MS degree in Systems Engineering & Management from the Massachusetts Institute of Technology (MIT). He has over 300 publications, three international patents being utilized in the Aerospace Industry, and graduated 35 Master and 24 Doctoral students as advisor and co-advisor. He has consulted with NASA, NSF, ONR, NIST, Lockheed Martin Corporation, Boeing, Tyco, and others. His experience includes Ohio University, BF Goodrich Aerospace, Honeywell Laboratories, the National Institute of Standards and Technology, NASA, and MIT. He has received many awards among them ONE NASA in 2006, the Alumni of the Year of the Technological University of Panama in 2008, Fulbright Scholar in 2008, Two NASA Group Achievement Awards, the Emerald Literati Network Awards for Excellence 2007, the 2004 Arch T. Colwell Merit Award from the Society of Automotive Engineers (SAE), the 23rd Annual Hispanic Engineer National Achievement Awards Corporation (HENAAC) Education Award Winner in STEM in 2011, the Engineer Educator of the year 2011 by the US Engineer's Council, and the 2013 International Joseph McFarland Award from SAE.