Urban strategies for Waste Management in Tourist Cities. D2.5
Status quo (baseline) assessment report

Gruber, Iris; Obersteiner, Gudrun; Romein, Arie; Eriksson, Mattias; Fertner, Christian; Grosse, Juliane; Bjorn Olsen, Trine

Publication date
2017

Document Version
Final published version

Citation (APA)
Gruber, I., Obersteiner, G., Romein, A., Eriksson, M., Fertner, C., Grosse, J., & Bjorn Olsen, T. (2017). *Urban strategies for Waste Management in Tourist Cities. D2.5: Status quo (baseline) assessment report*. Urban-Waste.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

URBAN-WASTE – 690452 – D2.5

URBAN-WASTE

Urban strategies for Waste Management in Tourist Cities

D2.5 – Status quo (baseline) assessment report

Grant Agreement No:	WASTE-6b-2015 690452	**Project Acronym:**	URBAN-WASTE
Project Title:	Urban Strategies for Waste Management in Tourist Cities		
Funding scheme :	Horizon 2020: Eco-Innovative Strategies: "Waste: a resource to recycle, reuse and recover raw materials"		
Project Coordinator:	Gobierno de Canarias (Government of Canary Islands)		
Start date of the project :	01/06/2016	**Duration of the project:**	36 months
Contractual delivery date:	31/07/2017		
Actual delivery date:	31/08/2017		
Contributing WP:	2		
Dissemination level:	Public		
Editors:	Gudrun OBERSTEINER, Iris GRUBER		
Contributing Authors:	Trine BJØRN OLSEN, Mattias ERIKSSON, Christian FERTNER, Juliane GROßE, Iris GRUBER, Gudrun OBERSTEINER, Arie ROMEIN		
Reviewed by:	Line Kai-Sørensen Brogaard, Susan Buckingham, Claudia De Luca, Marie Kazeroni		

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

Abstract BOKU

This report (Deliverable D2.5) refers to URBANWASTE Work Package 2, Task 2.6. Within this deliverable the present situation of waste management in the selected pilot cases ("the baseline") is described. Main goal of the task is the quantification of the status quo with respect to tourist waste production and to the total urban production of waste in the pilot cities before the implementation of the URBANWASTE strategies (developed in WP 4). The actual waste generation and treatment of each pilot case also considering spatial data is described and an assessment of environmental, social and economic impacts is performed.

Further, the results of this work package serve as a basis for further decision-making. The output of this status quo assessment shall assist the decision making process within WP 4 to set specific targets for each pilot case. It shall support the development of strategies in waste prevention and management policies within WP 4. Selected waste prevention and management measures will be implemented in each pilot case within WP6 and they will be subsequently assessed within WP 7 aiming at displaying improvements (reduced impacts by implementing innovative waste management strategies in touristic processes).

The database of the selected pilot cases (Copenhagen, Dubrovnik, Florence, Kavala, Lisbon, Nice, Nicosia, Ponta Delgada, Syracuse, Tenerife) generated within Task 2.5 is critically reviewed, inconsistencies are clarified and missing data are included. The database is assessed by a benchmarking process with three cities (Berlin, Vienna, Zurich) providing reliable waste management data and showing best-practice examples in waste prevention and management. This comparison allowed a plausibility check of the background data and indicator sets.

Based on the results of the analysis of the database, differences and similarities regarding the material, waste and energy flows, touristic processes and background conditions of the selected pilot cities are described.

The last aspect in this report is the general evaluation of touristic impact on waste generation. The evaluation of the environmental impacts of waste management practise in selected pilot cities is carried out by using the Life Cycle Assessment (LCA). This gives the possibility to figure out on the one hand hotspots of environmental impacts and on the other hand, to identify the most promising waste prevention and recycling measures in terms of environmental impacts resulting from tourist waste.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

Contributors

NAME	COMPANY	CONTRIBUTIONS INCLUDE
Iris GRUBER Gudrun OBERSTEINER	Universität für Bodenkultur Wien (BOKU)	Chapters 1, 3, 4, 7 and 9 Contributions to Chapters 2 and 8.1
Arie ROMEIN	Technische Universiteit Delft (Delft University of Technology)	Chapter 6
Mattias ERIKSSON	Sveriges Lantbruksuniversitet – Swedish University of Agricultural Sciences	Contribution to Chapters 2, 8 and 9
Christian FERTNER Juliane GROßE	University of Copenhagen	Contribution to Chapters 2 and 9 Chapter 5
Trine BJØRN OLSEN	Aarhus University - AU Herning	Contributions to Chapter 8

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

Table of Contents

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

List of Figures

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

List of Tables

List of Equations

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

Executive Summary

This report (**Deliverable D2.5**) refers to URBANWASTE **Work Package 2**, **Task 2.6**. Within this deliverable the present situation of waste management in the selected pilot cities ("the baseline") is described. The main goal of the task is the quantification of the status quo with respect to tourist waste production and to the total urban production of waste in the pilot cities before the implementation of the URBANWASTE strategies (developed in WP 4). The actual waste generation and treatment of each pilot city also considering spatial data is described and an assessment of environmental, social and economic impacts is performed.

The database generated within Task 2.5 is critically reviewed to clarify inconsistencies and complete missing data. To detect inconsistencies in the database it was assessed by a **benchmarking process**. The benchmarking was part of the data evaluation. **The goal was to collect a set of reliable background data from European best performers in waste management to retrieve default data/values against which pilot case data can be compared**. The importance of this activity can be seen in finding out the normal range of figures (e.g. per capita waste generation) in order to be able to identify mistakes in the figures provided by the pilot cases as well as to gain a better understanding of the data itself and its background (e.g. identifying which figures might have to be further clarified regarding their composition etc.). **Berlin (Germany), Vienna (Austria) and Zurich (Switzerland)** were chosen to serve as **Benchmarks** representing best performing cities in term of waste management. Benchmarking was performed using data for the **year 2015**. Benchmarking with some Baltic cities failed because of the lack of data availability.

Benchmarking was done for per capita generation of selected waste streams. Because of inconsistencies in data availability and quality only a selected set of waste streams turned out to be suitable for WP 2 evaluations. Those waste streams included residual waste, organic waste, selected recyclables (mainly packaging waste) and WEEE. In order to consider the differences in tourism intensity[1] in the 11 URBANWASTE pilot cases, a "**tourism adjusted resident population**" **was used as reference base for per capita waste amounts**. More details on the calculation of the chosen reference base is presented in Chapter 2.1.

In order to ensure suitable data quality for the subsequent assessments (e.g. of the tourists' impact on waste generation) data on waste generation, on local resident population and number of nights spent by tourists was thoroughly cross-checked with the pilot case partners. Most of the **clarification questions** that came up were related to the **types of waste behind specific waste streams** for which amounts were reported or explanations for **noticeable increases / decreases in** waste generation **data** or data on nights spent by tourists. For some data sets, **data gaps were filled** by using for example census population data or data retrieved from online accommodation booking platforms.

Clarifying the types of waste behind specific waste streams for which data were reported revealed that **only selected sets of waste generation data (i.e. waste streams) are suitable to be used in further (statistical) analyses: Residual waste, (Total) Organic waste, selected recyclables (Paper & Cardboard, Glass, Metals/Metal packaging, Plastics/Plastic packaging. Co-mingled fractions of recyclables** (metals, plastics and paper & cardboard) had to be used if no separate data were available. A differentiation between data on packaging waste only (metals; plastics) and mixtures of packaging waste with non-packaging waste from the same materials (e.g. metal hangers and frying pans or plastic toys and plastic hangers respectively) was not always possible.

---

[1] **Tourism intensity** is the ratio of nights spent at tourist accommodation establishments relative to the total permanent resident population of the area. http://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:Tourism_intensity

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

Inconsistencies in the database could be partly explained. Due to **differences in the collection systems** in the pilot cases waste streams resulting from tourism (mainly waste from hotels and restaurants) are collected either as municipal solid waste or commercial waste. In both cases it is not possible to allocate the figures directly to tourist activities as always a mixture (e.g. of household and similar to household waste (hotel waste) or hotel waste and other commercial waste) is collected. Depending on the share of total waste coming from tourism activities that is represented in the reported data, **the comparability and also the significance of data may be limited.** The organisation of waste management in the pilot city has to be considered for data analysis **if waste from tourist establishments is represented in the provided data sets** (mainly representing municipal waste data in this project). In the case of the 11 URBANWASTE pilot cases, all hotels are represented in the data reported by Florence, Kavala, Nicosia, Ponta Delgada, Santander, Syracuse and Tenerife, only a part of the hotels is represented in the data reported by Lisbon and Nice, and in Copenhagen most tourist establishments have arrangements with private collectors, thus, not being represented in the reported municipal waste data. For Dubrovnik, data on waste generation could not be provided on the spatial scale of the pilot case.

In places where there is a **refund system for selected packaging materials** (such as in Copenhagen, Dubrovnik and Ponta Delgada), it further has to be considered if the amounts of packaging waste collected through the refund system are included in the waste data provided, in order to determine what share of total generated waste is covered by the reported data.

Significant increases / decreases in waste generation in the considered period 2000 – 2015 could be attributed to:

- **Changes in the waste management systems** such as the introduction of separate collection of (additional) recyclable waste streams (e.g. …),
- Advertising / awareness raising campaigns (e.g. Tenerife, …),
- **Inconsistencies in reporting / bad data quality:** Due to staff shortages in the summer holiday season, waste amounts could not be recorded every day (e.g. Kavala).
- **Economic crisis:** could be the reason for increase (paper & cardboard e.g. stronger activities of waste pickers, as well as decrease (residual waste) in waste generation

The significant increase in the number of nights spent by tourists in Nicosia in 2012 could be explained by **Cyprus having the Presidency of the Council of the European Union** from July - December 2012. For the peak in tourists' overnight stays in Florence in 2013 no explanation could be given.

Chapter 6 presents a **grouping of the pilot cases** on the basis of a series of primarily socio-economic characteristics. The similarities and differences between the pilot cases that are revealed by this grouping enables a better understanding of data and interpretation of the results from various evaluations and assessment performed now and later in the URBANWASTE project. Although the number of case studies (11), and nature of analysis (inductive statistical) do not readily lend themselves comprehensive conclusions visualisation of the data by tables and graphs allowed to distinguish some groups in a rather loose, indicative way:

- The national capitals Copenhagen and Lisbon are distinguished by population size and density, predominantly urban land use, a large service sector and a high GDP per capita.
- Dubrovnik-Neretva and Kavala are the opposite of these national capitals for all these features. Tenerife contrasts sharply with the other pilot cases by the large size of its tourist industry.

- The three municipalities forming Tenerife pilot case (Adeje, Arona and Puerto de la Cruz) have by far the largest tourism industry of all pilot cases. The number of nights spent by tourists in this pilot case are seven to eight times higher than in the other pilot cases.
- The remaining six pilot cases differ among one another on single variables, but the available data did not allow to group these based on profiles of combinations of variables.

Within Chapter 5 the pilot cases can be grouped into **three types based on their spatial characteristics**. First, the **big cities or dense urban areas**, characterised by a high share of urban area and a low share of nature areas, a high density of population and roads. From the URBANWASTE pilot cases this type includes Copenhagen, Florence, Lisbon, Nicosia and Santander. These pilot cases can have significant tourism, but other activities related to the urban economy have a bigger importance. The second type are **large authorities** (big municipalities, regions and metropolitan areas), sometimes with big cities included, characterised by a considerable rural hinterland. Dubrovnik-Neretva County, Nice Cote d'Azur Metropolitan Area, Kavala, Ponta Delgada and Syracuse are examples of this type. Finally, there are **small cities or municipalities** which however are **characterized by considerable tourism**. This group includes all three municipalities forming the pilot cases Tenerife (Adeje, Arona and Puerto de la Cruz). The three types are **idealized types**, while the real cases usually are more diverse. However, the grouping allows discussing general differences in spatial context as well as challenges and conditions for sustainable tourism.

For **evaluating waste generation resulting from tourist activities** quantitative data on waste generation, local resident population and nights spent by tourists were considered. As a first step, **descriptive statistical analysis** was used **to identify dataset and waste streams that are suitable for being analysed in detail** regarding tourism's impact on waste generation. Comparing annual data for waste generation and the variation in number of overnight stays per year did not produce any suitable results. Due to limited data availability comparing trends in monthly waste management and overnight stays was only possible for the pilot cases Ponta Delgada, Santander and Tenerife.

In-depth statistical analysis was performed using data from **Kavala, Ponta Delgada, Santander and Tenerife**. The data used represent the **monthly data on residual waste generation and tourism intensity (overnight stays/local resident) from 2013 – 2015 (i.e. n = 36 for each pilot case)**. Tenerife pilot case was analysed in two different ways: In a first step, aggregated data (i.e. sum of the three municipalities) were used. In a second step, the individual data sets of Adeje, Arona and Puerto de la Cruz were combined for analysis.

For Kavala and Ponta Delgada, tourism`s impact on waste generation could not be proved (low statistical significance with R^2 only 0,7 % and 16 % respectively of the variance of data is explained). **For Santander and Tenerife** at least a a low proportion of the variance in tourists' waste generation is explained (R^2 = 0,5 for Tenerife and 0,6 for Santander). Analysing the three municipalities on Tenerife separately (R^2 = 0,88) showed a high correlation between waste generation and tourism. Considering only results with sufficiently high R^2 values shows that **tourists' residual waste generation amounts about 1,6 to 2,1 kg per overnight stay**.

One main aspect in this report is the general evaluation of touristic impact on waste generation. The evaluation of the environmental impacts of waste management practise in selected pilot cities is carried out by using Life Cycle Assessment (LCA). This gives the possibility to figure out on the one hand hot spots of environmental impacts and on the other hand to identify the most promising waste prevention and recycling measures in terms of environmental impacts resulting from tourist waste.

The aim of the **assessment of the environmental status quo** within chapter 8.1 is to provide a general picture on the environmental impact of current waste management practice in the pilot cities and regions to point out

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

actual hotspots and provide information on which activities, from an environmental point of view under the existing circumstances, the focus should be laid.

Global Warming Potential caused by waste generation and waste management activities differs widely between the different pilot cases. The big differences can be explained by two main issues. First of all, the amount of waste generated; second the existing waste management system. According to the results, while landfilling has been confirmed as the worst final waste disposal alternative, composting and material recovery showed the best performance. Concerning Global Warming Potential organic waste makes the largest contribution and was therefore investigated more in detail. Organic waste was treated with four major methods: landfill, composting, incineration and anaerobic digestion. Since landfilling of organic waste gives rise to greenhouse gas emissions due to methane leakage, this was the most important Waste fraction for cities to divert from landfill Significantly lower emissions were achieved in the cities collecting landfill gas or treating the organic waste with any other method. This was mainly due to less methane leakage but also to the substitution of other products when recycling nutrients and energy from the organic waste.

For pilot cases without any existing treatment of residual waste to reduce the environmental impact of waste management, the focus should be laid on separate collection and appropriate treatment of food waste (as relevant fraction of organic waste resulting from tourist activities) as this is the main reason for negative impacts of landfilling in terms of Global Warming Potential.

In addition to the environmental assessment, the **social and economic importance of tourism** was also **assessed** for the 11 URBANWASTE pilot cases. **Social life cycle assessment** (SLCA) was used in a limited form with a focus on jobs in relation to workers, society and local community. Social assessment in relation to jobs requires data on wages, working hours, gendered distribution of labour, social benefits, employment, access to resources and technological development. Such detailed data collection is only possible on a company level (or later on the level of concrete waste prevention measures) and not on the city or pilot case level. Therefore, data collected within the WP 2 and WP 3 surveys on the status quo situation only included usable data for local unemployment. These show a large difference in the local unemployment rates in the pilot areas, ranging from 6,4 % to 25,7 %. For the impact assessments later in the project additional data about wages, working hours, gender distribution, social benefits, employment, access to resources and technological development would be needed in order to conduct a more detailed social assessment in relation to jobs.

Eco-efficiency (EE) has been the methodology chosen for the economic assessment of waste in relation to tourism in the pilot cases. Defined as the ratio between economic performance and environmental impact, EE links environmental impacts with monetary costs in a simple way that is easy to communicate. However, from the status quo survey it has not been possible to express any clear EE relationships between the cost of the waste management systems and the amount of waste fractions collected. This is because the available data for collected waste fractions and expenditures for cleaning of public spaces are not directly related to each other. However, one relationship that could be established is the ratio of expenditures for cleaning of public spaces and the revenue in the tourism industry. Here a large variation is visible between the pilot cases ranging from 0,1 % to 21,3 %. Only a few and very general economic data are widely available from the initial status quo survey of the pilot cases. For the subsequent impact assessments in the project it is recommended to apply principles from Life Cycle Costing (LCC) and, if possible, Cost Benefit Analysis (CBA) to obtain a more detailed description of scenarios and measures that can support the local decision-making in the pilot areas. However, this requires economic data at a much more detailed level, which means that the subsequent impact assessment should be limited to one or very few specific waste fractions.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

The results of this work package shall serve as a basis for further decision-making. The output of this status quo assessment shall assist the decision making process within WP4 to set specific targets for each city. It shall support the development of strategies in waste prevention and management policies within WP4. Selected waste prevention and management measures shall be implemented in each pilot case within WP6 and they will be subsequently assessed within WP7 aiming at displaying improvements (reduced impacts by implementing innovative waste management strategies in touristic processes). Therefore, the following conclusions can be summarised.

As it turned out that in most of the pilot cases the contribution of tourists to the overall annual waste generation is statistically not significant, general changes in the collection system of recyclables are not feasible in the interest of tourism alone, and cannot be expected. Therefore, the focus in terms of waste prevention and recycling should be laid on measures that assist existing systems. Only the separate collection of organic waste can be seen as one major issue that can be implemented easily in hotels and this would have major impacts at least in all pilot cases without existing (organic) waste treatment.

Within Deliverable D2.7 (Gruber & Obersteiner, 2017) identified waste prevention and management strategies have been categorised into:

- well-known policy instruments mainly based on information and awareness building;
- provision of infrastructure (e.g. bins for separate collection of food waste);
- regulatory instruments (e.g. ban of plastic bags);
- economic instruments; and
- voluntary agreements (e.g. use of returnable containers).

Both waste management and prevention practices in pilot cases, as well as international best practice, focus on food consumed by tourists. Also the environmental assessment of the status quo in pilot cases came to the same conclusion that **prevention and recycling of food waste** should be the priority to be focussed on. This is especially important in pilot cases where no separate collection of organic waste is implemented and residual waste is landfilled without prior treatment, such as in **Kavala, Nicosia, Ponta Delgada, Syracuse** and **Dubrovnik.** Most waste prevention measures should deal with food waste prevention as well as food waste management like:

- selective collection of organic waste for recycling in tourist areas and subsequent composting activities, either at the point of waste generation or centrally, including the exploitation of biogas from organic waste;
- separate collection and use of cooking oil.

Both measures could be implemented without changing the whole waste management system in the respective region and composting facilities are comparably cheap compared to e.g. incinerators. The much better way, of course, would be to focus on **food waste prevention** which might be implemented by measures described in Gruber & Obersteiner (2017). In general, measures such as the following could be implemented:

- side dishes on request;
- doggy bag;

This project has received funding from the European Union's Horizon 2020 research
and innovation programme under grant agreement No 690452

- offering smaller portions;
- smaller units for buffets.

Connected to the activities concerning food waste are measures to reduce mixed packaging waste that normally cannot be recycled very well, like **cups of coffee to go or other disposable dishes**.

Measures relevant for cities with existing separate collection of plastic waste, like **Lisbon, Nice, Nicosia, Ponta Delgada or Santander,** could be the **installation of public drinking water fountains** (and accompanying information measures) like already existing in Copenhagen or Florence. Tourists could be encouraged to refill their empty drinking bottles, thus, reducing PET-bottles waste. Also the provision of **refillable drink bottles as giveaway** including respective information on waste prevention could be a possibility.

As it has been shown the generation of glass packaging waste seems to be influenced by tourism. **Implementation of re-useable packaging** (if available) especially for restaurants could be a promising measure.

Besides activities dealing with food and food waste as two additional general issues, the **promotion of re-use activities** shall also be kept in mind as promising to reduce tourist waste generation. Most identified international best practice examples connected to tourist waste management also refer to eco labelling and connected guidelines.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

1. Introduction

Tourism directly and indirectly generates around 10 % of the world's GDP, thus being one of the most important industries worldwide and driving socio-economic development in many regions. However, 1.1 billion tourists every year cause not only emissions from transport and touristic activities, but also can be linked to an unsustainably high consumption of renewable and non-renewable resources (incl. water) and high waste production. The generation of solid waste is considered to be one of the most relevant negative externalities of tourism. The combination of special geographical and climatic conditions, the seasonality of tourism flows and the specificity of the tourism industry, as well as the high number of tourists as waste producers, result in specific challenges related to waste prevention and management that tourist cities have to face compared to non-touristic cities. URBANWASTE therefore aims at developing strategies to reduce municipal waste production as well as to foster the re-use, recycling, collection and disposal of waste, thus, supporting local policy makers to find sustainable answers to the waste related challenges of tourist cities.

Within **Work Package 2**, background data is collected and a Life Cycle approach is used to assess the waste related impacts of tourism. In a first stage a proper **methodology** (Task 2.2) was developed and **data requirements** were defined. A newly developed **database** (Deliverable D2.4) covering all URBANWASTE pilot cases was developed and provides the information necessary for linking touristic processes to resource consumption and waste generation, prevention, recycling, treatment and disposal activities in order to analyse how tourism is responsible for **positive and negative impacts** considering the three pillars of sustainability (environment, society and economy). In a second procedural step relevant to this report, a **baseline assessment** was carried out (Task 2.6), to assess the current situation in selected URBANWASTE pilot cases. In addition, **information on existing technologies** for innovative waste management and **best practices** in waste prevention and management strategies related to touristic activities was gathered within this Work Package (Task 2.8).

This report (Deliverable D2.5) refers to URBANWASTE **Work Package 2, Task 2.6**. The main goal of the task is to quantify the status quo with respect to tourist waste production and to the total urban production of waste in the pilot cases before the implementation of URBANWASTE waste prevention and management strategies (developed in WP 4). Three major activities are performed to fulfil these goals. First of all, the collected data had to be cross-checked for reliability. The database had to be critically reviewed, inconsistencies clarified and missing data included. Based on the results of the analysis of the database, in a next step a clustering approach of the pilot cases was used to point out differences and similarities regarding the material, waste and energy flows, touristic processes, background conditions and special conditions of the URBANWASTE pilot cases. The second major activity consisted in quantifying the impact of tourist activities on waste generation before, in the last step, an assessment of environmental, social and economic impacts is performed.

The main results of this task are the quantification of the status quo with respect to tourist waste production and to the total urban production of waste (including its environmental, social and economic impacts) in the pilot cities before the implementation of URBANWASTE strategies (which will be developed within Work Package WP 4). The results of this Task 2.6 will be further used as input for Work Package WP 4.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

1.1 The 11 URBANWASTE pilot cases

The following section contains a short description of the 11 URBANWASTE pilot cases: Copenhagen, Dubrovnik, Florence, Kavala, Lisbon, Nice, Nicosia, Ponta Delgada, Santander, Syracuse and Tenerife (Table 1). All analyses and assessments performed within Task 2.6 of Work Package 2 refer to those spatial entities. More detailed descriptions of the pilot case areas can be found in report "D2.7 - Compendium of waste management practices in pilot cities and best practices in touristic cities" (Gruber and Obersteiner, 2017).

Pilot Case	km^2	inhabitants
Copenhagen	86	601.448
Dubrovnik-Neretva County	1.783	122.568
Florence	100	377.207
Kavala	351	70.501
Lisbon	100	504.471
Métropole Nice Côte d'Azur	1.400	537.769
Nicosia	21	55.014
Ponta Delgada	233	68.809
Santander	35	172.656
Syracuse	208	123.248
Tenerife / Adeje	106	45.405
Tenerife / Arona	82	79.928
Tenerife / Puerto de la Cruz	9	29.412

Table 1: Pilot Cases

Copenhagen

The corresponding spatial area of URBANWASTE pilot case "Copenhagen" is the municipality of Copenhagen. The area of the municipality is 86,2 km2[2]. The total number of inhabitants by first day in the fourth quarter of 2016 was 601.448 inhabitants. Copenhagen, the capital of Denmark, is part of a bigger metropolitan area with more than 1 million inhabitants.

Dubrovnik

The corresponding spatial area of URBANWASTE pilot case "Dubrovnik" is Dubrovnik-Neretva County. Dubrovnik-Neretva County is the southernmost county in the Republic of Croatia. The county covers a total area of 9.272,37 km^2, of which 7.489,8 km^2 or 80,78 % belongs to the Adriatic Sea, and has the population of 122.568.

[2] *StatBank Denmark: http://www.statistikbanken.dk/statbank5a/default.asp?w=1440*

Florence

The corresponding spatial area of URBANWASTE pilot case "Florence" is the city of Florence (Tuscany, Italy). Regione Toscana is full partner in URBANWASTE, but the analysis of urban metabolism and the implementation of the strategies will take place in the city of Florence. Florence is located in a basin surrounded by hills and bisected by the Arno River. Within an area of around 100 km², Florence counts 377.207[3] inhabitants.

Kavala

The corresponding spatial area of URBANWASTE pilot case "Kavala" is the municipality of Kavala, located in the Region of East Macedonia and Thrace, Greece. Kavala has 70.501 inhabitants[4] and its area is 350,61 km².

Lisbon

The corresponding spatial area of URBANWASTE pilot case "Lisbon" is the municipality of Lisbon. The municipality covers an area of about 100 km² and had 504.471 inhabitants in 2015. The municipality of Lisbon is part of the Lisbon Great Metropolitan Area (LGMA), a type of administrative entity in Portugal.

Nice

The corresponding spatial area of URBANWASTE pilot case "Nice" is the intercommunal structure "Métropole Nice Côte d'Azur" (MNCA). It was created in 2011 - succeeding an earlier intercommunal cooperation – and currently composes 49 municipalities, with Nice as the major city. Its total population in 2014 was 537.769 inhabitants, on a territory representing over 1.400 km².

Nicosia

The corresponding spatial area of URBANWASTE pilot case "Nicosia" is the municipality of Nicosia (Lefkosia), the capital of Cyprus. Due to the political situation and Nicosia being a divided capital, the URBANWASTE pilot case covers only the Greek-Cypriot part. This part of Nicosia Municipality had 55.014 inhabitants in 2011 on an area of 20,72 km².

Ponta Delgada

The corresponding spatial area of URBANWASTE pilot case "Ponta Delgada" is the municipality of Ponta Delgada (Azores). Ponta Delgada is the administrative capital of the Autonomous Region of the Azores in Portugal. It is located in the south of São Miguel Island, the largest and most populated island in the archipelago. The municipality has a population of 68.809 inhabitants (2011) and an area of 232,99 km².

[3] *ISTAT 2014 http://www.istat.it/storage/urbes2015/firenze.pdf*
[4] Data from 2011

Santander

The corresponding spatial area of URBANWASTE pilot case "Santander" is the municipality of Santander. Santander, the capital of the autonomous region of Cantabria (Spain), has 172.656 (2016) inhabitants and an area of approximately 35 km^2.

Syracuse

The corresponding spatial area of URBANWASTE pilot case "Syracuse" is the municipality of Syracuse (Sicily, Italy) The municipality has 123.248 inhabitants and its area covers 207,78 km^2.

Tenerife

The corresponding spatial area of URBANWASTE pilot case "Tenerife" does not comprise the whole island of Tenerife (Autonomous Community Canary Islands, Spain) but only the three municipalities of **Adeje, Arona and Puerto de la Cruz**. These three municipalities have been chosen as they are the three most representative municipalities in terms of touristic activities, having the largest number of tourists on the island and a wide and varied range of services and facilities for all its visitors being near the two airports of the island. Adeje and Arona are located in the south of Tenerife, Puerto de la Cruz in the north of the island.

Adeje: inhabitants (2015): 45.405, area 106 km^2

Arona: inhabitants (2015): 79.928, area 82 km^2

Puerto de la Cruz: inhabitants (2015): 29.412, area 9 km^2

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

2. Approach / Methodology

Task 2.6 deals with the analysis of the data provided by the URBANWASTE pilot cases within Task 2.5. It was structured in six activities:

- Data evaluation (incl. filling data gaps);
- Benchmarking for waste generation and recycling;
- Grouping of pilot cities regarding material, waste and energy flows, touristic processes and background conditions;
- Identification of tourists' impact on waste generation;
- Analysis of spatial characteristics of the pilot cases;
- Status-Quo assessment of environmental, social and economic impacts.

In the following section, the (methodological) approaches for all activities is described in more detail.

2.1 Data Evaluation and Benchmarking

Preceding the analysis of the databases filled by the 11 URBANWASTE pilot cases with data on waste generation and management, socio-economic data and tourism data, gaps in the database were identified and cross-checked regarding whether default values and/or literature data could be used where data are missing.

The benchmarking activity performed within this task was part of the data evaluation. In order to retrieve default data/values against which pilot case data can be compared, a set of reliable background data was collected from European cities judged as the best performers in waste management. Benchmarking thus not only enabled the normal range of figures to be established (e.g. per capita waste generation), but also supported the identification of mistakes in provided data as well as gaining a better understanding of the data itself and its background. Because of the lack of reliable waste management data for Dubrovnik, no benchmarking data could have been generated for this pilot case.

Because of their high quality waste management systems and publicly accessible data on waste generation in these cities, **Berlin (Germany), Vienna (Austria) and Zurich (Switzerland) were chosen to serve as benchmarks**. For benchmarking, data for the **year 2015** was taken.

Benchmarking was done **for per capita generation of different waste streams (incl. selected recyclables)**. Calculating benchmarks for waste prevention – as originally intended - turned out to be not feasible as it is difficult (both in terms of methodological issues as well as data availability) to find comparable data such benchmarks could be based on. Using data on the number of waste prevention activities and strategies currently implemented in the UBRANWASTE pilot cases – as intended - turned out to be not suitable as the quality of the provided information (especially the completeness of the reported activity lists) varied too much between the pilot cases.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

In order to consider the differences in tourism between pilot cases, the **tourism intensity** according to http://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:Tourism_intensity was included into the analyses (Equation 1).

Equation 1: Tourism intensity (Eurostat, 2017)

$$Tourism\ intensity = \frac{nights\ spent\ at\ tourist\ accomodation\ establishment}{total\ permanent\ resident\ population\ of\ the\ area}$$

For comparing the 11 URBANWASTE pilot cases, for this benchmarking activity it was decided to use **"tourism adjusted resident population"** (Equation 2) **as the reference base for per capita waste amounts** instead of solely the local resident population.

Equation 2: Calculation of tourism adjusted resident population (reference base for Benchmarking)

TOURISM ADJUSTED RESIDENT POPULATION (taRP)
= Adjusted resident population + Tourist equivalent population

Adjusted resident population[5]
= Local resident population[6] * National Ratio for residents' nights at home

National Ratio for residents' nights at home
= National population[7] * Number of residents' nights at home / Total resident nights per year

Number of residents' nights at home
= National population * 365 - Number of tourism nights[8]

Total resident nights per year
= 365 * national population

Tourist equivalent population
= number of nights spent by tourists[9] / 365

For this calculation, both data provided by the URBANWASTE pilot case partners as well as Eurostat data was used. More detailed information on the "National Ratio for residents' nights at home" that was derived from Eurostat data for all countries of the pilot cases as well as for Austria, Germany and Switzerland is given in Annex 11.1. Summarizing, residents spend 93,95 % to 98,68 % of the total nights a year at home. The underlying assumption for this approach for comparison is that tourists produce the same amounts of residual waste and selected recyclables as residents do.

5 = Number of local residents adjusted for the nights not spent at home (= place of permanent residence) due to travels

6 Source: data provided by URBANWASTE pilot case partners [Number]

7 Source: Eurostat database [demo_pjan], [Number]

8 Source: Eurostat database [tour_dem_tntot], [Number]. The "number of tourism nights" (tour_dem_tn) represents all tourism nights spent by residents, aged 15 or over, outside their usual environment for personal or professional/business purpose. A tourism night (or overnight stay) is each night that a guest actually spends (sleeps or stays) or is registered (his/her physical presence there being unnecessary) in a collective accommodation establishment or in private tourism accommodation (Eurostat, 2017).

9 Source: data provide by the pilot case partners, [Number]; calculated according to Caramiello et al., 2009

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

2.2 Analysis of spatial characteristics of the pilot cases

There was no spatial (GIS) data collected in WP 2 by the pilot case partners, but only data referring to the whole administrative entities as described above. Therefore, the spatial analysis in Chapter 5 builds on data acquired from various freely available databases covering all the pilot case areas. These include data on coastline, land use and nature areas from the European Environment Agency (EEA, 2015; EEA 2016; EEA 2017), data on population distribution from Eurostat (Eurostat, 2015) and data on roads and various touristic features derived from OpenStreetMap (Geofabrik, 2017). The data refers to the same spatial entities which all the other data in WP 2 also refers to, making it possible to combine both. The analysis provides an overview of the spatial structure of the pilot cases by looking at urban, touristic and nature areas. The data is summarized by spatial structure profiles for each city.

2.3 Grouping of pilot cases regarding their socio-economic characteristics

Based on the analysis of the database, in a next step a clustering approach of the pilot cities shall brings information on differences and similarities regarding the material, waste and energy flows, touristic processes and background conditions. Chapter 6 is based on statistical data on waste-related, tourism-related and socio-economic data that was gathered by the pilot cases. These separate data files were brought together into one comprehensive excel database. Because of the very small sample of n = 11, bivariate and multivariate statistical techniques have not been used to analyse the data. Besides, univariate descriptive statistics have not been used because of the inevitable loss of information. Instead, this small sample enables conclusion to be drawn from visualisation of the data by means of tables, line and bar charts and scatter plots. Grouping the pilot cases brings information on differences and similarities regarding a selection of mainly socio-economic variables.

2.4 Analysis of tourism's impact on waste generation

For evaluating waste generation resulting from tourist activities, quantitative data on waste generation, local resident population and nights spent by tourists were considered. Analysis focused on assessing the current situation regarding the waste generation by tourism only and main waste fractions affected by tourism (e.g. organic waste, packaging waste and residual waste). In contrast to the benchmarking activity, for the analysis of tourism's impact on waste generation "**local resident population**" was chosen as the **reference base**. Other than analysing per capita waste generation based on tourism adjusted resident population, using only the local resident population shows that the higher tourism intensity is (i.e. the more overnights stays there are per local resident) the more kg waste should be produced per capita.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

As a first step of analysing tourism's impact on waste generation, data on per capita waste generation was compared to the corresponding tourism intensity. This **descriptive statistical analysis** was done with MS Excel. In detail, the following steps were performed in order to identify data sets suitable for in-depth statistical analysis:

- Comparison of annual data on waste generation and tourist overnight stays separately for all pilot cases and groups of pilot cases respectively as well as separately for all waste fractions. This is in order to identify annual variations in waste amounts which can explicitly be explained by tourism.
- Comparison of monthly data on waste generation and tourist overnight stays separately for all pilot cases which could provide monthly data. Separate comparison for all waste fractions, in order to identify monthly variations in waste amounts which can explicitly be explained by tourism.
- Selection of pilot cases that can provide data suitable for more detailed analysis of tourisms' impact, and selection of waste fractions positively affected by touristic processes.

In-depth statistical analysis of selected data sets was performed applying two approaches: First, a model was used to separately calculate per capita waste generation per tourist and per local resident. Secondly, data was analysed and evaluated using linear regression models. For statistical modelling and in-depth analyses, the statistical programme "R" was used. Linear regressions were performed at confidence levels of 95 % and t-distributed.

The model (Ofner, 2011) for analysing the relationship between waste generation and the intensity of tourism is based on the **assumption that due to tourism seasonality there are differences in waste generation over the period of a year** in cities or regions strongly influenced by tourism. It assumes that during the months of low tourism season, waste disposal is mainly generated by residents and in the main tourism season the additional quantity is generated by tourism.

The evaluation steps, thus, are based on the following hypotheses:

- There is a correlation between the generation of waste (kg) and tourism (overnight stays).
- The amount of waste (in kg) per overnight stay (per inhabitant) can be quantified for cities and regions with high level of tourism.

Data requirements for this analysis are:

- Monthly data on waste generation (reported as kg per local resident)
- Monthly data on nights spent by tourists (overnight stays)
- Number of local resident population (only annual data available)

As this model should only be applied for cases with high levels of tourism, the first step using this model is to **identify the intensity of touristic pressure on the pilot case**. For identifying how strong the influence of tourism on waste generation might be, the ratio between local resident population and (tourism including) equivalent resident population was calculated.

The next step consists of defining the **months of high and low tourism**. The months of low tourism are identified by separately calculating the overnight stays per day for each pilot case for every month of the period 2013 – 2015. All months with a below-average (annual) number of overnight stays per day are counted as low season and those with an above-average number of overnight stays are counted as high tourism.

Next, waste generation from local residents and tourists respectively (in kg / local resident and kg / overnight stay) is estimated. Therefore, the average monthly per capita waste generation (in kg; including tourism) in the low tourism season is calculated to be used as an estimation for waste generation by local residents (without tourism). This is done separately for each year and each pilot case. Then, the amount of average monthly per capita waste in the low season is subtracted from the monthly values. What remains is the waste generation that can be attributed to tourism (i.e. excluding waste generation by local residents). Those values could then further be statistically evaluated using linear regression models.

2.5 Status-Quo Assessment of environmental, social and economic impacts of waste generation

According to Deliverable 2.2 "Methodology framework document as guidance for accompanying assessments" (Ramusch et al., 2016) for the evaluation of environmental impacts of implemented measures Life Cycle Assessment was chosen. To achieve more sustainable production and consumption, the environmental implications of the entire life cycle from "cradle to grave" (supply-chain of products, both goods and services, their use, and waste management) has to be considered. Life Cycle Assessment (LCA) is an internationally standardised method to quantify all relevant emissions and resources consumed and the related environmental and health impacts and resource depletion issues that are associated with any goods or services ("products"). Life Cycle Assessment is therefore a vital and powerful decision support tool, complementing other methods, which are equally necessary to help effectively and efficiently make consumption and production more sustainable (European Commission, 2010).

The following methodological issues follow the general structure of LCA according to ISO standards (ISO 14040ff):

- goal and scope definition;
- life cycle inventory (LCI) analysis;
- assessment of the potential impacts (Life Cycle Impact Assessment, LCIA) associated with the identified forms of resource use and environmental emissions (ISO 14042);
- interpretation of the results from the previous phases of the study in relation to the objectives of the study (ISO 14043).

The **goal** of this study is to provide a status quo assessment of environmental impacts resulting from actual waste management activities in 11 pilot cities and regions in Europe, which were selected for this project. The study focusses on proper accounting of environmental burdens connected with waste management in the 11 URBANWASTE pilot cases. Therefore, the so called attributional modelling approach was chosen according to ILCD Handbook (European Commission, 2010). A comparison between pilot cases is not allowed because of different circumstances in different pilot cases and therefore an evaluation of their different waste management systems performance was not the goal of the study. The focus was to **point out environmental hotspots of actual waste management activities** and **to learn more about the most relevant parts of waste management activities** in the selected pilot cases to define possible focus areas for future waste prevention

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

and management options. This shall assist the decision making process within WP 4 on relevant waste prevention and management measures for each pilot case.

The definition of the **functional unit**, that is the focus of the study, is a special issue for LCA studies of waste management options, since LCA for waste management differs from product LCA. In a product LCA the functional unit is usually defined in terms of the system's output, i.e. the product itself (for example, per MJ or km of transportation biofuels, or per number of mobile phones produced). In an LCA for waste management, the functional unit must be defined in terms of system's input, i.e. the waste. The management of the quantity of specific waste, or the waste of one household, or the total waste of a defined geographical region in a given time (e.g. 1 year) can be chosen as the functional unit.

Within URBANWASTE the waste produced by and connected with tourists' activities is of special interest. Nevertheless, normally this waste is collected together with household waste or commercial waste. Therefore, no specific values for tourist waste are available. In ten out of eleven pilot cases most of the tourist waste (mainly from public waste bins, restaurants or hotels) is collected together with household waste. Distinctively, in Copenhagen waste from hotels, restaurants and other tourist relevant establishments enters the commercial waste stream. Very often the subsequent recycling and treatment options of household and commercial waste are similar. The main difference is that, usually, commercial waste has a higher purity of separately collected fractions.

In this study, the functional unit to which the results are referred is therefore the amount of municipal solid waste produced in the year 2015 for each pilot city.

The **waste streams** included in the analysis were chosen based on their relevance for tourist activities. Therefore, the focus was laid on the main waste fractions: residual waste, paper and cardboard, plastic, glass, metal, and organic waste. 'Other' fractions that might be influenced by tourism, including bulky waste like furniture or old electrical appliances (WEEE e Waste Electrical and Electronic Equipment) from hotels, were not included in the analysis as the collection systems in different pilot cases vary too much to have reliable results. Wastes like tires or hazardous waste have not been included in the study as they were considered not relevant in relation with tourist activities.

As one of the main waste fractions produced from and influenced by tourists is food waste the **organic waste fraction** was emphasised and therefore is treated in a separate chapter.

