Journal of Urban Management 6 (2017) 66–79

Contents lists available at ScienceDirect

Journal of Urban Management

journal homepage: www.elsevier.com/locate/jum

Developing an indicators plan and software for evaluating Street Cleanliness and Waste Collection Services☆

Iago López[a,*], Verónica Gutiérrez[b], Félix Collantes[a], David Gil[a], Rafael Revilla[a], José Luis Gil[a]

[a] *Department of Science and Techniques of Water and Environment. University of Cantabria, Avda. Los Castros, s/n., 39005, Santander, Spain*
[b] *Department of Communications Engineering, University of Cantabria, Plaza de la Ciencia, s/n., 39005 Santander, Spain*

ARTICLE INFO

Keywords:
Street cleanliness
Waste collection
Performance indicators
Resources optimisation
Smart cities

ABSTRACT

An app to evaluate the Street Cleanliness and Waste Collection Service was developed. This app is based on a Plan of Indicators that can be used to evaluate the Street Cleanliness and Waste Collection Service of Santander municipality. Specific methodologies for calculating and evaluating 59 indicators have been developed to obtain information regarding the status of the different elements of the service. The Plan of Indicators has been applied to Santander city. The app was designed to address, but is not limited to, the following goals: i) to obtain, store and calculate information regarding the above indicators and ii) to disseminate the results of the status of the elements of the Service to the public sector. The app that was developed can provide a quick view of the results obtained for each indicator in each district, which is useful for making an appropriate diagnosis of the city's cleanliness and is the first step in the decision making and Service optimisation processes. Detailed results for the Street Cleanliness Index are shown for each district of Santander city. The Street Cleanliness Index values are also related to the Frequency Street Cleanliness Services parameters. Pearson correlation coefficient results suggest that an inverse relationship between the Street Cleanliness Index values and the Frequency Street Cleanliness Services/population density ratio exists ($R^2 = -0.63$). The results show that Street Cleanliness Index worst values exist for those districts that have a lower Frequency Street Cleanliness Services /population density parameter. The results are useful for designing and optimising the Street Cleanliness Service. For the decision making process, resources should be allocated where necessary, which seems to be those districts with lower Frequency Street Cleanliness Services /population density ratios.

1. Introduction

Street Cleanliness and Waste Collection is a service that local councils usually outsource to local providers. To check whether the Services are being executed according to a set of performance standards, Quality Controls are necessary (Garrido *et al.*, 2011). The Street Cleanliness and Waste Collection Service (SCWCS) includes sweeping roads and footpaths, waste collection and, in some cases, ensuring the cleanliness and maintenance of containers, bins and tree-grates. Thus, the goal of the Quality Control of the

Abbreviations: SCWCS, Street Cleanliness and Waste Collection Service; KQI, Key Quality Indicators

Peer review under responsibility of Zhejiang University and Chinese Association of Urban Management.

* Corresponding author.
E-mail address: lopezy@unican.es (I. López).

http://dx.doi.org/10.1016/j.jum.2017.06.002
Received 17 January 2017; Received in revised form 23 May 2017; Accepted 22 June 2017
Available online 28 June 2017

SCWCS is to guarantee a level of cleanliness and maintenance, to ensure that all of the rules are followed and to establish a rational framework between the work that is done and that which is planned. This last factor might affect the way in which outsourced services are valued and paid for (Sevilla *et al.*, 2013).

Traditionally, Quality Control of the SCWCS is performed by considering performance indicators, which is one of the ways to evaluate these kind of services (Simoes and Marques, 2012). Performance indicators are calculated as the ratio between the work done and the work planned, based on the performance of the equipment and the staff assigned to a specific service. However, the performance of the SCWCS is not necessarily related to its quality. In this sense, it is possible to analyse the maintenance and cleanliness status of a specific element that is the object of the service. For example, the performance indicator of street cleanliness is related to the ratio between the area swept and the area that should be swept (real/theoretical); the quality indicator can be related to the amount of litter in a specific area. In other words, the performance of a specific subservice may reach 100%, which may not reflect the cleanliness status of the street. Therefore, both indicators are not clearly related.

This fact can produce discrepancies between the results of the performance indicators and the quality of the Service. Consequently, the analysis of the SCWCS must account for the information that is collected regarding an element object of the service and not only with respect to the performance of the SCWCS. An analysis of the literature in this area reveals a major gap in the existence of key quality indicators for evaluating the SCWCS. Moreover, it is necessary to standardise classification criteria, which would allow the comparison of information from different indicators between different municipalities.

Although municipalities might, in some cases, spend more than 15% of their budgets on the Service, this process is generally not optimised. Because of the tasks and costs involved in the process (Simoes *et al.*, 2012), Street Cleanliness and Waste Collection are activities in which there are opportunities for savings by simply improving the efficiency of the process (Álvaro, 2007).

The appropriate cleanliness and maintenance status of the public furniture related to the SCWCS (e.g., bins, containers, tree-grates) of a city are directly related to the city's public image (Riccio *et al.,* 1988). Moreover, a clean city attracts business and tourism and is valued in a positive way by its citizens (Bel, 2006; Benito-Lopez et al., 2011; De Borger *et al.*, 1994; Forcada *et al.,* 1996; Giménez and Prior, 2003; Kuniyal *et al.*, 2003).

The motivation of this study is to address issues that are considered important, such as the quality and governance of urban services, the disparities between the budget spent and the resulting quality of service and the efficiency in management of public entities. This would contribute to the proper management of public expenditure and improve the quality and cost of an essential service for any city (Sevilla *et al.,* 2013). Therefore, this work aims to improve this Service for any city by checking the suitability of several indicators to give a true reflection of the level of cleanliness that a city presents.

In this study, two main goals have been set: i) to develop a Plan of Indicators that can be used to evaluate the SCWCS, with the following specific goals: a) to define indicators to analyse the quality of the Street Cleanliness and Waste Collection Services; b) to develop methodologies to calculate and evaluate each indicator; and c) to set the minimum and desirable values that each indicator should fulfil; and ii) to develop software with the following general goals: a) to obtain, store and calculate information regarding above the quality indicators of the SCWCS and b) to disseminate the results of the status of the elements of the SCWCS (e.g., containers, bins) to the public sector through the OpenData City Service.

Finally, as an example, we attempt to demonstrate some ways to optimise the Street Cleanliness Service in Santander city by analysing the resources assigned to each district and how these resources are related to the Street Cleanliness Index in each district.

The paper has been organised as follows. In the Material and Methods section (Section 2), the Plan of Indicators for Evaluation of Street Cleanliness and Waste Collection Service and the App developed to collect and analyse the information regarding the Service are described. In this section also the study area and the sampling design carried out in Santander city is described. In the Results section (Section 3), general results of the Service for Santander city are shown, together with the detailed results for one specific indicator (Street Cleanliness Index) and its relationship with the resources allocated in each district, which form the basis to carry out the optimisation of the Service, as shown in the final subsection. Finally, the main conclusions are described in Section 4.

2. Material and methods

2.1. Plan of indicators for evaluation of Street Cleanliness and Waste Collection Service

The first step consists of the development of Key Quality Indicators (KQI). A set of 59 KQI was developed, in which indicators were divided into 4 different areas: i) street cleanliness (21 indicators), ii) waste collection (6 indicators), iii) container status (10 indicators) and iv) beach cleanliness (22 indicators). In some cases, areas were also divided into several scopes (for example, street cleanliness area was divided into the following scopes: street cleanliness, bin status, tree-grate status, waste collection point status and graffiti and painting). Consequently, for each of the scopes defined by a single area, several indicators have been created based on the particularities associated with the service related to the topic.

A specific methodology for obtaining the value of each indicator was developed. In general, indicators were designed to measure the cleanliness status, maintenance status, filling status and functionality status of the different elements (e.g., containers, bins, tree-grates, streets) of the city. At this point, it is necessary to note that the methodology for each indicator is not included for obvious length limitations.

