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Rethinking Food Waste Hierarchy in Urban Circular Economies through the Dynamics of Food, Energy, Water, and Carbon Nexus: Case of Bristol

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Abstract

Food waste is a multi-faceted complex problem for urban circular economies with critical impacts not only on food system, but also for energy, water, and climate systems. In this context, this study adopted a group model building approach to system dynamics modelling to investigate the life cycle impacts of food management options on food, energy, water and carbon nexus throughout the supply chain and in duration of time. The aim of this work is to examine the usefulness of circular economy's waste hierarchy framework which prioritises the options as reduction, redistribution, animal feed, anaerobic digestion (AD), compost, incineration, and landfill, respectively. For this, a quantitative system dynamics model is developed to simulate the dynamics of food (waste) and its energy, water, and carbon footprints in Bristol city in the UK from 2018 to 2030. Our findings suggest that the reduction and redistribution order in the waste hierarchy framework should be shifted for food waste management in upstream supply chain. This is because the redistribution of food surplus has lower energy, water, and carbon footprint than the reduction. When prioritising the energy and water footprint to greenhouse gases (GHG) emissions, the food waste hierarchy framework also requires significant changes as AD treatment and incineration options have less, and animal feed and compost options have more, energy and water footprint. This leads to conclude that the circular economy's waste hierarchy does not necessarily lead to environmental sustainability. Moreover, regarding the average results of animal feed option in reducing carbon footprint and poor results in reducing energy and water footprint, this study suggests that using food to feed animals should be regarded as food waste rather than food surplus. Hence, food waste is defined as 'any food and inedible parts which is not consumed by human regardless of its destination'. Despite insufficiency and inconsistency of data, this simulation-based study is the first dynamics modelling research in this area which provides valuable data-driven insights in the complexities of urban food (waste) impacts on energy, water, and carbon nexus. While this study has been focused on environmental impacts, further research is required to comprehend the dynamic impacts of social and economic factors of food waste management on urban circular economies.

Keywords: Food, Energy, Water, and Carbon Nexus; Circular Economy, System Dynamics Modelling, Waste Hierarchy, Group Model Building