The **boundaries** of the system under study are not limited to the geographical boundaries of the pilot cases but are extended to the whole waste chain: from the generation of waste to recycling, treatment and final disposal of residual waste (i.e. waste that does not undergo further treatment), which in some cases may take place outside the city borders.

After the definition of the goal and scope of the study, **the life cycle inventory**, (ie data about energy and material flows as well as emissions to the environment throughout the life cycle of the case study (ISO 14041)), has to be compiled. In some of the countries of the respective pilot cities, such as Spain (Fernandez-Nava et al., 2014; Montejo et al., 2013; Quiros et al., 2015), Portugal (Herva et al., 2014), Denmark (Andersen et al., 2012; Boldrin et al., 2011; Manfredi and Christensen, 2009), Greece (Koroneos, 2012) and Italy (Buratti et al., 2015; Cherubini et al., 2009; Fiorentino et al., 2015; Panepinto et al., 2015; Ripa et al., 2017) a number of LCA studies that focused on waste management are already available, but only in the case of Copenhagen was the LCA performed for the pilot city. Most of these studies aimed at identifying the best practices of separate collection and treatment options for recyclable materials as well as residual mixed waste. The variability of impact potentials as a function of municipal waste management complexity calls for the use of site-specific data when

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

the LCA goal and scope definition phase refers to a local waste management plan (Beylot and Villeneuve, 2013). As Laurent et al. (2014), point out in their review, generalized results from meta-analyses should be used with caution. As LCA results are strongly dependent on the context or local specificities, within this project a trade-off between data availability (in some pilot cities even no accurate data on waste composition are available), manageability (concerning personal and time resources) and significance had to be made. Therefore, it was decided not to rely on the literature but to perform a site specific LCA for each pilot case.

As the detailed **data** on the preferred **technology** are only available for some pilot cases it was decided to do the assessment by the use of generic data either included in the databases of GaBi 6.0 (thinkstep, 2016), or to use data on waste management processes available on the Institute of Waste Management of BOKU University of Natural resources and Life Sciences, Vienna. For **energy** inputs to waste management processes, as well as substituted energy from waste incineration, local energy mixes were considered for each pilot city. According to (Salhofer et al., 2007) **transportation** is not a relevant issue for the environmental impact of waste recycling and treatment processes and was therefore not included in the life cycle modelling.

As the study focusses on the detection of environmental hotspots of recycling and treatment processes in different European cities, a zero burden approach was used and no environmental impacts from the prior life cycle stages have been allocated to the different waste streams.

Life cycle impact assessment and modelling in general was performed using the software GaBi 6.0 (Thinkstep, 20016). Among the impact assessment methods, the ReCiPe Midpoint (H) v.1.12 (http://www.lcia-recipe. net/) was chosen, considering that it includes several midpoint indicators. The ReCiPe method provides characterization factors (Goedkoop et al., 2009) to quantify the contribution of the different process flows to each impact category. Further, in order to yield a reliable estimate of the relative magnitude of the potential impacts and resource consumption, the impact categories can be related to reference information (normalization). In ReCiPe Midpoint (H), normalization factors are calculated with reference to the European emissions in the year 2000 (Wegener Sleeswijk et al., 2008). According to the project, goals for the first status quo assessment as relevant impact category Global Warming Potential (GWP, in kg CO2 eq) were chosen.

In addition to the environmental assessment, the **social and economic** importance of tourism was also assessed for the 11 URBANWASTE pilot cases. **Social life cycle assessment (SLCA)** was used in a limited form with a focus on jobs in relation to workers, society and local community. Social assessment in relation to jobs requires data on wages, working hours, gender distribution, social benefits, employment, access to resources and technological development. Such detailed data collection is only possible on a company level (or later at the level of concrete waste prevention measures) and not a the city or pilot case level. Therefore, data collected within the WP 2 and WP 3 surveys on the status quo situation only included data for local unemployment.

Eco-efficiency (EE) has been the methodology chosen for the economic assessment of waste in relation to tourism in the pilot cases. Defined as the ratio between economic performance and environmental impact, EE links environmental impacts with monetary costs in a simple way that is easy to communicate.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

3. Data Evaluation

Iris GRUBER

Accurately assessing the impact of tourists on waste generation as well as the status-quo of the total urban production of waste (including its environmental, social and economic impacts) requires high quality data. To ensure this, preceding the analysis of the status-quo in the 11 URBANWASTE pilot cases with respect to tourist waste production and total urban production of waste, data evaluation was carried out. The data provided was evaluated (reviewed), gaps in the database were identified and cross-checked with default values and/or literature or other publically available data, including where data are missing.

In order to ensure that the pilot case databases are completed with data (as far as possible with respect to the differences in data availability in the pilot cases), a first round of data evaluation had already been performed within Task 2.5 when pilot case partners were still filling in the databases. More information on the differences in availability of various waste related, socio-economic and tourism related data sets in the 11 URBANWASTE pilot cases can be found in the URBANWASTE project's report "D2.3 – Report on indicator sets and touristic processes" (Gruber et al., 2016). In a second step, as a basis for the benchmarking and the assessment of tourists' impact on waste generation (Chapters 4 and 7), data on waste **generation**, on **local resident population** and **number of nights spent by tourists** were thoroughly cross-checked.

3.1 Clarification of data sets

For cross-checking the above mentioned data sets, several rounds of data clarification with the local pilot case partners were performed. Most of the **clarification questions** were related to the following issues:

- Clarification of **types of waste behind specific waste streams** for which amounts were reported:
    - Metals: Does the reported data on the waste fraction "metals" represent only metal packaging or also scrap metals such as metal frying pans or metal hangers?
    - Plastics: Does the reported data on the waste fraction "plastics" represent only plastic packaging or other types of plastic waste as well? Please give examples for the types of plastic packaging that is included.
    - Co-mingled fraction of recyclables: Please give examples of the different types of packaging materials that are collected within this waste stream?
    - WEEE: Does the reported data on WEEE represent only those amounts of WEEE collected by the municipality or also those WEEE collected through stores selling electrical and electronic equipment etc.?
- Explanations for **noticeable increases / decreases in** waste generation **data** or data on nights spent by tourists

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

3.2 Filling in data gaps

For identified gaps in the database it was examined whether default values and/or literature or other publicly available data could be used. Where data was not available on the pilot cases scale but on a bigger spatial scale (e.g. regional scale), additional data have been used via extrapolation to estimate reliable figures on the pilot case scale.

DATA ON WASTE GENERATION

For most pilot cases data on waste management at the scale of the pilot case area was available at least for the main waste fractions such as residual waste, organic waste (if separately collected) and selected recyclables, and at least on an annual basis for some years of the period 2000-2015. For **Dubrovnik no reliable data on waste generation and management are available**. Although for data collection the relevant institutions have been contacted by pilot case partners -Dubrovnik Neretva County Waste Management Agency and Dubrovnik Neretva County Department for Environment and Nature Protection- it was not possible to get reliable data for the pilot case region. This is due to manifold reasons: as the waste collection is covered by local government units, details on the county (=pilot case level) are not available. It also seems that not all 22 DNC local government units have the relevant data. As major waste separation and collection guidelines for Croatia entered into force in 2016, first data for some sectors will be available only in 2017. However, one main reason is that except for the official municipality companies, there are 11 private companies registered within the Dubrovnik pilot case region. As they and also private waste managing companies from other parts of Croatia collect different types of waste in the pilot case area, there is no bundling and summary of these data. Dubrovnik therefore could not have been included in all analyses of Task 2.6 relying on waste related data (e.g. Benchmarking, Environmental Assessment).

For **Tenerife**, only data on separately collected recyclables were available at the pilot case scale (being the three municipalities of Adeje, Arona and Puerto de la Cruz) and on a monthly basis. For residual waste and organic waste fractions, monthly data was only available at the "AYUNTAMIENTO" level which accounts for 93 – 98 % of the total waste generation of the "MUNICIPIOS" (for the period 2013-2015). Data on waste generation at the "MUNICIPIO" scale is composed of "urban" waste ("AYUNTAMIENTO" waste data) and waste from enterprises such as hotels, food and catering industry, restaurants, pubs, bars, shopping malls, shops ("PARTICULARES" waste data). For "PARTICULARES" and "MUNICIPIO", only annual amounts for residual waste and organic waste streams were available for each Tenerife pilot municipality. Further, monthly data for residual waste and organic waste fractions were available but only at the whole island scale and not separately reported for each municipality. By using the monthly variations in waste generation retrieved from the data for the whole island of Tenerife it was possible to **estimate the monthly generation of residual and organic waste** by "PARTICULARES" for each of the three Tenerife pilot case municipality and, thus, in a next step, the monthly waste generation **on "MUNICIPIO" scale**.

DATA ON LOCAL RESIDENT POPULATION

Data on local resident population of the URBANWASTE pilot case areas (mainly municipality scale) for at least some years of the period 2000 – 2015 could be provided by all 11 URBANWASTE pilot cases. For **Dubrovnik, Kavala, Nicosia and Ponta Delgada**, however, only **census data** for the years **2001** and **2011** was available. The years in-between were estimated by the authors (linear extrapolation of census data). For Lisbon, population data was only provided for the years 2001, 2001, 2004-2011 and 2015. Population figures for the missing years were estimated by the authors (linear extrapolation using available data).

DATA ON NUMBER OF NIGHTS SPENT (OVERNIGHT STAYS) OF TOURISTS

7 out of 11 URBANWASTE pilot cases were able to provide data on the number of nights spent by tourists at the spatial scale of the pilot case studies. In the remaining **4 pilot case studies** the following situations occurred: either **data on overnight stays was not available at all (Syracuse)** or not available at the spatial scale of the pilot case study area but only at **bigger scales such as provincial or regional scale (Kavala, Ponta Delgada)** or even **national scale (Dubrovnik)**.

In the case of **Syracuse**, **data on the number of tourist arrivals and on the average length of stay was used to estimate the number of nights spent by tourists**. Data on the number of tourist arrivals on a municipal scale were only available from 2015 onwards. For the years 2000-2014 only data on a provincial scale was available. According to the local pilot case study project partners, about 45 % of the provincial arrivals can be allocated to Syracuse (Sammito 2017). Data on the average length of stay was only available for the years 2002-2003 and 2009-2013. The other years were calculated using the mean value of the available data in order to be able to estimate the number of overnight stays in Syracuse municipality for the years 2003-2015.

In the case of **Kavala and Ponta Delgada**, **additional data on the number of hotels at different spatial scales (local, regional) retrieved from online accommodation booking platforms (such as www.booking.com or www.trivago.com) and OpenStreetMap (www.openstreetmap.org) was used** to estimate the share of tourists' overnights stays in the pilot case study areas in relation to total nights spent by tourists in the region (or the scale data is available for). The underlying assumption for this approach is that hotels and other types of tourist accommodation establishments have the same distribution of capacities per establishment type and occupancy rates in both the local and the regional area.

For Ponta Delgada, the number of overnight stays at the municipality scale was estimated by using overnight stay data on a regional scale (whole island of Sao Miguel) and the share of the island's hotels and other accommodations that are located in Ponta Delgada (approx. 60 % of hotels and 40 % of non-hotel accommodation; www.booking.com). Multiplying the share of the total island's accommodation located in Ponta Delgada with the number of regional overnight stays showed that approximately 57 – 59 % of the total regional overnights stays can be allocated to the municipality of Ponta Delgada.

For Kavala, **estimating the number of nights spent by tourists within Kavala municipality turned out to be difficult because other data on the tourism industry that could have been used for this purpose was either not available or showed huge variations depending on the data sources.** The number of tourist establishments located in Kavala, for example, varied between 12 (www.openstreetmap.org), 20 (google maps reached via official Kavala tourism homepage http://tourism.kavala.gov.gr), 74 - 83 (www.booking.com, depending on the date the site was visited), and 125 (www.trivago.com). Similar variations were visible for the number of tourist accommodations in the region "East Macedonia and Thrace Region" for which data on overnight stays was available: 20 according to www.booking.com, 187 according to OpenStreetMap, 383 according to a report from ITEP (2015) on the Greek hotel industry (only hotels), and 1874 according to www.trivago.com. Due to these inconsistencies in information about tourist establishments in Kavala and East Macedonia and Thrace region, data from both OpenStreetMap and www.trivago.com was used to estimate Kavala's share of the regions' total overnight stays. According to OpenStreetMap, Kavala's share of the region's tourist accommodation establishments is about 6,4 %, the share of hotels about 6,2 %. According to www.trivago.com, about 6,7% of the region's total tourist accommodation establishments and about 6,3% of the East Macedonia and Thrace region's hotels are located in Kavala.

This project has received funding from the European Union's Horizon 2020 research
and innovation programme under grant agreement No 690452

Another problem with using such data retrieved from **online accommodation booking platforms** is that the **"destinations"** that can be used to narrow down the search results **do not necessarily correspond with official territorial boundaries, and the spatial scale of the area the results are related to might not be clear**. In the case of Kavala, for example, it was not clear if the results for "Kavala" refer to establishments located only within the borders of the municipality of Kavala or within the regional unit of Kavala (including the municipalities of Kavala as well as the neighbouring municipalities of Nestos and Paggaio).

In order to cross-check if the hotels listed to be in "Kavala" according to www.trivago.com, the map showing the accommodations provided by www.trivago.com was overlaid with a map showing the borders of Kavala municipality retrieved from Wikipedia (Wikipedia 2017). The comparison revealed that 49 of the 125 accommodations reported to be in Kavala according to www.trivago.com are not located within the municipality borders. The remaining 76 tourist accommodation establishments located within Kavala municipality account for about 4 % of the total number of East Macedonia and Thrace region's accommodation establishments. Based on this as well as the results from OpenStreetMap, the ratio of 5 % was in the end be used for estimating the number of nights spent in Kavala municipality from the provided data on the total number of nights spent in East Macedonia and Thrace region.

For further verification of the approach described above, the estimated numbers of nights spent by tourists in Kavala municipality were compared with those numbers resulting from using overnight stays in the regional unit (Kavala, Nestos, Paggaio; available only for total 2013, 2014 and 2015) multiplied with the ratio of the estimated number of accommodations in Kavala municipality in relation to the total number of accommodation establishments in Kavala, Nestos and Paggaio according to www.trivago.com (about 26 %). For 2014 and 2015 the difference between those two calculation approaches is less than ± 5 %. For 2013 the difference is 215 %, but the reported number of overnight stays for 2013 is about 3 times higher than the ones reported for 2014 and 2015. As this figure seems totally out of place and the number of nights spent in East Macedonia and Thrace region does not show any significant increase in this year, the number of nights spent in the regional unit for 2013 was not used for verifying the above explained estimations.

For **Dubrovnik** it was not attempted to estimate the number of nights spent by tourists at the pilot case study scale as all other data relevant for further analyses to be performed in Task 2.6 were not available at this scale.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

3.3 Results of and lessons learnt from data clarification

3.3.1 Waste streams suitable for subsequent (statistical) analyses

Clarifying the types of waste behind specific waste streams for which data were reported revealed that **only selected sets of waste generation data (i.e. waste streams) are suitable to be used in further (statistical) analyses**. These waste data sets include:

- Residual waste
- (Total) Organic waste
- Selected recyclables:
  - Paper & Cardboard
  - Glass
  - Metals/Metal packaging
  - Plastics/Plastic packaging
  - Co-mingled fractions of recyclables (metals and plastics and paper & cardboard) if no separate data was available

Regarding data on metals/metal and plastics/plastic packaging it has to be mentioned that **in many cases it was not possible to receive separated data on metal packaging and scrap metals** (e.g. frying pans, metals hangers, …) **and plastic packaging and other plastic waste** (e.g. toys, plastic hangers, storage boxes, …) respectively. For some pilot cases it could be assumed that the reported amounts contain mainly packaging waste, but, nevertheless, for any analysis of data on recyclables this data characteristic has to be kept in mind. For data on co-mingled fractions of different recyclables data, clarification showed that the collected amounts of metal and plastic fractions are mainly composed of packaging waste. A detailed overview on what is behind specific recyclable fractions for each pilot case is given in Annex 11.4.

Further, **"municipal solid waste (MSW)" turned out to be not suitable** for use in **further analyses** as there are too many differences in what is included in the data reported as MSW. For some pilot cases, data on MSW was just the sum of residual waste, bulky waste (if available), WEEE (if available), organic waste (if available) and (at least some) recyclable fractions such as paper & cardboard, glass, metals/metal packaging and plastics/plastic packaging, while for other pilot cases MSW further included e.g. street sweeping waste, hazardous waste, used cooking fats and oils as well as a long list of other recyclables such as tyres, wood, construction and demolition materials and many more. **Instead**, the **sum of selected recyclables ("SUMrec")** and the **sum of residual waste, total organic waste and selected recyclables ("SUMres+org+rec") was calculated** to be used in subsequent (statistical) analyses.

Detailed data on PET-bottles and metal packaging (both considered to be potential hotspots of waste streams influenced by touristic activities) were only available for Nicosia. However, these data were estimated figures using data on total amounts of metal and plastic waste respectively multiplied with the proportional share of metal packaging and PET-bottles in these waste streams known from composition analyses. A similar calculation could have been performed for Ponta Delgada using data about the composition of the co-mingled fraction of metals and plastic packaging (available for the whole island of Sao Miguel). As such estimations in general contain a lot of uncertainties and two data sets are not enough for reliable (statistical) analyses, the

This project has received funding from the European Union's Horizon 2020 research
and innovation programme under grant agreement No 690452

authors decided that within Task 2.6 an in-depth analysis of the waste streams PET-bottles and metal packaging is not possible. Another problem with detailed data on PET-bottles and metal packaging is that in cities having a refund system for certain packaging materials in place (e.g. Copenhagen, Ponta Delgada or Berlin) these waste streams possibly do not even appear in waste statistics (such as in Copenhagen).

3.3.2 Limited comparability of data because of differences in the share of total waste generate in the pilot case that is represented in the reported data

Waste from tourist establishments:

All the waste management data used for any of the analyses within Task2.6 was at the spatial scale of the pilot case study (i.e. mainly on municipality level) in order to allow the analysis of impacts on local level. **As waste management data provided by the pilot cases usually is data on municipal waste collection,** it is **important to know if tourist establishments** (e.g. hotels and similar accommodation such as hostels, Bed&Breakfasts etc., restaurants, camping sites, marinas, public structures such as museums, etc.) **are covered with these data about municipal waste collection** (or if they dispose their wastes using other waste collection and disposal systems). Together with **"food and beverage provision for tourists", "accommodation**" is considered to be a **hotspot in terms of waste generation caused by tourism** (Ramusch et al.,2016b).

Experiences from similar projects show that the collection of waste from tourist establishments can be covered either by the local waste management authority (public utility service), by private enterprises on behalf of the local waste management authority, or a combination of both. Thus, hotels might not always be represented in municipal waste data.

Regarding the **representation of waste from hotels (and other tourist establishments) in the data provided by the pilot case study partners** the situation in the 11 URBANWASTE pilot cases is as follows:

- **All hotels are represented in the reported data**: Florence, Kavala, Nicosia, Ponta Delgada, Santander, Syracuse, Tenerife
    - In **Florence**, **Nicosia** and **Ponta Delgada** only the municipality (local waste management authority) is responsible for collecting MSW from tourist establishments.
    - In **Kavala**, all waste streams are collected by the municipality, except hazardous waste which is collected by private actors. Hotels are also serviced by the municipality. Hazardous waste is not looked at in the subsequent analyses of tourism´s impact on waste generation.
    - In **Santander**, waste from tourist establishments is collected and treated together with waste streams collected from households. The waste management as public utility service is provided by a local waste management enterprise through a public tender.
    - In **Syracuse**, tourist facilities' waste is collected by the service operated by the same private company (on behalf of the municipality) as waste from households.
    - Data in **Tenerife** covers both "urban" generators (meaning households) and waste from enterprises such as hotels, food and catering industry, restaurants, pubs, bars, shopping

This project has received funding from the European Union's Horizon 2020 research
and innovation programme under grant agreement No 690452

malls, shops. The service of collection of MSW is carried out by private enterprises on behalf of the municipal department of environment.

- **Only a part of the hotels is represented in the reported data:** Lisbon, Nice
    - In **Lisbon**, the collection of waste from tourist establishments is covered by the municipal waste collection systems; collection from businesses that generate more than 1.100 litres (1,1 m^3) a day is also done by private companies.
    - In **Nice**, waste collection of tourist establishments is covered by the Metropole Nice Côte d'Azur (with partners from the private sector). There is no further information on the share of hotels that might not be represented by the provided data.
- **No or hardly any hotels are represented in the reported data:** Copenhagen
    - In **Copenhagen** most tourist establishments have arrangements with private collectors. Only some are serviced by the municipality. Thus, waste from hotels does not end up in the MSW. The same is true for food waste. As the reported data covers only the amounts collected by the municipality, Copenhagen cannot be included in the subsequent analysis of tourists' impact on waste generation.

In Dubrovnik, waste collection from tourist establishments is covered by municipal waste collection, but hotels and restaurants can also contract authorised private companies. However, data on waste generation could not be provided for the pilot case area.

More detailed information on the organisation of municipal waste collection in the 11 URBANWASTE pilot case studies can be found in the project report "D2.7 - Compendium of waste management practices in pilot cities and best practices in touristic cities" (Gruber and Obersteiner, 2017).

Waste from touristic ships:

The collection of waste from touristic ships is carried out by private hauliers in all of the 9 URBANWASTE pilot cases with access to the sea (i.e. all except Florence and Nicosia). The port usually is not managed by the municipality, but under the responsibility of the port authority. As none of the pilot cases could provide data on the amounts of waste generated by touristic ships, this aspect of tourism related waste generation could not be analysed in detail within this task.

Refund systems for selected packaging waste:

In cases where there is a refund system for refund packaging materials (e.g. "green dot" or similar deposit-refund system) in place (such as in Copenhagen, Dubrovnik and Ponta Delgada) it further has to be considered if the amounts of packaging waste collected through the refund system are included in the waste data provided or not in order to determine what share of total generated waste is covered by the reported data. For Ponta Delgada, for example, the **data on amounts of packaging collected through the refund system** was **included** in the waste data provided by the pilot cases. In Copenhagen, such data had to be **additionally requested** as refunded packaging is not waste per definition and, thus, does not appear in any waste figures. To allow comparison with the other pilot cases, the amounts of refunded packaging (glass, metals, plastics) collected via the refund system in Copenhagen were added to the reported waste data.

3.3.3 Significant increases / decreases in time-series data on waste generation and number of nights spent by tourists

In general, **most pilot cases show a slight decrease in residual waste** together with a **slight to significant increase in amounts of selected recyclables** in the period 2000 - 2015. The trend in organic waste is not so uniform – sometimes showing strong variations between different years or a strongly increasing trend. The **number of nights spent** by tourists show an **increasing** trend in all 11 URBANWASTE pilot cases.

Significant increases / decreases in waste generation in the considered period 2000 - 2015 were visible in the data provided by Florence, Kavala, Lisbon, Nice, Nicosia, Ponta Delgada, Syracuse and Tenerife.

In **Florence**, the strong increase in the amounts of organic waste could be explained by the fact that the separate collection of organic waste has not always been in place in Florence. The progressive increase in collected amounts may, thus, be related to the **progressive extension of the separate collection of the organic waste** to all households and commercial users in Florence. Moreover, in recent years in some parts of the city the less efficient "street bin" collection service has been replaced by the more efficient "door-to-door" collection service, which could also have produced a positive effect on the collection rate of the organic waste. The big differences in the collected amounts of paper & cardboard waste may be related to the **economic crisis**. However, it cannot be excluded that some **commercial users** for this waste fraction **have chosen not to use the municipal waste collection service**, as they could get some revenues from selling cardboard directly to paper preprocessors, or that some waste prevention best practices have produced some positive effect.

In **Kavala**, there is a (sometimes quite strong) decrease in the generation of residual waste since 2008. Partly this decrease could be explained with the introduction of separate collection of specific fractions, in 2009 . Paper and cardboard were the only recyclables with separate collection until March 2015, when metals and plastic packaging were added. In June 2015, separate collection of glass was introduced.

Further, a detailed look at monthly data on residual waste generation shows a decrease in amounts generated in the summer months for the years 2013 - 2015, i.e. during high season for tourism. As in Kavala municipal waste collection is also serving hotels, there should be a peak in waste generation during summer, not a drop, as indicated. The explanation for this phenomenon is **bad data quality (inconsistencies in reported figures)**: During the summer months, the amount of wastes collected is indeed higher due to tourism compared to the remaining months of the year according to the reports from the employees and according to the decisions taken at a municipality level to extend the working hours of the site in order to allow for collection of the extra amounts of wastes. However, the figures do not reflect the reality for the summer months for the years 2013, 2014, and 2015 due to the fact that only one employee was responsible for recording the waste amounts during the summer months and because of periods of annual leave there is a possibility that the amounts of waste were not recorded for certain days. For the future this type of situation is effectively addressed since October 2016, when a proper track scale was installed and a day to day recording system was put in place.

Data on waste generation in **Lisbon** show a strong increase in the collected amounts of organic waste and a peak from 2005-2010 for paper & cardboard waste. The strong increase in the collected amounts of organic waste is explained mainly because together with implementing a door-to-door selective collection the frequency of the collection of the mixed waste was decreased from 6 to 3 times per week. The peak for paper

& cardboard is related to the activity of paper pickers that steal this waste from the bins to sell directly to the resellers, as a result of the economic crisis.

For residual waste, there is a noticeable drop in the amount of residual waste (as well as all other fractions we analysed) collected in February and August in every year from 2013 – 2015. Especially in August, the drop is significant because in this month there is a peak in the number of nights spent by tourists. These drops can be explained by the fact that a high number of Lisbon residents go on holidays in these months and only a few hotels are covered by municipal waste collection, i.e. represented in the available data.

For **Nice** a permanent increase in the collected amounts of organic waste (this is in fact green waste collected at collection sites in bring system) and a drop in collected amounts of residual waste in 2009 indicate the expansion of separate collection of organic waste which only partly can explain the dropped amounts of residual waste.

Data for **Nicosia** show a strong increase in the collected amounts of various recyclables, from a change in the waste management system. Recyclable materials (paper, glass, PMD) are collected from the collective system on behalf of Nicosia Municipality (first contract signed in June 2008). Nicosia had increased gradually the total number of special bins which were installed for the separate collection of recyclable materials (focussing on the city centre and especially to the biggest waste producers such as restaurants, snack bars etc.). Moreover, the communication with citizens regarding the dissemination of the information related to recycling was improved. Organic waste collection started in 2011. The collection of green (garden) waste from households and businesses is done without charge and accompanied by awareness campaigns, leading to a strong increase in collected amounts. The noticeable decrease in the collected amounts of PMD (co-mingled fraction of metal & plastic packaging) and residual waste from 2011 onwards is a result of the financial crisis. It seems that the consumers had altered their consuming and shopping habits and were purchasing fewer products during this time.

For **Ponta Delgada** as for most other cities there are inconsistencies in the database for the years before 2010. As for most European cities, it can be assumed that changes in the collection system or changes in the recording are responsible for this phenomenon. A peak in the collected amounts of paper&cardboard in 2010 has been detected, which could not be clarified.

In **Syracuse**, from 2012 onwards there is a strong increase in the collected amounts of paper & cardboard, glass, metals and plastics due to the implementation of two new collection platforms. Before 2012, waste was collected and managed by platforms in Catania (a province near Syracuse). Organic waste also shows a strong variation which can be explained by the fact that for organic waste from households there only was a trial collection from 2012-2013 in parts of the city. The strong variations for green waste which has to be deposited at municipal waste collection centres can be explained by poor data quality. Only after 2012 with the new collection platforms in Syracuse has waste data improved. The drop for residual waste collected in 2008 can be explained as a result of the economic crisis.

For **Tenerife**, significant variations in collected amounts are visible for paper & cardboard and for organic waste. For paper & cardboard the variation can be explained by the fact there are three municipalities in Tenerife (Adeje, Arona, Puerto de la Cruz) forming the URBANWASTE pilot case "Tenerife". While Adeje and Puerto de la Cruz show just a slight increase in collected amounts of paper & cardboard, in Arona there was a peak for 2008 – 2009 with significantly higher amounts. This can be attributed to a special announcement of waste collection service and advertising campaigns made for businesses with waste similar to household waste (special focus on paper & cardboard). Regarding organic waste, for Adeje and Puerto de la Cruz a decreasing trend with quite strong variations is visible for green (garden) waste. This variation probably can be explained by seasonal campaigns, especially in parks and squares (tree pruning), and other factors such as the vacation of the person who compiled the data and was not replaced. For food waste from kitchens there is a peak in 2010 and 2011 which is probably due to special awareness campaigns for hotels, restaurants and bars in those years. In the following years, implementation might have failed because of the economic crisis. With the crisis there have been fewer awareness campaigns, trials of new collection systems, and other similar measures.

Detailed information on the trends in waste generation for the period 2010 – 2015 for all pilot cases can be found in Annex 11.2.

Significant increases / decreases in the number of nights spent by tourists in the period 2000 – 2015 were only visible in Florence and in Nicosia. The peak in **Florence** in 2013 (dropping back to a before-2013-level from 2014 onwards) **could not be explained** by the pilot case partners. In **Nicosia**, the peak in the number of overnight stays in 2012 **can be explained by Cyprus having the Presidency of the Council of the European Union** from July - December 2012. In connection, many conferences and meetings had taken place in 2012 leading to a high number of tourists staying in Nicosia. Further, general tourist traffic was exceptionally high in 2012, falling back within normal levels/ranges from 2013 onwards.

A summarizing overview on the data sets that were finally used for further analyses (incl. information on the spatial and temporal scales the data sets were available as well as on where data gaps were filled with estimated data) is provided in Annex 11.3.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

4. Benchmarking for waste generation and recycling

Iris GRUBER & Gudrun OBERSTEINER

Benchmarks normally mark the reference value of best performances. They can be used in comparative analysis to identify existing differences and reasons for those differences as well as to show potentials for improvement. The idea of benchmarking performed within Task2.6 of Work Package WP 2 was different. As it was already explained in previous chapters, the direct comparison (benchmarking) between pilot cases is not possible due to different reasons (different range of tourism waste collected within municipal waste collection, different waste collection systems (more or less separate collection) in general, different influence of tourists…) Therefore, the process of benchmarking was part of the data evaluation process mainly to detect outliers. **The goal was to collect a set of reliable background data from European best performers in waste management providing reliable data sets to retrieve default data/values against which pilot case data can be compared**. The importance of this activity can be seen in finding out the normal range of figures (e.g. per capita waste generation) in order to be able to identify mistakes in the figures provided by the pilot cases as well as to gain a better understanding of the data itself and its background (e.g. identifying which figures might have to be further clarified regarding their composition etc.).

Berlin (Germany), Vienna (Austria) and Zurich (Switzerland) were chosen to serve as **benchmarks** representing best performing cities in term of waste management. Benchmarking was performed using data for the **year 2015**.

As explained in more detail in Chapter 3, because of inconsistencies in data availability and quality only a selected set of waste streams turned out to be suitable for WP 2 evaluations such as benchmarking. Those waste streams include:

- Residual waste
- Organic waste
- Selected recyclables (mainly packaging waste)
- WEEE

For Dubrovnik (Dubrovnik Neretva County) it was not possible to provide reliable data on waste management. Therefore, benchmarking was not possible for this pilot case.

Benchmarking was done for per capita amounts collected by the municipality for the selection of waste streams mentioned above. In order to consider the differences in tourism intensity[10] in the 11 URBANWASTE pilot cases, a "**tourism adjusted resident population**" (Equation 2) **was used as reference base for per capita waste amounts**. More details on the calculation of the chosen reference base is presented in Chapter 2.1.

[10] **Tourism intensity** is the ratio of nights spent at tourist accommodation establishments relative to the total permanent resident population of the area. http://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:Tourism_intensity

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

4.1 Residual waste

Figure 1 shows the per capita amounts of residual waste collected by the municipality in 10 of 11 URBANWASTE pilot cases as well as in the Benchmarking cities Berlin, Vienna and Zurich. In the URBANWASTE pilot case, the per capita amounts of residual waste range from a minimum of 262 kg per person and year (kg/cap.a) in Copenhagen to about 546 kg/cap.a in Nicosia. Per capita amounts of residual waste in the benchmarking cities (Berlin, Vienna, Zurich) range from about 179 kg/cap.a to about 292 kg/cap.a. In comparison, only in Copenhagen, Kavala and Florence are per capita amounts for residual waste in a similar range as the benchmarks. In Nicosia, Syracuse or Tenerife, on the other hand, per capita generation of residual waste is about 1,5 to twice as high as in the benchmark cities.

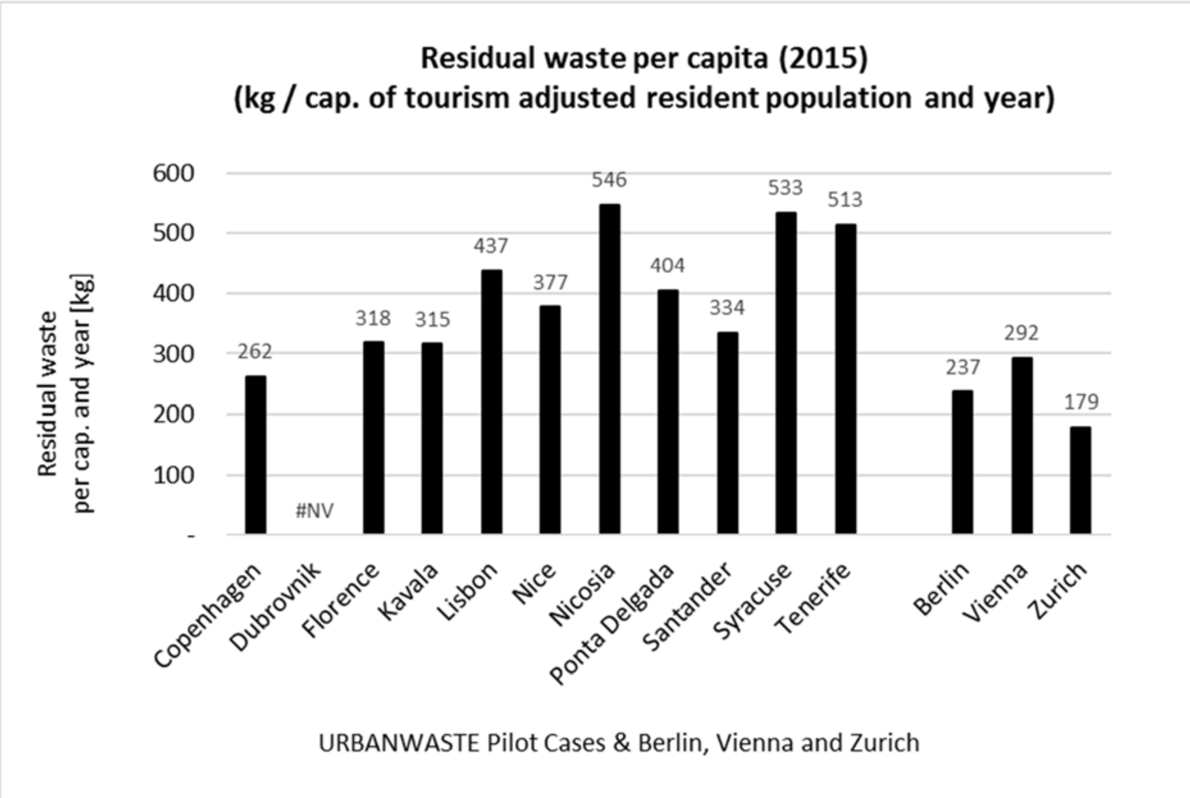


*Figure 1: Residual waste per capita (2015) in the URBANWASTE pilot cases & Berlin, Vienna and Zurich [kg/(cap.*a)]. Reference base: per capita of tourism adjusted resident population (Equation 2). For Dubrovnik no reliable data on residual waste was available. In Zurich, an unknown amount of bulky waste is included in the figures for residual waste; separating these data was not possible.*
#NV … No value

For a correct interpretation of the figures presented in Figure 1 it has to be taken into account that the share of waste generated by commercial activities collected within the municipal collection service is not exactly known; neither for the pilot cases nor for the benchmarking cities. Beside the lower rates of collected recyclables, the higher share of commercial waste included in the MSW collection might also be a reason for high per capita generation of waste in some of the pilot cases.

4.2 Waste of electrical and electronic equipment (WEEE)

Getting comparable data on WEEE split in the categories **"small WEEE" and "big WEEE"** (i.e. refrigerator, washing machines etc.) turned out to be not as easy as thought because sometimes publically available data on WEEE collected by the local waste management authority was reported e.g. as **"total WEEE"** only (without any further information on the composition of the WEEE fraction) or split into categories different to the ones used in URBANWASTE. In Vienna, for example, in publically available waste management reports WEEE was split into non-hazardous and hazardous WEEE and further into different categories such as lamps, cooling equipment, etc.

For most URBANWASTE pilot cases only data for "total WEEE" was reported. More detailed data was only provided for Nicosia and Santander. Experience, however, shows that the local waste management authority in many cases has more detailed data than the ones published.

Further, data on collected WEEE amounts can vary much depending on the data source. Experience shows that WEEE data reported by the municipal waste management authority usually only represents the amounts collected through the municipal waste collection service or via municipal waste collection centres. WEEE returned to shops and stores selling electrical and electronic equipment[11] often is not included in such data. Data from (national) authorities in charge of coordinating WEEE collection and disposal, on the other hand, usually represents both WEEE collected by the municipality as well as WEEE taken back from shops because of European take-back obligations.

Data on WEEE collection received from the URBANWASTE pilot cases (Figure 2) **in most cases only represent the amounts collected by municipal waste collection and do not include the amounts collected through shops and stores**. This is true also for benchmarking city Vienna[12]. Only for Syracuse, the amount of collected WEEE includes also that collected through stores selling electrical and electronic equipment. However, WEEE collected through **municipal waste collection usually represents only a small share of total WEEE collected via various channels**. For Lisbon, for example, it is known that citizens are delivering almost of their WEEE directly to the supermarkets.

Copenhagen, Florence, Berlin, Vienna and Zurich show high amounts for collecting WEEE. The comparably high per capita amounts for Syracuse can be explained by the fact that - in contrast to all other pilot cases and benchmark cities – the reported figures include those WEEE amounts taken back by shops and stores.

Although WEEE might be a very interesting waste stream in terms of waste generation caused by tourism (through hotels disposing TV sets, minibars etc.), the data on WEEE that was provided by the pilot cases do not allow a more detailed analyses of tourism's impact on WEEE generation. WEEE, thus, will not be included in more detailed evaluations of WP 2.

[11] In order to comply with the European WEEE Directive shops and stores selling electrical and electronic equipment face a take-back obligation in terms of producer responsibility.

[12] For Berlin and Zurich, it could not be clarified if the reported amounts only represent municipal collection.

This project has received funding from the European Union's Horizon 2020 research
and innovation programme under grant agreement No 690452

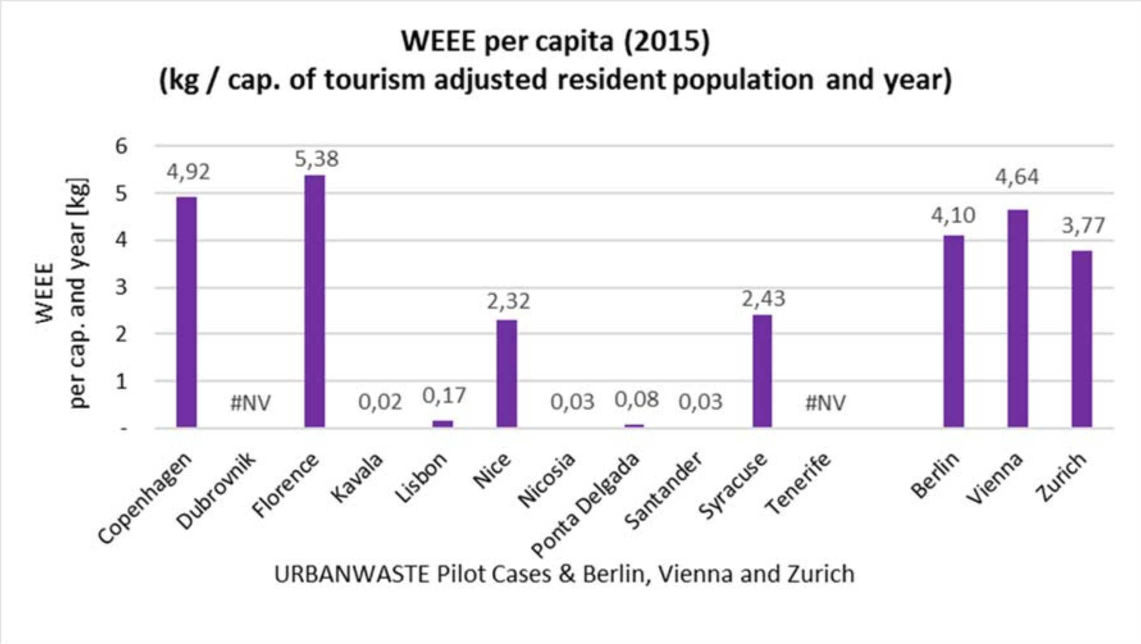


*Figure 2: WEEE per capita (2015) in the URBANWASTE pilot cases & Berlin, Vienna and Zurich [kg/(cap.*a)]. Reference base: per capita of tourism adjusted resident population (Equation 2). For Dubrovnik there was no reliable data available. For Tenerife, data on WEEE is only available on the scale of the whole island. Only for Syracuse, the presented data include not only amounts collected through municipal waste collection service but also WEEE taken back by shops and stores. For Berlin and Zurich, it is not clear if the presented amounts include also WEEE taken back by shops and stores.*
#NV … No value

4.3 Organic waste

Organic waste was identified in URBANWASTE project report "D2.1 - Literature Review on Urban Metabolism Studies and Projects" (Ramusch et al., 2016b) as one of the hotspot waste streams in terms of waste generation from touristic activities. Organic waste in the meaning of this report can include one or more of the following organic waste fractions:

- **Organic waste** (food and garden waste) **from households**
- **Green (garden) waste** (trees, grass, bushes) from public and private gardens
- **Food waste** from kitchens, canteens, restaurants, bars

Figure 3 gives an overview on the per capita amounts of organic waste collected in the URBANWASTE pilot cases as well as in Berlin, Vienna and Zurich. It further displays the kind of organic waste fraction(s) that is/are collected in a specific pilot case as well as their relation in terms of collected amounts.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

Separate collection of at least some types of organic waste were in place in 2015 in all pilot cases except Dubrovnik and Santander, as well as in Berlin, Vienna and Zurich. However, data on the collected amounts were not available for all pilot cases and benchmark cities:

- For Copenhagen, data on food waste from commercial kitchens etc. was not available as the collection of this waste is not covered by municipal waste collection. The collected amounts are, thus, not represented in the data provided for analysis. From autumn 2017 onwards all households in Copenhagen will start separating their bio-waste for anaerobic digestion.
- For Kavala, no reliable data on organic waste was available although a sort of separate collection of organic waste (composting units) from households is in place.