Finally, for each indicator, a quality criterion to be fulfilled was set. Two criteria were selected: minimum goal and desirable goal. Minimum and desirable goals for every KQI were set taken into account the expert's judgment. Together with the sampling process, the auditor provides information on its own perception regarding the specific element analysed (bins, streets, containers, etc.). One task that is necessary to develop in the future is try to assess the public perception regarding the Service, and the different tasks involved in such Service, which will allow to fit the value of the different goals of the KQIs to the public perception. Global qualification is also provided for each indicator using a 0–10 scale, obtaining a qualification of 5 when the minimum goal is reached and a qualification of 10 when the desirable goal is reached.

Appendix A presents i) the list of Key Quality Indicators, ii) a brief description of each KQI and iii) the minimum and desirable goals to be fulfilled for each KQI (Table A.1).

2.2. Development of software for evaluation of Street Cleanliness and Waste Collection Service

Created to transform the experience of evaluating the quality of the SCWCS within cities, the software/app that is shown in this study combines both reporting and analytic tools that has been designed for the hyper-connected world in which we live.

Based on a modular approach, the application is designed to guarantee its scalability and expandability. Using web technologies powered by HTML5, CSS3, and JavaScript, the software application boasts fast, responsive, and highly functional capabilities. Among others, the main objective of such application is to allow end users to carry out sampling campaigns on the streets in order calculate parameters related to the quality of the service and, therefore, to evaluate and analyse Key Quality Indicators (KQIs) using graphical representations.

Designed based on the principles of responsive design, it permits auditors of the service to use tablets or smartphones to carry out the measurements online when sampling different streets in a city. With this responsive design, the web pages that have been developed automatically adjust to fit the size of a browser window, regardless of whether it is a browser on an electronic device that may be used to collect or represent the information.

Within the application, different web forms are available to the auditors of the service for taking measurements that permit us to calculate the proposed indicators. When using the form, the end user must select the street name and census division (district and section) of the area where the user is taking the sample and start filling in the different parameters. Once the form has been completed, the user sends the information, and both the measured parameters and the calculated indicators are stored within the application database.

To calculate the KQIs, it is important to highlight that the application can be parameterised to adapt the proposed model to the characteristics of a particular city. The end user can also parameterise street names and census divisions (districts and sections) within a city, which are used when collecting data relative to a service. Based on the consideration that census divisions represent land areas of different size in which more or less the same users of the service live, it is considered the best way to present the indicators that have been defined. For the particular case of Santander, the information related to the streets is synchronised periodically within the application by using the OpenData portal that is available for the city (datos.santander.es).

In terms of parametrization, it is important to note that the methodology proposed by Femp and TECNOMA (2007) included a set of values. What we have done within this work, is to build a set of online tools that permits to simple information and calculate the corresponding metrics and KQIs. In order to validate such approach, we carried out several measurement campaigns that permitted us to adapt the initial model to the context of the service and the city we are analysing.

The application permit end users to visualize and represent KQIs or other reported information, which makes it easier to analyse how the service is provisioned in the city. To this end, bar graphs, pie charts, line graphs, and histograms provide excellent resources for the results of the application that has been implemented. In this sense, the graph and chart representations included within the application allows large amounts of information to be condensed into easy-to-understand parameters related to the SCWCS that have been measured by the sampling team. In this sense, the application allows representative indicators to be presented by using both maps and pie charts.

The map representation is used to evaluate the areas of the city where the quality of the service is better or worse. To this end, the average value of the indicator is presented using a range of colours table that is applied to the corresponding geographical area. From the application, the user can select such areas with different levels of detail: districts, sections or even at the street level. However, pie charts are circular charts that are used to compare the contribution to the whole value of the indicator due to different factors. Such charts are divided into sectors that equal the size of the quantity represented.

2.3. Software/app interface

The software has been designed to be more flexible; in this context, it is possible to i) collect information, ii) store information and iii) visualise results. The collection of information can be done by selecting the element for which information will be collected (e.g., street, container, bin, tree-grate). The storage of information tab allows the collected information to be modified or corrected, as necessary.

Finally, the results tab provides a powerful tool for the diagnosis and visualisation of the SCWCS results. In this sense, it is possible to select the period of analysis, the area and/or scope to be analysed, the district/s, section/s and streets, and the indicator/s desired. Moreover, the visualisation of results can be done through numerical or graphical representation (e.g., pie charts, box plots, histograms) or by mapping the results of indicators.

2.4. Study area and sample design

2.4.1. Study area

Santander is located in the north of Spain and had approximately 175,000 inhabitants in 2015. Santander is divided into 8 districts: Centro, Cazoña, Miranda, Puertochico, Puerto, Alta, Albericia and Peñacastillo, which have different characteristics with respect to the types of streets and roads, social class, age of the resident population, level of studies of the resident population and population density, among others, which assumes differences in the land use and activities carried out in each district. Consequently, the Street Cleanliness and Waste Collection Service should be designed accordingly.

Ascan-Sadisa is the company that carries out the Street Cleanliness and Waste Collection Service in Santander city. The company provides citizens with different elements for use and enjoyment, such as bins, containers, and tree-grates, both in the city and at the beaches. The company has developed several tasks to keep these elements and the streets clean, such as street cleanliness, bins maintenance, and container cleanliness. The company also distributes staff and equipment across the city and establishes the frequency of different services according to, at least theoretically, several factors, such as population density, main activity in the district (commercial, residential or industrial activities), street type, season of the year, or cultural habits of the population.

Information regarding waste generation per year in the period 2004 and 2016 was provided for the company. Municipal solid waste (MSW) generated per capita ranged between 1.026 kg/hab·day in 2004 and 0.944 kg/hab·day in 2011, while packaging waste ranged between 1.39 kg/hab·year in 2004 and 10.01 kg/hab·year in 2011, and paper/cardboard ranged between 16.79 kg/hab·year in 2004 and 29.58 kg/hab·year in 2007. The decrease in MSW generation and the increase in packaging and paper/cardboard generation from year 2007 can be due to an increase in the number of package and paper/cardboard containers, together with an environmental education campaign promoted by the city council.

2.4.2. Sample design

The goal of the sample design is to determine the minimum sample size to ensure the representativity of the results. Eq. (1) was used to determine the minimum sample size:

$$n = \frac{k^2 \cdot p \cdot q \cdot N}{e^2 \cdot (N-1) + k^2 \cdot p \cdot q} \tag{1}$$

where n is the minimum sample size (i.e., the number of streets, bins, and containers that should be sampled in the city or a district), p is the probability that an event will take place, q is equal to $1\text{-}p$ and $p = q = 0.5$, N is the total population (i.e., the number of streets, bins or containers located in the city or a district), k is the sampling interval (in this case, $k = 1.96$, ensuring a 95% confidence interval) and e is the estimation error (in this case, 0.1).

In the next table (Table 1), the following are shown: i) the number of different types of elements located in Santander city, ii) the minimum number of elements that should be sampled, and iii) the number of elements that were sampled.

Sampling was carried out from April 2014 to October 2015 on a daily basis, from Monday to Friday, with the goal of collecting the most information possible to provide an appropriate diagnosis of the city. More than 1200 elements of public furniture were sampled.

Considering the number of elements sampled, the next section shows the results obtained for Santander city. Note that this number of samples was taken to analyse Santander city as a whole (Section 3.1). When a specific district is analysed (Section 3.2.2), it is necessary to obtain a minimum number of samples according to the number of elements in that specific district.

3. Results

3.1. Evaluation of the SCWCS in Santander city (Spain): general results

Using the methodology developed for each indicator and the values set for the fulfilment of every indicator (Appendix A, Table A.1), this section explains the results obtained via application of the methodology.

There is one indicator ($MANT_{GAME}$) that is evaluated not by a classification criterion but rather by a checklist. Therefore, in this case, the minimum and desirable goals are not specified. In the following table (Table 2), the indicator name, the minimum and desirable goal and the result and qualification for every indicator are shown.

The results for each indicator and a global qualification for each indicator are shown. Global qualification is shown using a 0–10 scale, and the qualification value is obtained via interpolation, with the qualification equal to 5 when the minimum goal is reached and to 10 when the desirable goal is reached.

In this point, it is necessary to mention that, despite only KQI values for Santander city are shown in Table 2, a global evaluation for every district and/or sector can be obtained. As we have mentioned in Section 2.2. the scalability and expandability of the app allows to

Table 1
Number of different types of elements, the minimum number of elements to be sampled and the number of elements that were sampled in Santander city.

