Chapter 7
Measures to Increase Efficiency and Reduce Costs on Solid Waste Service Collection Operation

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ABSTRACT

The megacity of Lima generates daily around 9,000 t of wastes (organic and non-organic). This waste is collected by a network of municipalities with a customer service level of 43% and average cost of 38 $/t. This research is focused in Comas, a district of Lima. This district generates dairy 450 t of waste. The authors propose a key performance index to increase efficiency (customer service level) and reduce operating costs for waste collection service on Comas district (Lima) by using an on-line demand tool, based on the current population density and the waste generation of a certain area of Comas. They apply a reverse zone distribution (RZD), a term introduced in this study, as a result of an adapted methodology and supported by new technology trends, such as the internet of things. The RZD's value chain has many similarities with a commercial one; however, it differs fundamentally in the attention to the citizen.

INTRODUCTION

Urban logistics is a broad research and application field that led to a wide research-practice community (Ogden, 1992; Taniguchi et al., 2001; Macharis and Melo, 2011; Gonzalez-Feliu et al., 2014; Taniguchi and Thompson, 2015; Gonzalez-Feliu, 2018b, 2019). Although traditionally related to last-mile and urban B2B deliveries, urban logistics has evolved for more than 40 years and the variety and nature of flows

considered in this field is nowadays wider (Gonzalez-Feliu, 2018b). Indeed, three main categories of external flows, i.e. those that contribute to road occupancy and pollution in urban roads, are nowadays considered as belonging to urban goods transport and logistics: inter-establishment flows (i.e. B2B deliveries), end-consumer movements (B2B and some C2C flows) and urban management flows (i.e. those that allow urban functions to be operational). That last category, although it represents about 4% of the total traveled distances and 8% of road occupancy issues (Gonzalez-Feliu, 2018a) of all urban goods transport and logistics flows, is crucial to ensure the city's function.

Worldwide, 2.01 billion municipal solid waste are generated per year. Likewise, the waste generated by people daily averages 0.74 k, but fluctuates between 0.11 to 4.54 k. The highest-income countries generate 34% of the world's total waste. It is expected that by 2050, global waste will grow to 3.40 billion. On the other hand, approximately 1,600 million t of greenhouse gas emissions equivalent to carbon dioxide were generated in 2016, which represents approximately 5% of global emissions. It is expected that emissions related to solid waste will increase to 2.6 billion t of carbon dioxide by 2050 (World Bank Group, 2018).

Waste management flows represent, according to Gonzalez-Feliu (2018a), 1% of total traveled distances and 2% of total road occupancy issues. Since waste is, in general, collected along each street, it is difficult to quantify it in number of trips. Indeed, a waste collection route is assimilated to an arc routing problem and not to a nodal vehicle routing one (Cattaruzza et al., 2017), i.e. waste collection routes are defined as a one-path route where freight, more precisely waste, is collected on an arc and not on a node, so it is not evident to define a set of trips as on classical deliveries (Holguin-Veras et al., 2005). On the other hand, waste collection is crucial in city management (Hoornweg and Bhada-Tata, 2012 ; Pires et al., 2019), since it ensures the continuance of street hygiene, as well as contributes to urban health and inhabitant's quality of life (Botta et al., 2002). In Latin American countries, socio-economic and cultural issues have an influence on a sub-efficient use and appropriation of the urban waste management systems (Berdier, 2014).

In 2016, Peru's urban household produced more than 7 million t of waste (Ministerio del Ambiente, 2019). Metropolitan Lima contains about one third of the total population of the country, so it is then the highest generator of household waste in the country (Durand and Metzger, 2009). The metropolitan area is divided into 50 districts, administrated as independent municipalities, of different nature and characteristics (Metzger et al., 2015).

Economic growth and movement towards urban areas influence the per capita generation of waste. The awareness of the amount of waste generated, particularly by rapid urbanization and population growth, as well as the types of waste generated, allows local governments to select the appropriate management methods, plan future demand, design systems with an adequate number of vehicles, establish efficient routes, establish objectives for the diversion of waste, monitor progress and adapt as waste generation patterns change. In addition, using accurate data, governments can realistically allocate budget and land, evaluate relevant technologies and consider strategic partners, for the provision of services related to waste management (World Bank Group, 2018).

In this context, the importance of improving the efficiency of the waste management system in a metropolitan area such as Lima is evident (Xantem and Michaels, 1960; Arnillas Lafert, 1998; Llerena et al., 2011), not only on a logistics viewpoint, but also from an "efficient use" perspective. To that, IoT and TIC can contribute to a better management and planning of such systems. However, to implement those technologies, it is important to know the current context and application field, as well as characterize the current waste collection logistics system in order to improve it.

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