While all of the pilot cases with organic waste collection (as well as Berlin and Vienna) collected green (garden) waste in 2015, organic waste from households was only collected in Florence, Berlin, Vienna and Zurich. Systems for a separate collection of food waste from kitchens, canteens, restaurants and bars existed only in Lisbon and Vienna. For Copenhagen and Syracuse, the collection of organic waste from households was foreseen to start in 2017.

The highest amounts of organic waste per capita in 2015 occurred in Florence with a total of about 105 kg organic waste per capita, followed by benchmark city Vienna with about 65 kg organic waste per capita.

Comparing only data on **organic waste from households (food and garden waste)** it shows that the per capita amounts of Florence are around 83 kg per capita 2,5 to 4 times as high as in the benchmark cities (20 – 36 kg/cap.a. This, however, may result from the fact that commercial users in Florence are also covered by municipal collection of organic waste. However, there is no separated data on organic waste from commercial users. The authors thus assume that food waste from commercial users such as kitchens, restaurants etc. are included in the data provided on "organic waste from households" instead of reporting it separately as it is the case in Vienna, for example.

Per capita amounts of **green (garden) waste** range from 2,23 kg per capita in Lisbon to 43 kg per capita in Ponta Delgada. It may be speculated that this waste fraction may be more strongly influenced by spatial characteristics of the pilot case than by touristic activities. Nevertheless, comparing the per capita amounts of green (garden) waste to the share of nature (incl. urban green) areas have in the total pilot case areas (Table 3) reveals no obvious first sight correlations. Further it has to be mentioned that the figures provided for Nice pilot case (Métropole Nice Cote d'Azur, MNCA) on the collection of (green) garden waste are not representative for the whole pilot case area as green (garden) waste is separately collected in only 4 out of 49 municipalities of the MNCA.

Food waste from kitchens, restaurants and similar commercial establishments is only separately collected in Lisbon and Vienna by door-to-door collection. However, in contrast to Lisbon, in Vienna door-to-door collection is also available for organic waste collected from households (at least in a major part of the city). In Lisbon, on the other hand, door-to-door collection of organic waste is only available for businesses (i.e. for food waste) and households can bring their organic waste only to certain civic amenity sites. These differences in collection systems for organic waste may explain the high difference in the ratio of collected amounts of organic waste from households and food waste from commercial establishments between these two cities.

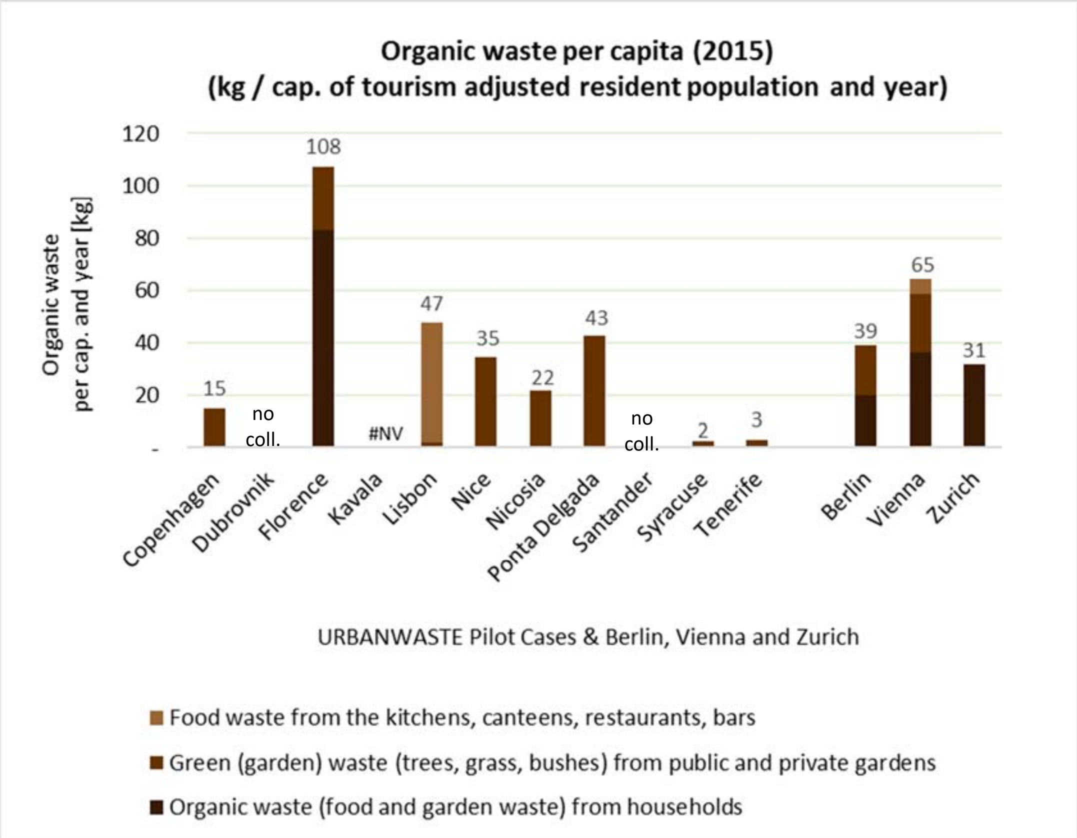


*Figure 3: Organic waste per capita (2015) in the URBANWASTE pilot cases & Berlin, Vienna and Zurich [kg/(cap.*a)]. Reference base: per capita of tourism adjusted resident population (Equation 2). For Kavala, no reliable data on organic waste was available although separate collection of organic waste from households is in place. In Dubrovnik and Santander there is no separate collection of organic waste. For Nice pilot case (Métropole Nice Cote d'Azur, MNCA), data on the collection of (green) garden waste are not representative for the whole pilot case area as green (garden) waste is separately collected in only 4 out of 49 municipalities of the MNCA.*
no coll. … no collection system; #NV … No value

4.4 Selected recyclables

Data evaluation revealed that looking at all kinds of recyclables collected in the pilot cases is not suitable because of inconsistencies in data availability and quality. Thus, the following (mainly packaging) recyclables were selected for in-depth analyses in WP 2:

- Paper & cardboard
- Glass
- Metals/metal packaging
- Plastics/plastic packaging
- Co-mingled fraction of (paper & cardboard and) metals and plastic packaging.

Figure 4 gives an overview of the differences in the collection of those recyclables in the 11 URBANWASTE pilot cases, including information on collected amounts in 2015. Comparison of the illustrated per capita amounts reveals a very diverse picture:

In Syracuse and Kavala, less than about 20 kg recyclables were collected **per capita** in 2015. For Kavala it, though, has to be mentioned that data for 2015[13] might not be very reliable as the system of separate collection of recyclables was changed within this year (for further information refer to Chapter 3.3.3). In **Santander, Tenerife, Ponta Delgada and Nicosia about 30 – 50 kg recyclables per capita** have been collected in 2015, **Nice and Copenhagen** reported collected amounts between **50 – 60 kg per capita**. With about **78 kg per capita, Lisbon** is just slightly below the range of per capita amounts collected in the benchmark cities. The amount of recyclables collected per capita in **Berlin, Vienna and Zurich** show very little variation, lying within a very small range of **87 – 93 kg.** Data for Zurich (87 kg per cap.), though, only represents paper & cardboard, glass and metals. Data on plastic recyclables were not publically available.

Florence is the only pilot case exceeding the benchmark cities in terms of per capita collection of these selected recyclables. Further, with about **150 kg per capita** the collected amount in Florence is about 10 times the amount collected in Syracuse and about 1,5 times the amount collected in the benchmark cities. These high amounts of separately collected recyclables may be explained by the fact that in Italy, and in Tuscany in particular, the assimilation rate of commercial waste to municipal waste collection is very high, i.e., in general all waste generated by commercial activities is collected within the municipal collection service, which is not common practice in many European cities.

For Dubrovnik, no reliable data about separately collected recyclables was available. Despite legal obligations, only 8 out of 22 local authorities within Dubrovnik Neretva County have implemented a (at least partial) selective collection scheme for paper, plastics, glass, textile and metal by setting up bring banks. Data on the amounts collected through these systems are, however, not available. 14 local authorities (out of 22) do not have any separate collection schemes in place, except for bulky waste (Gruber and Obersteiner, 2017).

Although it was tried to **present only data on metal and plastic packaging** in this section (i.e. excluding for example metal hangers, frying pans and other small scrap metals, plastic hangers or plastic toys), this **was not possible to achieve for every pilot case** as the level of detail of available data varied a lot. Table 24 (Annex 11.4), therefore, gives a detailed overview on data availability and background information on selected waste streams.

Further, for drawing conclusions from the above mentioned data it has to be taken into account that **refund systems for certain packaging materials are in place in Copenhagen, Dubrovnik, Ponta Delgada and Berlin** (Table 2). For Copenhagen and Ponta Delgada it was possible to get data on the amounts of packaging waste collected through these systems, for Dubrovnik and Berlin it was not. Those amounts, thus, are missing in the figures presented in Figure 4.

[13] For Kavala, the amount of per capita collected glass in 2015 was extrapolated using the available information on collected amounts from June 2015 to December 2015. The amount of per capita collected co-mingled fraction of paper &cardboard, metals and plastics represents the sum of paper & cardboard collected separately from January to March 2015 and the co-mingled fraction collected from April to December 2015.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

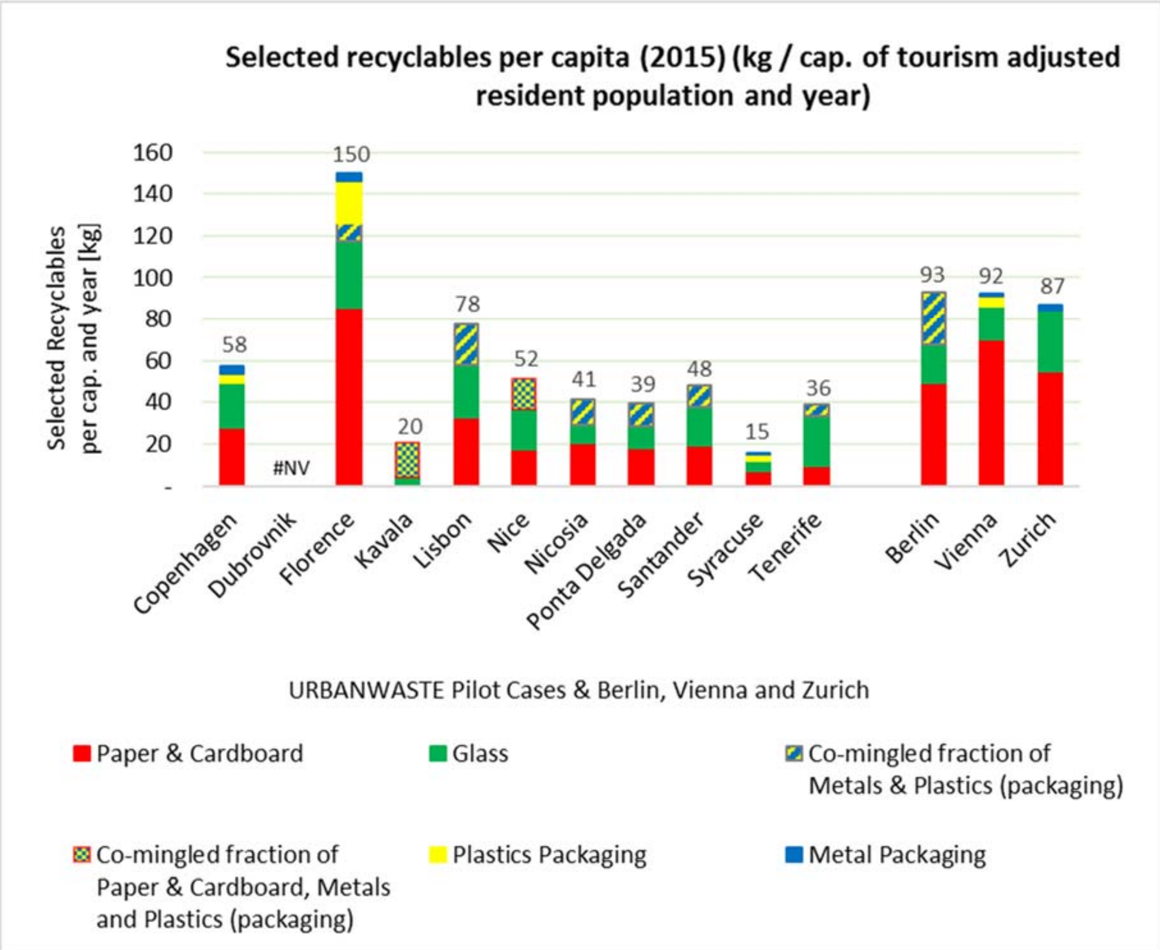


*Figure 4: Selected recyclables (mainly packaging) per capita (2015) in the URBANWASTE pilot cases & Berlin, Vienna and Zurich [kg/(cap.*a)]. Reference base: per capita of tourism adjusted resident population (Equation 2). For Dubrovnik there was no reliable data although separate collection of recyclables is available in at least some parts of the pilot case. Data for 2015 for Kavala might not be very reliable as the system of separate collection of recyclables was changed within this year. Data for Zurich only represents paper & cardboard, glass and metals; data on plastic recyclables was not publically available.*
#NV … No value

Table 2: Refund System for selected packaging wastes in the URBANWASTE pilot cases

Pilot Case	Types of refund packaging	Additional information
Copenhagen	bottles and cans	In Denmark there is a deposit on most containers for carbonated soft drinks, water, beer and wine (bottles, cans). The deposit encourages the consumer to return the empty beverage container for recycling and thus prevents improper disposal and littering. The amount of deposit varies dependent on the type of beverage container.
Dubrovnik	PET-bottles	Like elsewhere in Croatia, plastic packaging (PET bottles) can be returned to shops for a recovery of 0.50 HRK per bottle (€¢ 7).
Ponta Delgada	- paper/cardboard; - plastic (includes PET) and metals; - glass	Green Dot System

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

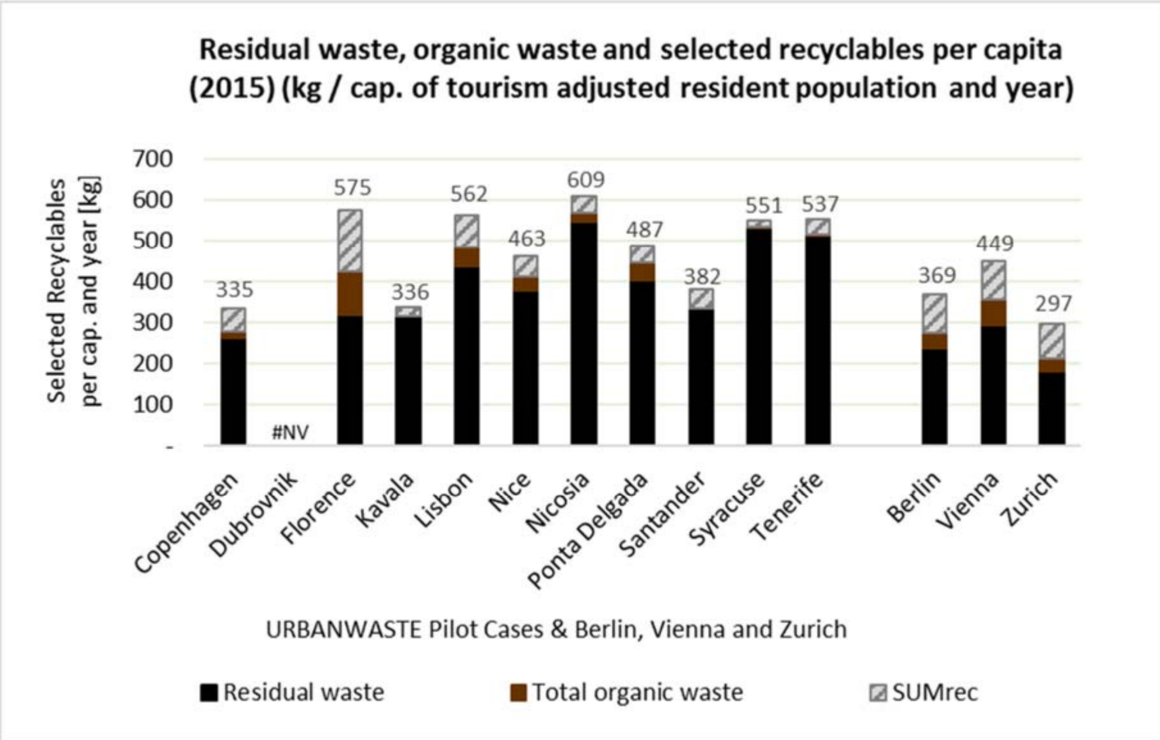


*Figure 5: Selected recyclables (mainly packaging) per capita (2015) in the URBANWASTE pilot cases & Berlin, Vienna and Zurich [kg/(cap.*a)]. Reference base: per capita of tourism adjusted resident population (Equation 2). For Dubrovnik no reliable data was available.*

Comparing the per capita amounts of residual waste with those of selected separately collected recyclables (Figure 5) it can be shown that the more recyclables (paper & cardboard, glass, metals, plastic packaging) are collected, the less residual waste is produced. Such correlation is valid for at least the benchmark cities Berlin, Vienna and Zurich as well as Copenhagen, Florence, Nice and Santander. On the other hand, a correlation of this kind is not visible from the data presented in this report for Kavala, which has a comparably low amount of residual waste per capita but also a low amount of recyclables per capita. **It has to be taken into account that waste generation in general reflects the economic status of a region**. Therefore, **a direct comparison between cities is not relevant without reflecting the socio-economic background**. But, in general, the benchmarking turned out as useful tool to detect inconsistencies of data and to analyse and scrutinise the reliability of data. Only on the basis of the information of benchmarking cities it was possible to ask the correct questions to pilot cases on their data.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

5. Spatial structure – distribution of urban, touristic and nature areas

Christian **FERTNER** & Juliane **GROẞE**

Cities are diverse entities. Many different features can occur in different areas of a city. For example, in terms of tourism in the 11 pilot cases of the URBANWASTE project we can imagine that some areas are significantly more interesting for, or affected by, tourism than other areas in the same city. This could include historical centres, coastal areas and beaches or nature areas of special interest.

Furthermore, generic spatial or geographical features of a city, such as urban density, land use or the extent of nature areas, are important framing conditions for waste production (in the form of local pressure or driving forces) as well as potentials for waste handling (e.g. in form of local treatment potentials). Any comparative view on the cities as well as the transfer of potential lessons needs to consider such – and other – context.

In this section, we will provide an **overview on the spatial structure** of the pilot cities by looking at:

- **Urban areas** (urban land use, transport infrastructure)
- **Touristic areas** (e.g. hotels and restaurants but also population density as proxy for attraction)
- **Nature areas** (natural land cover, nature protection sites, coastal zones)

We will summaries those with a few key indicators in 'spatial structure profiles' for each city and group them into three types according to the spatial context. Before that, we will shortly describe the spatial delineation and the data used for the analysis.

5.1 Spatial delineation and data sources

Different territorial authorities in URBANWASTE represent the pilot cases: 11 **municipalities** (Copenhagen, Florence, Kavala, Lisbon, Nicosia, Ponta Delgada, Santander, Syracuse and Tenerife[14]), one **county** (Dubrovnik Neretva) and one **metropolitan area** (Métropole Nice Cote d'Azur, MNCA). Most data collected in WP 2 refers to these entities. They are also the basis for the analysis in this section. In the case of the municipality of Nicosia, the analysis only considers the part of the municipal area where data was available (see Chapter 1.1).

The average area of the pilot cases is 350 km^2 (median 102 km^2) – however, there are big differences, ranging from 8 km^2 in the case of Puerto de la Cruz (Tenerife) to almost 1,800 km^2 of the Dubrovnik Neretva County. In URBANWASTE Deliverable 2.6 (Fertner & Große, 2017), we used the area within a 10 km radius from the city centre for data analysis to improve possibilities for comparison of environmental features. However, using the administrative areas has the advantage to connect the analysis to other data provided by city partners. Figure 6 shows both delineations for all 11 pilot cases.

[14] Tenerife pilot case comprises three municipalities: Adeje, Arona and Puerto de la Cruz

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

As there was no specific spatial data collected for each pilot case in WP 2, we used freely available data from different sources, covering all pilot cases. This includes data from the European CORINE Land Cover database (EEA, 2016) and from OpenStreetMap (Geofabrik, 2017). The data is spatially explicit, that means the exact location (coordinates) of features is known - not just on an aggregate level as e.g. the postcode or the municipality. This information makes it possible to fetch the data to any chosen spatial extent and illustrate them on maps to show spatial differences and identify hotspots.

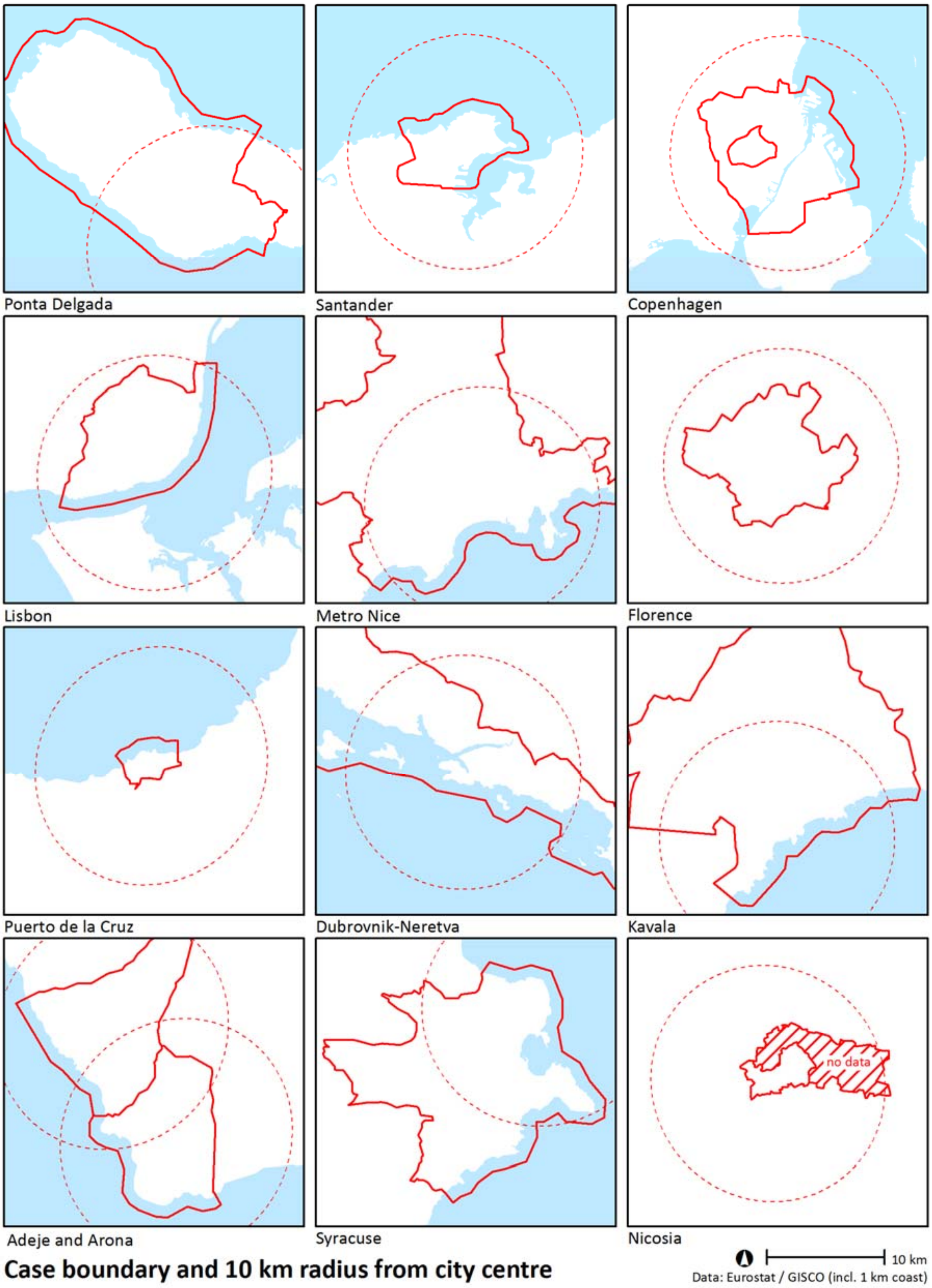


Figure 6: Administrative boundary and 10 km radius from city centre (Adeje, Arona and Puerto de la Cruz belong to Tenerife pilot case)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

5.2 Urban areas

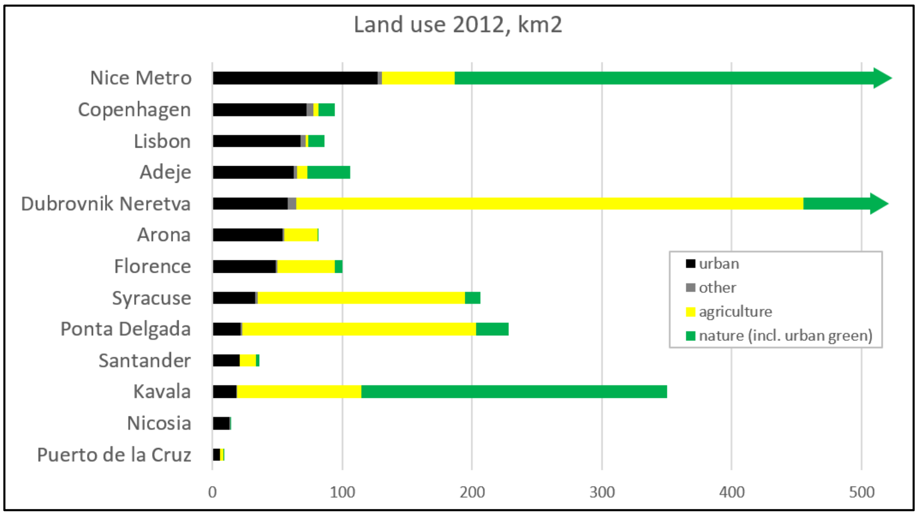
The pilot cases with the biggest land area are Dubrovnik Neretva, Nice Metro and Kavala. Looking only at the urban area (contiguous built-up area), we can see that Nice Metro has by far the biggest urban area in the project, followed by Copenhagen and Lisbon (Table 3). In relative terms, i.e. related to their administrative boundaries, **the municipalities of Nicosia (90 %), Lisbon (79 %) and Copenhagen (77 %) are the most urbanised** (Table 7). This means also that those three pilot cases have relatively the least resources of open land inside their administrative boundaries (respectively 8 %, 17 % and 18 %) and are most likely highly dependent on their immediate hinterland[15]. The spatial distribution of land use in the URBANWASTE pilot cases is shown in Figure 8.

Table 3: Land use in 2012 in the URBANWASTE pilot cases, km²

Name (sorted by urban area)	Total (km²)	urban	other	agriculture	nature (incl. urban green)	water
Nice Metro	1463,0	127,0	3,8	55,7	1274,5	38,9
Copenhagen	88,6	72,7	5,2	3,9	12,7	15,7
Lisbon	85,8	68,1	3,9	1,7	12,7	19,7
Adeje*	106,0	62,8	2,8	7,8	32,7	12,7
Dubrovnik Neretva	1792,8	58,2	6,4	390,1	1309,9	739,6
Arona*	81,9	53,8	1,3	26,0	0,5	17,7
Florence	101,8	48,6	1,5	44,4	5,6	1,7
Syracuse	205,5	33,1	2,1	159,3	11,7	43,4
Ponta Delgada	233,5	21,8	1,4	180,2	25,0	70,9
Santander	34,7	21,1	0,4	12,3	2,5	19,5
Kavala	351,3	18,4	0,8	95,9	235,4	23,4
Nicosia	14,8	13,3	0,3	0,3	0,9	0,0
Puerto de la Cruz*	8,6	5,7	0,0	3,1	0,2	5,8

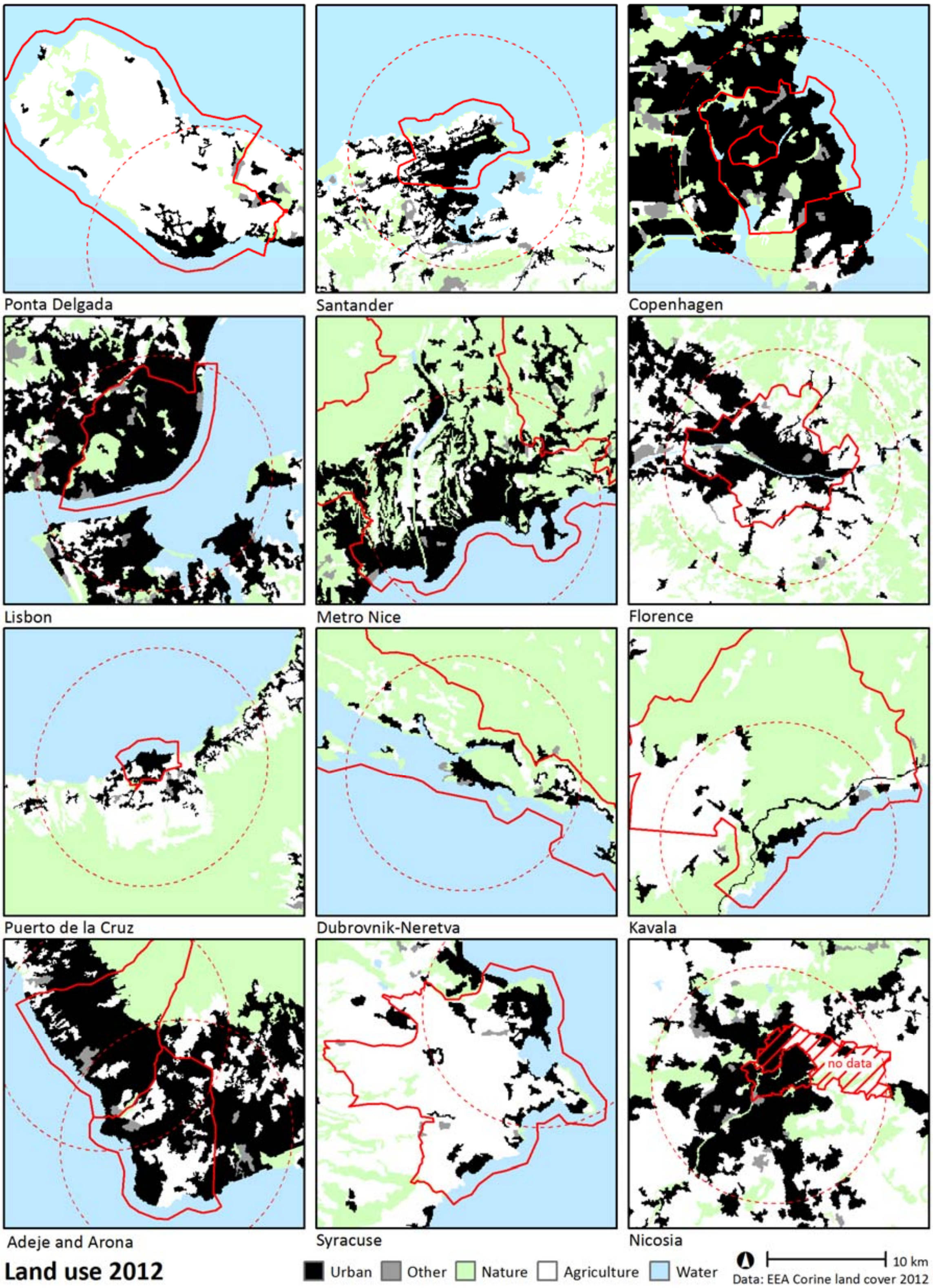
Data source: EEA, 2016

* The three municipalities of Adeje, Arona and Puerto de la Cruz belong to the pilot case Tenerife.



[15] A city is highly dependent on its rural hinterland for a range of ecosystem services (food, water, air, recreation, resources, energy, climate etc.) and even human resources – some of these relations can reach very far, even globally.

Figure 7: Land use in 2012. Adeje, Arona and Puerto de la Cruz belong to Tenerife.



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

Figure 8: Spatial distribution of land use in 2012. Adeje, Arona and Puerto de la Cruz belong to Tenerife.

Another general feature of urban areas is road density. OpenStreetMap[16] provides comprehensive road data for all cities. In Table 4 we can see that Lisbon municipality has the longest network of highways on its territory, followed by Nice Metropolitan area – despite that Lisbon is much smaller in area than the latter. Looking at road density, Lisbon municipality also leads the table with 1,462 km^2.

Table 4: Road density in 2017, km

Name (sorted by highways per total area)	Highway (km)	primary roads (km)	Highways per total area (m)	Primary roads per total area (m)
Lisbon	125,5	111,7	1462	1301
Santander	33,4	39,4	964	1137
Puerto de la Cruz*	2,5	3,5	293	407
Florence	29,1	68,1	286	669
Adeje*	25,5	17,2	240	162
Arona*	17,8	39,2	217	479
Copenhagen	19,0	47,1	214	531
Syracuse	37,2	45,3	181	221
Kavala	49,0	40,1	139	114
Ponta Delgada	21,8	84,0	93	360
Nice Metro	94,1	152,5	64	104
Dubrovnik Neretva	51,2	373,1	29	208
Nicosia	0,0	31,8	0	2142

Data source: Geofabrik/OpenStreetMap, 2017

* The three municipalities of Adeje, Arona and Puerto de la Cruz belong to the pilot case Tenerife.

[16] OpenStreetMap / OSM (www.osm.org) is a collaborative mapping project with over 1 million registered users. Data quality differs in different locations depending on the local user community or the provision of government data to the project. However, the quality of road data can be considered sufficiently good (Zhang & Malczewski, 2017) – especially for an overall analysis of spatial structure as in this report.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

5.3 Touristic areas

The pilot case partners provided data on overnight stays and accommodation. However, this information was only available on an aggregated level (e.g. for the whole municipality) and information on other points of interests for tourists (e.g. restaurants) was not collected. An alternative source for data on touristic (and other) infrastructure is OpenStreetMap[17], a global collaborative mapping project. Data quality differs, but the variety of features available provides interesting insights. Table 5 shows the counts of selected touristic infrastructure in the 11 pilot cases.

Table 5: Selected touristic infrastructure counts (19th June 2017)

category	OpenStreetMap feature class	Adeje*	Arona*	Copenhagen	Dubrovnik Neretva	Florence	Kavala	Lisbon	Nice Metro	Nicosia	Ponta Delgada	Puerto de la Cruz*	Santander	Syracuse
food	bar	49	33	259	87	96	13	157	83	12	58	62	102	12
	biergarten				24	1		1						
	cafe	50	41	647	130	207	15	488	83	34	108	58	80	28
	fast_food	14	20	1227	29	49	8	75	104	10	20	17	9	4
	pub	15	23	169	11	38		20	18	21	12	16	24	
	restaurant	158	189	614	332	405	48	888	531	41	148	169	179	79
	food total	**286**	**306**	**2916**	**613**	**796**	**84**	**1629**	**819**	**118**	**346**	**322**	**394**	**123**
hotel etc.	guesthouse	4	1	1	78	30	1	27	14	2	24	1	10	29
	hostel	2	3	14	23	19		49	8	1	8		18	3
	hotel	96	86	101	115	174	10	183	239	11	66	85	45	47
	motel				5		1	1	1		2			
	hotel etc. total	**102**	**90**	**116**	**221**	**223**	**12**	**260**	**262**	**14**	**100**	**86**	**73**	**79**
waste	recycling	91	9	83	12	5	1	45	41	1	18	3	30	6
	recycling_clothes			2	1			3	2					
	recycling_glass	6	1	30	1	3		26	161				234	24
	recycling_metal												1	
	recycling_paper			3				1	12				78	
	waste_basket	65	20	46	24	11		65	171		58	2	64	1
	waste total	**162**	**30**	**164**	**38**	**19**	**1**	**140**	**387**	**1**	**76**	**5**	**407**	**31**
water	drinking_water	3	1	38	22	117	13	103	181		10	1	88	8
	water_well	20	23					1	1		6	9	1	
	water total	**23**	**24**	**38**	**22**	**117**	**13**	**104**	**182**	**0**	**16**	**10**	**89**	**8**

Data source: Geofabrik/OpenStreetMap, 2017

* The three municipalities of Adeje, Arona and Puerto de la Cruz belong to the pilot case Tenerife.

[17] OpenStreetMap / OSM (www.osm.org) is a collaborative mapping project with over 1 million registered users. Data quality differs in different locations depending on the local user community or the provision of government data to the project. The data shown here can therefore have different quality. However, it provides a great range of features. A description of all categories is available on https://wiki.openstreetmap.org/wiki/Map_Features#Amenity.

Note: OSM is potentially always up to date, while other similar data is often several years old. This allows for almost live monitoring of changes. E.g. can we compare the dataset used for this report (19th June 2017) with a dataset at the end of the URBANWASTE project to analyse changes.

The spatial distribution of the features listed in Table 5 is shown in the maps subsequently presented in this Chapter. Additionally, we also include population density as a proxy for touristic attraction of urban areas (Figure 11). Population as well as touristic features are concentrated in specific locations. Especially **the majority of hotels can be found in relatively small areas** in most pilot cases (Figure 12). The graphs in Figure 9 summarize these patterns of spatial concentration[18]. They show that in all pilot cases except for Nice Metro and Dubrovnik-Neretva, which both cover a very large area, **50 % of all hotels can be found within 4 km^2 and 75 % with 10 km^2**. **Restaurants are a bit more spread**, especially in the bigger cities such as Copenhagen and Lisbon, but still concentrated (Figure 13). **Population is also concentrated, but in general to a lesser degree than hotels and restaurants**. Again, the bigger cities and regions (Dubrovnik Neretva, Nice Metro, Lisbon, Copenhagen, Ponta Delgada and Florence) are less concentrated than the others.

