Minimizing Costs and CO_2 Emissions in Urban Waste Management: A Bi-Objective Facility Location Problem with Seasonal Demand Fluctuations

Giulia Caselli[1], Giomaria Columbu[1,2], Manuel Iori[3], Carlo Alberto Magni[1], Matheus Oliveira[4]

[1]DEMB, University of Modena and Reggio Emilia, Modena, 41121, Italy.
[2]Iren Ambiente SpA, Reggio Emilia, 42123, Italy.
[3]DISMI, University of Modena and Reggio Emilia, Reggio Emilia, 42122, Italy.
[4]Department of Informatics, Federal University of Viçosa, MG, 36570-900, Brazil.

Abstract

Urban waste generation is increasing worldwide at a dramatic pace, making it crucial to develop efficient, cost-effective, and environmentally responsible waste management systems for fast-growing urban areas. This paper addresses a bi-objective facility location problem arising from the real-world waste industry, in which different classes of recyclable urban waste must be collected from sources and delivered to treatment or disposal facilities. The decisions are the number and location of the new intermediate transfer facilities to be opened and the optimal waste flow across the network. The goals are the minimization of the total costs and the CO_2 emissions. We present a single-period mixed integer linear programming model and then extend it to a multi-period setting, which better reflects the dynamics of waste production with seasonal fluctuations and generalize to further applications. We apply an ϵ-constraint algorithm to solve our models on two real-world case studies, obtaining approximated-but-well-structured Pareto sets of non-dominated solutions with 25% reduction of emissions while maintaining economic efficiency compared to the current state. The efficacy of the models is confirmed by further computational experiments on randomly created instances, showing that the models can be employed for analogous applications in cost-and-emission-driven waste management strategies.