Type of element	Number of elements	Minimum number of elements to be sampled	Number of elements sampled
Streets	2421	93	616
Containers	3508	94	169
Bins	6552	95	385
Tree-grates	714	85	114
Waste Collection Points	1426	91	53

Table 2
Results and qualification for each KQI in Santander city. In some cases, results are not shown due to i) 95% of representativity was not reached or ii) no data available due to sampling schedule limitations.

Area	Scope	KQI Nomenclature	Minimum goal	Desirable goal	Result	Qualif
Street Cleanliness Status	Street Cleanliness	IS_{LV}	IS_{Lv} < 125	IS_{Lv} < 70	114	5.7
		$\%IS_{LV}$	< 70 in 75% streets	< 70 in 100% streets	40.7%	2.7
		$\%IS_{SV}$	< 70 in 75% surface	< 70 in 100% surface	47.6%	3.2
		%DETRITUS	< 20% length	= 0% length	–	–
	Bins Status	ILL_{BINS}	ILL_{BINS} < 2	ILL_{BINS} = 0	0.27	9.1
		$\%ILL_{BINS}$	= 0 in 75% bins	= 0 in 100% bins	71.8%	4.8
		IEM_{BINS}	IEM_{BINS} < 6.5	IEM_{BINS} = 0	11.6	2.7
		$\%IEM_{BINS}$	= 0 in 75% bins	= 0 in 100% bins	21.1%	1.4
		$\%PF_{BINS}$	$\%PF_{BINS}$ < 10%	$\%PF_{BINS}$ = 0%	11.5%	4.9
	Tree-grates Status	$IS_{TREE\ GRATES}$	$IS_{TREE\ GRATES}$ < 11	$IS_{TREE\ GRATES}$ = 0	1.5	8.9
		$\%IS_{TREE\ GRATES}$	= 0 in 75% tree grates	= 0 in 100% tree grates	79.2%	5.8
	Waste Collection Points*	$ISPA_A$	$ISPA_A$ < 150	$ISPA_A$ < 100	–	–
		$\%ISPA_A$	< 100 in 75% WCP	< 100 in 100% WCP	–	–
		$ISPA_B$	$ISPA_B$ < 4	$ISPA_B$ < 2	–	–
		$\%ISPA_B$	< 2 in 75% WCP	< 2 in 100% WCP	–	–
	Graffiti and painting	$FREC_{PAINT}$	$FREC_{PAINT}$ < 2	$FREC_{PAINT}$ = 0	–	–
		IS_{PAINT}	IS_{PAINT} < 6.5	IS_{PAINT} = 0	–	–
		$\%SA_{PAINT}$	$\%SA_{PAINT}$ < 27.5	$\%SA_{PAINT}$ < 10%	–	–
		$FREC_{BOARDS}$	$FREC_{BOARDS}$ < 2	$FREC_{BOARDS}$ = 0	–	–
		IS_{BOARDS}	IS_{BOARDS} < 6.5	IS_{BOARDS} = 0	–	–
		$\%SA_{BOARDS}$	$\%SA_{BOARDS}$ < 27.5%	$\%SA_{BOARDS}$ < 10%	–	–
Waste Collection Status	RSU, cardboard and packaging Waste Collection	ILL_{CONT}	ILL_{CONT} < 2	ILL_{CONT} = 0	1.23	6.5
		$\%ILL_{CONT}$	= 0 in 75% cont	= 0 in 100% cont	17.6%	2.3
		$\%PA_{EC}$	$\%PA_{EC}$ < 25%	$\%PA_{EC}$ = 0%	–	–
		$\%PA_{VOL}$	$\%PA_{VOL}$ < 25%	$\%PA_{VOL}$ = 0%	–	–
		$\%EC_{PA}$	$\%EC_{PA}$ < 25%	$\%EC_{PA}$ = 0%	–	–
		$\%EC_{VOL}$	$\%VOL_{PA}$ < 25%	$\%VOL_{PA}$ = 0%	–	–
Container Status	MSW, cardboard and packaging Container Status	$IEP\text{-}IN_{CONT}$	$IEP\text{-}IN_{CONT}$ < 15	$IEP\text{-}IN_{CONT}$ = 0	8.9	6.5
		$\%IEP\text{-}IN_{CONT}$	= 0 in 75% cont	= 0 in 100% cont	35.1%	2.3
		$IEP\text{-}EX_{CONT}$	$IEP\text{-}EX_{CONT}$ < 7.5	$IEP\text{-}EX_{CONT}$ = 0	12.6	2.0
		$\%IEP\text{-}EX_{CONT}$	= 0 in 75% cont	= 0 in 100% cont	0	0
		$\%SA_{CONT}$	$\%SA_{CONT}$ < 27.5%	$\%SA_{CONT}$ < 10%	42.2%	2.5
		IO_{CONT}	IO_{CONT} < 1.5	IO_{CONT} = 0	0.7	7.0
		$\%IO_{CONT}$	= 0 in 75% cont	= 0 in 100% cont	42.2%	2.8
		IEM_{CONT}	IEM_{CONT} < 8	IEM_{CONT} = 0	4.7	6.6
		$\%IEM_{CONT}$	= 0 in 75% cont	= 0 in 100% cont	30.9%	2.1
		$\%PF_{CONT}$	$\%PF_{CONT}$ < 10%	$\%PF_{CONT}$ =0%	0	10
Beach Cleanliness Status	Waste Collection	$ILL_{PAP\ BEACH}$	$ILL_{PAP\ BEACH}$ < 2	$ILL_{PAP\ BEACH}$ = 0	–	–
		$\%ILL_{PAP\ BEACH}$	= 0 in 75% bins	= 0 in 100% bins	–	–
	Container and Bins Status	$IEM_{PAP\ BEACH}$	$IEM_{PAP\ BEACH}$ <6.5	$IEM_{PAP\ BEACH}$ = 0	–	–
		$\%IEM_{PAP\ BEACH}$	= 0 en 75% bins	= 0 en 100% bins	–	–
		$\%PF_{PAP\ BEACH}$	$\%PF_{PAP\ BEACH}$ < 10%	$\%PF_{PAP\ BEACH}$ = 0%	–	–
		$IO_{PAP\ BEACH}$	$IO_{PAP\ BEACH}$ < 1.5	$IO_{PAP\ EBACH}$ = 0	–	–
		$\%IO_{PAP\ BEACH}$	= 0 in 75% bins	= 0 in 100% bins	–	–
	Sand Cleanliness	IS_{SAND}	IS_{SAND}	IS_{SAND}	–	–
		%SIEVE	%SIEVE > 75%	%SIEVE = 100%	–	–
		%SEAWEED	%SEAWEED < 20%	%SEAWEED = 0%	–	–
	Infrastructure maintenance	$FREC_{PAINT\ BEACH}$	$FREC_{PAINT\ BEACH}$ < 2	$FREC_{PAINT\ BEACH}$ = 0	–	–
		$IS_{PAINT\ BEACH}$	$IS_{PAINT\ BEACH}$ < 6.5	$IS_{PAINT\ BEACH}$ = 0	–	–
		$\%IS_{PAINT\ BEACH}$	= 0 in 75% walls	= 0 in 100% walls	–	–
		$\%SA_{PAINT\ BEACH}$	$\%SA_{PAI\ BEACH}$ < 27.5%	$\%SA_{PAINT\ BEACH}$ < 10%	–	–
		$\%LA_{FENCES}$	$\%LA_{FENCES}$ < 20%	$\%LA_{FENCES}$ = 0%	–	–
		$IEM_{SHOWERS}$	$IEM_{SHOWERS}$ < 5	$IEM_{SHOWERS}$ = 0	–	–
		$\%IEM_{SHOWERS}$	= 0 in 75% showers	= 0 in 100% showers	–	–
		IEM_{BOARDS}	IEM_{BOARDS} < 6	IEM_{BOARDS} = 0	–	–
		$\%IEM_{BOARDS}$	= 0 in 75% boards	= 0 in 100% boards	–	–
		IEM_{ACCESS}	IEM_{ACCESS} < 4	IEM_{ACCESS} = 0	–	–
		$\%IEM_{ACCESS}$	= 0 in 75% accesses	= 0 in 100% accesses	–	–
		$MANT_{GAME}$	Checklist		–	–

fully evaluate and analyse KQIs in every district and sector of the city. The global evaluation issue it is described in Appendix B.