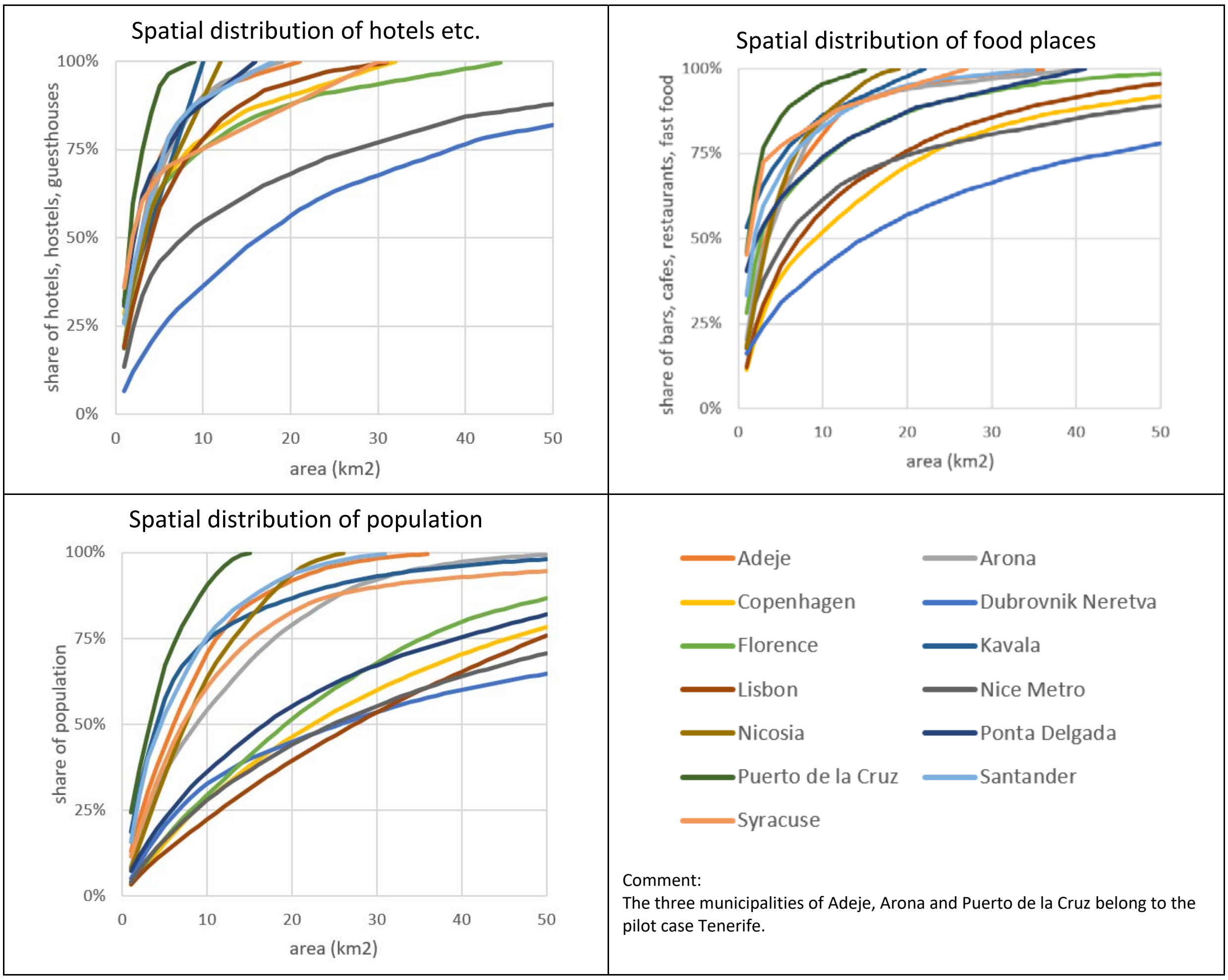


Figure 9: Spatial distribution of hotels, restaurants and population in the pilot cities.

---

18 The basis of this is location data of hotels, restaurants etc. from OpenStreetMap (Geofabrik, 2017) aggregated to 1 km^2 grid cells. For each cell (= square kilometre) we therefore have the number of different features occurring as well as the population number, derived from Eurostat (2015).

This project has received funding from the European Union's Horizon 2020 research
and innovation programme under grant agreement No 690452

The graph in Figure 10 shows the **area which experiences potentially high tourist activity** – at least in an urban context. It shows the number of square kilometre cells with at least 10 hotels etc. or 10 food places (restaurants, fast food, bars, cafés etc.). That means, for example, that there is an area of 8 km^2 in Lisbon with at hotel density of 10 or more per km^2. The area is not necessarily continuous but could be shared between different locations in the city. However, from the maps in Figure 12 it can be seen that they are **usually concentrated in one place**. It has to be taken into account that the size of hotels and therefore the number of tourists staying there is not reflected in Figure 10, e.g. the medium size of a hotel in Tenerife might be larger than in Lisbon.

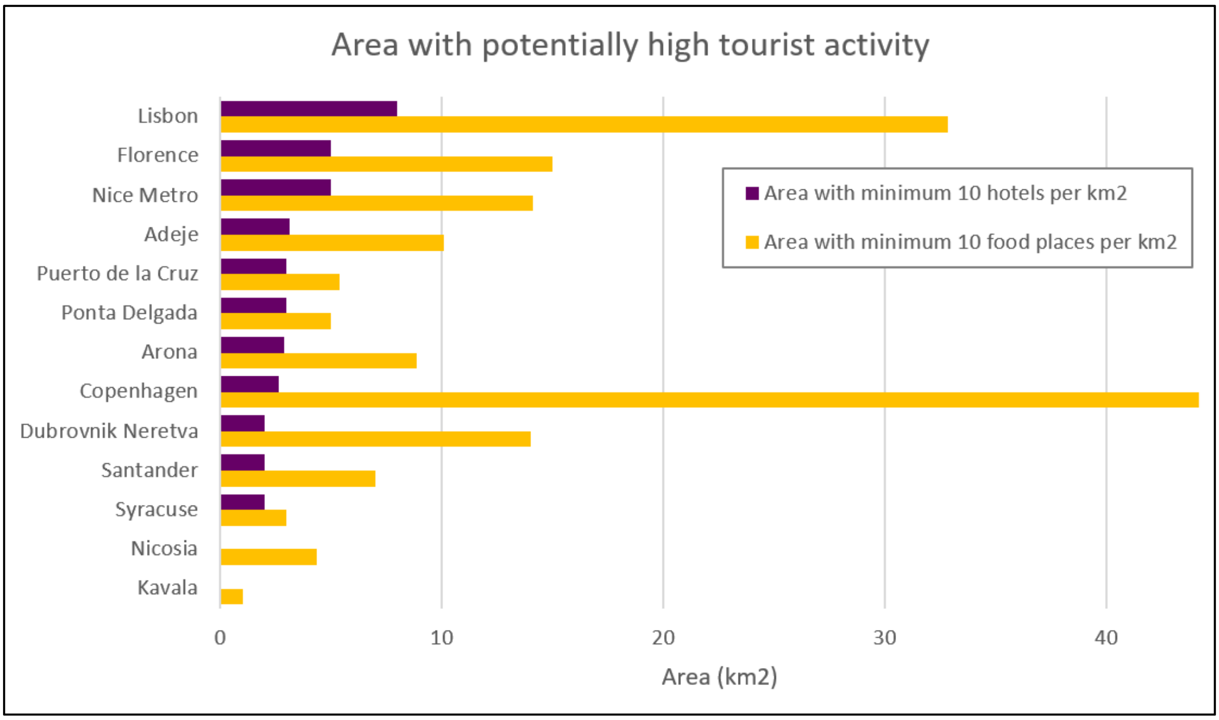


Figure 10: Area with potentially high tourist activity. Adeje, Arona and Puerto de la Cruz belong to Tenerife.

Data on waste features (waste baskets and various recycling containers) seems, unfortunately, to be of very different quality in the pilot cases. This is probably because many of such features are rather small in size and are therefore not mapped by all OpenStreetMap contributors. E.g. looking at the maps of Copenhagen, Lisbon or Florence (Figure 14), which are all densely built-up within their administrative area, it seems unrealistic that there are many areas in the city not containing these features. Data on public water (drinking fountains or wells) seems to be slightly better, but in some cities, the numbers are very low which is also unrealistic (Figure 15). We won't interpret the data further here, but for the URBANWASTE project it could be discussed if the cities should make an effort in digitizing these features during the project period so we could use updated data in a later part of the project, e.g. WP7).

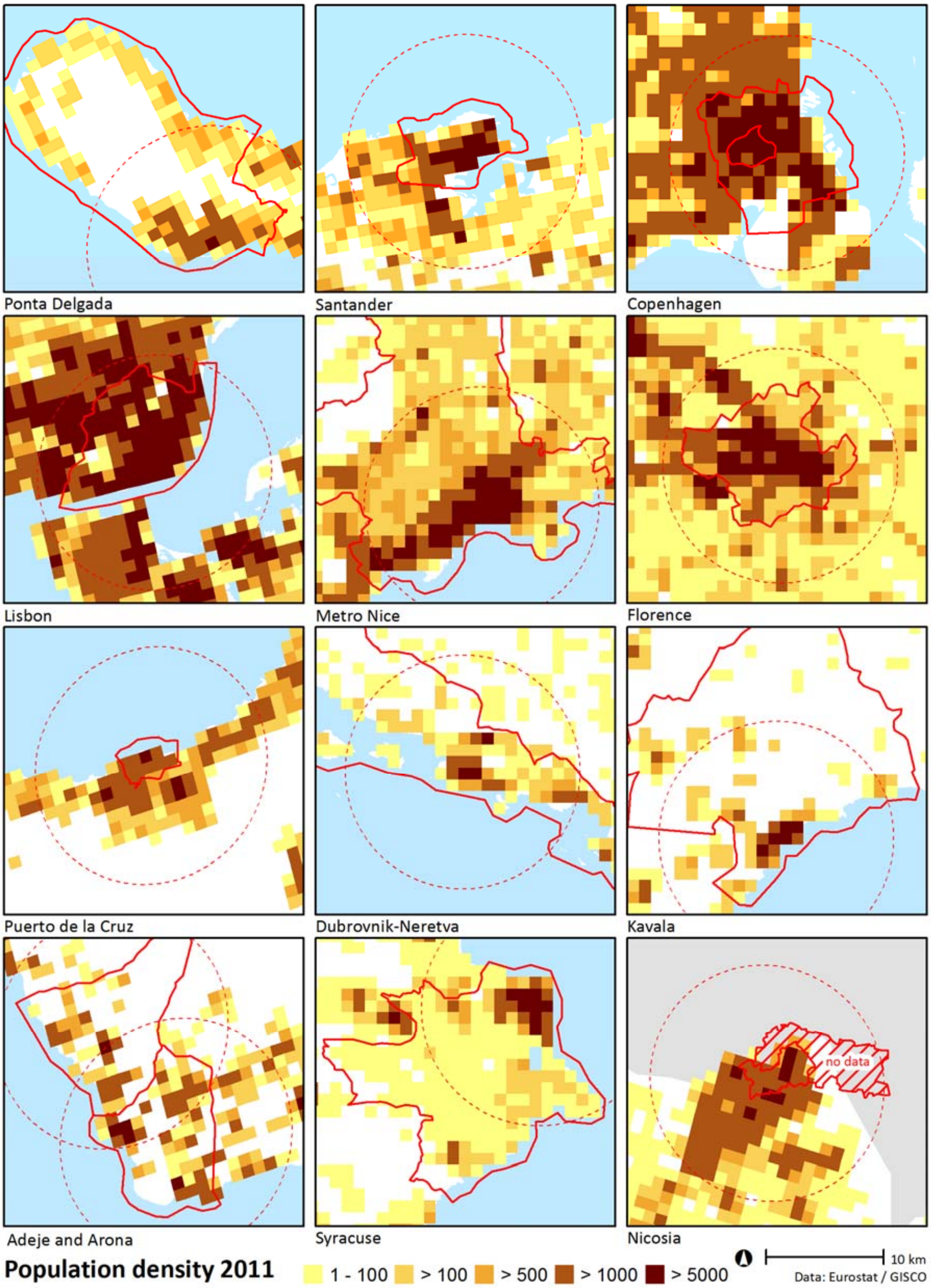


Figure 11: Spatial distribution of population in 2011. Adeje, Arona and Puerto de la Cruz belong to Tenerife.

This project has received funding from the European Union's Horizon 2020 research
and innovation programme under grant agreement No 690452

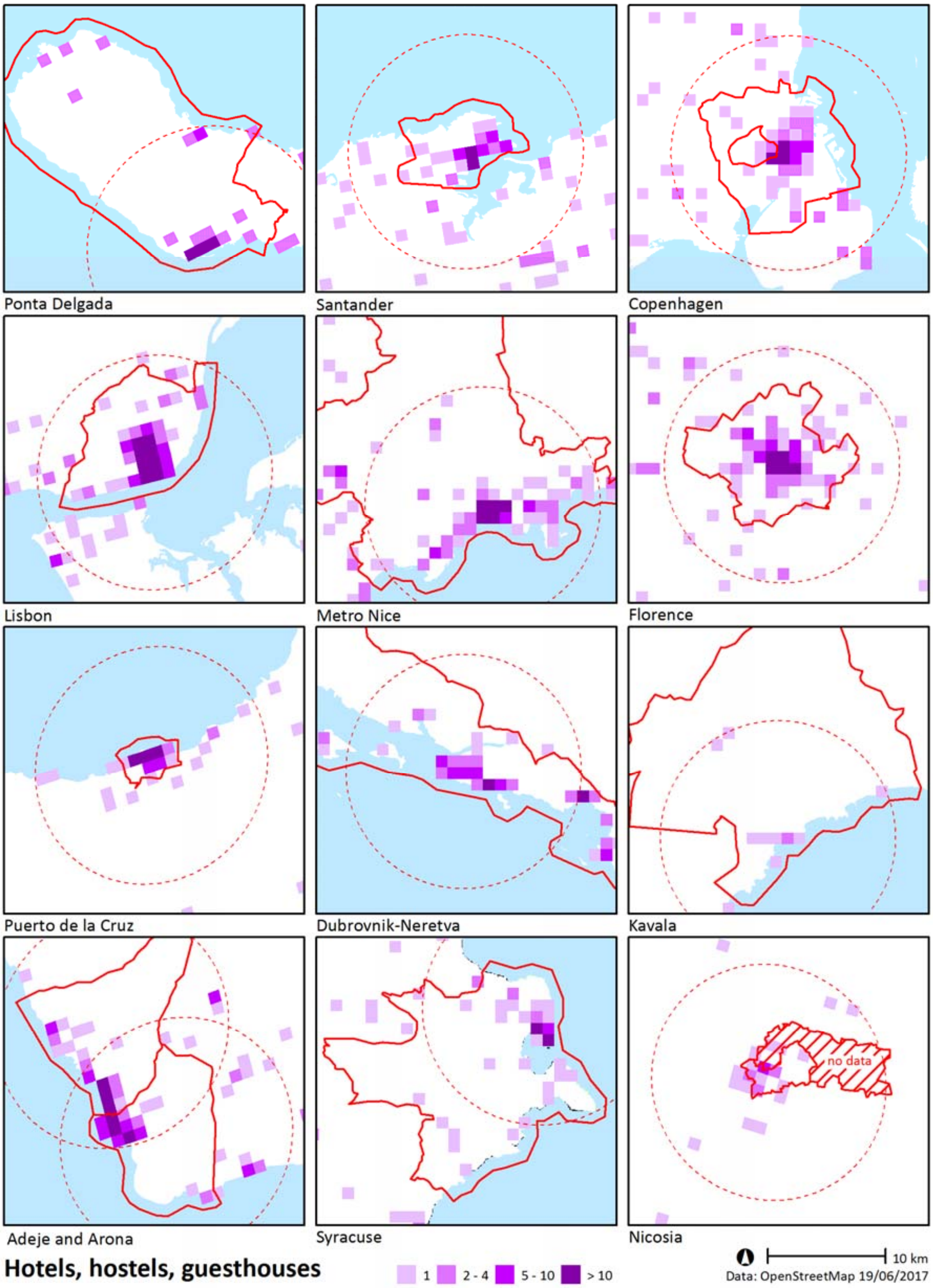


Figure 12: Spatial distribution of hotels, hostels and guesthouses in 2017. Adeje, Arona and Puerto de la Cruz belong to Tenerife.

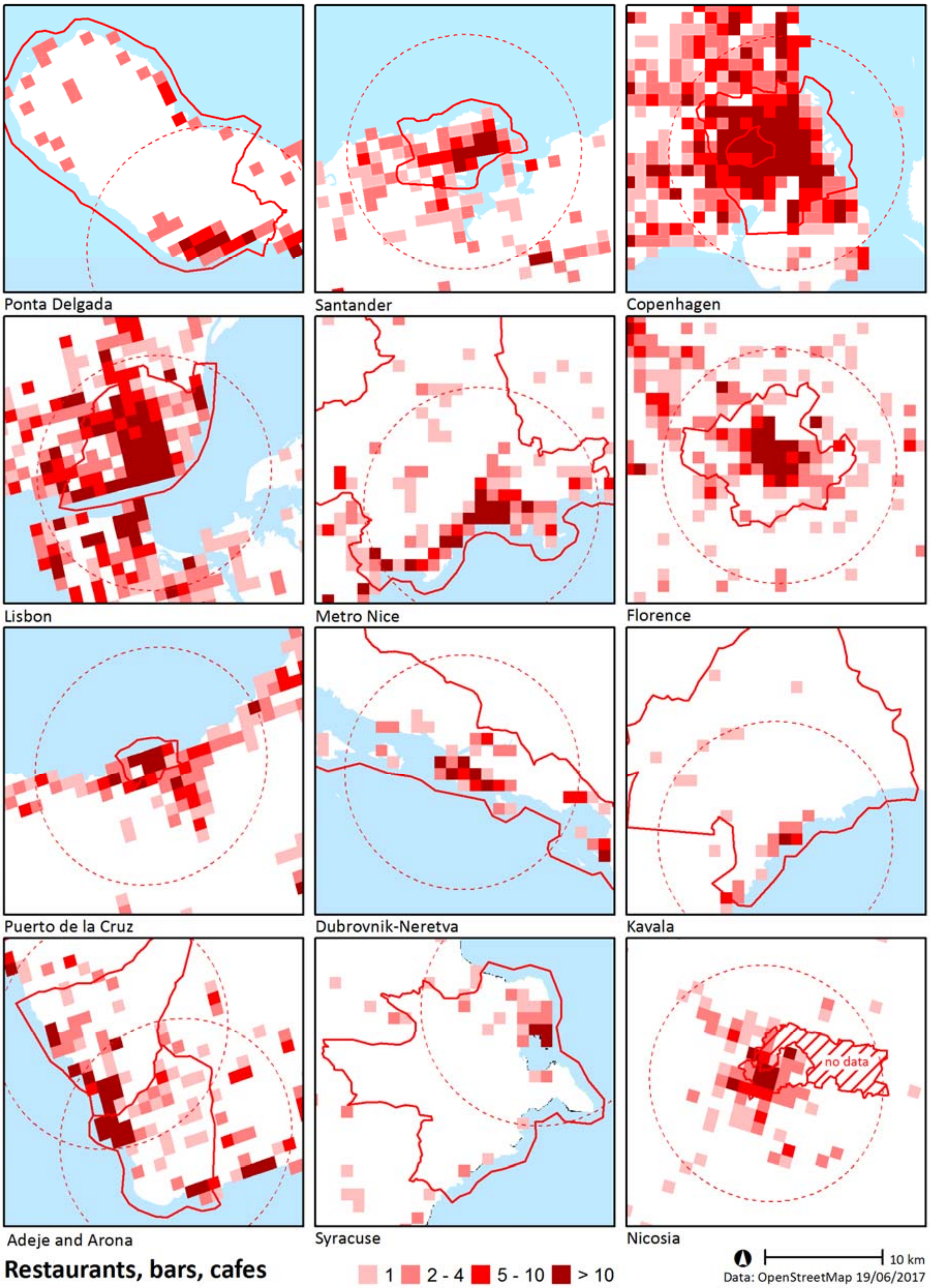


Figure 13: Spatial distribution of restaurants, bars, cafes etc. in 2017. Adeje, Arona and Puerto de la Cruz belong to Tenerife.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

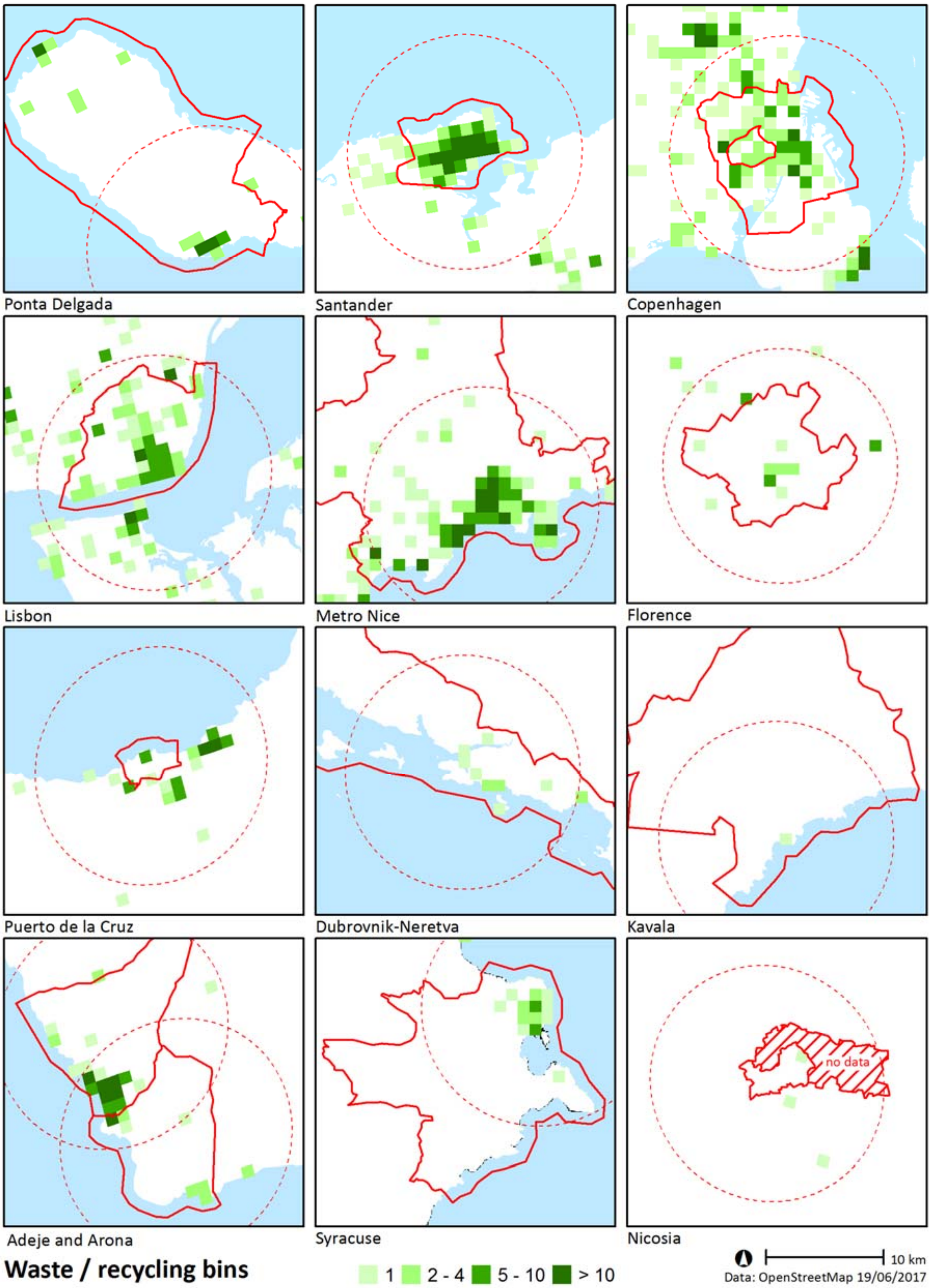


Figure 14: Spatial distribution of waste and recycling bins in 2017. Adeje, Arona and Puerto de la Cruz belong to Tenerife.

This project has received funding from the European Union's Horizon 2020 research
and innovation programme under grant agreement No 690452

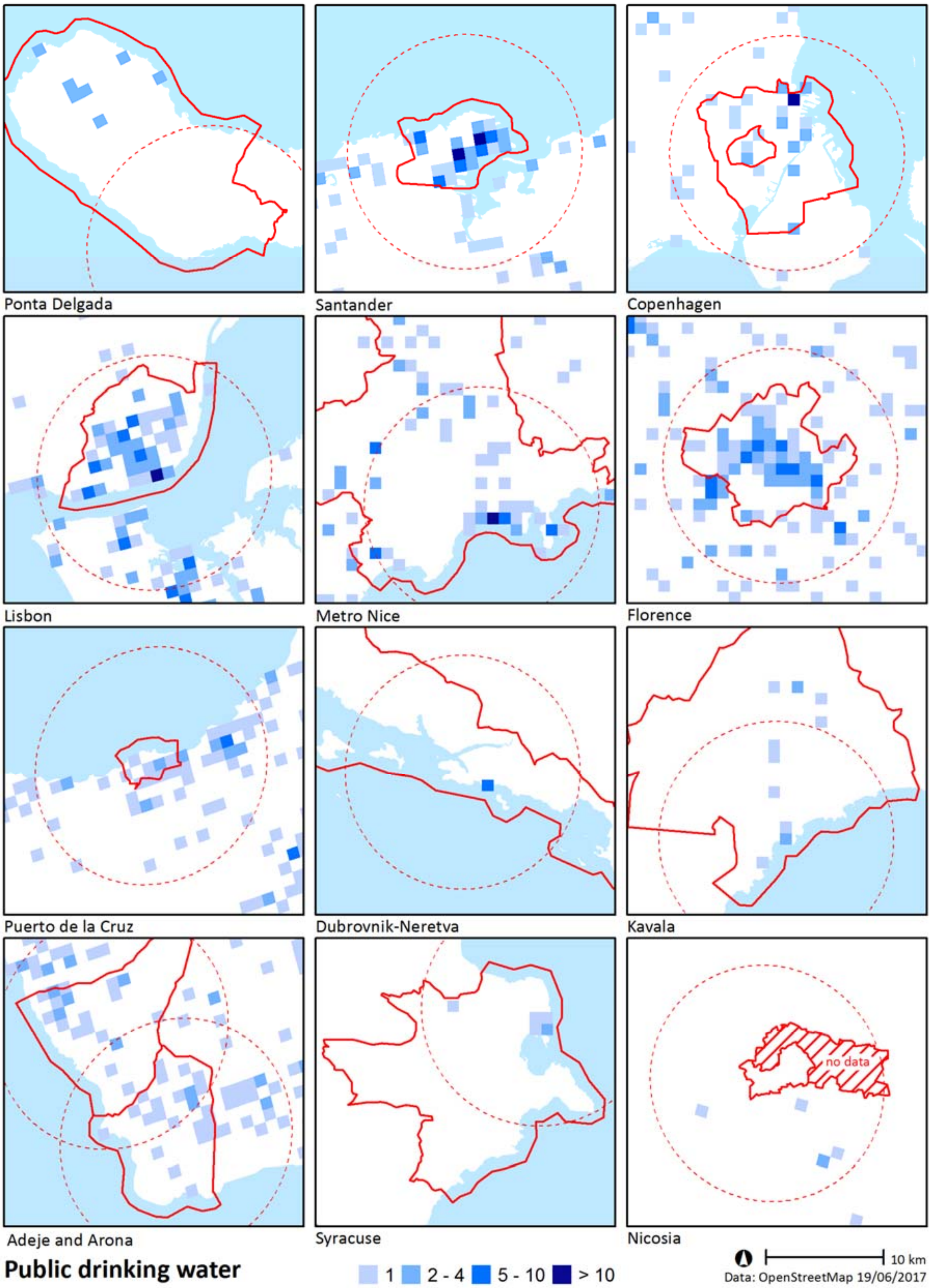


Figure 15: Spatial distribution of public drinking water in 2017. Adeje, Arona and Puerto de la Cruz belong to Tenerife.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

5.4 Nature areas and environment features

Nature areas can be under pressure from general urban and economic development including touristic activities. At the same time, these areas can also contribute to the mitigation of negative effects of those activities. This can include improvement of the air quality, water cleaning and provision or also waste treatment, recreational areas, quiet refuge or retreat areas etc. Table 6 shows the share of area covered by nature areas (EEA, 2016), coastal areas (EEA, 2015) and areas protected by Natura 2000 (EEA, 2017).

Table 6: Nature, coastal and Natura 2000 areas in the URBANWASTE pilot cases

Name (sorted by nature area)	nature (km^2, excl. agriculture)	% of total land area	Coastal area (km^2)	% of total land area	Natura 2000 (km^2)	% of total area
Dubrovnik Neretva	1309,9	74%	593,0	33%	1457,3	58%
Nice Metro	1274,5	87%	32,7	2%	505,5	34%
Kavala	235,4	67%	22,1	6%	0,8	0%
Adeje*	32,7	31%	13,5	13%	64,2	54%
Ponta Delgada	25,0	11%	57,8	25%	0,0	0%
Copenhagen	12,7	13%	31,7	36%	5,7	5%
Lisbon	12,7	15%	18,8	22%	2,0	2%
Syracuse	11,7	6%	41,4	20%	21,7	9%
Florence	5,6	6%	0,0	0%	0,2	0%
Santander	2,5	7%	17,3	50%	1,0	2%
Nicosia	0,9	6%	0,0	0%	0,0	0%
Arona*	0,5	1%	15,8	19%	28,6	29%
Puerto de la Cruz*	0,2	3%	5,4	62%	0,0	0%

Data sources: EEA 2015, EEA 2016, EEA 2017.
* The three municipalities of Adeje, Arona and Puerto de la Cruz belong to the pilot case Tenerife.

As also illustrated in Figure 16, the pilot cases have different types of nature areas within their territory. Nicosia and Florence have no coastal area within their territory. Nice Metro does, but because of the big total area, coastal areas do not fill a lot. On the other hand, the metropolitan area (Nice Metro) includes big nature areas with Natura 2000 status. Natura 2000 areas exist only in half of the pilot cases.

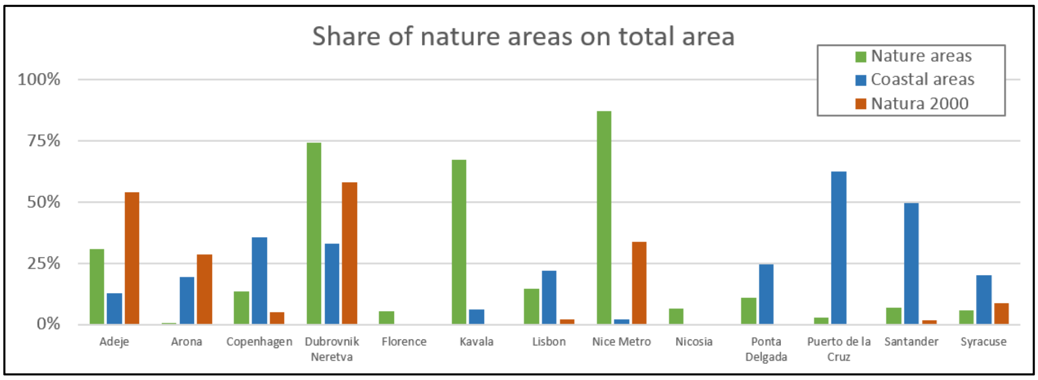


Figure 16: Share of nature areas in the URBANWASTE pilot cases. Adeje, Arona and Puerto de la Cruz belong to Tenerife.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

5.5 Key indicators and profiles

5.5.1 Key indicators

Table 7 summarizes the spatial structure analysis of the 11 URBANWASTE pilot cases in eight key indicators.

Table 7: Key indicators of spatial structures in the URBANWASTE pilot cases

Category	Urban structure			Touristic structure			Nature structure	
Indicator	Urban area	Highways	Primary roads	Population density	Hotels	Food places	Nature & open space	Coastal area
Denominator[19][20]	% of total land area	km per 100.000 inhabitants		per km^2 of urban area	counts per 100.000 inhabitants		% of total land area	
Adeje*	59%	55	37	743	206	613	38%	13%
Arona*	66%	22	49	1.484	108	383	32%	19%
Copenhagen	82%	3	8	7.986	17	503	18%	36%
Dubrovnik-Ner.	3%	20	304	2.105	94	500	96%	33%
Florence	48%	2	18	7.775	46	210	50%	-
Kavala	5%	69	57	3.842	14	119	95%	6%
Lisbon	79%	5	22	7.412	36	323	17%	22%
Nice Metro	9%	10	28	4.224	45	153	91%	2%
Nicosia[21]	90%	-	58	4.124	20	214	8%	-
Ponta Delgada	9%	-	122	3.152	96	503	90%	25%
Puerto de la Cruz*	66%	9	12	5.173	289	1.094	37%	62%
Santander	61%	12	23	8.198	26	228	41%	50%
Syracuse	16%	20	37	3.697	38	100	83%	20%

Year of data: Population data provided by pilot case partners: 2011-2016; urban and nature area: 2012 (EEA 2016); roads, hotels, food places: 2017 (Geofabrik 2017); coast line: 2006 (EEA 2015).
* The three municipalities of Adeje, Arona and Puerto de la Cruz belong to the pilot case Tenerife.

5.5.2 Spatial structure profiles

The spatial profiles presented in the following are strongly simplified, but still allow a general comparison of the spatial structure of the pilot cases. The indicators from Table 7 were standardized[22] in order to see relative differences between them in each pilot case. The values do not mirror a good or bad situation, but simply illustrate different situations. E.g. although Copenhagen has many hotels, relatively seen they are below the average of the other cases because Copenhagen is also a big municipality in terms of population, just as Lisbon,

[19] Some of the indicators above could be related to number of tourist arrivals or overnight stays instead of population or area.
[20] In general, it can be discussed which denominator to use for all the indicators to get comparable figures. The following options are available:

- Total land area (e.g. share or % of total land area)
- Total urban area (e.g. per km^2 of urban area)
- Population (e.g. per 100.000 inhabitants)
- Tourists (e.g. per 100.000 overnight stays)

[21] The delineation of Nicosia case area might change in case the pilot case partner will be able to provide an official boundary file. Numbers need then to be re-calculated.
[22] The authors used the z-score standardization, which transforms the indicators into standardized values with an average 0 and a standard deviation 1 and thereby keeps its metric information.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

Florence, Santander and Nicosia. Similar could be expected from Nice, however, as the pilot case area encompasses the metropolitan area (with a total of 49 municipalities), and not just the city of Nice, features of the peri-urban and rural hinterland outweigh that. Nice pilot case has therewith more in common with Ponta Delgada, Dubrovnik-Neretva County, Kavala and Syracuse, which all have rather big territories including rural hinterlands. A third group are areas with relatively little nature (smaller cities) but strong tourism – these include all three municipalities forming the Tenerife pilot case. The three groups of spatial structure situations,

1. Bigger cities,
2. Large authorities with rural hinterland and
3. Tourism cities

can be used for further work in URBANWASTE. However, this grouping is only based on the few spatial structure indicators, while many other aspects relevant in the project (e.g. waste production and treatment, governance structures) were not looked at in this spatial analysis.

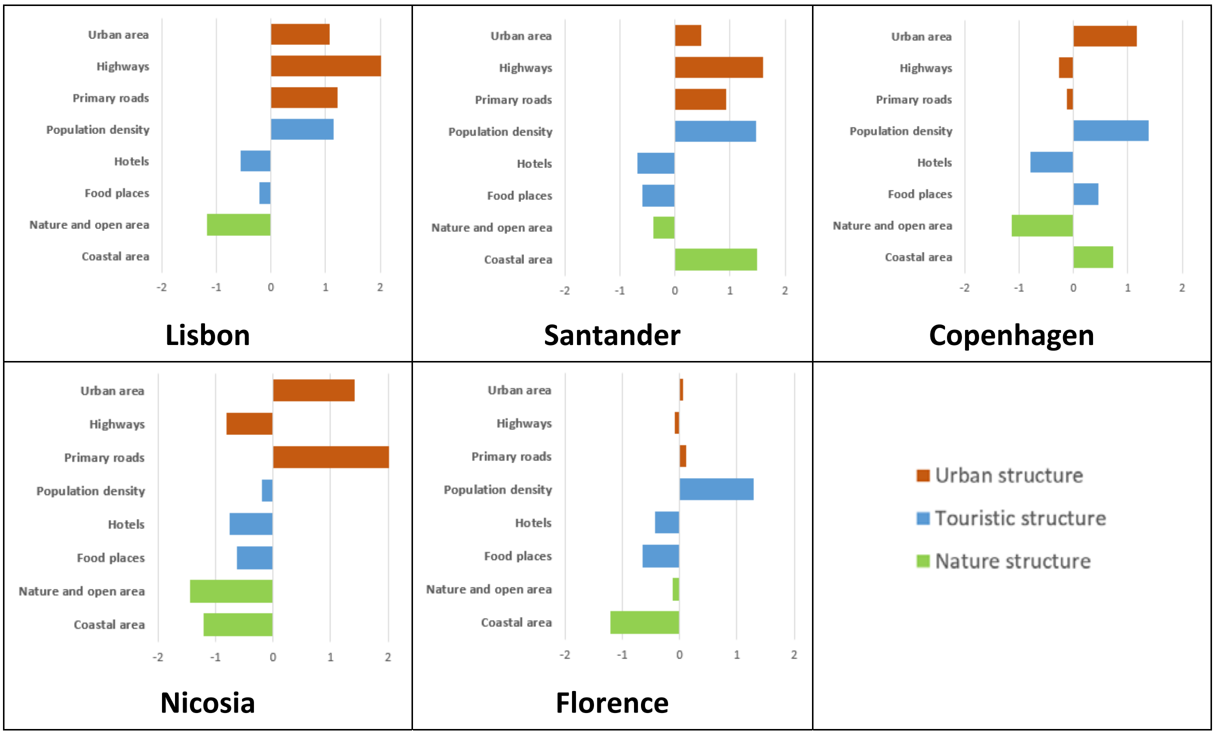


Figure 17: URBANWASTE pilot cases belonging to spatial structure profile 1: Bigger cities

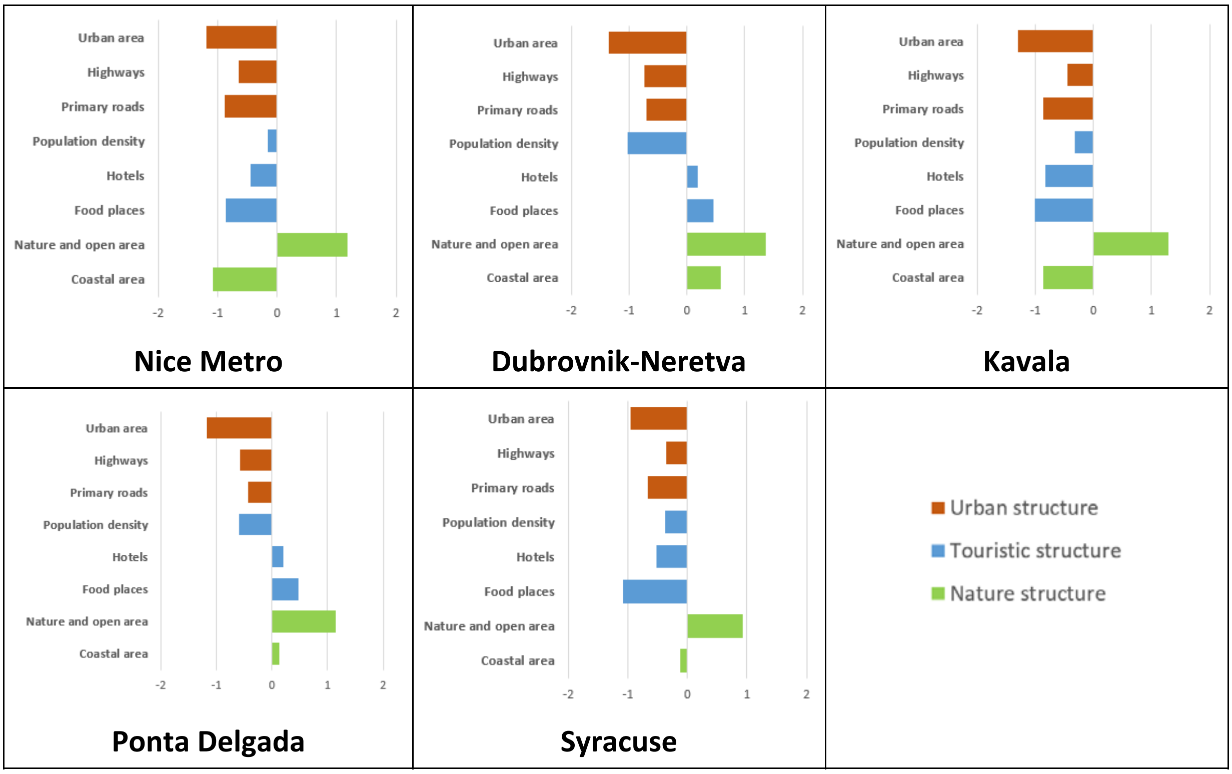


Figure 18: URBANWASTE pilot cases belonging to spatial structure profile 2: Large authorities/municipalities with rural hinterland

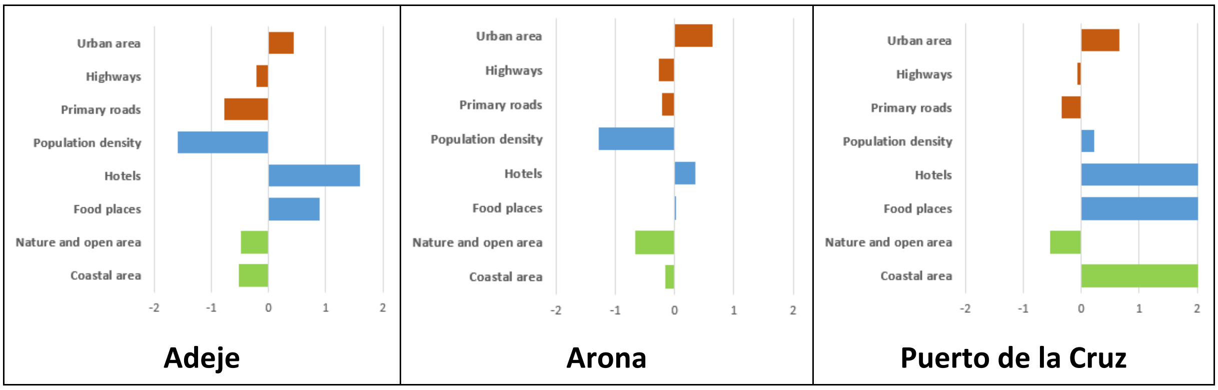


Figure 19: URBANWASTE pilot cases belonging to spatial structure profile 3: Tourism cities. Adeje, Arona and Puerto de la Cruz belong to Tenerife.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

6. Grouping of pilot cases according to socio-economic characteristics

Arie ROMEIN

The 11 pilot cases being partners in the URBANWASTE project embrace a broad variety of characteristics. They differ in size, in geography and climate, in legal and institutional contexts and in socio-economic structure. Further, the waste behaviour of their population may differ, among other factors, due to those that belong to internal and external barriers (Deliverable D3.2; de Luca et al., 2017). Finally, they attract different numbers and different types of tourists – sun, sea and sand lovers; visitors of urban attractions and amenities; fans of cultural heritage - and tourists from different countries of origin. It is suggested that tourists' environmental thinking and actions vary with more or less strict environmental laws, powerful environmental pressure groups and established 'green culture' at home (de Luca et al., 2017).

