Exploring options for optimizing food-energy-water nexus at the building, neighborhood, and city level.

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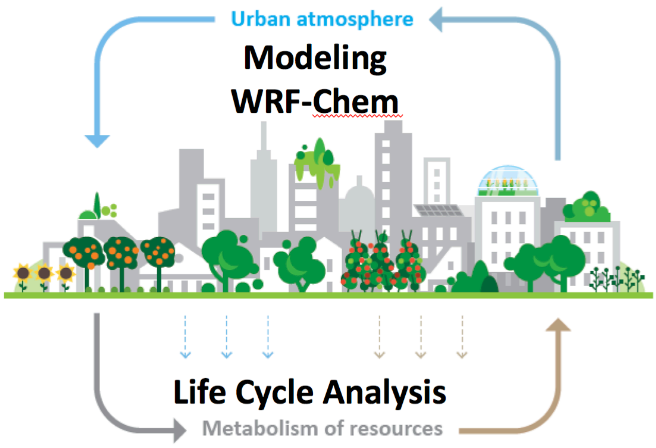
ABSTRACT

Supplying food to growing population in cities worldwide has become of critical importance. Recently, new urban agriculture systems, such as rooftop greenhouses, are being explored as a potential means to partly meet the city food demand. Integrated-RTGs (i-RTG) are especially attractive because, as the name implies, the optimizing of synergies between the greenhouse and the building through flow exchanges of residual heat, $CO_{2,}$ water recycling, or harvested rainwater can improve the overall resource management and metabolism of energy and water. The advantages are many. In terms of social well-being, it provides on-demand, ultra-fresh, locally-grown and pathogen-free food and can improve social and cultural interactions. Environmentally, it can provide low-energy pathways to food production by using less irrigation, less fertilizers and less transportation. Furthermore, exploiting nutrient-rich sources such as urban organic waste and residential wastewater as well as making use of rainwater recovery systems, especially in high-density areas, can further reduce environmental impacts of the food-energy-water nexus in cities.

However, there is still little knowledge about the costs and environmental impacts of i-RTGs and other forms of local food production which need to be evaluated to determine the feasibility and avoid unintended consequences. In this sense, we use life cycle assessment (LCA) and other tools from Industrial Ecology to evaluate the food-energy-water nexus at the building, neighborhood, and city level to best optimize these resources. At the building level, we have conducted several studies using the i-RTG on the campus of the Autonomous University of Barcelona. Given the i-RTG's moderate temperatures year-round, we have produced crops such tomatoes, chard, green beans, and lettuce with yields comparable to conventional production, at lower cost, and lower environmental impacts due to reduced mineral fertilizer, zero energy requirements for temperature control, the use of rainwater for irrigation, and the avoided food transportation. At the neighborhood scale, I will describe and illustrate how to determine best combinations of roof space to collect rainwater, grow food, and use photovoltaic panels based on indicators such as self-sufficiency, CO_2 emissions generated and avoided. At the city level, I will share some of our progress in identifying and geo-referencing green infrastructures throughout Barcelona as we attempt to optimize how nutrient recovery from wastewater can meet the fertilizer demand of these green infrastructures.

Our next steps are to develop methods that include both atmospheric modeling and life cycle modeling to have an integrative assessment of the effect of green infrastructures in cities. To do so, Oslo and Barcelona have been chosen as case study cities given their differences in weather, climate, precipitation, geography, urban morphology, green infrastructure, and population densities. Our goal is to provide city planners and policy makers the guidance they presently lack to determine how the growth in urban food production and green spaces can be managed to enhance urban sustainability and avoid unintended consequences, and promote wider and diffused social benefits I am presently searching for collaborators and stakeholders to keep the research relevant to Oslo's social needs, urban planning, and sustainability goals.

GRAPHICAL ABSTRACT



KEYWORDS

Life Cycle Assessment, Resource Management, Industrial Ecology, Vertical farming, Urban Agriculture, Nutrient Budget, Rainwater Harvesting, Nutrient Recovery, atmospheric modeling.

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