For a better interpretation of the results, an example is given: the $\%IS_{LV}$ value is equal to 40.7%. In this case, the minimum goal is that IS_{LV} should be less than 70 in 75% of the streets, and the desirable goal is that IS_{LV} should be less than 70 in 100% of the streets. A $\%IS_{LV}$ qualification equal to 2.7 is obtained via interpolation between the minimum goal and the worst goal (not shown in the table), which is an IS_{LV} value lower than 70 in 0% of the streets.

As shown, for example, in the Waste Container Status area, the inner cleanliness status (IEP-IN_{CONT}), odour status (IO_{CONT}) and maintenance status (IEM_{CONT}) of the containers achieve good qualification, with values of 6.5, 7.0 and 6.6, respectively. Additionally, the percentage of containers that are not available (due to breakage or filling) reaches the best qualification possible (%PF_{CONT} = 10), which means that all of the containers analysed are available for users. However, the classification of the outer cleanliness status (IEP-EX_{CONT} = 2.7) is not good. Consequently, the Plan of Indicators reveals that subservices related to the outer cleanliness of containers are not working properly and should be improved. The software also provides the results for each type of container separately, i.e., each indicator for MSW, package and paper/cardboard containers separately.

Furthermore, the software can provide detailed information about each indicator for each of the geographic or demographic divisions of Santander city (district and section). In the following subsections, detailed results for the Street Cleanliness Index (IS_{LV}) are shown.

3.2. Street Cleanliness Index (IS_{LV}) results in Santander city (Spain)

3.2.1. Street Cleanliness Index: assessment methodology and evaluation

The Street Cleanliness Index (IS_{LV}), defined by the Spanish Federation of Municipalities and Provinces (Femp and TECNOMA, 2007), is the only method for the evaluation of the quality of different street cleaning services. The Street Cleanliness Index (IS_{LV}) for a specific street is defined as follows (Eq. 2):

$$IS_{LV} = \frac{\lambda \cdot C}{n \cdot S} \cdot 100 \qquad (2)$$

where S is the observation area (which depends on the type of pavement, the mode of vehicle parking and the length of the street), C is the weighted quantity of litter in the street, and λ and n are correction factors (n depending on meteorological conditions and the conservation status of the pavement and λ depending on the extraordinary circumstances existing in the observation area). Details regarding the calculation of the Eq. 2 parameters can be found in Femp and TECNOMA (2007) and Sevilla *et al.*, (2013). Once a Street Cleanliness Index (IS_{LV}) value for each street is obtained, such value can be classified according to the criteria shown in Table 3. As shown, the lower the IS_{LV} value is, the cleaner the street is and, consequently, the better the qualification is. A code colour for qualification purposes was considered.

The next step is to set the goal to be met by a municipality. In the case of Santander city, the minimum goal to reach is $IS_{LV} < 125$, and the desirable goal to reach is $IS_{LV} < 70$ (Table 2) for each of the geographical divisions of Santander city, i.e., districts and sections.

3.2.2. Street Cleanliness Index: detailed results

As an example of the software power, in this section, the results of the Street Cleanliness Index (IS_{LV}) in Santander city are shown. Streets were analysed from April 2014 to October 2015. For each street analysed, one IS_{LV} value was obtained. More than 600 streets were analysed in Santander city (Table 1).

The next table (Table 4) shows i) the number of streets in each district of Santander city, ii) the minimum number of streets that should be sampled in each district, and iii) the number of streets that were sampled in each district.

The software provides information (both numerically and graphically) regarding the Street Cleanliness Index (IS_{LV}) for each geographic or demographic division of the city of Santander. In the next figures, the results of the IS_{LV} value for Santander city are shown in a map both for each district (Fig. 1) and for each section (Fig. 2) of the city.

The results of IS_{LV} for each district are representative because the requirements of Eq. 1 regarding the minimum number of streets were met. However, the results of IS_{LV} for each section are not always representative; it was not possible to fully sample every specific district due to the high sampling effort required for that purpose. Nevertheless, the results in Fig. 2 show the results for those sections that met the requirements of Eq. 1.

We can observe that the worst results (red and orange painted areas) for cleanliness were found in the Centro and Puerto districts (Fig. 1). The sections with the worst classifications were found in the Castilla-Hermida conurbation, which has the highest

Table 3
Street Cleanliness Index (IS_{LV}) classification.

Street Cleanliness Index (IS_{LV})	Qualification	Street Cleanliness Index (IS_{LV})	Code colour
$IS_{LV} < 70$	10	$IS_{LV} < 70$	(blue)
$IS_{LV} = 85$	7.5	$70 \le IS_{LV} < 100$	(green)
$IS_{LV} = 125$	5	$100 \le IS_{LV} < 150$	(yellow)
$IS_{LV} = 175$	2.5	$150 \le IS_{LV} < 200$	(orange)
$IS_{LV} \ge 200$	0	$IS_{LV} \ge 200$	(red)

Table 4
Number of streets in each district, the minimum number of streets to be sampled, and the number of elements that were sampled in each district of Santander city.

District	Number of streets	Minimum number of streets to be sampled	Number of streets sampled
Centro	175	63	69
Cazoña	255	70	77
Miranda	237	69	80
Puertochico	316	74	79
Puerto	194	65	69
Alta	131	56	62
Albericia	205	66	79
Peñacastillo	908	87	101
Santander per districts	2421	550	616

population, pedestrian and traffic densities in all of Santander city. Conversely, the best results for cleanliness (blue and green painted areas) were found in the Peñacastillo and Albericia districts, which both have the lowest population, pedestrian and traffic densities.

As defined in Eq. (2), the *C* parameter value of the Street Cleanliness Index (IS_{LV}) is the weighted quantity of litter in the street, and its value depends on the type and amount of litter found in the street. Details regarding the *C* value can be found in Femp and TECNOMA (2007) and Sevilla *et al.* (2013). From this information, the software can provide information regarding the influence of the different types of waste on the Street Cleanliness Index (IS_{LV}) for each district and section of Santander city. Table 5 shows the percentage of the type of waste for Santander city in each district.

The Street Cleanliness and Waste Collection Service in Santander provides equipment for street cleanliness, which primarily include items for sweeping (Ogunsola *et al.*, 1994; Al-Rajhi *et al.*, 1996), brushing (Davies et al., 1987), vacuuming (Butler *et al.*, 1992; Ball *et al.*, 1996) and washing, which leads to the entry of pollutant loads into the combined sewer system (Gromaire-Mertz et al., 1998). Table 6 shows the frequency of street cleanliness resources assigned in Santander (in percentage hours/week). For example, in the Centro district, 40.98% of the hours of street cleanliness are assigned for the manual sweeping service.

The information provided in Tables 5 and 6 show that i) uncollected sweeping litter (mainly sticky waste on the pavement) found on pavement occurs with a higher percentage (more than 74% in all districts of Santander; Table 5) and ii) a high percentage of resources are assigned to waste that is easy to remove (e.g., paper, butts, peel fruits, shells). In contrast, a low percentage of resources is assigned for sticky waste (less than 16% in all districts of Santander; Table 6), which is more difficult to remove.

These results suggest that street cleanliness resources should be assigned i) according to the type of waste found in the streets and the degree of difficulty of removal and ii) to those districts with worse the Street Cleanliness Index (IS_{LV}) values. Obviously, the IS_{LV} value is influenced by the resources assigned in a district. The higher the number of resources assigned is, the better the expected IS_{LV} value is; conversely, the lower the number of resources assigned is, the worse the expected IS_{LV} value is.

A question at this point arises regarding how resources are assigned. In Santander city, an analysis revealed that resources were assigned according to “the experience of the Company in this task and adjusted to the needs of Santander city, regarding its composition, urban structure and population”. The next section explains the relationships between the IS_{LV} values and several resource parameters related to the Street Cleanliness Service.