This chapter explores differences and similarities of the 11 pilot cases by means of a selection of mainly socio-economic variables. The objective is to group the pilot cases - not in clusters by means of formal statistical techniques but in a loose and rather indicative way. This grouping further shall assist finding out which reasons other than tourism are responsible for the differences in waste generation in the pilot cases.

6.1 Data, variables and analysis

The statistical data was collected by representatives of the pilot cases and provided for analyses in the form of individual small pilot case databases filled with existing secondary data. The pilot case databases are built up hierarchically, consisting of three main thematic areas, twelve categories and some hundred variables. The thematic areas and categories are listed in Table 8, the selection of variables used in this chapter in Table 9. Most of the selected variables are in the thematic areas of socio-economic and tourism related data. Part of the selected variables include a time series on annual basis for the period since 2000. The most recent year is 2015 for all pilot cases except Santander that also provided some data of 2016.

Table 8: Thematic areas and categories of data

Thematic area	Waste-related data	Socio-economic data	Tourism-related data
Categories	Municipal solid waste	Population	Turnover of tourism industry
	Collected fractions of recyclables	Economically active population	Tourist accommodation establishments
	Residual waste	Production and income	Tourist arrivals
	Waste prevention	Heating type of buildings	
	Waste management		.

For a few variables in the pilot case databases no data is available at all. More often, data is incomplete, i.e. missing for some pilot cases or for some years in the time series, in particular before 2010. Another imperfection of the collected data is diversity of geographical levels of scale. Due to the different spatial scales of the pilot cases and the fact that for some pilot cases there is a lack of data on pilot area scale, data for quite a few variables are a mix of municipal, metropolitan, provincial and in some instances even national data. The actual selection of variables depended not only on their relevance for this chapter, but also on the accuracy of the data: variables for which data of many pilot cases is missing or data is hardly comparable due to diversity of scales, were left out the of the analysis.

Table 9: Selection and description of variables used in this chapter

Selected Variables	**Short name**
Waste related data	
Total amount of residual waste (tons)	RESIDUtot
Socio-economic data	
Total local resident population	POPtotal
Total number of households	POPhh
Total Area	AREA
Average household size	HHavsize
GDP per capita (at special scale of study area i.e. city or region)	GDP/capita
Sector Agriculture (NACE Rev. 1 A, B)	POPecactive_agr
Sector Industry (NACE Rev. 1 CF)	POPecactive_ind
Sector Services (NACE Rev. 1 GP)	POPecactive_serv
Employment rate	EMPLrate
Unemployment rate	UNEMPLrate
Total female population	POPfemale
Total male population	POPmale
Age 0-14	POP0-14
Age 15-59	POP15-59
Age 60 and more	POP60plus

Selected Variables	Short name
Tourism-related data	
Number of bed places in hotels and similar accommodation	HOTELbeds
Number of bed places in holiday and other short-stay accommodation	SH-STAYbeds
Number of bed places in camping grounds, recreational vehicle parks and trailer parks	CAMPSbeds
Nights spent in hotels and similar accommodation	NIGHTShotels
Nights spent in holiday and other short-stay accommodation	NIGHTSshortstay
Nights spent in camping grounds, recreational vehicle parks and trailer parks	NIGHTScamps

Use of formal statistical techniques, both descriptive univariate measures (arithmetic mean and standard deviation) and bi- and multivariate statistics that reveal relationships between variables or cases (cities), was problematic due to the above mentioned imperfections of the data, i.e. the considerable amount of missing data and the variety of geographical scales. Furthermore, the limited number of cases – eleven, or even less in case data of some pilot cases is missing – is problematic due to the susceptibility of results of statistical analysis for outliers. Hence, the data in this chapter is mainly analysed by simple visual representations in frequency tables and line and bar graphs.

6.2 Population geography

The size of the pilot cases in terms of population is shown in Figure 20 and Table 9. In 2015, three of the 11 pilot cases are in the range between half a million and 600 thousand inhabitants: Copenhagen, Lisbon and MNCA. As Figure 20 shows the population size of most of pilot cases remained stable or increased very weakly in the 15 year period since 2000. Notable exceptions are Copenhagen with population size increasing by 17 % and Lisbon where a quite steady pattern of population decrease was interrupted by a sudden increase of 17 % between 2010 and 2011. As a once-only incident, it is highly probable that this was caused by a change of administrative boundaries rather than demographic growth. Florence represents a medium-sized pilot case with a population of almost 400 thousand inhabitants. The seven other pilot cases are relatively small with less than 200 thousand inhabitants, of which three – Kavala Nicosia and Ponta Delgada - count even less than 100 thousand.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

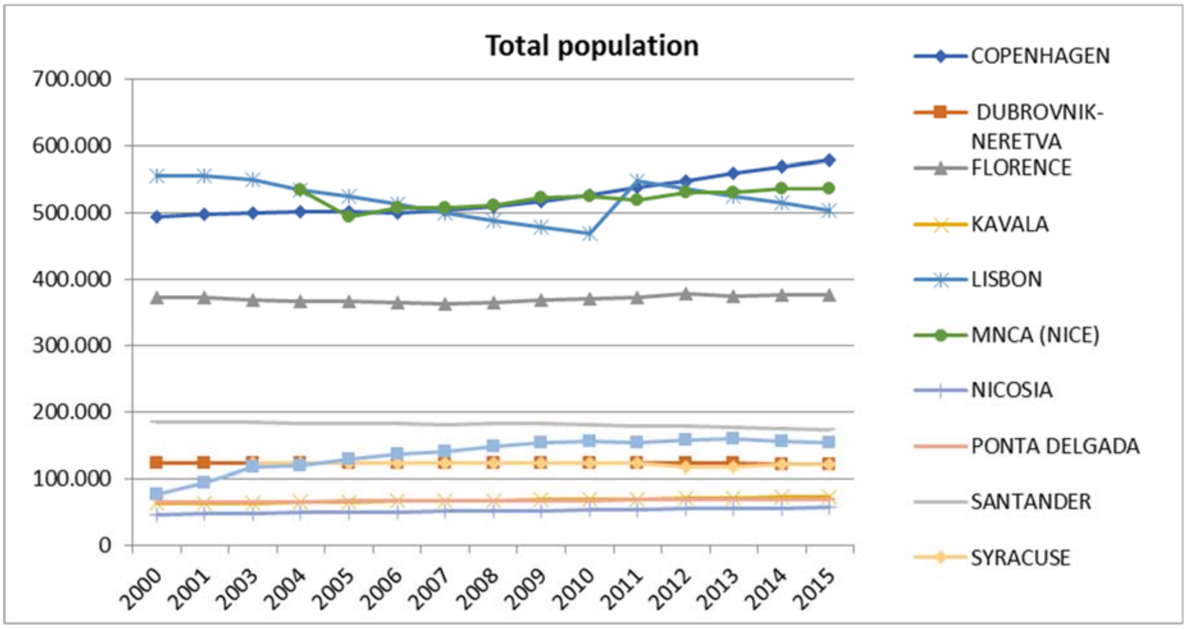


Figure 20: Total population in the URBANWASTE pilot cases 2000-2015. Tenerife pilot case does not cover the whole island of Tenerife, but consists only of the three municipalities Adeje, Arona and Puerto de la Cruz.

Population density is also highest in the two national capitals Copenhagen and Lisbon. For MNCA, on the other hand, population density is very low (Table 10). This corresponds with the very limited share of land use in this metropolitan area that is urban (Table 10). Based on '*les chiffres clés*' on the official website of MNCA, the population density of the municipality of Nice - one of the 49 communes of MNCA - is 4846.4 (year unknown). A similar conclusion is highly likely for Dubrovnik Neretva, Kavala and Ponta Delgada: low shares of urban land use, low population densities and a considerable gap between densities in their urban and non-urban parts. The population density of Syracuse could not be calculated as the data provided on population and area were on the municipal and provincial scale respectively.

Table 10: Population density and share of urban land use 2015

	Population	Area (km²)	Population density	Share of urban land use*
Copenhagen	580,295	86	6747.6	77%
Lisbon	504,471	100	5044.7	79%
Santander	173,957	35	4970.2	58%
Florence	378,174	102	3707.6	49%
Nicosia	57,626	21	2744.1	90%
Tenerife	154,745	197	785,5	62%
MNCA (Nice)	536,327	1465	366.1	9%
Ponta Delgada	69,884	232	301.2	10%
Kavala	73,384	351	209.1	5%
Dubrovnik Neretva	122,447	1781	68.8	3%
Syracuse	122,503	2.109	n.d.	16%

* Figure 7

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

6.3 Demography

The databases contained information about the population distribution by sex (Figure 21) and by three broad age groups (Figure 22). The share of females is larger than of males in all pilot cases except Lisbon. Female majority ranges from 51,0 % in Copenhagen and Syracuse to 53,8 % in Santander. In Lisbon, on the other hand, males are in the majority: 54,0 % against 46,0 % of females. The difference of almost eight percent between the sexes in Santander and Lisbon is considerably large.

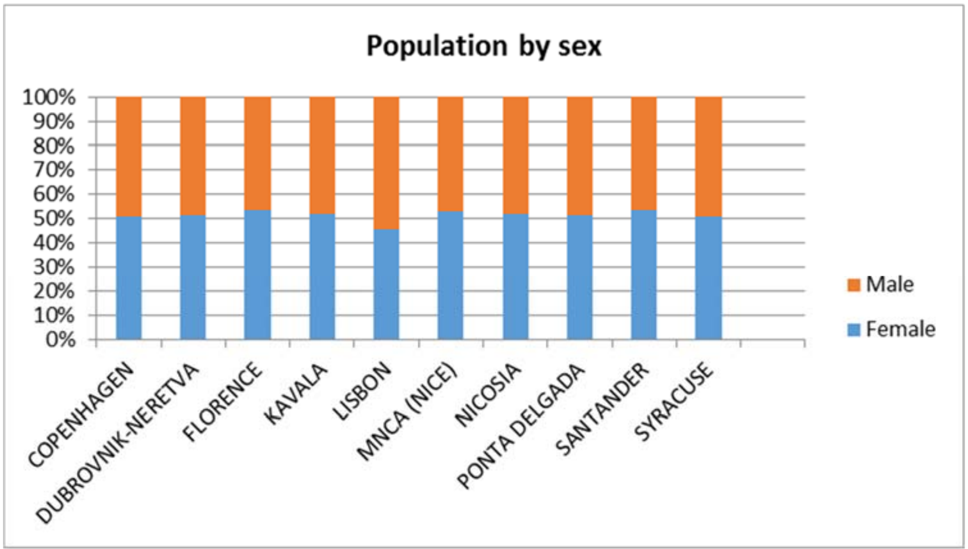


Figure 21: Distribution of population by sex (data for 2015). For Tenerife pilot case no data was available.

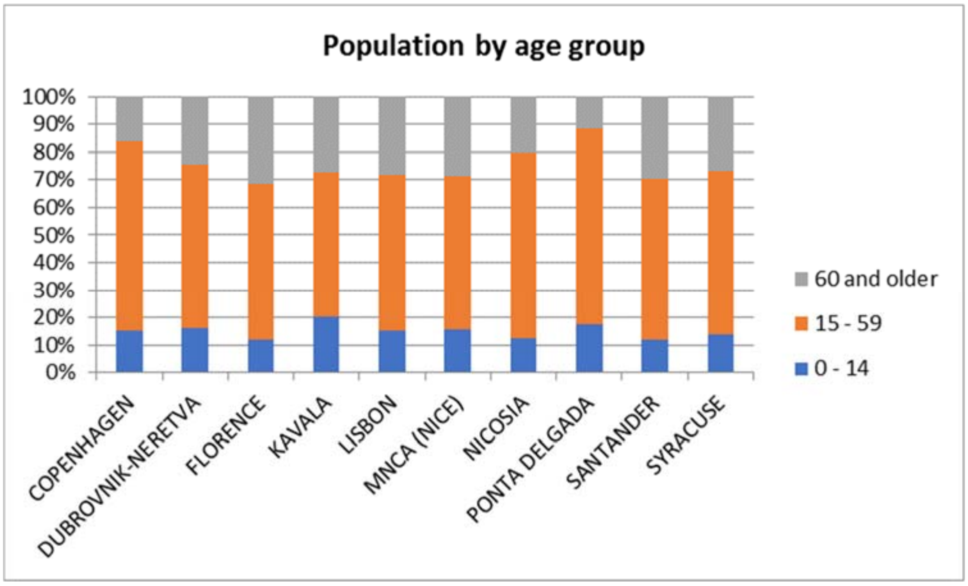


Figure 22: Distribution of population by age groups (data for 2015). For Tenerife pilot case no data was available.

The distribution by age (Figure 22) shows that the percentages of children up to 15 years are highest in Ponta Delgada (17,4 %) and Kavala (20,4 %). The percentages of people in the broad group of 15 to 60 years – the most active population of students and working people - are highest in Copenhagen (69,0 %) and, again, Ponta Delgada (71,0 %). The highest shares of senior citizens being 60 years and older live in Santander (29,7 %) and Florence (31,7 %). Their shares are smallest, on the other hand, in Ponta Delgada (11,7 %) and in Copenhagen (14,0 %).

In addition, data on the average size of households was provided (Figure 23). The average household size is largest in Dubrovnik-Neretva and Ponta Delgada and smallest in Copenhagen and Florence. The reasons for a small average size are matter of conjecture, but one may suggest that the general trend by young people to settle in main cities' core areas for a variety of qualities of place factors and to live in one- or two-person households (mainly students and DINKY's[23]) is probably stronger in north-western European cities (like Copenhagen) than in southern European cities. The small average household size in the southern European city of Florence may have something to do with the relatively greying population. A very remarkable and questionable value is the 1,16 persons per household in MNCA: this value would indicate that out of each six households five are one person households, one is a two-person household, and no household is larger than two persons, which is indeed a rather unrealistic value.

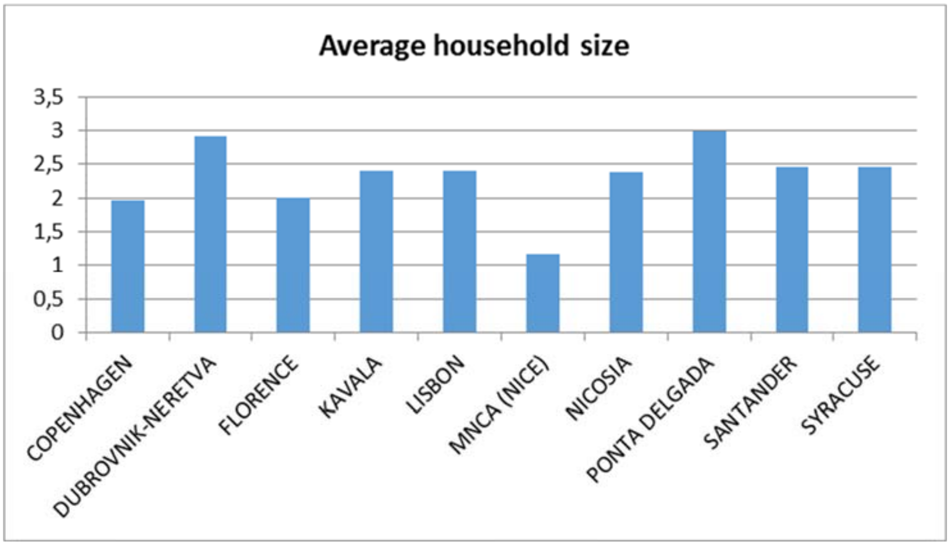


Figure 23: Average household size (data for 2015). For Tenerife pilot case no data was available.

[23] Double Income, No Kids Yet

This project has received funding from the European Union's Horizon 2020 research
and innovation programme under grant agreement No 690452

6.4 Economic performance and employment

The definition for economically active population (EAP), originally by the OECD[24], refers to the actual rather than potential active population. Unfortunately, data on the size of EAP (in 2015) was delivered on pilot area scale only by Nicosia, Ponta Delgada, Santander and Syracuse. For the seven other pilot cases, data is either not available (MNCA and Tenerife) or available on all possible levels of scale, i.e. metropolitan area, province, region and nation, but not on pilot area scale. Relating these figures with those of total population makes no sense because for most pilot cases these latter are available on a different spatial scale.

Two **adequate indicators** of the economic performance of the pilot cases are both related to the size of employment: the **employment and the unemployment rate**. These rates are defined as respectively 'the number of persons in employment as a percentage of the population of working age, i.e. 15-64 years' (Eurostat) and 'the number of unemployed persons as a percentage of the civilian labour force, i.e. the total labour force excluding armed labour force' (OECD). (Further information can be found in URBANWASTE project report D2.1 - Literature Review on Urban Metabolism Studies and Projects. Ramusch et al., 2016b).

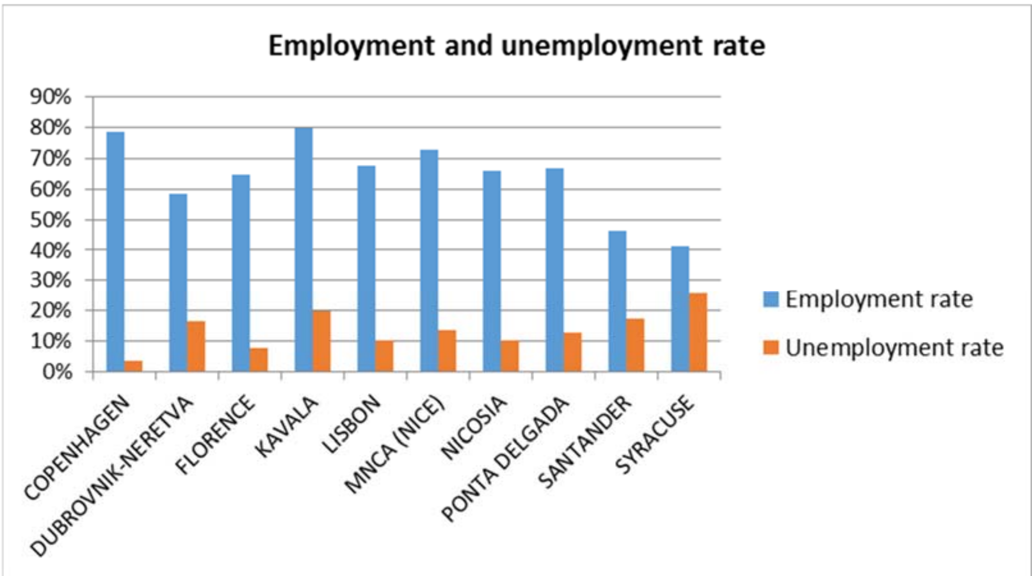


Figure 24: Employment and unemployment rate (data for 2015). For Tenerife pilot case no data was available.

Figure 24 reveals a strong contrast between the extremes: Copenhagen, on the one hand, and Santander and Syracuse, on the other hand. Copenhagen has the second highest employment rate (78,5 %) – with a gap of only 1,3 % to the highest (Kavala) but over 6,1 % to the third highest (MCNA) – and the lowest unemployment rate (3,8 %). It is questionable, however, if Kavala used the same definitions for both these rates as the other pilot cases did, for it is the only pilot case where the two rates sum up to exactly 100 %. Syracuse and Santander, on the other hand, both have employment rates between 40 % and 50 %, and unemployment rates around 20 %, pointing at less economic performance. The other pilot cases are between these two extremes.

24 https://stats.oecd.org/glossary/detail.asp?ID=730; retrieved 3 August 2017

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

These results should be 'handled with care' however: only the data of Nicosia and Syracuse are on municipal level, the other data are on regional level and in the case of Copenhagen even on national level.

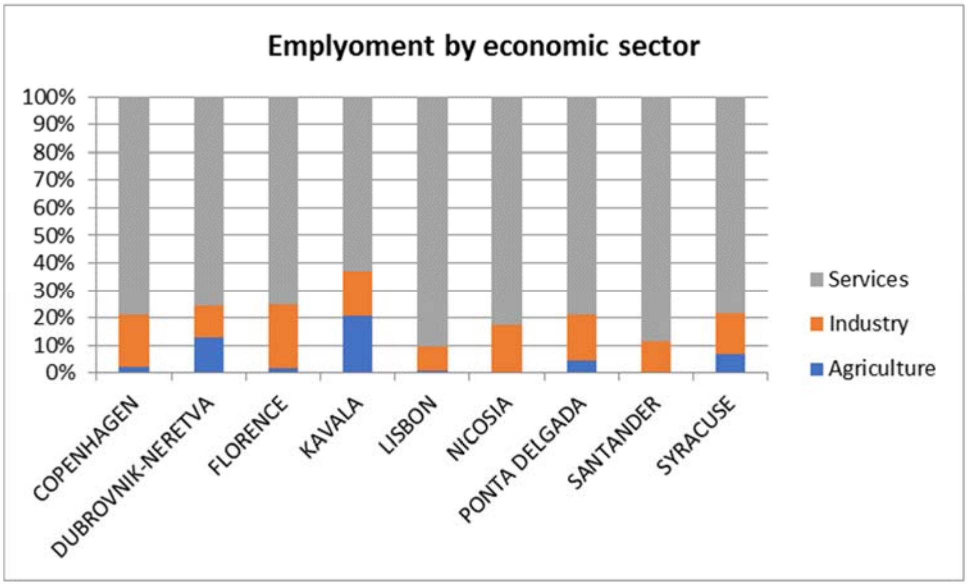


Figure 25: Employment by economic sector (2015). For the pilot cases MNCA and Tenerife no data was available.

The structure of the economy is reflected in the distribution of local labour force over the three major economic sectors, i.e. agriculture, manufacturing industries and services. For the interpretation of Figure 25, it should be taken into account that data are in the same mix of administrative levels as those of the employment and unemployment rate. Hence, the data of most pilot cases also include the economically active population of their usually less urban or rural regional hinterland. The four pilot cases with the largest shares of jobs in agriculture (Dubrovnik, Kavala, Ponta Delgada and Syracuse) are those with the smallest shares of urban land use (Table 10, Figure 7). In each pilot case, the service sector is the largest employer. With over 80 %, the highest shares in this sector are found in the regional capital Santander and the national capitals and governmental seats Nicosia and Lisbon. Copenhagen has the same status, but the data in Figure 25 relate to Denmark as a whole.

Direct indicators of the economic performance of a city are income level and the gross value of production per capita. Three such indicators were included in the database - GDP per capita, GNI per capita and average household disposable income. The available data on GDP per capita are the most adequate out of those three. The data shown in Figure 26 are the values of the GDP in the most recent year of availability: 2012 for Copenhagen, 2014 for Dubrovnik-Neretva and 2015 for the others. Excluding Tenerife (for which no reliable data were available), it shows that the GDP per capita is by far the largest in the two large capital cities Lisbon and Copenhagen and least in the two pilot cases with the largest part of their economic active population in the agricultural sector, Kavala and Dubrovnik Neretva.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

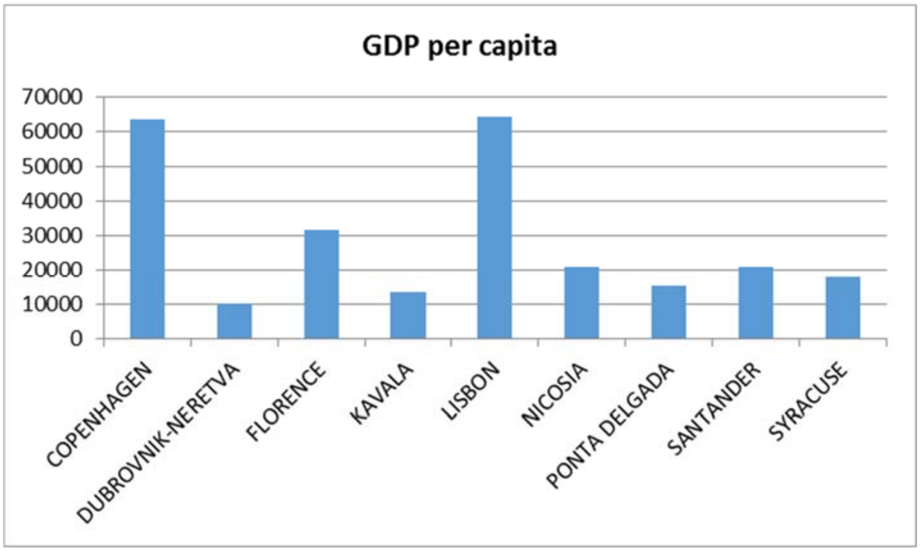


Figure 26: GDP per capita 2015. For Copenhagen, the most recent year of available data is 2012, for Dubrovnik-Neretva it is 2014. For the pilot cases MNCA and Tenerife no reliable data was available.

6.5 Size of tourism sector

One of the tourism related variables in the database is the annual turnover of the tourism industry. Based on the Eurostat definition (URBANWASTE project report D2.1 - Literature Review on Urban Metabolism Studies and Projects. Ramusch et al., 2016b), this turnover comprises the total invoiced value of market sales of goods and services. Unfortunately, the provided data is both limited to only six pilot cases and hardly comparable because of a variety of administrative levels of scale and years.

More adequate available data, i.e. more complete and better comparable, as indicators of the size of the tourism industry in the pilot cases, are the number of beds and the number of nights spent in tourist accommodation per 1.000 inhabitants. Most bed places are located and most nights are spent in hotels, but these are supplemented by 'holiday and other short stay accommodations' and by 'camping grounds, recreational vehicle parks and trailer parks'.

The more recent the year, the more data was available for both indicators (Figure 27, Figure 28). In most pilot cases, the number of beds and nights spent increased weakly but gradually during these fifteen years. Nevertheless, during the whole period, most pilot cases hardly exceed 100 bed places and 20.000 tourist nights per 1.000 inhabitants. Exceptions are Kavala since 2013 - earlier data is not available for this pilot case - with 240 bed places per 1.000 inhabitants or the notable peak of over 33.000 tourist nights per 1.000 inhabitants in Florence in 2013 (being about 10 thousand more than in all other years). However, in all pilot cases the numbers of bed places and nights spent per 1.000 inhabitants are very low compared to Tenerife that has a numbers of beds and tourist nights per 1.000 inhabitants seven to eight times as high as of most other pilot cases.

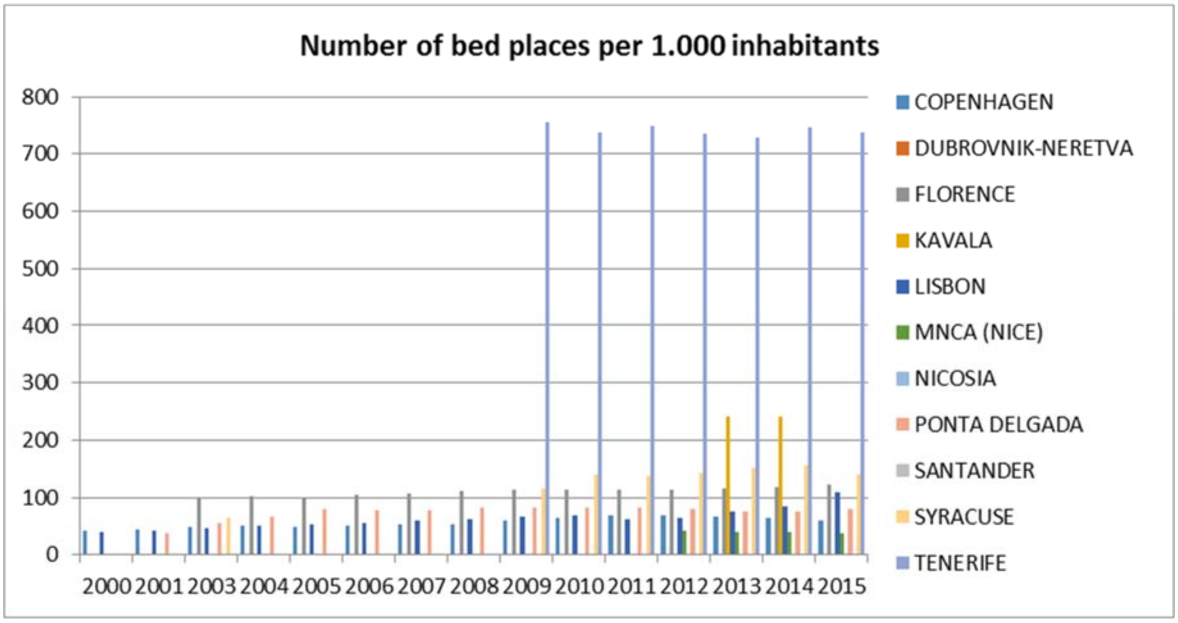


Figure 27: Number of bed places per 1.000 inhabitants

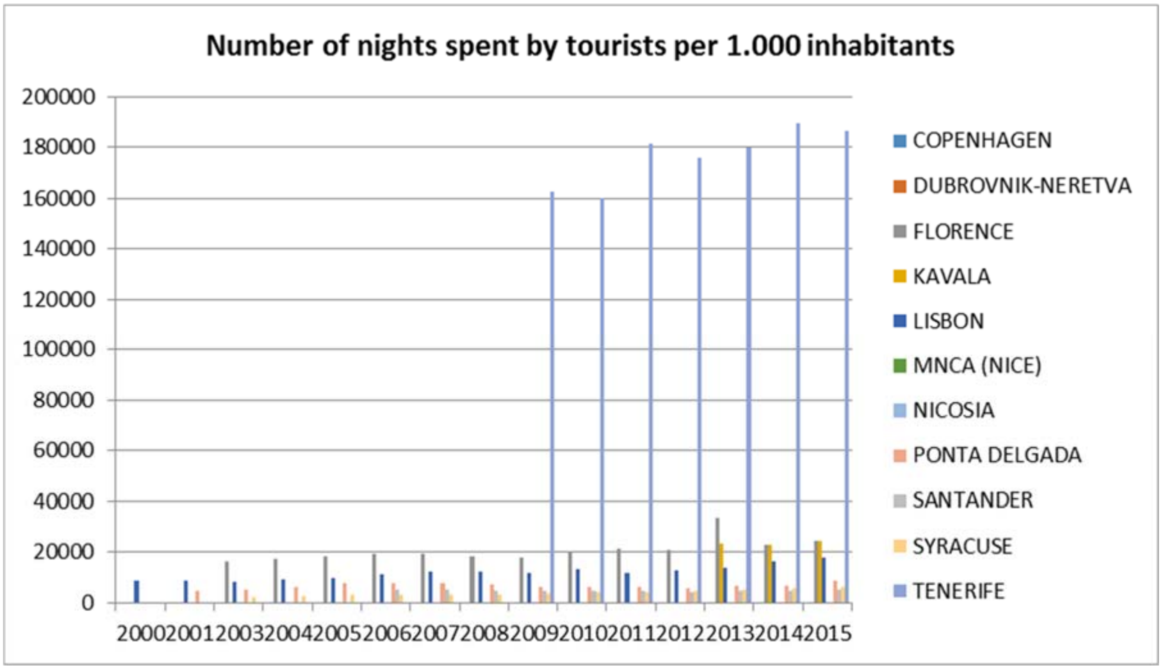


Figure 28: Number of tourist nights per 1.000 inhabitants

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

6.6 Socio-economic factors with influence on the generation of residual waste

The general impression presented by Figure 29 is a gradual decrease of the amount of residual waste per 1.000 inhabitants generated in the 10 pilot cases for which data is available. This picture is quite obvious for Copenhagen, Florence, Kavala and Ponta Delgada. In Lisbon and Nicosia, the decrease was mostly the effect of an abrupt drop in one particular year, 2011 and 2013 respectively. In MNCA, Santander, Syracuse and Tenerife, amounts of residual waste per 1.000 inhabitants remained rather stable over the period 2009 - 2015. In 2015, waste generation per 1.000 inhabitants was least in Copenhagen (257 tons) and highest in Nicosia (523 tons). The average amount of the 10 pilot (without Dubrovnik) cases decreased from 470 tons per 1.000 inhabitants in 2009 to 399 in 2015 – representing a decrease of 15 % in this eight year period.

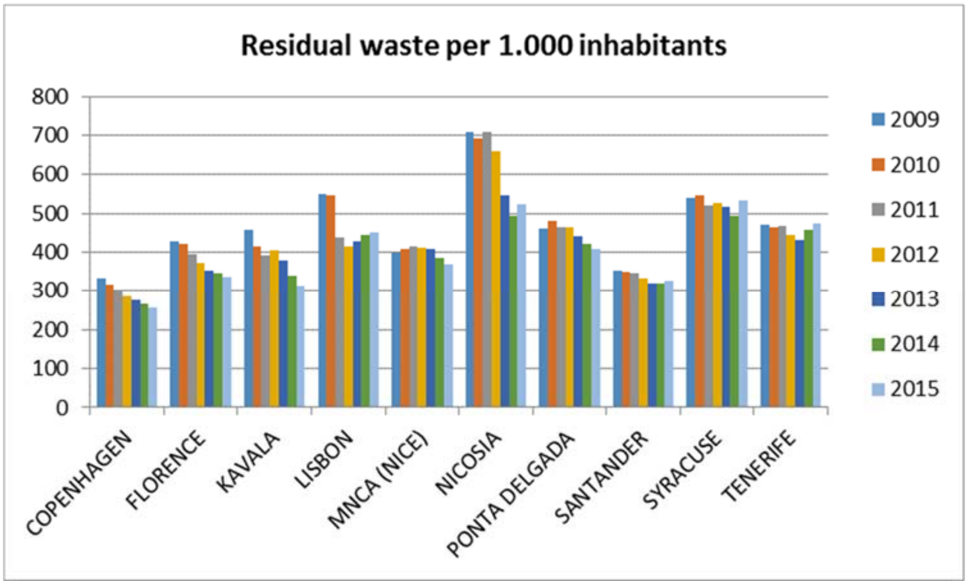


Figure 29: Total amount of residual waste (tons) per 1.000 inhabitants (2009-2015). For Dubrovnik-Neretva no data was available.

In order to explore if some of the socio-economic characteristics of the pilot cases discussed above show a statistically significant influence on residual waste generation, several features such as economic performance indicators or population structure were correlated with the total amount of residual waste per 1.000 inhabitants (in tons). As the number of 11 pilot cases (if data indeed was available for all of them) represents a too small sample for a valid regression analysis, scatterplots were used to depict possible relationships between residual waste generation and a number of independent socio-economic variables. However, is has to be emphasised that these observations are only first impressions regarding which socio-economic features might influence residual waste generation in the pilot cases. For statistically significant statements, a much larger sample as well as multivariate, probably non-linear regression techniques would be required.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

The results for relating residual waste production with indicators measuring economic performance are presented in Figure 30 and Figure 31. Figure 30 suggests that there is a positive relationship between GDP per capita and residual waste production: the higher the GDP per capita the more residual waste is produced. The outlier in this plot is Tenerife with a GDP per capita of about 100 €, which most likely results from errors in data. However, relating residual waste generation to the average household income does not show trend as clear as it is visible for GDP per capita.

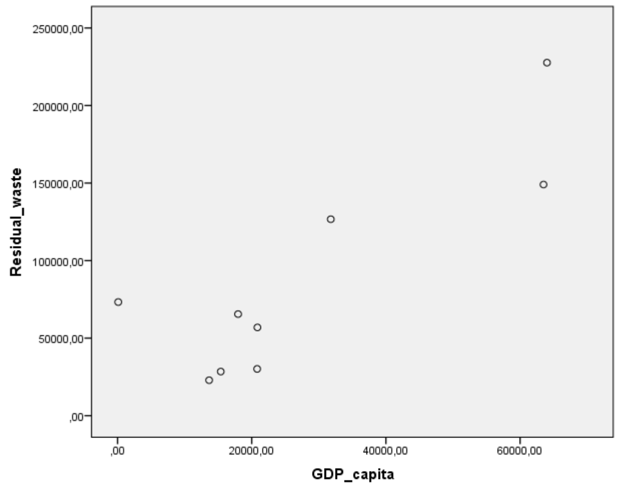


Figure 30: Scatterplot of the total amount of residual waste per 1.000 inhabitants (in tons) and GDP per capita (in €). Data for Dubrovnik-Neretva and MNCA were not available.

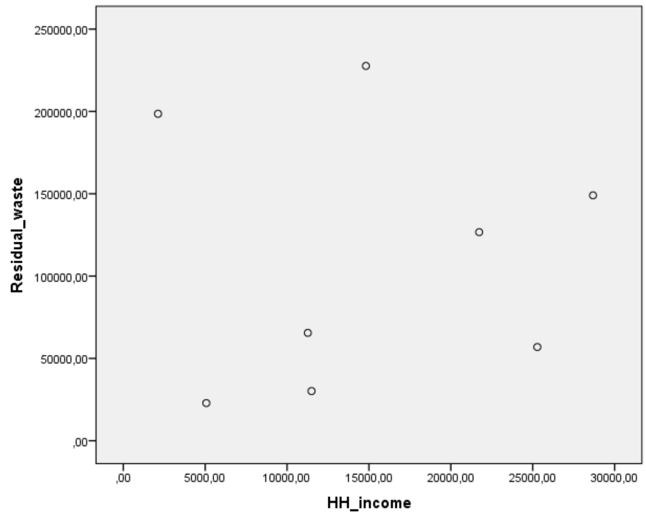


Figure 31: Scatterplot of the total amount of residual waste per 1.000 inhabitants (in tons) and average household income (in €), 2015. Data for Dubrovnik-Neretva, Ponta Delgada and Tenerife were not available.

Relating residual waste production with the demographic features such as the proportion of females and of the age group 15-59 did not produce any useful results, and therefore is not presented in detail in this report.

This project has received funding from the European Union's Horizon 2020 research
and innovation programme under grant agreement No 690452

Figure 32 indicates that a higher share of economic active population working in the service sector is related to as higher per capita generation of residual waste. Based on this finding the number of jobs in service sectors or in tourism industry respectively seems to also be useful for analysing tourism's impact on waste generation. A detailed analyses of the impact of tourism on waste generation using the number of overnight stays is presented in Chapter 7.

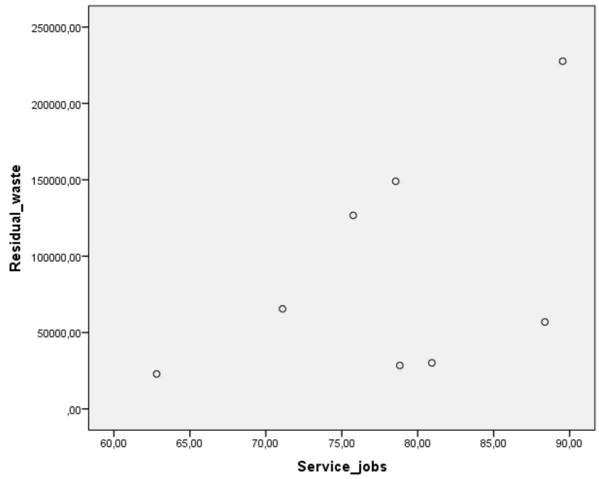


Figure 32: Scatterplot of the total amount of residual waste per 1.000 inhabitants (in tons) and proportion of economic active population (EAP) in service jobs, 2015. Data for Dubrovnik-Neretva, MNCA and Tenerife were not available..

6.7 Conclusion

The challenge of grouping the 11 URBANWASTE pilot cases regarding (mainly) socio-economic features in such a way that the pilot cases in the same group are more similar (in some sense or another) to each other than to those in other groups. The available data did not permit grouping in strictly defined clusters by means of a sophisticated statistical technique. Nevertheless, several of the typical features that are observed in this chapter enable similarities and differences between the pilot cases to be marked.

Copenhagen and Lisbon are national capitals that score highest, or among the highest, in terms of population size, population density, share of working population in service sectors (in particular Lisbon), GDP per capita, and the proportion of the population in the age group 15-59 of the most active people (in particular Copenhagen). There are indications that a higher GDP per capita result in higher residual waste generation, but, contradicting, Copenhagen produced the least amount of residual waste per 1.000 inhabitants of all pilot cases in 2015 (Figure 30). Reasons for this phenomenon are given in Chapter 4 (In Copenhagen waste from hotels is not collected within the municipal waste collection!)

