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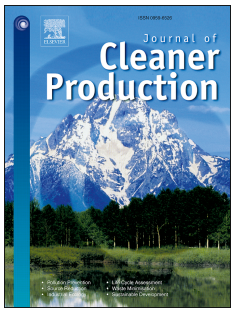

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Environmental assessment of an integrated rooftop greenhouse for food production in cities

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Abstract

Vertical farming is emerging as an effective measure to grow food in buildings and can increase food production in urban areas in a more sustainable manner. This study presents a comprehensive environmental assessment of food production in an integrated rooftop greenhouse (i-RTG) – an innovative vertical farm consisting of a rooftop greenhouse connected to a building – and considers rainwater, residual heat (energy), residual air (CO_2) and food from an industrial ecology perspective. This synergistic connection preserves resources and improves conditions in the greenhouse and the building. The goal of the study is to show the feasibility of the system and to calculate the environmental impacts from its whole life cycle, from infrastructure to end of life, by comparing these impacts with those of conventional production. The results show that the system is feasible and produced 30.2 kg/m^2 of tomato over 15.5 months. The synergy with the building allows the cultivation of winter-fall crops without supplying heating and maintained an average temperature 8 °C higher than that outdoors. Moreover, rainwater was used to irrigate the crops, reducing consumption from the water supply network by 80-90%. The environmental assessment showed that the operation of the i-RTG has more impacts than the infrastructure (structure of the greenhouse, rainwater harvesting system and equipment) due to the use of fertilisers, which account for 25% of the impacts in four of the six impact categories studied. Regarding the infrastructure, the greenhouse structure and rainwater harvesting system of the building have substantial environmental impacts (over 30% in four of the six impact categories). Comparison with a conventional greenhouse demonstrates that the i-RTG has a better environmental performance, showing between 50 and 75% lower impacts in five of the six impact categories (for instance, 0.58 kg of CO_2 equivalent per kg of tomato vs. 1.7 kg), mainly due to the reduced packaging and transport requirements. From this study, it was concluded that optimisation of the amount of infrastructure material and management of the operation could lead to even better environmental performance in future i-RTG projects.

Keywords: food security, urban agriculture, vertical farming, LCA, water-energy-food nexus, industrial ecology