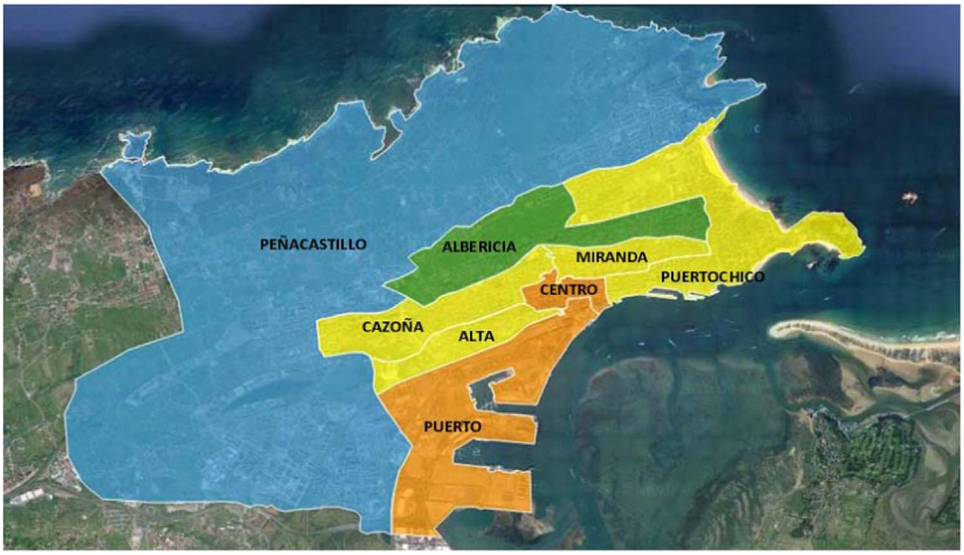

Fig. 1. Street Cleanliness Index (IS_{LV}) classification for each district of Santander city.

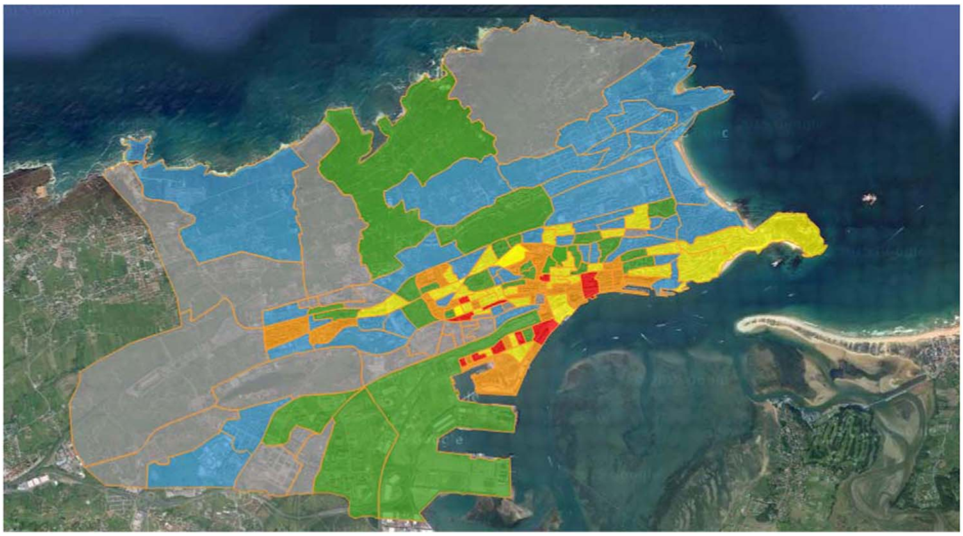

Fig. 2. Street Cleanliness Index (IS_{LV}) classification for each section of Santander city.

Table 5
Percentage of type of waste according to weight in the calculation of Street Cleanliness Index for each district of Santander city.

		Percentage of type of waste in Santander city (%)				
District	IS_{LV}	Inorganic litter	Organic litter	Bins	Tree-grates	Uncollected sweeping litter
Centro	157	10.47	0.84	0.29	1.11	87.39
Cazoña	110	15.64	0.84	0.21	0.77	82.54
Miranda	109	14.14	1.33	0.12	1.44	82.97
Puertochico	108	10.42	0.77	0.18	1.58	87.06
Puerto	169	16.50	2.24	0.29	1.28	79.69
Alta	131	7.82	0.07	0.31	2.64	89.16
Albericia	82	17.36	2.47	0.39	1.06	78.72
Peñacastillo	52	21.48	0.19	0.27	3.14	74.92

3.2.3. Street Cleanliness Index: optimisation of the service

The goal in this subsection is to analyse the relationships between the resources assigned to the Street Cleanliness Service, more specifically, the Frequency of Street Cleanliness Service (FSCSs) parameters and the Street Cleanliness Index values. The analysis of the Street Cleanliness Index (IS_{LV}) value in combination with FSCS parameters could be useful both for designing the specific Street Cleanliness Service and for optimising the existing one. For this reason, it is necessary to analyse which of these FSCSs better explains the IS_{LV} values.

With this goal in mind, several FSCS parameters in each district of Santander city can be described as follows: Frequency of Street Cleanliness Service (FSCS) denotes the hours/week in which all sweeping, washing and sticky cleaner services occur in a

Table 6
Percentage of hours/week for each of the Street Cleanliness Service resources in Santander city (in %).

District	Frequency (Hours/week, in %) for each of the street cleanliness services								
	Sweeping Services						Water Flow Services		Total
	Manual			Mechanical	Revision	Sticky cleaner	Manual	Mechanical	
	Manual	Motorised	Motorised team						
Centro	40.98	0.00	0.00	0.88	26.71	10.24	20.22	0.96	100
Cazoña	39.92	0.00	0.00	8.44	22.03	10.73	5.44	13.44	100
Miranda	49.25	0.00	0.00	7.31	16.92	13.22	2.82	10.48	100
Puertochico	41.02	0.42	0.00	10.62	20.41	10.48	5.94	11.11	100
Puerto	38.53	12.46	0.00	0.36	23.29	13.44	11.38	0.54	100
Alta	40.12	0.63	0.00	12.31	14.67	10.43	1.46	20.38	100
Albericia	33.01	7.32	7.69	11.04	15.19	9.15	0.00	16.60	100
Peñacastillo	10.27	35.45	33.03	1.81	1.51	15.10	0.00	2.83	100

Table 7
Street Cleanliness Index (IS_{LV}) values and Frequency of Street Cleanliness Services (FSCSs) for several demographic parameters. Type of district: UR: mainly urban; RU: mainly rural. Main activity in the district: C: commercial; R: residential; I: industrial; RST: restoration. Pedestrian density in the district: HPD: high pedestrian density; LPD: low pedestrian density.

District	IS_{LV}	Frequency of street cleanliness services (FSCS) (hours/week)	FSCS/%pop. (hours/week)	(FSCS/pop. density) *1000 (hours/week)	(FSCS/pop.density.per. street)*10 (hours/week)	Type of district
Puerto	169	66.96	6.57	11.77	7.24	UR–R–I–HPD
Centro	157	87.84	15.46	3.13	15.35	UR–C–R–HPD
Alta	131	86.28	10.08	4.60	7.49	UR–R–LPD
Cazoña	110	83.88	5.25	4.54	7.60	UR–R–LPD
Miranda	109	68.10	7.61	3.02	10.23	UR–R–LPD
Puertochico	108	85.86	8.62	15.35	15.46	UR–C–R–RST –HPD
Albericia	82	98.34	6.07	10.68	7.06	UR–R–LPD
Peñacastillo	52	59.58	2.43	30.78	12.53	RU–R–LPD

district. Using demographic parameters and this FSCS value, several FSCS parameters can be obtained. The demographic parameters considered were i) the percentage of population in each district of Santander (%pop), ii) the population density in each district of Santander (pop.density), and iii) the population density per street in each district of Santander (pop.density.per.street). Table 7 shows the Street Cleanliness Index (IS_{LV}) value and the FSCS parameters described above for each district of Santander city. Values for the FSCS parameters were obtained as follows. The Centro District of Santander has the following values: i)%population = 5.68%; ii) population density = 28044 hab/km^2; and iii) population density per street = 57.21 hab/street. Consequently, i) FSCS/% pop = 87.84/5.68 = 15.46; ii) (FSCS/pop.density)·1000 = (87.84/28044)·1000 = 3.13; iii) (FSCS/pop.density.per.street)·10 = (87.84/57.21)·10 = 15.35. The remaining values were obtained similarly.