Dubrovnik Neretva and Kavala are pilot cases with (by far) the largest areas of non-urban land use, the lowest population density, relatively most people working in agriculture, the highest unemployment rate and the lowest GDP per capita.

This project has received funding from the European Union's Horizon 2020 research
and innovation programme under grant agreement No 690452

The three municipalities forming Tenerife pilot case (Adeje, Arona and Puerto de la Cruz) have by far the largest tourism industry of all pilot cases. The number of bed places in tourist accommodations and the number of nights spent by tourists in these municipalities are seven to eight times higher than in the other pilot cases. In spite of the comparatively big tourism industry, the amount of residual waste produced per 1.000 inhabitants is in the middle range of all pilot cases. Apart from tourism related characteristics, however, a socio-economic profile of Tenerife is hard to make because much of the demanded data is missing.

Subgroups of the other six pilot cases share single features – e.g. the GDP per capita is rather low in Nicosia, Ponta Delgada, Syracuse and Santander, and the share of senior citizens are highest of all 11 pilot cases in Santander and Florence. However, groups based on profiles of combinations of variables like for Copenhagen and Lisbon, and for Dubrovnik Neretva and Kavala, cannot be made with the available data.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

7. Tourism's impact on waste generation

Iris **GRUBER** & Gudrun **OBERSTEINER**

For evaluating waste generation resulting from tourist activities the main waste fractions affected by tourism (i.e. organic waste, packaging waste and residual waste) were analysed in connection with data on local resident population and nights spent by tourists. For this purpose, per capita waste generation was correlated with the corresponding tourism intensity. In contrast to the benchmarking activity, for this analysis "local resident population" was chosen as reference base for analyses.

As correlating per capita waste generation data from all pilot cases (kg per local resident and year or kg per local resident and month) with the corresponding tourism did not produce any useful results, the analysis of tourism's impact on waste generation was structured into the following steps:

- **Comparison of annual data on waste generation and tourist overnight stays** separately for all pilot cases and groups of pilot cases respectively as well as separately for all waste fractions in order to identify annual variations in waste amounts which can explicitly be explained by tourism.
- **Comparison of monthly data on waste generation and tourist overnight stays** separately for all pilot cases which could provide monthly data and separately for all waste fractions in order to identify monthly variations in waste amounts which can explicitly be explained by tourism.
- **Selection of pilot cases** that can provide data suitable **for more detailed analysis** of tourisms' impact and selection of waste fractions positively affected by touristic processes.
- **In-depth statistical analysis** to assess waste generation from tourists (kg per overnight stay) for selected pilot cases and selected waste fractions.

7.1 Comparison of annual data on waste generation and tourist overnight stays

Correlating per capita residual waste generation in the pilot cases (annual data) with tourism intensity (Figure 33) shows that there are two clusters: Tenerife (upper corner on the right) and the sum of all other pilot cases.

This project has received funding from the European Union's Horizon 2020 research
and innovation programme under grant agreement No 690452

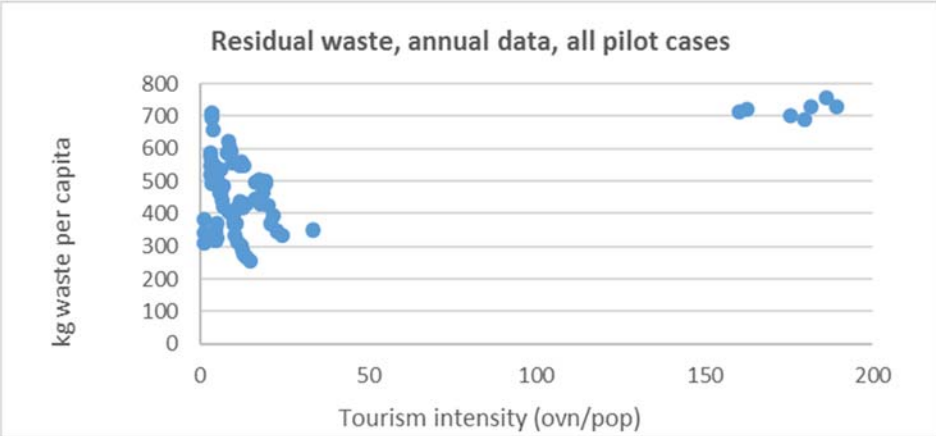


Figure 33: Correlation of per capita generation of residual waste and tourism intensity for all pilot cases (annual data)

Analysing the cluster of all pilot cases except Tenerife is not feasible in order to identify tourism's impact on waste generation as the results **do not show any clear trends** (Figure 34). As already described in the chapters on data evaluation and benchmarking, inconsistencies in data might be one of the reasons that such a general comparison does not produce useful results.

Also, **grouping all pilot cases for analyses** according to, for example, the share of total hotels that is represented by the available data, their spatial structure profiles (Chapter 5.5.2) or into different categories of tourism intensity **failed to produce any useful results**.

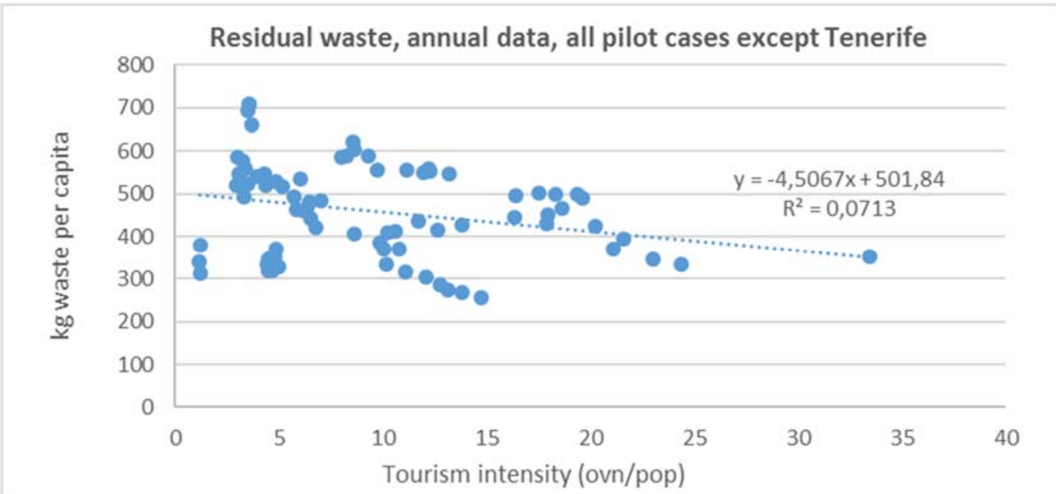


Figure 34: Correlation of per capita generation of residual waste and tourism intensity for all pilot cases but Tenerife (annual data)

Analysing Tenerife pilot case separately shows that there is a positive correlation in terms of the higher the number of nights spent by tourists (i.e. tourism intensity) the more residual waste is produced per local resident. This would indicate that tourism has a notable influence on a region's waste generation, but there are **not enough data points for meaningful statements on trends when using only annual data** (N=7) (Figure 35).

Looking at **monthly data** (N=36), on the other hand, shows a **more significant trend**. Also the R^2 is better for explaining about 50 % of the variability instead of only 12 % when using annual data (Figure 36).

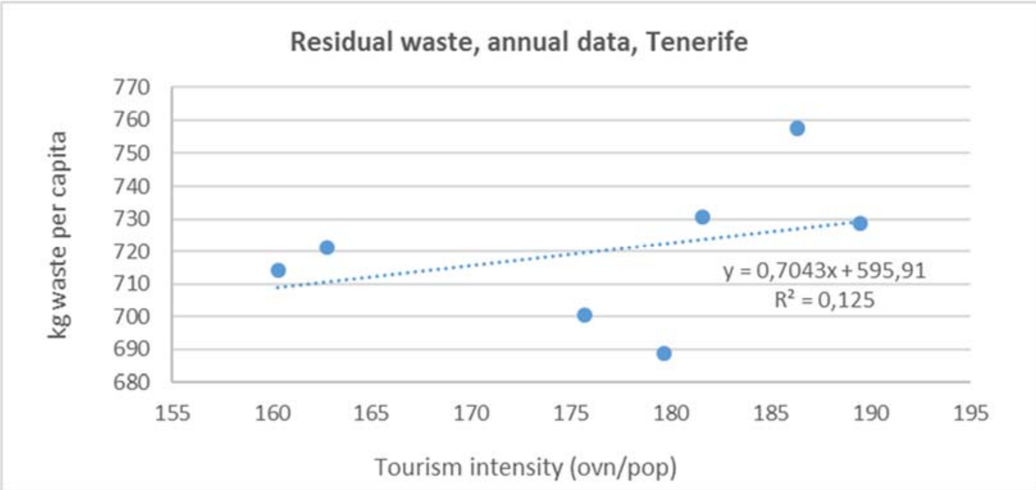


Figure 35: Correlation of per capita generation of residual waste and tourism intensity for Tenerife pilot case (annual data; N=7). The pilot case Tenerife consists of the three municipalities Adeje, Arona and Puerto de la Cruz.

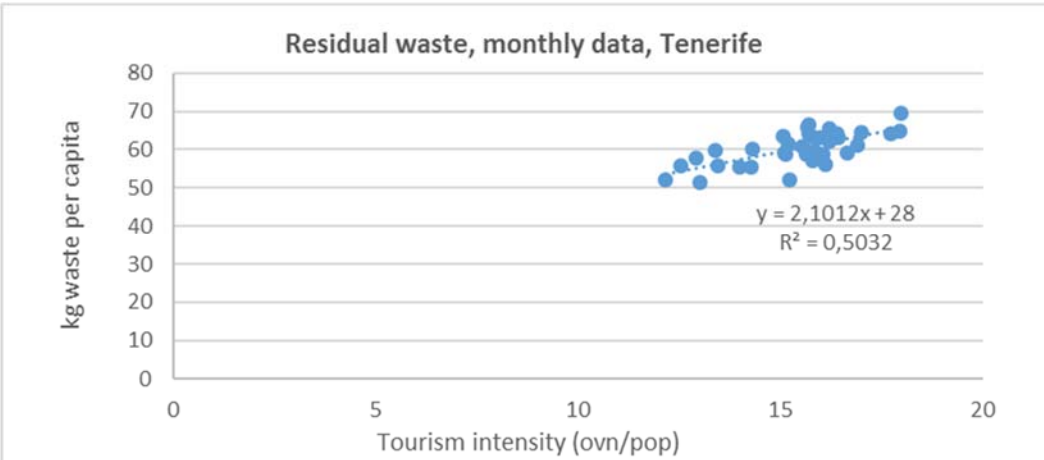


Figure 36: Correlation of per capita generation of residual waste and tourism intensity for Tenerife (monthly data; N=36)). The pilot case Tenerife consists of the three municipalities Adeje, Arona and Puerto de la Cruz.

As analysing monthly data did result in more statistically significant correlations this approach was followed for further analyses.

7.2 Comparison of monthly data on waste generation and tourist overnight stays

Waste generation data on a monthly scale is available for the pilot cases Kavala, Lisbon, Nicosia, Ponta Delgada, Santander and Tenerife. Monthly data on number of nights spent by tourists is available for Kavala, Lisbon, Ponta Delgada, Santander and Tenerife only. **Comparing trends in monthly waste management and overnight stays data** in order to find if variation in waste generation follows the monthly variation in number of overnight stays was therefore only **possible for the pilot cases Kavala, Lisbon, Ponta Delgada, Santander and Tenerife.**

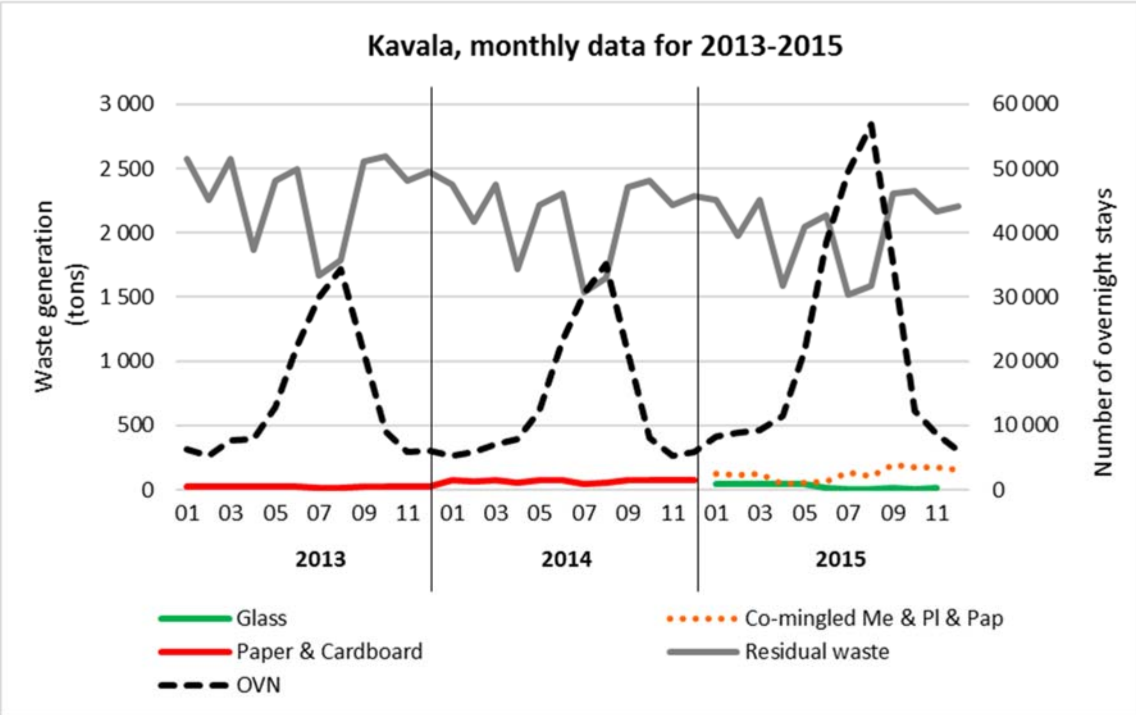


Figure 37: Comparison of waste generation and number of overnight stays in Kavala (monthly data for 2013-2015)

In **Kavala** (Figure 37), summer months are the high season of tourism. Peaks in the number of overnight stays are clearly visible for all summer months from 2013-2015. For waste generation, there is no such trend visible. Actually, especially for residual waste it seems that there is less residual waste in summer months though the number of tourists is extremely high. This can be explained by **bad data quality** because of inconsistent data recording as explained in chapter 3.3.3

However, looking at Figure 37 it could safely be assumed that there would be a peak in residual waste in August in case the waste recording would be correct. Unfortunately, a proper track scale was installed only in October 2016. Using more recent but more accurate data to verify this assumption, thus, is not possible at the time this report was prepared. Using data on residual waste for analysing the tourism's impact on waste generation is, thus, not possible for Kavala. Using data on separate collected recyclables for this purpose is also

This project has received funding from the European Union's Horizon 2020 research
and innovation programme under grant agreement No 690452

not possible for this pilot case because these datasets only reflect that the collection system for recyclables was changed (expanded) in 2015.

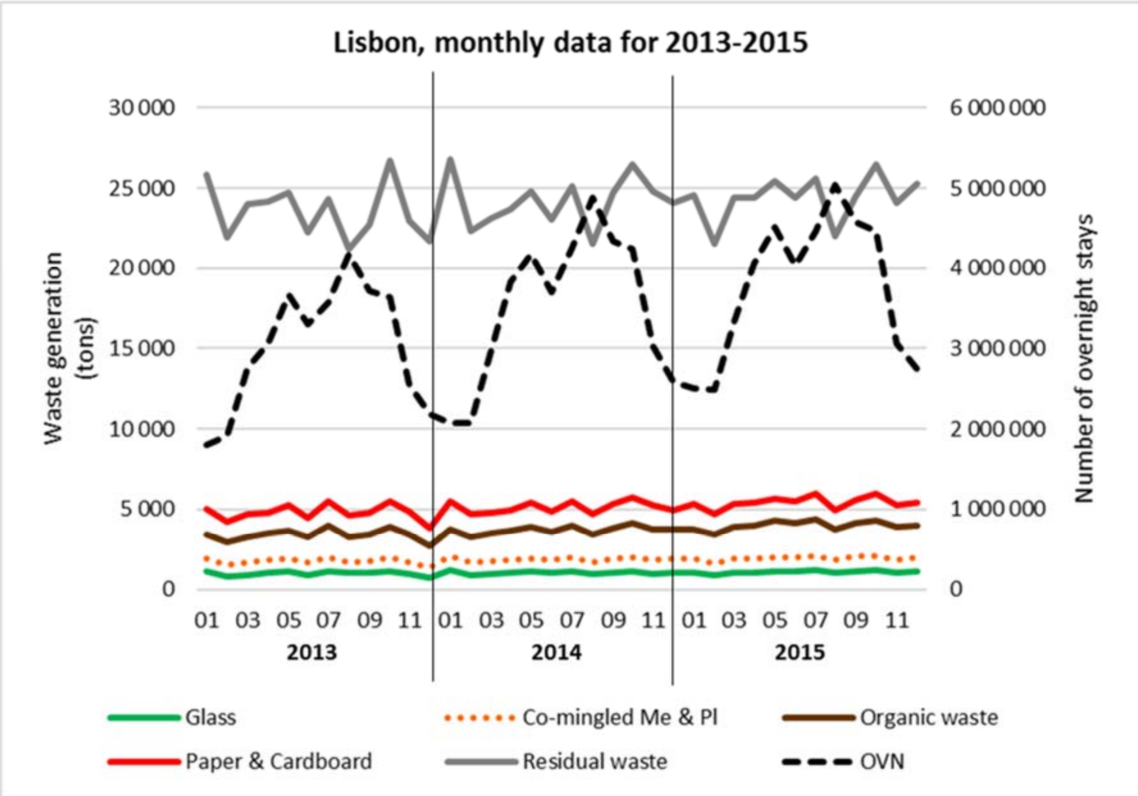


Figure 38: Comparison of waste generation and number of overnight stays in Lisbon (monthly data for 2013-2015)

In **Lisbon** (Figure 38), there seems to be the same situation as in Kavala, meaning during the months with the highest number of overnight stays (summer season), there is a significant drop in waste amounts. All recyclables as well as organic waste show very similar variations as residual waste, including a noticeable drop in collected amounts in months with a peak in tourist numbers.

However, in contrast to Kavala, for Lisbon the share of all hotels in the pilot case that are represented in the provided data (which represent the amounts collected by municipal waste collection) is unknown, but assumed to be very low. As according to pilot case partners a high number of Lisbon residents go on holidays especially in August, the drops in waste generation can be explained by this fact. Thus, without more detailed information to what extent hotels are included in the available data, including Lisbon in the analysis of tourism's impact on waste generation seems not suitable.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

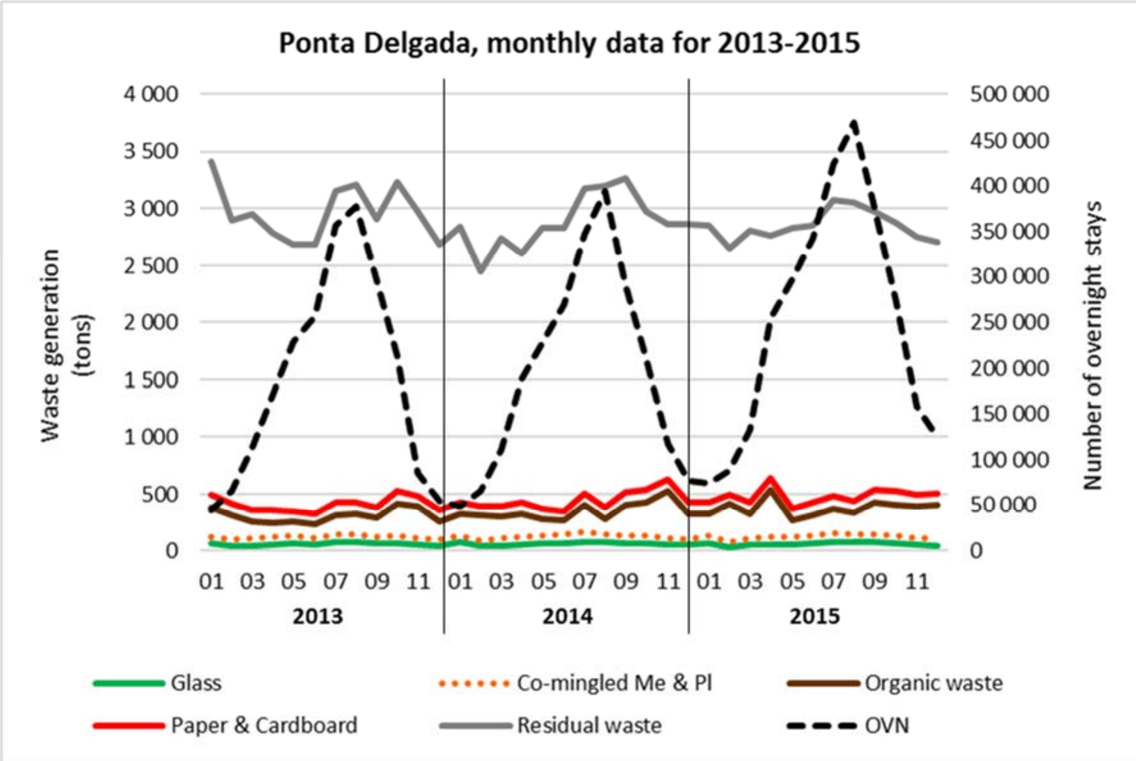


Figure 39: Comparison of waste generation and number of overnight stays in Ponta Delgada (monthly data for 2013-2015)

In **Ponta Delgada** (Figure 39), summer months are the high season of tourism. Peaks in the number of overnight stays are clearly visible for all summer months from 2013-2015. For waste generation, a similar trend is visible, but the peaks are less pronounced that in the tourism data (especially for separately collected recyclables the correlation seems less pronounced than for residual waste). Ponta Delgada is one of those URBANWASTE pilot cases where we can assume that all waste generated by hotels is represented by the data provided for analysis as only the municipality is responsible for collecting MSW from tourist establishments. This data, thus, seems suitable to be used for analysing the tourism's impact on waste generation.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

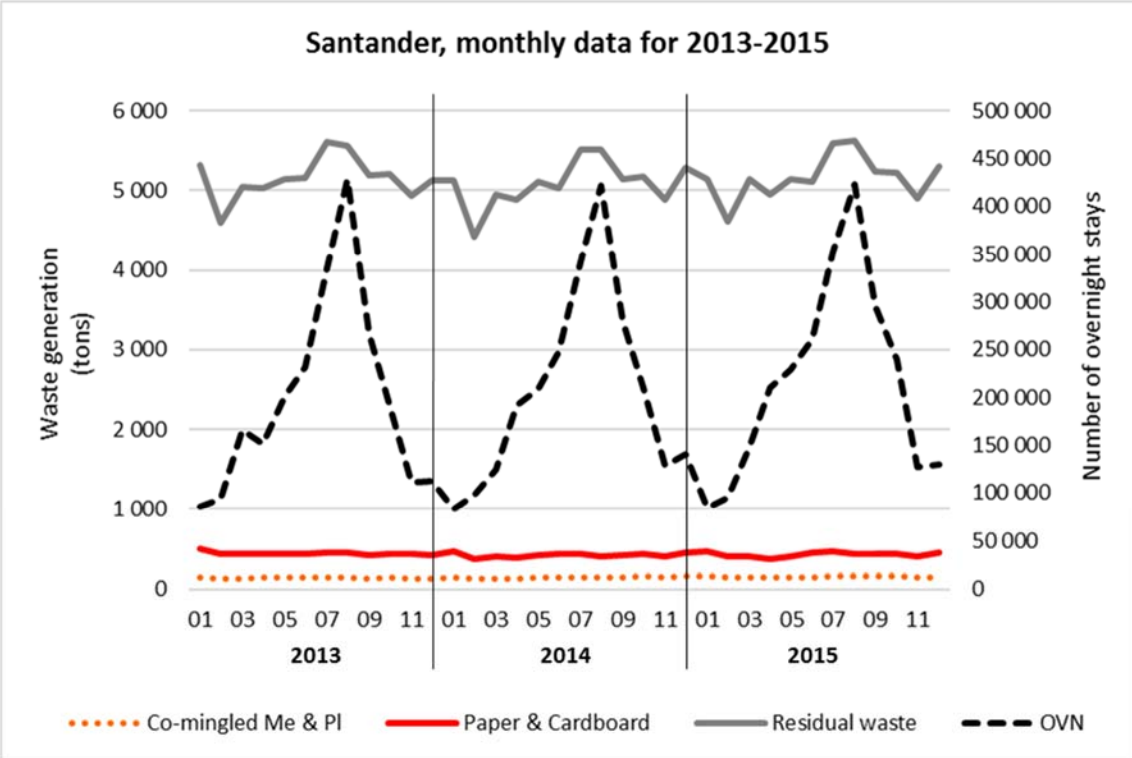


Figure 40: Comparison of waste generation and number of overnight stays in Santander (monthly data for 2013-2015)

In **Santander** (Figure 40), summer months are the high season of tourism. Peaks in the number of overnight stays are clearly visible for all summer months from 2013-2015. For waste generation, a similar trend is visible, but the peaks are less pronounced than in the tourism data (especially for separately collected recyclables there is hardly any correlation to overnight stays visible). Santander is one of those URBANWASTE pilot cases where we can assume that all waste generated by hotels is represented by the data provided for analysis as waste from tourist establishments is collected and treated together waste streams collected from households. This data, thus, seems suitable to be used for analysing the tourism's impact on waste generation.

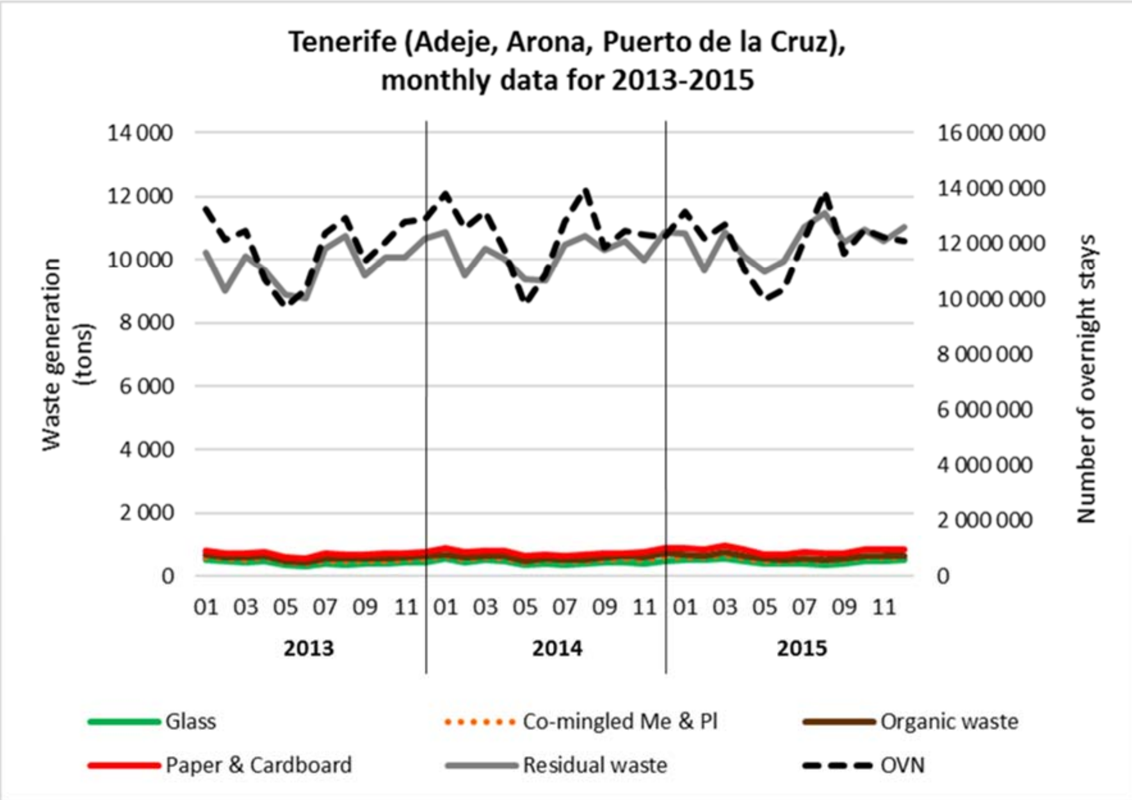


Figure 41: Comparison of waste generation and number of overnight stays in Tenerife pilot case (monthly data for 2013-2015). Tenerife pilot case comprises the three municipalities Adeje, Arona and Puerto de la Cruz.

In **Tenerife pilot case** (Figure 41), the number of overnight stays is high nearly the whole year. Only in spring the numbers are slightly lower. For waste generation, a very similar trend is visible, but the peaks are less pronounced that in the tourism data (also for separately collected recyclables). Only for organic waste a possible correlation of overnight stays and waste generation is less obvious. Tenerife pilot case (comprising of the three municipalities Adeje, Arona and Puerto de la Cruz) is further one of those URBANWASTE pilot cases where all waste generated by hotels in represented by the data provided for analysis. This data, thus, seems suitable to be used for analysing tourism's impact on waste generation.

Waste streams affected by tourism

In order to verify the assumption that data for Ponta Delgada, Santander and Tenerife is suitable for more detailed analyses of tourism's impact on waste generation, per capita waste generation (kg per capita and month) was correlated with monthly *tourism intensity*[25].

For residual waste (Figure 42) a correlation of per capita waste generation and tourism intensity is clearly visible. The higher the intensity of tourism is, meaning the higher the number of overnight stays per local resident is, the more kg waste are produced per capita. As residual waste was identified in various studies to be

[25] Tourism intensity = ratio of nights spent at tourist accommodation establishments relative to the total permanent resident population of the area

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

one of those waste streams most significantly influenced by touristic activities (report D2.1 - Literature Review on Urban Metabolism Studies and Projects, Ramusch et al., 2016b) this finding is not surprising.

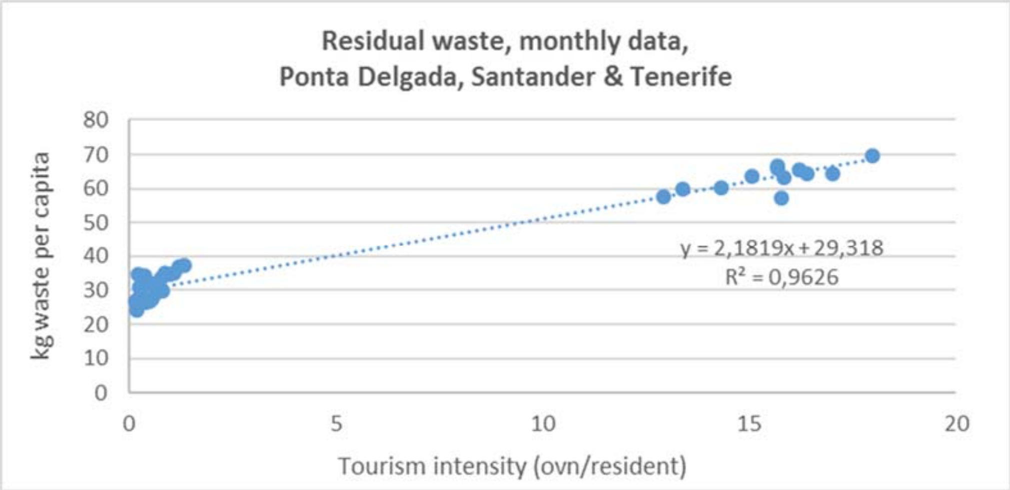


Figure 42: Correlation of residual waste per capita and tourism intensity in Ponta Delgada, Santander and Tenerife (monthly data for 2013-2015) (Reference base = local resident population)

For paper & cardboard (Figure 43) there seems to be no positive correlation between the intensity of tourism and per capita generation of paper & cardboard waste. This is not surprising as a connection between this waste fraction and tourists was not expected by the authors. Reading local magazines and newspapers, for example, often will be restricted by foreign language. Cardboard from food packaging also might not be attributable to tourists in the same way they are to local residents.

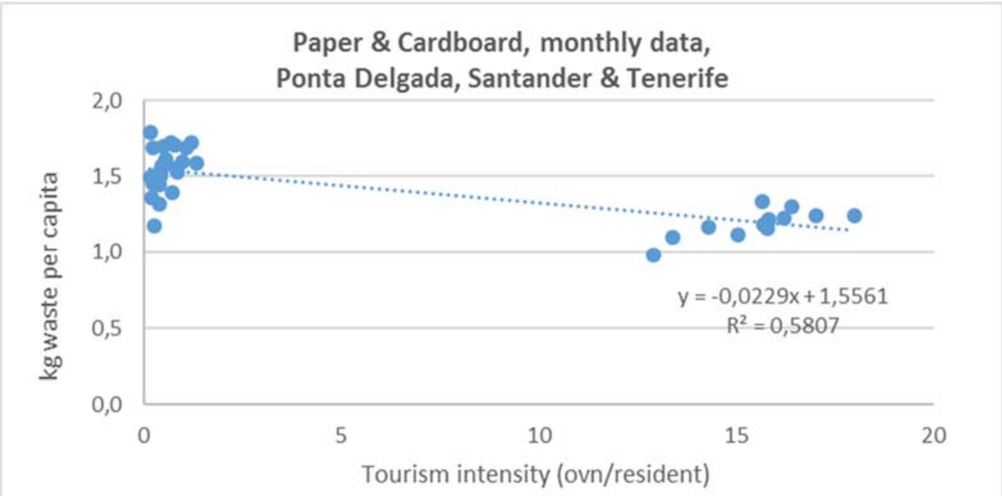


Figure 43: Correlation of paper & cardboard collected per capita and tourism intensity in Ponta Delgada, Santander and Tenerife (monthly data for 2013-2015) (Reference base = local resident population)

This project has received funding from the European Union's Horizon 2020 research
and innovation programme under grant agreement No 690452

Similar to residual waste, there seems to be a positive correlation between per capita amounts of glass collected in the pilot cases and the intensity of tourism (Figure 44).

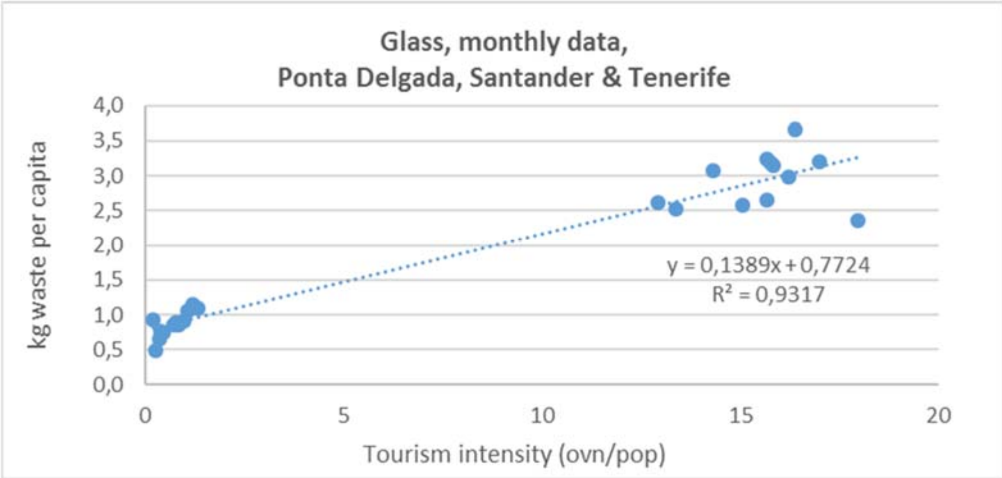


Figure 44: Correlation of glass collected per capita and tourism intensity in Ponta Delgada, Santander and Tenerife (monthly data for 2013-2015) (Reference base = local resident population)

In all three analysed pilot cases, metals and plastic packaging are being collected as a co-mingled fraction. The results presented in Figure 45 indicate that there is no positive correlation between the number of tourists (or overnight stays respectively) and the amounts of metals and plastics collected per capita. This is surprising as it was expected that the sum of tourists buys, for example, a huge amount of plastic bottles which should be reflected in waste data. However, these results might rather indicate that tourists do not buy many plastic bottles to take with them but rather go to hotel bars, restaurants or cafes if they are thirsty.

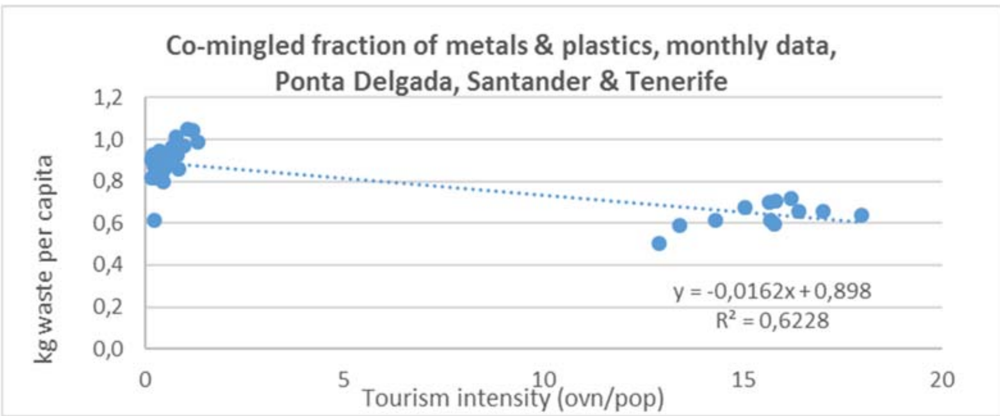


Figure 45: Correlation of metals and plastic packaging collected per capita and tourism intensity in Ponta Delgada, Santander and Tenerife (monthly data for 2013-2015) (Reference base = local resident population)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

Another possible explanation is that tourists don't always throw this waste stream in the bins for separate collection, thus their plastic waste ends up in the residual waste. According to pilot case partners sorting is difficult for tourists because of the infrastructure, the type of accommodation they use, and the lack of information

Organic waste is one of those waste streams identified to be a hotspot in terms of waste generation from touristic activities. However, the data used for the analyses presented in this report represent the total amount of organic waste collected in the pilot cases, being composed of organic waste from households (mixture of food and garden waste), green (garden) waste from public and private gardens, and food waste from kitchens, canteens and restaurants. However, not all types of organic waste are collected in every URBANWASTE pilot case (Figure 3). In Ponta Delgada, for example, only green (garden) waste from public and private gardens is separately collected. In Tenerife, there is a collection of green (garden) waste and food waste from kitchens etc. In contrast to data on green (garden) waste, data on food waste from kitchen is only available on annual scale and only up to the year 2012 and shows considerable variation in the annually collected amounts. In relation to garden waste, food waste made up between 1 – 3% in terms of weight, while in 2010 and 2011 it suddenly made up nearly 60 % (explained by the pilot case partners with having special awareness campaigns for hotels, restaurants and bars in those years). In Santander, there is no collection of any type of organic waste. Therefore, this fraction **cannot be used for further analysis**.

7.3 Impact of tourism on waste generation

This analysis of the relationship between waste generation and the intensity of tourism is based on the **assumption that due to tourism seasonality there are differences in waste generation over the period of a year** in cities or regions strongly influenced by tourism.

The statistical concept used is outlined in Chapter 2.4. This analysis was performed for the pilot cases **Kavala, Ponta Delgada, Santander and Tenerife**. Only for those four URBANWASTE pilot cases are monthly data on waste generation and overnight stays available, which are prerequisites for such an analysis. The **analysed waste fraction** was **residual waste**.

For Kavala, the months of April, July and August were excluded from analysis because data quality for these months is bad. The Tenerife pilot case was split up into its three municipalities (Adeje, Arona and Puerto de la Cruz) in order to have a bigger dataset available for analysis.

7.3.1 Identification of pilot cases with a strong influence from tourism:

In general, waste generation is influenced by various factors. Therefore, monthly variation in waste generation may be caused by various reasons and not necessarily be an impact of tourism. A literature review done by Beigl et al. (2003), for example, shows that for variables such as population, population density, gross domestic product, private consumption, population portion between 15 to 59 years, rate of buildings with 1 or 2 dwellings, rate of one to two person households, tourism and employment rate, a high degree of evidence exists that they have a positive influence on the generation of municipal solid waste (MSW). Larger Household size and the rate of houses with solid fuel heating, on the contrary, are variables with a negative influence on the generated amounts of MSW. Through further statistical analysis, Beigl et al. (2003) could identify a significant positive influence of municipal solid waste (MSW) generation in countries and cities for gross domestic product and employment in the service sector. However, there are only few studies available using monthly data to compare differences in waste generation in tourist cities which cities with lower tourist impact. Rhyner (1992) concludes that, in general, the generation patterns for residential waste show lower than average in winter months and higher than average in summer months without tourist influence.

Applying a heuristic model such as the one described in Chapter 2.4 is only valid for municipalities where the seasonal variation can – most likely – be explained by tourism. **For identifying how strong the influence of tourism on waste generation might be, the ratio between local resident population and (tourism including) equivalent resident population was calculated.** Equivalent resident population represents the sum of local residents and tourist equivalent residents (calculated dividing the number of monthly overnight stays by the number of days per months). The ratio was calculated separately for each URBANWASTE pilot case for each month of the period 2013-2015.

The results (Table 11) show that only the three municipalities building Tenerife pilot case (Adeje, Arona and Puerto de la Cruz) are strongly influenced by tourism according to the definition presented above. However, looking at seasonal variation of tourism intensity, those three municipalities only show very low variation compared to Kavala, Ponta Delgada and Santander, which show significant seasonal variation in tourism intensity (Figure 37 to Figure 41 of descriptive analysis section).

Thus, for different reasons, none of the URBANWASTE pilot cases that could provide monthly data on waste generation as well as on number of nights spent by tourists is suitable to be analysed applying this heuristic model:

For the three municipalities located in Tenerife, there is too little seasonal variation in the number of overnight stays to use the seasonal average of amounts generated in months of low tourism season as an estimation for waste generation by local residents. Even in months of the low season (identified according to Ofner, 2011) the number of overnight stays is way too high to neglect the impact of tourism. Thus, the heuristic model could not be applied to those municipalities.

For Kavala, Ponta Delgada and Santander, seasonal variation in tourism intensity would be strong enough in order to apply this model (i.e. to use low season months as an estimation for waste generation of local residents). However, the share of tourists compared to local residents is only 0,83 %, 4,15 % and 2,55 % for Kavala, Santander and Ponta Delgada (per month; maximum values for 2013-2015; Table 11) whereas the usual seasonal fluctuation in waste data between month is about 20 % (Denafas et al., 2014). This could also be shown for cities like Kutaisi in Georgia and Boryspil in Ukraine which are not defined as tourist cities.

Thus, **if tourists make up only a low percentage compared to residents, it is difficult to draw any significant conclusions about the influence of tourism on waste generation as results might be outweighed by other influencing factors.** Nevertheless, the heuristic model described above was applied to those three pilot cases in order to check if available data still can be used for a preliminary approximation of tourisms' impact on waste generation. The results, however, do not represent statistically reliable conclusions.

Table 11: Evaluation of the intensity of tourism compared to local resident population

Identification of intensity of tourism	KAV	PON	SAN	TEN-ADE	TEN-ARO	TEN-PTO
MIN of 2013-2015	0,12 %	0,42 %	0,50 %	39,01 %	20,95 %	23,63%
MAX of 2013-2015	0,83 %	4,15 %	2,55 %	48,91 %	28,49 %	39,53%
AVG of 2013-2015	0,32 %	1,94 %	1,27 %	44,46 %	25,68 %	31,88%

The ratio between local resident population and (tourism including) equivalent resident population was calculated for each month of the period 2013 - 2015. Equivalent resident population represents the sum of local residents and tourist equivalent residents (calculated dividing the number of monthly overnight stays by the number of days per months).

7.3.2 Identification of months of high and low tourism season for the Kavala, Ponta Delgada and Santander

The months of the low tourism season were defined by separately calculating the overnight stays per day for each pilot case for every months of the period 2013 – 2015. All months with an under-average (annual) number of overnight stays per day were counted as a low season and those with an above-average number of nights were counted as high tourism season. Table 12 presents an overview on tourism seasonality for the year 2015 for Kavala, Ponta Delgada and Santander. Because of too little monthly variation it was not possible to define tourism seasonality for Adeje, Arona and Puerto (all three forming Tenerife pilot case) by using this approach.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

Table 12: Tourism seasonality in 2015 in Kavala, Ponta Delgada and Santander (2015)

Month	Kavala	Ponta Delgada	Santander
1	low	low	low
2	low	low	low
3	low	low	low
4	low	high	low
5	low	high	high
6	high	high	high
7	high	high	high
8	high	high	high
9	high	high	high
10	low	high	high
11	low	low	low
12	low	low	Low
Comments: Kavala: Same seasonality for 2013-2015. Ponta Delgada: In 2013 and 2014, April was low season. Santander: In 2013, May and October was low season.			

7.3.3 Estimation of waste generation from local residents and tourists respectively (in kg / local resident and kg / overnight stay)

The estimations for the generation of residual waste by local residents (excluding tourism) and tourists respectively are presented in Figure 46 (Kavala), Figure 47 (Ponta Delgada) and Figure 48 (Santander).

- Monthly generation of residual waste in Kavala ranges from about 28 to 34 kg per local resident (2013 - 2015). Monthly waste generation from tourism ranges from 0(*) to about 2 kg per local resident.
- Monthly generation of residual waste in Ponta Delgada ranges from about 33 to 37 kg per local resident (2013 - 2015). Monthly waste generation from tourism ranges from 0(*) to about 8 kg per local resident.
- Monthly generation of residual waste in Santander is about 26 kg per local resident (2013 - 2015). Monthly waste generation from tourism ranges from 0(*) to 3 kg per local resident.

(*) negative values were excluded. They result from using average values for calculation.

Due to the fact that the share of tourists compared to local resident population is very small even in months of high tourism season (< 5 %), translating the results for kg residual waste from tourism per local resident into kg per overnight stay in most cases does not produce any useful results. For Kavala, for example, translating the maximum value for monthly waste generation from tourism per local resident (1,69 kg / local resident) into kg per overnight stay would result in 26,77 kg per overnight stay, which is very unrealistic. The share of tourists compared to local resident population in this case is only 0,2 %. For Ponta Delgada and Santander, translating the maximum value for monthly waste generation from tourism per local resident (7,71 and 3,47 kg / local resident) into kg per overnight stay results in 6,79 and 4,28 kg per overnight stay, which seem to be more realistic values. The share of tourists compared to local resident population for the last two examples is 2,13 % and 2,55 % respectively. In any case, these examples highlight that it is not possible to draw any significant conclusions about the influence of tourism on waste generation as the influence of tourism possibly is superimposed by statistical background noise in waste generation data.

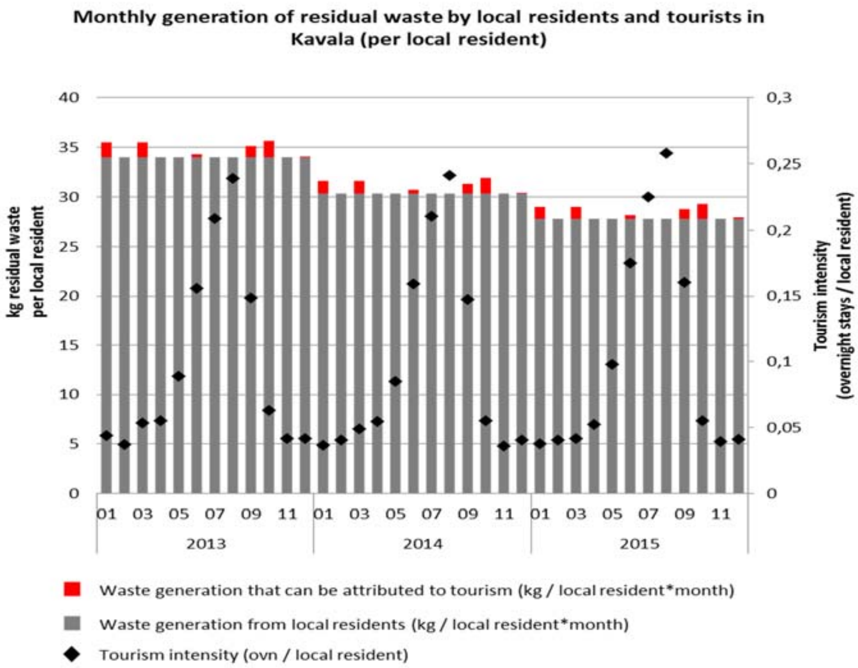


Figure 46: Monthly generation of residual waste by local residents and tourists in Kavala (2013-2015)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

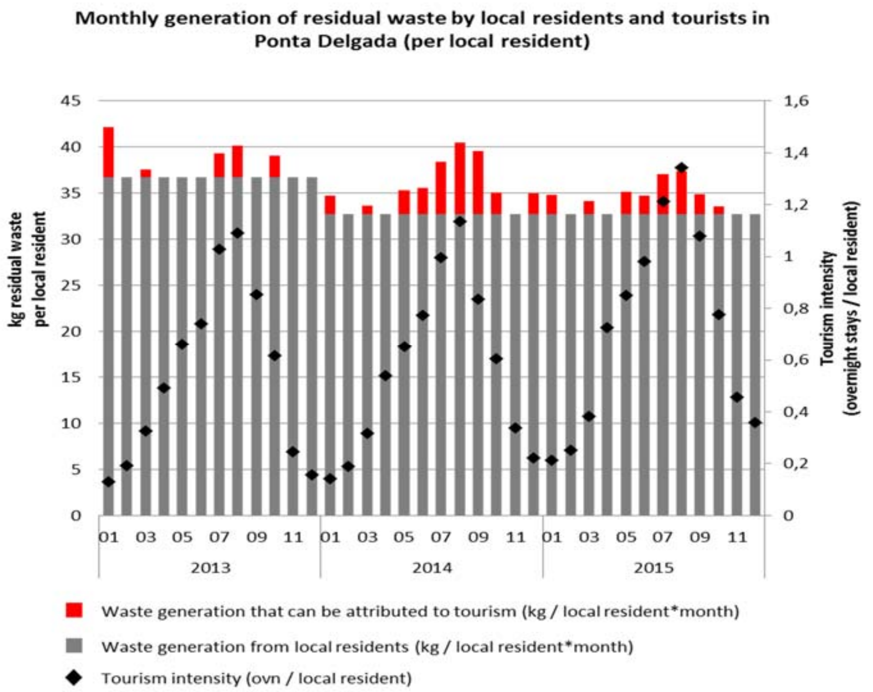


Figure 47: Monthly generation of residual waste by local residents and tourists in Ponta Delgada (2013-2015)

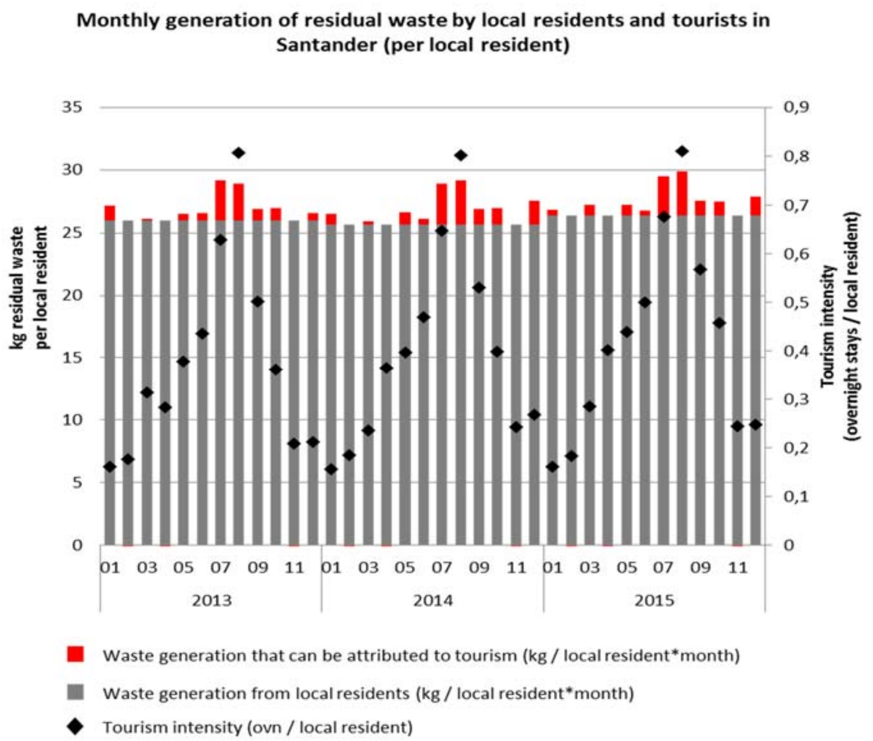


Figure 48: Monthly generation of residual waste by local residents and tourists in Santander (2013-2015)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

7.3.4 Results of statistical analysis of data using linear regression

Statistical analysis was done for the URBANWASTE pilot cases **Kavala, Ponta Delgada, Santander and Tenerife** as only for those pilot cases the available data was suitable for such an analysis. The data used represent the **monthly data on residual waste generation and tourism intensity (overnight stays/local resident) from 2013 – 2015 (i.e. n = 36 for each pilot case)**.

Tenerife pilot case was analysed in two different ways: In a first step (TEN_aggr), aggregated data (i.e. sum of the three municipalities) was used. In a second step (TEN_reg), the individual data sets of Adeje, Arona and Puerto de la Cruz were combined for analysis. In comparison, using individual data allowed an analysis of 108 data points instead of only 36 as in the case of using aggregated data.

Although it is known that data quality on waste generation in Kavala during summer is bad (Chapter 7.2), it could safely be assumed that there would be a peak in residual waste in summer months in case the waste recording would be correct. Therefore, it was decided to include Kavala into this analysis but exclude the months April, July and August for each year of the period 2013-2015 (n = 27) as those months seem to be the ones in which waste amounts have not been recorded every day.

For statistical modelling and in-depth analyses, the software "R" was used. The **linear regression model** used is described in Equation 3:

Equation 3: Linear regression model

y = a + b*x

y … dependent variable (total residual waste generated per month)

a … Intercept (non-touristic waste per month)

b … Tourism waste per overnight stay

x … independent variable (number of overnight stays per month)

An overview on the results is given in Table 13. Figure 49 to Figure 53 show the correlation between per capita residual waste generation and tourism intensity, the regression line as well as the confidence and prediction bands at 95 % for all analysed pilot cases. For Kavala and Ponta Delgada only 0,7 % and 16 % respectively of the variance of data is explained. These results cannot be considered to be reliable for estimating tourism's impact on waste generation. For the remaining pilot cases Santander and Tenerife, R^2 seems high enough to produce useful results. However, with an R^2 ranging between 0,5 (TEN_aggr) and 0,6 (SAN) still only a low proportion of the variance in tourists' waste generation is explained compared to analysing the three municipalities on Tenerife separately (TEN_ADE, ARO, PTO; R^2 = 0,88).

Considering only results with sufficiently high R^2 values (**SAN, TEN_aggr and TEN_ADE, ARO, PTO**) shows that tourists' residual waste generation amounts from about 1,6 to 6 kg per overnight stay. Whereas **residual waste generation of about 1,6 – 2,1 kg per overnight stay** seem to be a realistic value that is also fitting perfectly to the range of waste production per overnight stay reported in various studies that were included in the

This project has received funding from the European Union's Horizon 2020 research
and innovation programme under grant agreement No 690452

literature review performed at the beginning of this project (0,58 – 2,39 kg waste per tourist and day with an average of 1,76 kg; Ramusch et al., 2017), 6 kg residual waste per overnight stays seems highly unrealistic. However, having only 36 data points available for one pilot case still is too few to identify tourism's impact on waste generation.

Table 13: Results of statistical analysis using linear regression (residual waste)

Pilot Case	R^2	kg waste from tourists per ovn (b)	Confidence Intervals (95 %) Lower band (2,5 %)	Confidence Intervals (95 %) Upper band (97,5 %)	Non-touristic waste per resident per month (a)
KAV	0,007	5,029	-19,543	29,600	30,512
PON	0,157	3,358	0,641	6,075	33,242
SAN	0,573	5,984	4,184	7,785	24,472
TEN_aggr	0,503	2,102	1,374	2,829	27,996
TEN_ADE, ARO, PTO	0,881	1,632	1,517	1,748	35,251

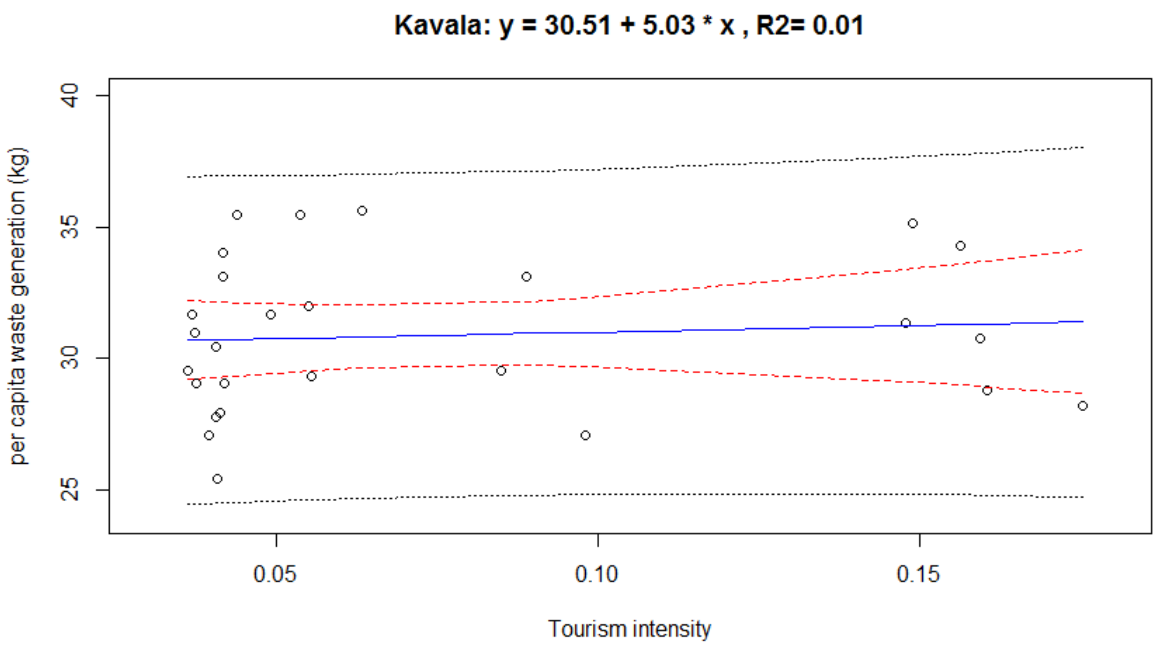


Figure 49: Influence of tourism intensity on waste generation in Kavala. N = 27. Confidence and prediction bands at 95 %.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

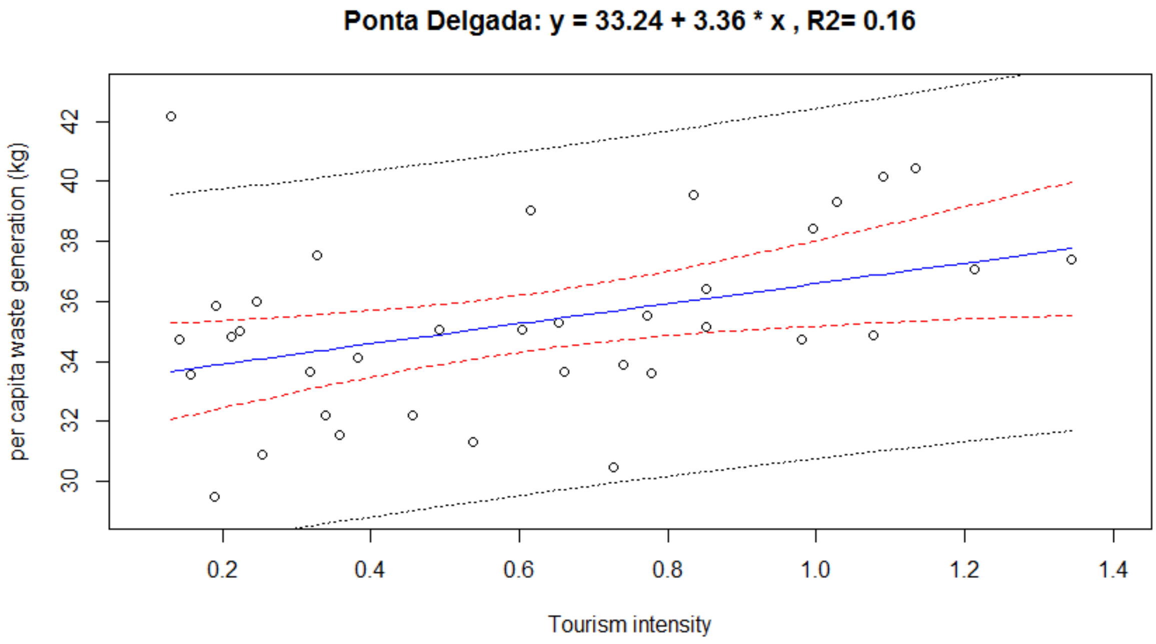


Figure 50: Influence of tourism intensity on waste generation in Ponta Delgada. N = 36. Confidence and prediction intervals at 95 %.

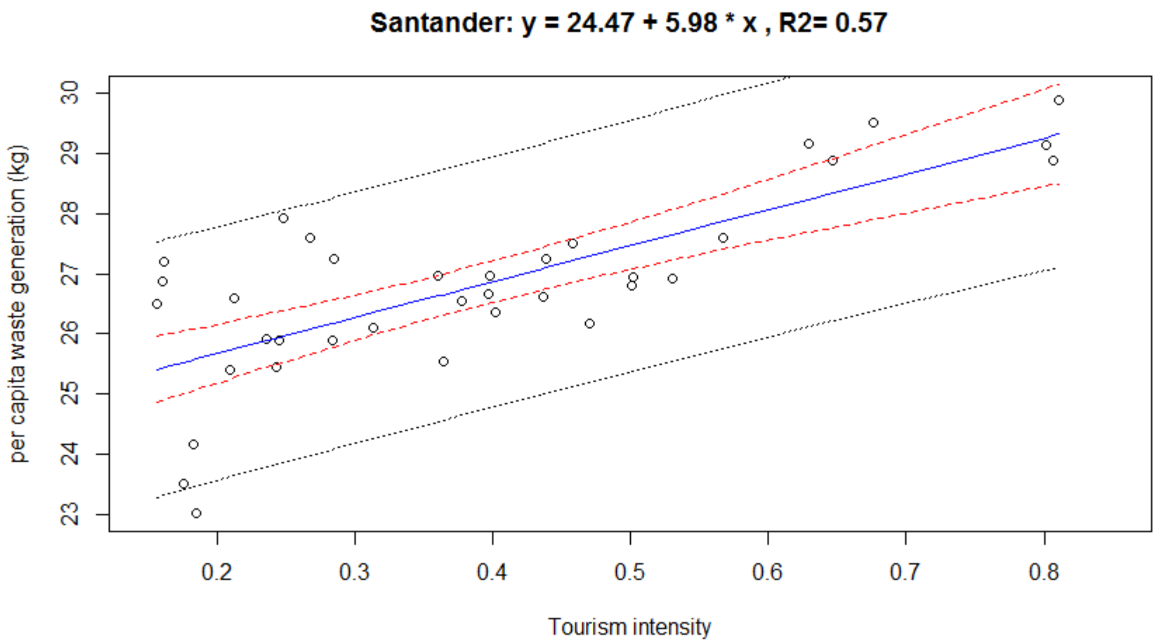


Figure 51: Influence of tourism intensity on waste generation in Santander. N = 36. Confidence and prediction intervals at 95 %.

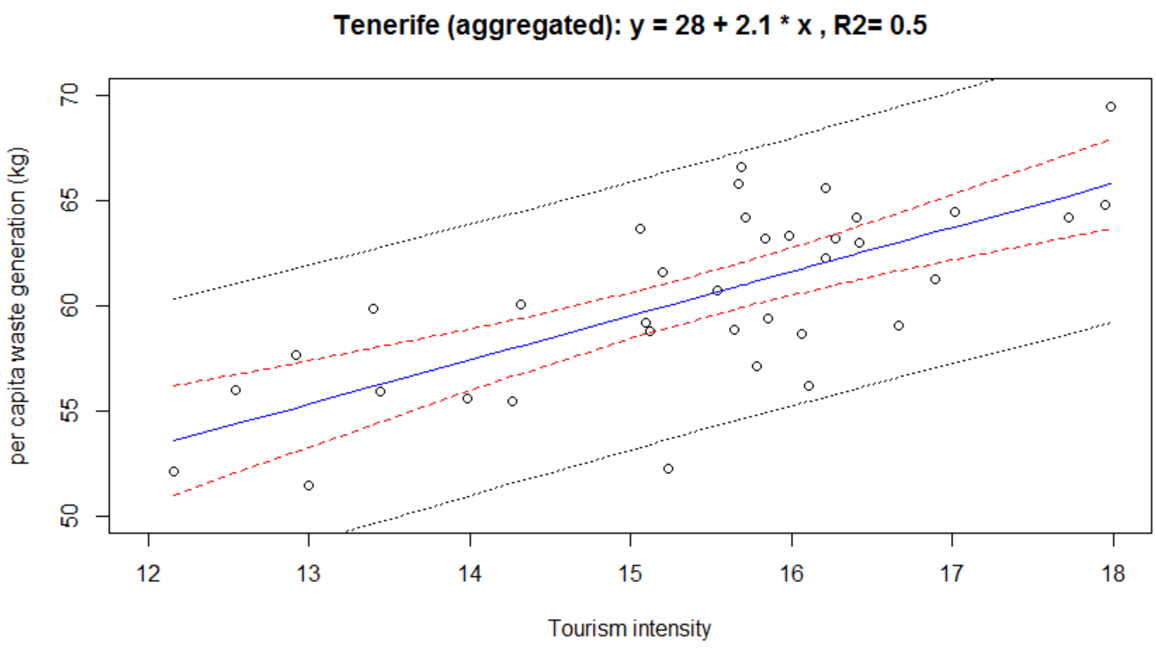


Figure 52: Influence of tourism intensity on waste generation in Tenerife (aggregated). N = 36. Confidence and prediction intervals at 95 %.

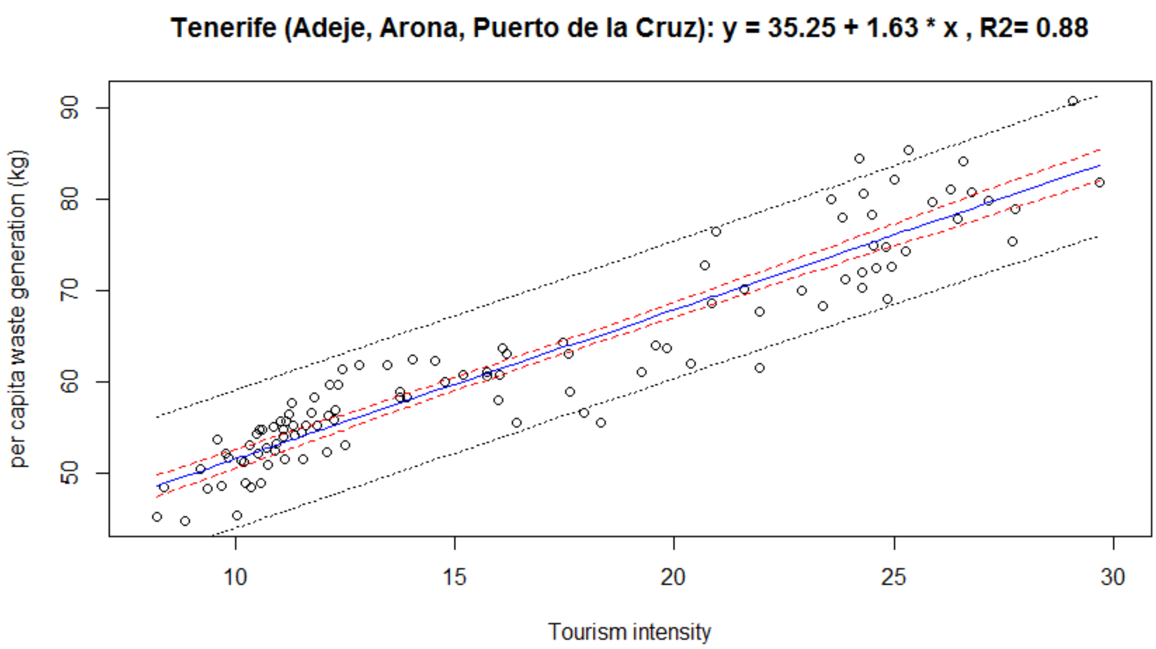


Figure 53: Influence of tourism intensity on waste generation in Adeje, Arona & Puerto de la Cruz (separate data for the three municipalities forming Tenerife pilot case). N = 108. Confidence and prediction intervals at 95 %.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

7.3.5 Waste generation from hotels in Copenhagen

For Copenhagen data on municipal waste generation was not suitable for being analysed using linear regression models. However, for this pilot case, data on the total amount of waste from hotels and restaurants is available. In the period 2011-2015, waste generation from hotels and restaurants in Copenhagen was in the range of 1,8 – 2,8 kg waste per overnight stay and 24,0 – 33,8 kg per local resident and year respectively (Table 14). The results for Copenhagen not only fit perfectly to the results from the applied linear regression models, but also into the range of waste production per overnight stay reported in the literature review reported in D2.1 (0,58 – 2,39 kg waste per tourist and day with an average of 1,76 kg; Ramusch et al., 2017).

Table 14: Waste generation from hotels and restaurants in Copenhagen (2011-2015), per overnight stay and per local resident and year

Waste from hotels and restaurant	Tourism intensity	kg / OVN	kg / local resident
2011	0,8	2,8	33,8
2012	0,8	2,3	29,9
2013	0,8	1,8	24,0
2014	0,7	2,2	30,3
2015	0,7	2,0	30,1

7.3.6 Conclusions regarding tourism's impact on waste generation

The descriptive statistical analysis used to identify dataset and waste streams that are suitable for being analysed in detail regarding tourism's impact on waste generation revealed that **effects on waste generation caused by touristic activities only were visible when monthly data was used**. Using annual data for this purpose did not produce any useful results. This might be due to the fact that for each pilot case – in the best case of data availability – a maximum of 16 data points was available for analysis or because in aggregated annual data the effects of high and low tourism season are levelled out.

For different reasons, neither of the URBANWASTE pilot cases that could provide monthly data on waste generation as well as on the number of nights spent by tourists turned out to be suitable to be analysed applying the model outlined by Ofner (2011) to separately calculate per capita waste generation per tourist and per local resident. For the three municipalities located in Tenerife, there is too little seasonal variation in the number of overnight stays to use the seasonal average of amounts generated in months of low tourism season as an estimation for waste generation by local residents. For Kavala, Ponta Delgada and Santander, seasonal variation in tourism intensity would be strong enough for applying this model, but the share of tourists compared to local residents is much lower than the usual seasonal fluctuation in waste data between months. This situation does not allow for drawing any significant conclusions about the influence of tourism on waste generation as results might be outweighed by other influencing factors.

Statistical analysis using linear regression models could only be performed for **Kavala, Ponta Delgada, Santander and Tenerife** as only for those pilot cases was the available data suitable for such an analysis. The results for relating residual waste generation from tourists per overnight stay to local residents (for the respective pilot case) are presented in Table 15.

This project has received funding from the European Union's Horizon 2020 research
and innovation programme under grant agreement No 690452

Table 15: Tourist waste generation related to local residents

Pilot Case	kg waste from tourists per ovn and months(b)*	Tourism intensity (OVN / local resident) (2000-2015**)	Kg per local resident and month
COP+	1,8 – 2,8	0,7 – 0,8	2 – 2,8
TEN_aggr	2,102	160,33 - 189,48	336,94 - 398,2
TEN_ADE	1,632	263,71 - 306,57	430,43 - 500,38
TEN_ARO		102,8 - 130,19	167,79 - 212,5
TEN_PTO		149,57 - 174,85	244,13 - 285,39

* results from statistical analysis using linear regression models, **as far as data is available, + COP not calculated but waste from hotels collected separately (data from 2011 – 2015)

Considering only results with sufficiently high R^2 values (TEN_aggr and TEN_ADE, ARO, PTO) shows that tourists' residual waste generation amounts from about **1,6 – 2,1 kg per overnight stay**. Figures from Copenhagen, where waste from hotels is separately collected, are in the same range. These results fit perfectly to the range waste production per overnight stay reported in various studies that were included in the literature review performed at the beginning of this project (0,58 – 2,39 kg waste per tourist and day with an average of 1,76 kg; Ramusch et al., 2017).

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

8. Environmental, social and economic assessment of status quo

Gudrun OBERSTEINER (Environmental impacts), **Mattias ERIKSSON** (Environmental impacts of organic waste treatment), **Trine BJØRN OLSEN** (Social and economic impacts)

A cornerstone of sustainable development is the establishment of affordable, effective and truly sustainable waste management. It must be emphasized that multiple public health, safety and environmental benefits accrue from effective waste management practices which concurrently reduce Greenhouse Gas (GHG) emissions and improve the quality of life, promote public health, prevent water and soil contamination, conserve natural resources and provide renewable energy benefits (Cherubini et al. 2009). Within the following chapter an assessment of environmental, social and economic impacts of existing waste management in the pilot cases shall point out hotspots and relevant issues concerning future measures and necessary activities to improve the existing system focussing on waste generation by tourist activities.

8.1 Environmental impact on climate change

Tourism nowadays is one of the most important industries in the world economy. Since estimates outline a consolidation of this trend, an accurate identification and assessment of the environmental impacts related to the life cycle of tourist activities is increasingly necessary (De Camillis et al., 2010). A detailed review and comparison of existing Life Cycle Assessment (LCA) case studies in the tourism sector showed that, at the one hand, the number of existing studies is limited and, at the other hand, most of existing LCA studies do not include waste management aspects in their system boundaries. (De Camillis et al., 2010) summarised that out of ten studies four mainly focussed on the construction sector and six focussed on travel issues beside accommodation and service.

Contrarily, the focus of this investigation is laid on the impact of tourist activities on waste generation and waste management. One main objective of WP 2 is to analyse the present situation of waste management in the selected URBANWASTE pilot cases ("the baseline") in terms of environmental impacts.

As it could be shown in previous chapters, for most of the pilot cities the influence of tourism on waste generation can hardly be proved mainly because of the lack of data. At the other hand, the success of implemented measures will not be reflected in the whole management system as during the project period no really big changes are possible. Therefore, the assessment of waste prevention and recycling measures will be performed for the concrete implemented pilot cases within WP 7.

The aim of this status quo assessment is to provide a general picture on the environmental impact of current waste management practice in the pilot cities and regions to point out actual hotspots and provide information on which activities - from an environmental point of view under the existing circumstances - the focus should be laid.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

As it could be shown in previous chapters, there is not only one possibility for proper waste management, but in fact each country and also each city has their own solution based on the different framework conditions. There are some **main issues to be taken into account when assessing the environmental impact of tourist activities in terms of waste management**:

- **Availability of data**: most of the waste generated from tourists will end up in hotels, restaurants or other tourist accommodations. In some pilot cases the waste of such service institutions is collected separately and ends up as commercial waste, while in others it is collected together with household waste and ends up as municipal solid waste, in some cities there is a mixture of both implemented. Therefore, as shown already in Chapter 3 and 4, used data have to be interpreted with care.
- **Treatment of residual waste**: depending on the disposal pathway of residual waste (especially if there is any treatment applied or the waste ends up in the landfill) the waste generated in general but of course also the waste generated by tourists has more or less negative environmental impacts.
- **Share of recyclables**: at the other hand, the proportion of waste that is separately collected and recycled also influences the environmental impact of tourist`s waste related behaviour.
- **Separate Collection/Treatment of organic waste**: a separate collection and recycling of organic waste will result in very high savings in terms of global warming potential.

Based on these circumstances specific measures on waste prevention and recycling will have different relative environmental impacts. As organic waste has a very high potential to influence the overall environmental performance of waste management it will be discussed in a separate chapter. In the following section the input parameters for the Life Cycle Assessment are described.

8.1.1 Input Parameter for Life Cycle Assessment (excl. organic waste)

The status quo assessment of waste management in the selected pilot cities was performed based on standard technology as under the existing framework no detailed analysis of specific technologies used is possible. Different treatment options for residual waste and recycling activities have to be taken into account.

In Figure 54 the qualitative composition of produced MSW is shown in terms of percentage (%): In most URBANWASTE pilot cases the share of separate collected recyclables is still very low. But the figures are in-line with country related figures.

This project has received funding from the European Union's Horizon 2020 research
and innovation programme under grant agreement No 690452

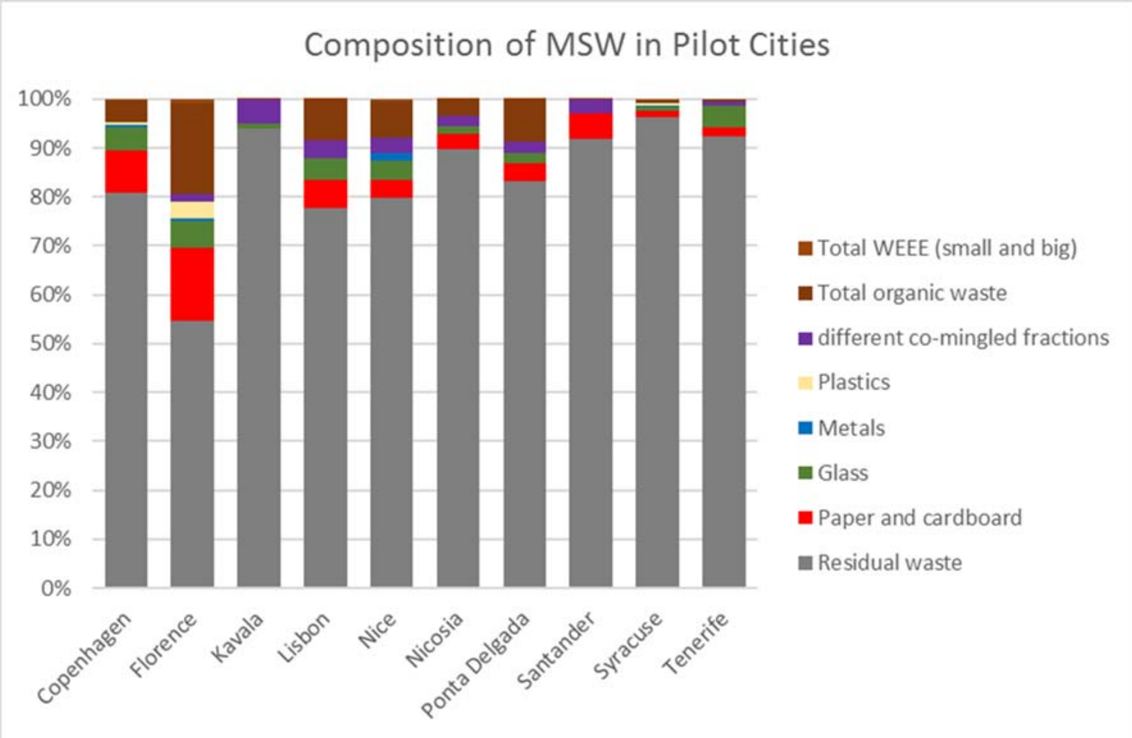


Figure 54: Composition of MSW in Pilot Cases in 2015

After being collected, the waste flows undergo different treatment and disposal processes including Mechanical **Biological Treatment (MBT)**, **Waste-to- Energy (WTE) plants** or direct **landfilling** with or without gas collection. **Recycling** is modelled also with **standard technology**. In most of the cities pilot cases, recyclables are collected as co-mingled fraction in different composition. As for the final recycling, the mixture has to be sorted and each fraction is recycled separately the total amount of collected co-mingled recyclables was allocated to the respective fraction according to mean values from those cities were each fraction is collected separately as well as mean values from benchmarking cities (Table 16)

Table 16: Waste composition of collected amounts used for Life Cycle Assessment co-mingled fractions allocated to different recyclables

waste management	Copenhagen	Dubrovnik	Florence	Kavala	Lisbon	Nice	Nicosia	Ponta Delgada	Santander	Syracuse	Tenerife
Residual waste	81,1%		55,3%	93,9%	77,8%	80,1%	89,7%	83,1%	91,8%	96,8%	92,5%
Paper and cardboard	8,7%		15,8%	3,9%	5,9%	3,7%	3,3%	3,7%	5,3%	1,3%	1,7%
Glass	4,7%		5,9%	1,1%	4,4%	4,0%	1,5%	2,1%	2,2%	0,8%	4,3%
Metals	0,4%		0,6%	0,2%	0,6%	2,1%	0,3%	0,4%	0,2%	0,0%	0,3%
Plastics	0,5%		3,8%	0,8%	3,0%	2,7%	1,7%	1,9%	0,5%	0,6%	0,6%
Total organic waste	4,6%		18,7%	0,0%	8,4%	7,4%	3,6%	8,8%	0,0%	0,4%	0,6%

As the goal of the study was not to do a comparison between cities and absolute environmental impact of waste management in each pilot case is not relevant for future decisions (as this is depending mainly on the size of the city) only relative impacts based on the waste generation per capita were used. Therefore, the **functional unit** of the LCA modelling is the treatment and recycling of kg waste produced per capita in the respective pilot case.

For Dubrovnik Neretva County no detailed waste data were available and general recycling level in Croatia is low and was around 4 % in 2010. Because of missing data no LCA could be performed for Dubrovnik.

The **Energy** used for waste management facilities as well as substituted energy by energy production from waste incineration or biogasification was taken as published in the latest Energy datasheets (EU Commission, 2017).

8.1.2 Organic Waste Input Parameter for LCA

This analysis used an attributional life cycle assessment to calculate the global warming potential (GWP100) of current waste management options used in 11 URBANWASTE pilot cases. The aim was to achieve a comparable value of the emissions from the current waste management regarding organic waste. The **functional unit** was set to **1 kg of organic waste** and the system boundaries are further described for each involved process.