A Pearson correlation coefficient was obtained between the Street Cleanliness Index (IS_{LV}) value and each of the FSCS parameters in Table 7. The Pearson results show an almost null linear relationship between IS_{LV} and FSCS (R^2 = 0.12) and FSCS/pop.density.per.street (R^2 = -0.05). The Pearson correlation coefficient shows a positive linear relationship between the IS_{LV} value and FSCS/%pop (R^2 = 0.67) parameter. In other words, the higher the FSCS/%pop value is, the higher the IS_{LV} value is (the cleanliness street status is worst), which seems illogical because a higher quantity of assigned resources should result in a better value in IS_{LV} value, in contrast to what was found. The Pearson correlation coefficient shows an inverse linear relationship between the IS_{LV} value and FSCS/pop.density (R^2 = -0.63). In other words, the higher the FSCS/pop.density value is, the lower the IS_{LV} value is and, consequently, the better the street cleanliness status is. A higher quantity of assigned resources should result in better IS_{LV} values.

As shown in Table 7, higher FSCSs/pop.density resources are assigned in Peñacastillo (FSCSs/pop.density = 30.78) and Albericia (FSCSs/pop.density = 10.68), which are periphery districts and have better IS_{LV} values. The Puertochico district also has a high FSCS/pop.density value (FSCSs/pop.density = 15.35); consequently, the expected IS_{LV} value should be low. However, the typology of the district, with several commercial and leisure shops, involves a high pedestrian traffic density and, consequently, can produce a high value of IS_{LV} = 108. The typology of the Miranda and Cazoña districts (mainly residential areas) could explain why the IS_{LV} values in these districts are similar to that of the Puertochico district (IS_{LV} = 110 and 109 vs 108), though the FSCS/pop.density is much lower in the Miranda and Cazoña districts (FSCS/pop.density = 4.54 and 3.02 vs 15.35) (Table 7). The low number of commercial and leisure shops could involve a low pedestrian traffic density, thus producing a similar value of IS_{LV} with far fewer resources assigned.

Consequently, the Street Cleanliness Service (and other services) should be designed based on demographic/geographic parameters, i.e., those that fit better with the IS_{LV} value. These results may not be conclusive, but they are a good starting point for analysing the relationships between the Street Cleanliness Index (IS_{LV}) and other demographic/geographic parameters, such as pedestrian traffic density in a district and type and percentage of shops in districts.

4. Conclusions

A Plan of Indicators for Evaluating the Street Cleanliness and Waste Collection Service is shown. The Plan includes i) the development of a set of indicators, ii) a methodology for calculating and evaluating such indicators, iii) the set of minimum and desirable values to be fulfilled for each indicator and iv) the results obtained for Santander city. The Plan of Indicators has shown to be an appropriate tool for evaluating and optimising the Street Cleanliness and Waste Collection Service. The Plan of Indicators is useful for analysing in detail the different indicators of each subservice of the Service.

This study presents, as an example, an analysis of the Street Cleanliness Service of Santander city. The analysis of the Street Cleanliness Index (IS_{LV}) value in each district, together with the specific resources assigned to street cleanliness in each district, could be useful for optimising the street cleanliness subservice. In this case, uncollected swept litter (mainly sticky waste) has the greatest influence on the Street Cleanliness Index value. However, the frequency of the resources assigned for the cleanliness of this type of waste is very low compared with the resources assigned for the collection of other types of waste (e.g., inorganic waste, organic waste). Consequently, resources for cleaning sticky waste should be assigned with higher frequency in all districts of Santander city.

Moreover, several FSCS (Frequency of Street Cleanliness Service) parameters are obtained and related to the Street Cleanliness Index (IS_{LV}) values. The parameter FSCS/pop.density could be an appropriate parameter for designing a Street Cleanliness Service because it has an inverse relationship with the IS_{LV} value (the higher the frequency of resources is, the lower the IS_{LV} value is). However, additional studies should be carried out to analyse the influence of other parameters on the IS_{LV} value, such as the behaviour of people or the pedestrian density.

The developed software is a powerful tool for collecting and storing information regarding the status of the public furniture assigned by the Street Cleanliness and Waste Collection Service and for showing the results of the different KQI developed in the Plan. Moreover, the software is flexible and adaptable to the different circumstances that can be observed in the management process of the SCWCS.

It is possible to add new KQI for both the SCWCS and other urban services. Moreover, the information obtained from this software can be as detailed as desired. This information can be obtained numerically and/or graphically. The final goal is to provide information to the managers and the public sector through the different platforms that have been developed for the management of Smart Cities; in the case of Santander city, the OpenData City Platform (datos.santander.es) provides a way to show and manage this information.

The study offers citizens a good way to obtain information regarding the cleanliness and maintenance status of public furniture and provides city managers with a better way of managing the SCWCS because its analysis is based on the quality of the Service and involves the fulfilment of quality standards instead of the performance of the Service. This approach is closely related to the payment per goal, which is a new paradigm of the relationships between the management of public services and the outsourced companies that offer those services. Most frequently, urban services are being paid for based on the fulfilment of established goals.

In this sense, this study provides city managers with a good starting point for both the short- and long-term decision making processes. City managers can use the results of the diagnosis of the cleanliness and maintenance of public furniture related to SCWCS to adopt a short-term decision by requesting outsourced companies to improve and optimise the Service. The described KQI and goals (minimum and desirable) can also be used for long-term decisions in future requests from the public through the enactment of quality goals and forcing outsourced companies to fulfil the required goals or provide payment based on the fulfilment of these goals. The software, together with the plan of indicators developed, can be a powerful tool for the analysis and optimisation of the Street Cleanliness and Waste Collection Service.

Appendix A. List and description of indicators

See Table A.1.

Appendix B. Global evaluation of districts and/or sectors

As we have mentioned in previous sections, scalability and expandability of app, allows to fully measure and analyse the different KQIs in order to provide a global evaluation of every district and/or sector. In this sense, KQIs of the Table 2 can be obtained for every district and/or sector. Consequently, a final value for the Service (and for each of the areas and scopes of the Service) can be obtained.

For example, if we pay attention on the Bins Status Scope of the Table 2, we can observe that, in Santander city: i) Qualification for every KQI ranges from 0 to 10; ii) Bins Status Scope has 5 KQIs (ILL_{BINS}, $\%ILL_{BINS}$, IEM_{BINS}, $\%IEM_{BINS}$, $\%PF_{BINS}$) and, consequently, the theoretical maximum qualification for the Bins Status Scope is 50; iii) the qualification obtained in such scope is 22.9 (9.1 + 4.8 + 2.7 + 1.4 + 4.9); iv) the global evaluation Score of Bins Status Scope is 22.9 over 50 (approx. 4.6 over 10).

In consequence, both for the global evaluation of Santander city, and each of the districts and sectors a table can be generated, as follows (Table A.2).

Table A.1
List of indicators for each area and scope, a brief description of each indicator and the minimum and desirable goals to be fulfilled for each indicator.

Area	Scope	KQI nomenclature	Indicator description	Minimum goal	Desirable goal	Units
Street Cleanliness Status	Street Cleanliness	IS_{LV}	Measures the Street Cleanliness Status	$IS_{Lv} < 125$	$IS_{Lv} < 70$	Nr. ítems/m^2
		$\%IS_{LV}$	Measures the Percentage of streets that do not reach a IS_{LV} value	< 70 in 75% streets	< 70 in 100% streets	%
		$\%IS_{SV}$	Measures the Percentage of surface streets that do not reach a IS_{LV} value	< 70 in 75% surface	< 70 in 100% surface	%
		%DETRITUS	Measures the Percentage of length street with presence of detritus	< 20% length	=0% length	%
	Bins status	ILL_{BINS}	Measures the filling level of the bins	$ILL_{BINS} < 2$	$ILL_{BINS} = 0$	Volume
		$\%ILL_{BINS}$	Measures the Percentage of bins whose filling level does not reach a ILL_{BINS} value	= 0 in 75% bins	= 0 in 100% bins	%
		IEM_{BINS}	Measures the level of maintenance and cleaning of the bins	$IEM_{BINS} < 6.5$	$IEM_{BINS} = 0$	Nr. ítems
		$\%IEM_{BINS}$	Measures the Percentage of bins whose clean and maintenance status do not reach a IEM_{BINS} value	= 0 in 75% bins	= 0 in 100% bins	%
		$\%PF_{BINS}$	Measures the Percentage of bins not available for use (due to breakage or filling)	$\%PF_{BINS} < 10\%$	$\%PF_{BINS} = 0\%$	%
	Tree-grates status	$IS_{TREE\ GRATES}$	Measures the tree-grates cleanliness Status	$IS_{TREE\ GRATES} < 11$	$IS_{TREE\ GRATES} = 0$	Nr. ítems
		$\%IS_{TREE\ GRATES}$	Measures the Percentage of tree-grates that do not reach a $IS_{TREE\ GRATES}$ value	= 0 in 75% tree grates	= 0 in 100% tree grates	%
	Waste collection points	$ISPA_A$	Measures the Waste Collection Points (WCP) Cleanliness Status in area A	$ISPA_A < 150$	$ISPA_A < 100$	Nr. ítems/m^2
		$\%ISPA_A$	Percentage of WCP that do not reach a $ISPA_A$ value	< 100 in 75% WCP	< 100 in 100% WCP	%
		$ISPA_B$	Measures the Waste Collection Points (WCP) Cleanliness Status in area B	$ISPA_B < 4$	$ISPA_B < 2$	Nr. ítems/m^2
		$\%ISPA_B$	Percentage of WCP that do not reach a $ISPA_B$ value	< 2 in 75% WCP	< 2 in 100% WCP	%
	Graffiti and painting	$FREC_{PAINT}$	Measures the cleanliness frequency of paint and graffitti	$FREC_{PAINT} < 2$	$FREC_{PAINT} = 0$	Days^{-1}
		IS_{PAINT}	Measures the Cleanliness Status of façades and walls due to painting and graffitti	$IS_{PAINT} < 6.5$	$IS_{PAINT} = 0$	Nr. ítems
		$\%SA_{PAINT}$	Measures the Surface of walls and façades with paint and graffitti	$\%SA_{PAINT} < 27.5$	$\%SA_{PAINT} < 10\%$	%
		$FREC_{BOARDS}$	Measures the cleanliness frequency of posters	$FREC_{BOARDS} < 2$	$FREC_{BOARDS} = 0$	Days^{-1}
		IS_{BOARDS}	Measures the Cleanliness Status of façades and walls due to posters	$IS_{BOARDS} < 6.5$	$IS_{BOARDS} = 0$	Nr. items
		$\%SA_{BOARDS}$	Measures the Surface of walls and façades with posters	$\%SA_{BOARDS} < 27.5\%$	$\%SA_{BOARDS} < 10\%$	%
Waste Collection Staus	RSU, cardboard, and packaging Waste Collection	ILL_{CONT}	Measures the filling level of the containers	$ILL_{CONT} < 2$	$ILL_{CONT} = 0$	Volume
		$\%ILL_{CONT}$	Measures the Percentage of containers that do not reach a ILL_{CONT} value	= 0 in 75% cont	= 0 in 100% cont	%
		$\%PA_{EC}$	Measures the Percentage of WCP with the presence of extra-container waste	$\%PA_{EC} < 25\%$	$\%PA_{EC} = 0\%$	%
		$\%PA_{VOL}$	Measures the Percentage of WCP with the presence of bulky waste	$\%PA_{VOL} < 25\%$	$\%PA_{VOL} = 0\%$	%
		$\%EC_{PA}$	Measures the Percentage of extra-container waste in WCP	$\%EC_{PA} < 25\%$	$\%EC_{PA} = 0\%$	%
		$\%EC_{VOL}$	Measures the Percentage of bulky waste in WCP	$\%VOL_{PA} < 25\%$	$\%VOL_{PA} = 0\%$	%
Container Status	MSW, cardboard and packaging Container Status	$IEP\text{-}IN_{CONT}$	Measures the inner cleanliness status of Containers	$IEP\text{-}IN_{CONT} < 15$	$IEP\text{-}IN_{CONT} = 0$	Nr. ítems
		$\%IEP\text{-}IN_{CONT}$	Measures the Percentage of containers that do not reach a $IEP\text{-}IN_{CONT}$ value	= 0 in 75% cont	= 0 in 100% cont	%
		$IEP\text{-}EX_{CONT}$	Measures the outer cleanliness status of Containers	$IEP\text{-}EX_{CONT} < 7.5$	$IEP\text{-}EX_{CONT} = 0$	Nr. ítems
		$\%IEP\text{-}EX_{CONT}$	Measures the Percentage of containers that do not reach a $IEP\text{-}EX_{CONT}$ value	= 0 in 75% cont	= 0 in 100% cont	%

(continued on next page)

Table A.1 *(continued)*

Area	Scope	KQI nomenclature	Indicator description	Minimum goal	Desirable goal	Units
		$\%SA_{CONT}$	Measures the Outer surface of containers affected by inadequate status	$\%SA_{CONT} < 27.5\%$	$\%SA_{CONT} < 10\%$	%
		IO_{CONT}	Measures the odour status of containers	$IO_{CONT} < 1.5$	$IO_{CONT} = 0$	Adimensional
		$\%IO_{CONT}$	Measures the Percentage of containers that do not reach a IO_{CONT} value	= 0 in 75% cont	= 0 in 100% cont	%
		IEM_{CONT}	Measures the maintenance status of containers	$IEM_{CONT} < 8$	$IEM_{CONT} = 0$	Nr.deficiencies
		$\%IEM_{CONT}$	Measures the Percentage of containers that do not reach a IEM_{CONT} value	= 0 in 75% cont	= 0 in 100% cont	%
		$\%PF_{CONT}$	Measures the Percentage of containers not available (due to breakage or filling)	$\%PF_{CONT} < 10\%$	$\%PF_{CONT} = 0\%$	%
Beach Cleanliness Status	Waste Collection	$ILL_{PAP\ BEACH}$	Measures the filling level of the bins at beaches	$ILL_{PAP\ BEACH} < 2$	$ILL_{PAP\ BEACH} = 0$	Volume
		$\%ILL_{PAP\ BEACH}$	Measures the Percentage of bins that do not reach a $ILL_{PAP\ BEACH}$ value	= 0 in 75% bins	= 0 in 100% bins	%
	Container and Bins Status	$IEM_{PAP\ BEACH}$	Measures the level of maintenance and cleaning of the bins of beaches	$IEM_{PAP\ BEACH} < 6.5$	$IEM_{PAP\ BEACH} = 0$	Nr. items
		$\%IEM_{PAP\ BEACH}$	Measures the Percentage of bins whose cleanliness status does not reach a $IEM_{PAP\ BEACH}$ value	= 0 en 75% bins	= 0 en 100% bins	%
		$\%PF_{PAP\ BEACH}$	Measures the Percentage of bins of beach not available (due to breakage or filling)	$\%PF_{PAP\ BEACH} < 10\%$	$\%PF_{PAP\ BEACH} = 0\%$	%
		$IO_{PAP\ BEACH}$	Measures the odour status of bins of beaches	$IO_{PAP\ BEACH} < 1.5$	$IO_{PAP\ EBACH} = 0$	Adimensional
		$\%IO_{PAP\ BEACH}$	Measures the Percentage of containers that do not reach a $IO_{PAP\ BEACH}$ value	= 0 in 75% bins	= 0 in 100% bins	%
	Sand Cleanliness	IS_{SAND}	Measures the Sand Cleanliness Status of Beaches	Methodology in progress		Nr. ítems/m^2
		%SIEVE	Measures the Percentage of the beach surface that has been sieved	$\%SIEVE > 75\%$	$\%SIEVE = 100\%$	%
		%SEAWEED	Measures the Percentage of the beach length with the presence of seaweed	$\%SEAWEED < 20\%$	$\%SEAWEED = 0\%$	%
	Infrastructure maintenance	$FREC_{PAINT\ BEACH}$	Measures the cleanliness frequency of paint/graffiti on beach walls	$FREC_{PAINT\ BEACH} < 2$	$FREC_{PAINT\ BEACH} = 0$	Days^{-1}
		$IS_{PAINT\ BEACH}$	Measures the Cleanliness Status of beach walls due to paint and graffitti	$IS_{PAINT\ BEACH} < 6.5$	$IS_{PAINT\ BEACH} = 0$	Nr. ítems
		$\%IS_{PAINT\ BEACH}$	Measures the Percentage of beach walls that do not reach a $IS_{PAINT\ BEACH}$ value	= 0 in 75% walls	= 0 in 100% walls	%
		$\%SA_{PAINT\ BEACH}$	Measures the Surface of beach walls with the presence of paint and graffitti	$\%SA_{PAI\ BEACH} < 27.5\%$	$\%SA_{PAINT\ BEACH} < 10\%$	%
		$\%LA_{FENCES}$	Measures the Length of beach fences with an inadequate maintenance status	$\%LA_{FENCES} < 20\%$	$\%LA_{FENCES} = 0\%$	%
		$IEM_{SHOWERS}$	Measures the Maintenance Status of showers at beaches	$IEM_{SHOWERS} < 5$	$IEM_{SHOWERS} = 0$	Nr.deficiencies
		$\%IEM_{SHOWERS}$	Percentage of showers that do not reach a $IEM_{SHOWERS}$ value	= 0 in 75% showers	= 0 in 100% showers	%
		IEM_{BOARDS}	Measures the Maintenance Status of information boards at beaches	$IEM_{BOARDS} < 6$	$IEM_{BOARDS} = 0$	Nr.deficiencies
		$\%IEM_{BOARDS}$	Measures the Percentage of information boards that do not reach a IEM_{BOARDS} value	= 0 in 75% boards	= 0 in 100% boards	%
		IEM_{ACCESS}	Measures the Maintenance Status of accesses for disabled persons at beaches	$IEM_{ACCESS} < 4$	$IEM_{ACCESS} = 0$	Nr.deficiencies
		$\%IEM_{ACCESS}$	Measures the Percentage of accesses for disabled persons that do not reach a IEM_{ACCESS} value	= 0 in 75% accesses	= 0 in 100% accesses	%
		$MANT_{GAME}$	Measures the Maintenance Status of game areas for children	Checklist		No units

Table A.2
Global evaluation of the Waste Collection and Street Cleanliness Service in Santander city, and evaluation for every scope and area of the Service. In some cases, results are not shown due to i) 95% of representativity was not reached or ii) no data available due to sampling schedule limitations.

	Area	Scope	Scope Qualification	Scope Final Score (over 10)	Area Qualification	Area Final Score (over 10)	Global Evaluation
GLOBAL EVALUATION SERVICE	Street Cleanliness Status	Street Cleanliness	Qualification obtained: 11.6 Maximum theoretical qualification: 40	2.9	Qualification obtained: —Maximum theoretical qualification: 210	–	
		Bins status	Qualification obtained: 22.9 Maximum theoretical qualification: 50	4.6			
		Tree-grates status	Qualification obtained: 14.7 Maximum theoretical qualification: 20	7.4			
		Waste collection points	Qualification obtained: — Maximum theoretical qualification: 40	–			
		Graffiti and painting	Qualification obtained: — Maximum theoretical qualification: 60	–			
	Waste Collection Status	RSU, cardboard, and packaging Waste Collection	Qualification obtained: — Maximum theoretical qualification: 60	–	Qualification obtained: — Maximum theoretical qualification: 60	–	
	Container Status	MSW, cardboard and packaging Container Status	Qualification obtained: 41.8 Maximum theoretical qualification: 100	4.2	Qualification obtained: 41.8 Maximum theoretical qualification: 100	4.2	
	Beach Cleanliness Status	Waste Collection	Qualification obtained: — Maximum theoretical qualification: 20	–	Qualification obtained: — Maximum theoretical qualification: 220	–	
		Container and Bins Status	Qualification obtained: — Maximum theoretical qualification: 50	–			
		Sand Cleanliness	Qualification obtained: — Maximum theoretical qualification: 30	–			
		Infrastructure maintenance	Qualification obtained: — Maximum theoretical qualification: 120	–			

References

Al-Rajhi, M., Seaward, M., & Al-Aamer, A. (1996). Metal levels in indoor and outdoor dust in Riyadh, Saudi Arabia. *Environmental International*, 22, 315–324.

Álvaro, A. (2007). La limpieza viaria: desconocida e incontrolable. *Residuos*, 99, 22–31.

Ball, J., Jenks, R., Aubourg, D. (1996). Dry weather build-up of constituents on road surfaces. In *Proceedings of the seventh international conference on urban storm drainage* (pp. 785–790). Hanover, Germany.

Bel, G. (2006). Un análisis de los gastos municipales por el servicio de residuos sólidos urbanos. *Revista de Economía Aplicada*, 14, 5–32.

Benito-López, B., Moreno-Enguix, M. D., & Solana-Ibáñez, J. (2011). Determinants of efficiency in the provision of municipal street-cleaning and refuse collection services. *Waste Management*, 31, 1099–1108.

Butler, D., Thedchanamoorthy, S., & Payne, J. (1992). Aspects of surface sediment characteristics on an urban catchment in London. *Water Science and Technology*, 25, 13–19.

Davies, D., Watt, J., & Thornton, I. (1987). Lead levels in Birmingham dusts and soils. *Science of the Total Environment*, 67, 177–185.

De Borger, B., Kerstens, K., Moeseny, W., & Vanneste, J. (1994). Explaining differences in productive efficiency: An application to Belgian municipalities. *Public Choice*, 3– 4, 339–358.

Femp, F.E., TECNOMA (2007). Guía Técnica para la Gestión de Residuos Municipales y Limpieza Viaria. Gráficas JUMA: Madrid.

Forcada, R.M., Gavete, M., Jerez, P., Marcos, V., Martínez, A.J., Ribot, F., 1996. La Enciclopedia del Medio Ambiente Urbano. Cerro Alto Editorial. Idea, Signo y Color, S.L.

Garrido, J., Requena, I., Rodríguez-González, M., Zamorano, M. (2011). . Definition of a dirtiness index using fuzzy logic to determine quality assessment of streets cleaning. In *Proceedings of the 4th international conference on approximation methods and numerical modelling*.

Giménez, V., & Prior, D. (2003). Evaluación frontera de la eficiencia de costes. Aplicación a los municipios de Cataluña. *Papeles de la Economía Española*, 95, 113–124.

Gromaire-Mertz, M. C., Chebbo, G., & Saad, M. (1998). Origins and characteristics of urban wet weather pollution in combined sewer systems: The experimental urban catchment 'Le Marais' in Paris. *Water Science and Technology*, 37, 35–48.

Kuniyal, J., Jain, A., & Shannigrahi, A. (2003). Solid waste management in and around the valley of flowers and Hemkund Sahib. *Waste Management*, 23, 807–816.

Ogunsola, O., Oluwole, A., & Asubiojo, O. (1994). Traffic pollution: Preliminary elemental characterisation of roadside dust in Lagos, Nigeria. *Science of the Total Environment*, 146(147), 175–184.

Riccio, L. J., Miller, J., & Bose, G. (1988). Polishing the big apple: Models of how manpower utilization affects street cleanliness in New York City. *Waste Management Research*, 6, 163–174.

Sevilla, A., Rodríguez, M. L., García-Maraver, A., & Zamorano, A. (2013). An index to quantify street cleanliness: The case of Granada (Spain). *Waste Management*, 33(2013), 1037–1046.

Simoes, P., & Marques, R. C. (2012). On the economic performance of the waste sector. A literature review. *Journal of Environmental Management*, 106(2012), 40–47.

Simoes, P., Cruz, N. F., & Marques, R. C. (2012). The performance of private partners in the waste sector. *Journal of Cleaner Production*, 29-30(2012), 214–221.