The **common process** that was modelled in the same way for all waste scenarios was **transport from the city to the place where the organic waste is treated or disposed**. This waste is in some cities collected separately and in some as part of a mixed waste stream, and the transportation from the city to the waste treatment had many potential routes. In order to simplify the calculations of transportation, the distances were set to equal the distance from the city centre to the place where the waste is treated or disposed. The waste was assumed to be transported with a truck 7.5-16 t with a EURO3 engine, which according to Ecoinvent (2017) emits 0.21 kg CO2e/tkm. For some cities this distance was set to 0 km since the treatment facility is located within the city borders.

The mixed organic waste was assumed to have the same properties as in Zhang et al. (2005) with a content of volatile solids of dry matter (VS) of 74 % and a total solid (TS) content of 87 %. The waste was also assumed to have an energy content of 6 MJ/kg of waste.

In each pilot city, one or several organic waste treatment methods were applied according to Bjørn Olsen et al. (2017). However, here we only considered the major treatment methodologies and neglected the impact of small scale anaerobic digestion and home composting even though such actions take place. To determine the characteristics of each investigated city the descriptions in Bjørn Olsen et al. (2017) was used and supplemented with specific questions to representatives for waste management organizations in each municipality. For the cities that had two major treatment pathways in place the share for each treatment was decided based on Bjørn Olsen et al., (2017) where Nice was assumed to have 90 % incineration and 10 % composting, Tenerife 54 % composting and 46 % landfill, and Santander with 50 % each for anaerobic digestion and composting. The different waste treatment methods modeled in the same way for each city independent of local variation, and according to the following descriptions based on Eriksson et al. (2015).

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

Table 17: Summaries of the processes assessed with focus on waste treatment option and what can be substituted in a system expansion. Only the major waste management option has been included in the calculation

City	Transport distance (km)	Waste treatment (Small scale alternatives in italic)	Share (%)	Product	Substitution
Copenhagen	0	Incineration		Electricity and district heating	Coal
Dubrovnik	15 km	Landfill		no	Nothing
Florence	6 km	Anaerobic treatment with composting		Biogas and digestate	Diesel, Mineral fertilizer
Kavala	10 km	Landfill		No	Nothing
Lisbon	17 km	Anaerobic treatment with composting		Biogas and digestate	Diesel, Mineral fertilizer
Nice	0 km	Incineration	90%	Electricity and district heating	Coal
		Composting	10%	Compost	Mineral fertilizer, peat
Nicosia	27 km	Landfill		no	Nothing
Ponta Delgada	10 km	Landfill with gas collection		Burned gas	Nothing
Santander	35 km	Anaerobic digestion	50%	Biogas and digestate	Diesel, Mineral fertilizer
		Composting	50%	Compost	Mineral fertilizer, peat
Syracuse	5 km	Landfill		No	Nothing
Tenerife	5 km	Compost	54%	Compost	Mineral fertilizer, peat
		Landfill with gas collection	46%	Biogas	Diesel

Landfill

At the landfill, the machinery costs for maintaining and compacting the landfill were assumed to be 21 g CO_2e/kg organic waste, in line with the results reported by Nilsson (2012). Methane production was calculated in accordance with Equation 5 for the anaerobic digestion scenario. Since organic waste include a lot of food products with easily available nutrients, it was assumed that half the carbon would be converted to methane and the rest oxidised into carbon dioxide (Björklund, 1998). Of the methane produced, it was assumed that 15 % would be captured in landfill and oxidised into carbon dioxide, in accordance with Björklund (1998). The produced landfill gas could be treated in three different ways in the pilot cities, captured and used for energy production, captured and flared or not handled at all so that the methane would leak out to the atmosphere. For the two alternatives where the gas was captured, 50 % of the land fill gas was assumed to leak out to the atmosphere but the rest was burned, either substituting diesel for energy production or without substituting anything when flared.

The assessment in this or any other scenario did not include production of machinery, construction or maintenance of buildings or any emissions related to the labour force.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

Composting

Machinery for production of windrows, the composting process and production of soil amendment was assumed to correspond to 42 g CO_2/kg composted waste. This included machinery usage, but no emissions from the compost. The compost process was assumed to give an output of compost with a mass corresponding to 40 % of the input waste (Andersen, 2010). This compost was assumed to replace peat as a soil amendment in a system expansion where the peat production gave rise to 2 kg CO_2e/kg of peat. In line with Andersen (2010), the compost was not assumed to completely replace peat in a 1:1 ratio. However, since there was a higher need for compost in some of the pilot cities it was assumed that 80 % of the compost replaced peat, which is higher than the 50 % in Andersen (2010).

Incineration with energy recovery

In this scenario, the food waste was assumed to be used in a large scale combined heat and power plant for waste incineration. The incinerated waste was assumed to substitute coal based on energy content. The substituted coal was assumed to have a specific emissions factor of 97 g CO_2e/MJ (Gode *et al.*, 2011). The lower heating value (LHV) was used for the organic waste which was calculated using Equation 4 (Alvarez, 2010), where the higher heating value (HHV) and water content (W) values were calculated from the VS/TS content and the constant from Alvarez (2010).

Equation 4: Lower heating value (LHV)

$$\mathrm{LHV} = HHV(1 - W) - 2.447 * \mathrm{W}$$

It can be assumed that the incineration plants use flue gas condensation to extract heat from moisture in the flue gases, meaning that the energy recovered from the incinerated waste should actually be higher than the LHV, however this was not included in the calculations.

Anaerobic digestion

The potential production of methane from the organic waste was calculated using Equation 5, where the theoretical potential methane production (Nm^3 CH_4) was determined by the percentage TS and percentage (VS) and specific production factor (Nm^3 CH_4/ton VS). The literature value (Carlsson & Uldal, 2009) for fruit and vegetable waste (0.666 Nm^3 CH_4/kg VS) was used for the mixed organic waste. Equation 5 gives the theoretical potential methane production and in reality this can be difficult to achieve. However, since much of mixed organic waste included discarded food products containing easily available nutrients, it was assumed that the entire theoretical yield was actually produced. The only loss of yield was assumed to be 1 % of organic waste that was sorted out with the packaging and the loss of 3.5 % dry matter that ended up in the digestate based on the reporting by Uppsala Vatten (2013).

Equation 5: Potential production of methane from organic waste

$$Nm^3\ CH_4 = DM * VS * \frac{Nm^3\ CH_4}{ton\ VS}$$

To produce biogas, the plant requires heat and electricity. Here it was assumed that the produced biogas was used to cover the internal energy use reducing the yield with 20 %. The product of the anaerobic digestion process was biogas, which was assumed to replace diesel as a fossil fuel used for marginal electricity production. The diesel emissions replaced were assumed to be 82.3 g CO_2/MJ (Eriksson & Ahlgren, 2013). Digestate produced in the biogas plant replaced production of nitrogen fertiliser. The substituted production of fertiliser was assumed to use natural gas as an energy source and, according to Ahlgren *et al.* (2010), production of mineral fertiliser emits 2.41 kg CO_2e/kg N. The amount of fertiliser replaced was based on the assumed nitrogen content of the organic waste. Mineral phosphorus emitting 3.6 kg CO_2e/kg P (Linderholm *et al.*, 2012) was also replaced by the digestate, with an average P-content of 12.7 g P/kg DM (Uppsala Vatten, 2013). Since the digestate was composted in several of the pilot cities the emissions of transportation were not included. However, methane leakage both from the anaerobic digestion plant and emissions from stored digestate was assumed to correspond to 2 % of he produced methane that was emitted to the atmosphere.

8.1.3 Results and Discussion (excl. organic waste)

Global Warming Potential caused by waste generation and waste management activities differs widely between the different pilot cases (Figure 55). The big differences can be explained by two main issues. First of all, the amount of waste generated: It can be assumed that the more waste is generated the higher is the environmental impact. Second influencing factor is the existing waste management system: Different waste treatment measures produce different emissions and therefore have different environmental impacts. It also has to be taken into account, that recycling and also incineration of waste often has in total positive impacts as the production of energy out of waste or the production of secondary good leads to environmental benefits as the use of primary resources (e.g. fossil fuel) can be saved. These savings are expressed in negative values in diagrams. (Figure 56). As only generic data have been used for the modelling, certain uncertainties have been taken into account as results might be a little bit worse or even better depending on the technology used.

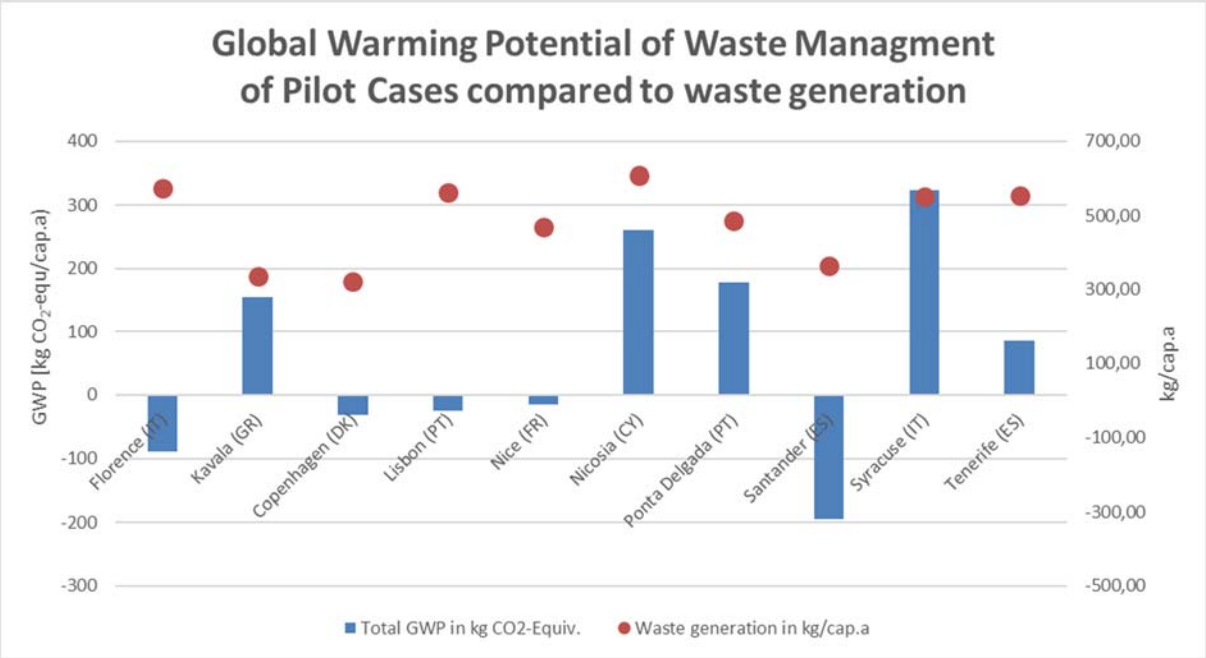


Figure 55: Global Warming Potential of waste management in pilot cases per capita and year

According to the results, while landfilling has been confirmed as the worst waste final disposal alternative, composting and material recovery showed the best performance. An integrated system (MRF, composting, incineration and landfilling) is considered as a solution towards improved sustainability to overcome the existing waste management problems.

Figure 55 shows the overall Global Warming Potential per capita and year caused by waste generation and treatment for each pilot case. Negative values result from savings (credits) given to the use of secondary goods (products and energy) because of substitution of primary resources (for e.g. metal or plastic production) and fossil fuel (for energy production).

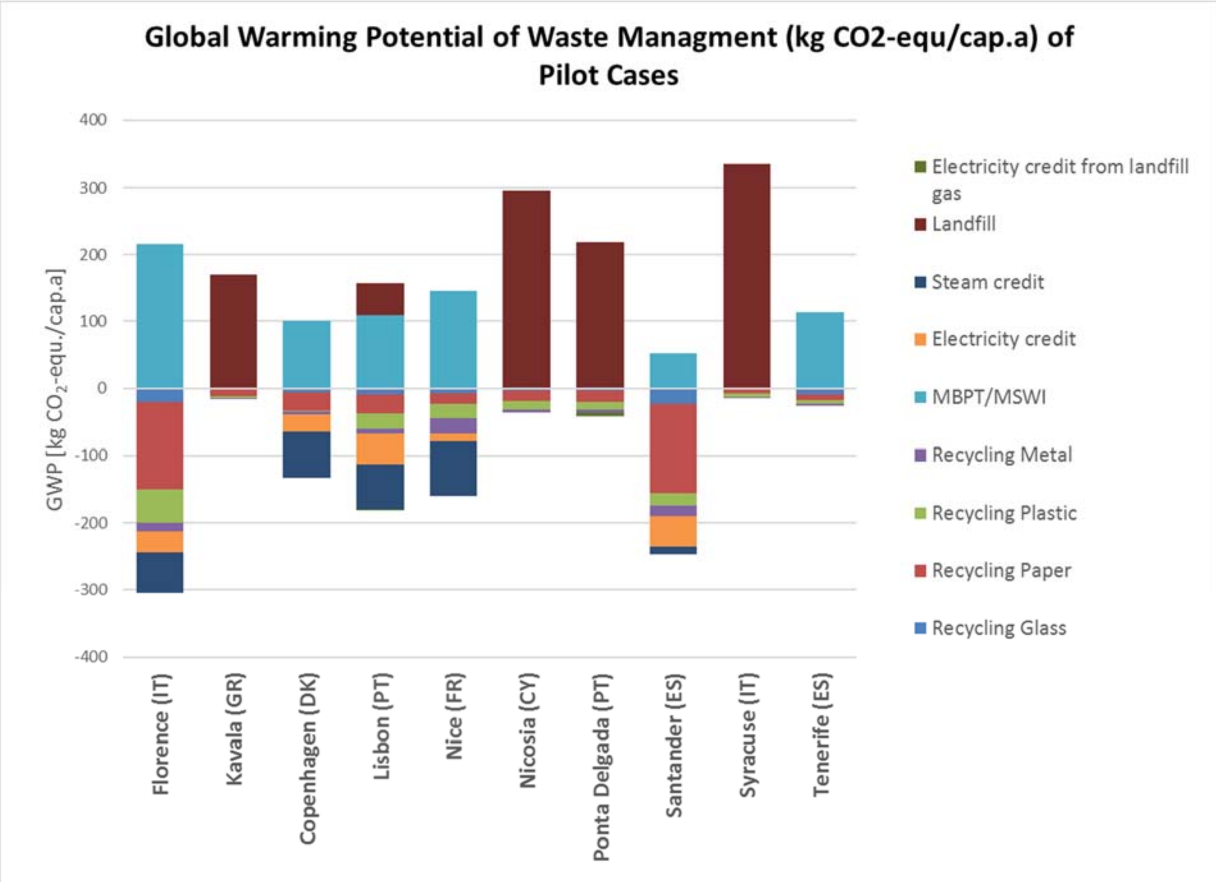


Figure 56: Global Warming Potential of waste management in pilot cases per capita and year (2015)

Looking at the results of Global Warming Potential per capita and year in detail (Figure 56) especially the benefits of recycling activities (e.g. in Florence and Santander) at the one hand and the negative impacts of landfilling but also of waste treatment can be seen.

Excluding the impacts caused by waste generation and focussing on the relative impacts per pilot case the results are a little bit different. As can be shown in Figure 57, in four pilot cases (Kavala, Nicosia, Ponta Delgada and Syracuse) environmental impacts from waste management are dominated by landfilling activities. Additionally, comparably high impacts could be shown for Tenerife, where the waste is treated before landfilling but no energy use of the high calorific fraction takes place as it is the case in Florence for example.

For all other pilot cases savings because of recycling activities are at least in the same range as environmental impacts caused by waste treatment because of direct emissions or energy use. Savings or negative values result from the methodological approach to assume that the use of e.g. secondary plastic or paper or the use of energy produced out of waste substitutes primary resources or energy produced out of fossil fuel.

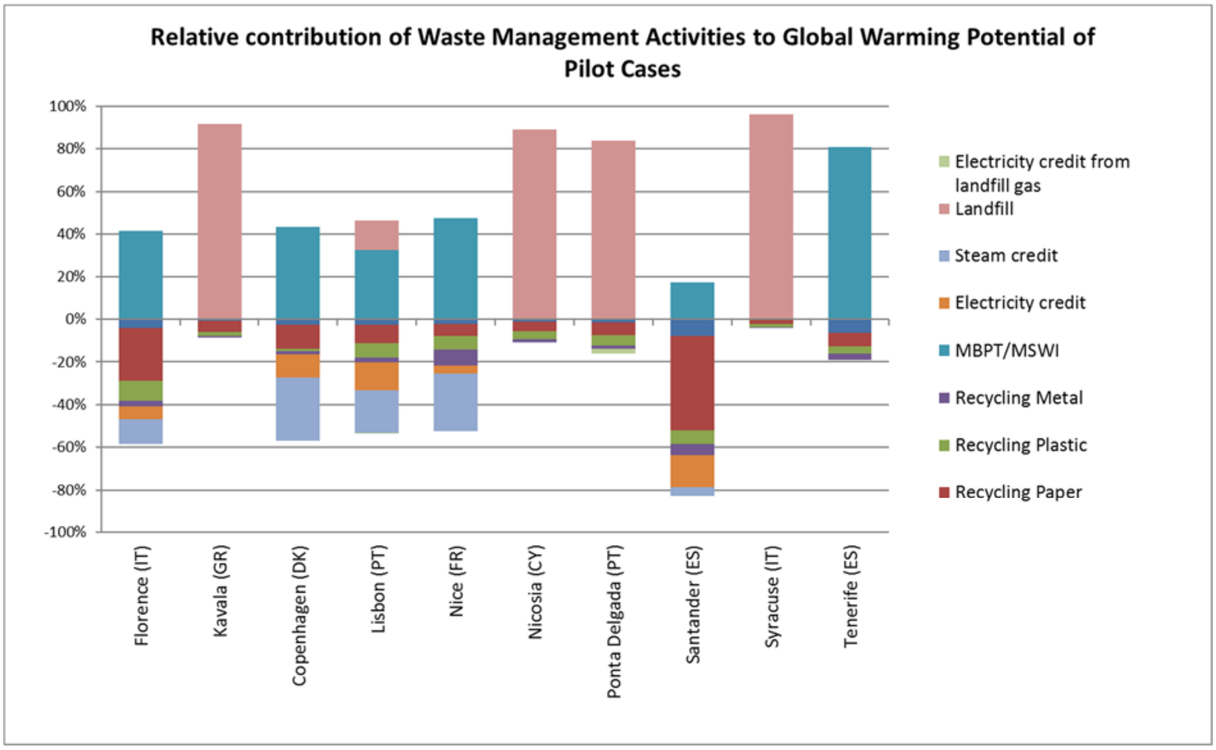


Figure 57: Relative contribution to Global Warming Potential of waste management activities of pilot cases

Depending on the actual waste management framework in the pilot cases specific measures would therefore have more or less positive impacts on Global Warming Potential caused by waste management activities in general and produced by tourists in the specific case.

The member countries of the European Union (EU) are required to implement waste management systems that comply with a hierarchy of options, over the following order of priority: prevention (in waste generation), preparing for reuse, recycling, other types of recovery (including energy) and, finally, disposal (Directive on Waste, 2008/98/EC of the European Parliament and Council of 19th November 2008). Moreover, sending biodegradable organic matter to landfill must be phased out gradually, in line with the targets set out by the Directive on the Landfill of Waste 1999/31/EC of the Council of 26th April 1999. Nevertheless, despite improved legislation and regulatory systems, public acceptance of the location of new waste disposal and treatment facilities is still very low, due to concerns about adverse effects on the environment and human health. Focus is therefore laid on the issue of organic waste in the following chapter.

This project has received funding from the European Union's Horizon 2020 research
and innovation programme under grant agreement No 690452

8.1.4 Organic waste – Results

The performance of organic waste treatment evaluated in terms of greenhouse gas emissions is highly dependent on the treatment used. This is clear from Figure 58 where landfilling organic waste generates the most greenhouse gases due to methane leakage from the anaerobic process taking place within the landfill. Therefore, any successful attempt to reduce the methane leakage will have a significant impact on the waste treatment outcome. This is clear from the scenarios where landfill gas is captured and either used for energy production (i.e. Tenerife), or just burned to produce the less potent greenhouse gas carbon dioxide (i.e. Kavala and Ponta Delgada). However, in this study we assumed that even if there was gas collection in place only 50 % of the landfill gas was captured, which is a rough assumption highly influencing the results.

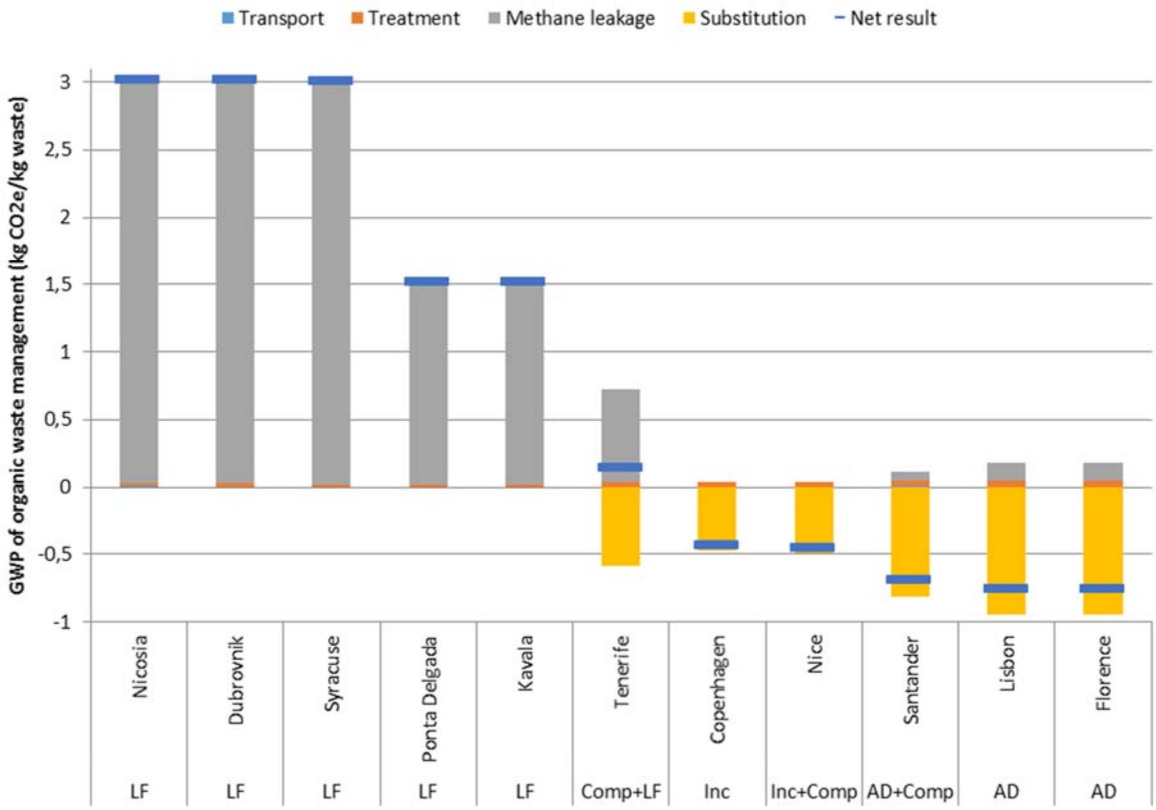


Figure 58: Performance of organic waste treatment in the 11 URBANWASTE pilot cases evaluated in terms of greenhouse gas emissions. The results for each pilot city sorted after the net GHG emissions from organic waste treatment correspond well to the waste hierarchy presented in Eriksson (2015). The waste treatment options included are Landfill (LF), Composting (Comp), Incineration (Inc) and Anaerobic digestion (AD).

Besides the leakage of methane, the most important process in this analysis is the substitution of other products or services which includes fossil fuels and mineral fertilizers. This reflects the fundamental idea of energy recovery and nutrient recycling since the use of virgin material can be avoided by using waste as a resource. However, from the results in Figure 58 it is clear that the most important factor for an efficient

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

energy/nutrient recovery and the avoidance of methane leakage is to have proper infrastructure in place in order to treat the organic waste accordingly.

The results fit well to the findings in Laurent et al. (2013a; b) where a similar hierarchy was established based on an extended literature review. However, since the outcome can depend highly on local characteristics, which only have been considered to a small extent in this study, the results should be interpreted with caution.

8.1.5 Conclusions

Especially for pilot cases without any existing treatment of residual waste to reduce the environmental impact of waste management, the focus should be laid on separate collection and subsequent treatment of food waste (as a relevant fraction of organic waste is resulting from tourist activities) as this is the main reason for negative impacts of landfilling in terms of Global Warming Potential.

As it turned out that in most of the pilot cases the contribution of tourists to the overall waste generation in the year is not that big, general changes in the collection system of recyclables to improve the collection and treatment of waste from tourist activities cannot be expected. Therefore, the focus in terms of waste prevention and recycling should be laid on measures that assist existing systems. Only the separate collection of organic waste can be seen as one major issue that can be implemented easy on hotel level and would have major impacts at least in all those pilot cases without existing waste incineration or mechanical biological pre-treatment of residual waste or organic waste treatment.

Within Deliverable D2.7 (Gruber & Obersteiner, 2017) identified waste prevention and management strategies have been categorised into

- well-known policy instruments mainly based on information and awareness building,
- provision of infrastructure (e.g. bins for separate collection of food waste),
- regulatory instruments (e.g. ban of plastic bags),
- economic instruments,
- voluntary agreements (e.g. use of returnable containers).

Both waste management and prevention practices in pilot cases as well as international best practice focus on food and beverage provision to tourists. Also the environmental assessment of status quo in pilot cases came to the same conclusion that **prevention and recycling of food waste** should be the priority to focus on. Especially in cities where no separate collection of organic waste is implemented yet and residual waste is landfilled without prior treatment like **Kavala, Nicosia, Ponta Delgada, Syracuse** and **Dubrovnik,** most waste prevention measures shall deal with food waste prevention as well as food waste management like:

- selective collection of organic waste for recycling in tourist areas and subsequent composting activities, either at the point of waste generation or centralised, as well as the production of biogas from organic waste;
- separate collection and use of cooking oils.

Both measures could be implemented without changing the whole waste management system in the respective pilot case and composting facilities are comparably cheap compared to e.g. incinerators. The much

This project has received funding from the European Union's Horizon 2020 research
and innovation programme under grant agreement No 690452

better way of course would be to focus on **food waste prevention** which might be implemented by measures described in Gruber & Obersteiner (2017). In general, measures like the following could be implemented:

- side dishes on request;
- 'doggy bags';
- offering smaller portions;
- smaller units for buffets (Less placed out, but refilled more often).

Connected to activities concerning food waste are all measures reducing mixed packaging waste that normally cannot be recycled very well like **cups of coffee to go or other disposable dishes**.

Although no statistical significant relation between tourism and plastic waste generation could be shown measures relevant for pilot cases with existing separate collection of plastic waste **like Lisbon, Nice, Nicosia, Ponta Delgada or Santander** could be the **installation of public drinking water fountains** (and accompanying information measures) that encourage tourists to refill their empty plastic drinking bottles, thus, reducing PET-bottles waste. Also the provision of **refillable drinking bottles as giveaway** including specific information on waste prevention could be a possibility. Florence´s and Copenhagen's separate collection of plastic and also water fountains are good examples.

As it could be shown especially the generation of glass packaging waste is related to tourism intensity. **Implementation of re-useable packaging** (if available) especially for restaurants could be a promising measure.

Besides activities dealing with food and food waste, the **promotion of re-use activities** shall also be kept in mind as a promising topic to reduce tourist waste generation. Most identified international best practice examples connected to tourist waste management also refer to eco labelling and connected guidelines to foster waste prevention at hotels.

8.2 Social Impact

Trine BJØRN OLSEN

For assessing the social aspects of waste generation related to touristic activities in the 11 URBANWASTE pilot cases it has been decided to use Social Life Cycle Assessment (SLCA). SLCA was developed from the ISO 14040 and 14044 standards, thus sharing its methodological approach with LCA, which is used for the assessment of the environmental impact of waste generation related to touristic activities in the URBANWASTE project.

Like LCA, SLCA represents a holistic approach for social assessment of products and services throughout their life cycle. The SLCA displays both positive and negative impacts and opposing results may occur when applying SLCA and LCA for the same system/scenario. Furthermore, the results of both approaches are very dependent on geographic location. The UNEP & SETAC guidelines for SLCA define five main stakeholder categories: Workers, local community, society, consumers and value chain actors with associated impact categories, subcategories and indicators (Figure 59).

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

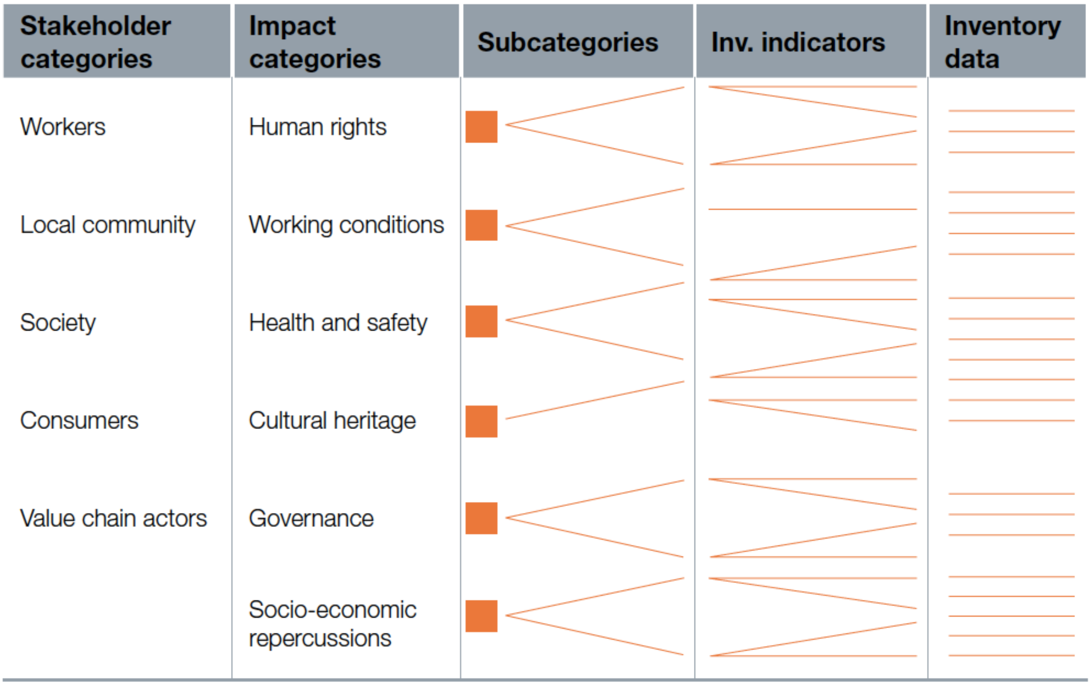


Figure 59: SLCA assessment system from categories to unit of measurement (UNEP & SETAC, 2009)

However, not all subcategories and indicators in the guidelines are relevant in a European context. Also the process of retrieving data for **SLCA** is very time consuming, and in consideration of the resources and timeframe of the project it therefore was decided to limit the social assessment to the **stakeholder categories** "**workers**", "**local community**" and "**society**".

Social indicators for the stakeholder group "**workers**" according to Jørgensen et al. (2008) can be expressed by e.g.:

- **Wages**, including equal remuneration on diverse groups, regular payment, length and seasonality of work and minimum wages;
- **Benefits**, including family support for basic commodities and workforce facilities;
- **Physical working conditions**, including rates of injury and fatalities, nuisances, basal facilities and distance to workplace;
- **Psychological and organizational working conditions**, such as maximum work hours, harassments, vertical two-way communication channels, health and safety committee, job satisfaction and worker contracts;
- **Training and education** of employees.

Social indicators for "**society**" and "**local community**" according to Jørgensen et al. (2008) can be defined by e.g.:

- **Development support and positive actions towards society**, including job creation, support of local suppliers, investments in research and development, infrastructure, and local community education programs;
- **Local community acceptance**, such as complaints from society, and presence of communication channels;
- **Ensuring of commitment to sustainability issues** from and towards business partners.

Such detailed data collection is only possible on a company level (or later on the level of concrete waste prevention measures) and not on the city or pilot case level. Therefore, data collected within the WP 2 and WP 3 surveys on the status quo situation only included usable data for local unemployment. Table 18 shows how social assessment regarding workers and society/local community in the pilot areas can be set up in an SLCA framework:

Table 18: An SLCA framework for stakeholder categories "workers" and "society/local community"

Stakeholder category	Subcategory	Indicator	Unit	Data
Workers	Fair salary	Minimum wages	quant. e.g. [€/month]	Not included in status quo survey
		The lowest paid workers are considering their wages meet their needs	quant. or semi-quant.	Not included in status quo survey
	Hours of work	Average hours of work (at each level of employment)	quant. e.g. [hours/week]	Not included in status quo survey
		Share of seasonal workers	quant. e.g. [%]	Not included in status quo survey
	Equal opportunities / Discrimination	Composition of governance bodies and breakdown of employees per category according to gender	quant. e.g. [%]	Included in status quo survey, but data are not representative
		Presence of formal policies on equal opportunities	Qualitative	Not included in status quo survey
	Social benefit / social security	Social benefits for workers (e.g. health insurance, child care, pension fund, education, accommodation etc.)	Qualitative	Not included in status quo survey
Society & local community	Local employment	Unemployment rate	quant. e.g. [%]	Pilot survey data ID [35]
		Employees in waste management	quant. e.g. [number]	Pilot survey data ID [18]
		Employees in tourist establishments	quant. e.g. [number]	Not included in status quo survey
	Access to material resources	Does the organization have a certified environmental management system	Qualitative	Survey data are not representative
	Technological development	Involvement in R&D activities	Qualitative	Not included in status quo survey
		Training and education of employees	Qualitative	Not included in status quo survey

Many of the above mentioned indicators aim at describing specific social aspects depending on specific company issues not relevant on the city level and therefore were not contained in the status quo surveys

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

performed within Work Packages WP 2 and WP 3 of this project. Also, most social assessment data are qualitative, which makes it difficult to weigh the indicators and to link them with functional units in a consistent way. The indicators used in the URBANWASTE project have to allow the display of impacts on a local level in order to guide the local decision makers. Therefore, only very general, individual indicators in terms of jobs have been selected for this first social assessment of the status quo situation in the pilot areas.

Table 19: Social assessment of status quo situation in terms of jobs

Subcategory	Inventory indicator	Copenhagen	Dubrovnik	Florence	Kavala	Lisbon	Nice	Nicosia	Ponta Delgada	Santander	Syracuse	Tenerife	Unit	Data source
Local employment	Unemployment rate, local	6,4	16,8	7,7	20,2	10,2	13,5	10,4	12,8	17,6	25,7	n/a	[%]	Pilot survey data ID [35], (year 2015)
	Unemployment rate, national (for comparison)	6,2	16,1	11,9	24,9	12,6	10,4	15,0	12,6	22,1	11,9	22,1	[%]	http://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&language=en&pcode=tsdec450&plugin=1 (year 2015)
	Employees in waste management	n/a	n/a	481	130	1.112	506	118	64	341	266	n/a	[n]	Pilot survey data ID [18], (year 2015)

As seen in Table 19 there is a **significant difference in employment rates** in the 11 pilot areas reflecting the dependency on geographical location. Also there are differences in whether the local unemployment rate lies above or below the national level in the pilot areas. In Florence, Kavala, Lisbon, Nicosia and Santander the local unemployment rate is significantly lower than the national average. Conversely, in Nice and Syracuse the local unemployment rates are significantly higher than the national average. In Copenhagen, Dubrovnik and Ponta Delgada the local unemployment levels are on a par with the national average. The highest unemployment rates are seen in Kavala and Syracuse, while the lowest unemployment rates are seen in Copenhagen and Florence.

Regarding the number of employees, the surveys only contain data on the **number of employees in waste management**. The number of waste workers per 1.000 inhabitants varies from 0,7 in Nicosia to 7,5 in Florence. However, without additional information on, for example, the number of employees in the tourism industry and on the working conditions such as hours of work, share of seasonal work and minimum wages it is difficult to interpret the significance of these differences and, thus, to give an accurate insight into the impact of tourism on the job situation in the pilot areas. National data for comparison of minimum wages, working hours and seasonal work could, for example, be retrieved from the EUROSTAT and OECD.stat databases.

Another indicator that may have an indirect influence on local employment is the extent of the organizations' involvement in development activities and education which can help increase the quality of services and enhance the professional competences of the employees.

Regarding **gender distribution**, nine case study partners returned data on the gender distribution of jobs in waste management for their respective areas. Because different areas use different categories for defining jobs, and because case studies have different responsibilities for waste management/handling, it is not possible to draw comparisons. However, in the majority of cases, men dominate professional and managerial roles (five (Florence, Nicosia, Nice, Santander, Syracuse) out of nine; in one (Tenerife) it was gender equal, and operations (in all of the three case studies – Florence, Lisbon and Santander, - which reported on this). Women dominate administrative roles in two of the three case studies (Florence and Ponta Delgada; Santander had more male administrators) which reported this. Dubrovnik/DUNEA and Kavala did not produce a breakdown of jobs by gender.

In order to support the development of scenarios for new eco-innovative and gender sensitive waste prevention and management solutions it would be useful to add more specific indicators that can display a coherence between the environmental conditions and development in terms of local employment later in the impact assessment.

Assessing the perception of the pilot case and the tourist industry's performance in relation to waste management is a way of associating social and environmental aspects. These data were collected in the survey performed within Work Package WP 3 and detailed information can be found in URBANWASTE project report "D3.2 - Situation and behavioural analysis of consume and waste behaviour and patterns" (De Luca et al., 2017). However, the results are not discussed in this section about the social aspects of the status quo assessment as this assessment solely relates to jobs.

Since local communities and organizations share the interest of access to material resources, assessing the extent of recognized eco-labelling schemes among organizations is another way of linking environmental and social aspects (UNEP & SETAC, 2013). The extent of eco-labeled tourist accommodations was included in the WP 2 survey, but only one pilot case provided this data. Thus, this indicator cannot be used for analysis and comparison of the pilot cases.

8.3 Economic Impact

Trine BJØRN OLSEN

As reported in the URBANWASTE project report "D2.2 - Methodology framework document as guidance for accompanying assessment" (Ramusch et al., 2016a), for the assessments to be performed within this project a set of methods was identified that is suitable to answer URBANWASTE specific questions. For assessing economic impacts, the method of Ecological Efficiency (EE) together with other cost-related methods such as CBA and LCC seemed to be most suitable.

Ecological-efficiency (EE) is a simple and flexible method to show environmental "value for money" of different strategies and measures. EE is defined as the relationship between economic performance and environmental impact, thus linking environmental impacts with monetary costs in a way that is easy to communicate and be understood.

Equation 6: Ecological Efficiency(EF)

$$eco - efficiency = \frac{environmental\ influence}{economic\ performance}$$

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

For the subsequent impact assessments in the project it has been suggested to apply principles from **Life Cycle Costing (LCC)** and possibly **Cost Benefit Analysis (CBA)** to obtain a more detailed description of scenarios and measures that can support the local decision-making in the pilot areas.

LCC aims to assess all costs throughout the life cycle of a product or service. However, in the URBANWASTE project it will only be possible to use the principles from LCC in a very simplified form and only on limited sections of the waste system. Focus should be kept on the most important environmental, social and economic consequences of the strategies and measures that will be developed during the project and therefore any data sets for costs and revenues must be well-defined, accessible and suitable to represent the scenarios. Internalizing environmental and social costs is very challenging and often these costs are hard to quantify, which should also be taken into consideration in regard of the time frame and resources of the project.

CBA can illuminate the pros or cons of a decision from a financial point of view. By attributing social and environmental conditions to economic value they are converted into monetary units, which can then be assessed and compared with each other. Due to the complexity of urban waste systems, sensitivity analyses should also be performed in order to prevent simplification of cause and effect linkages. Since the actual implementation of the URBANWASTE strategies and measures might happen at different times it could also be necessary to convert the impact costs into current prices. However, the societal perception of the importance of environmental and social aspects can be very different and therefore a subject to political discussion.

From the initial status quo survey performed within Work Package WP 2 only few and very general economic data are widely available in the URBANWASTE pilot areas: GDP per capita, turnover of the tourism industry and municipal expenditures for cleaning of public spaces (Table 20).

Table 20: Overview on general economic data available in the 11 URBANWASTE pilot cases. [1)] Data from 2012. [2)] Data from 2014. [3)] Italic indicates national level values, i.e. local data are not available.

Inventory data (2015)	Copenhagen	Dubrovnik	Florence	Kavala	Lisbon	Nice	Nicosia	Ponta Delgada	Santander	Syracuse	Tenerife	Unit	Pilot survey data ID
GDP per capita	63.493[1)]	10.177[2)]	31.783	13.651	64.010	n/a	*20.806*[3)]	15.383	20.847	n/a	n/a	[€ per capita]	[30]
Turnover of the tourism industry total	2.900	*7.950*	n/a	12	2.708	5.855	*2.112*	38	*119.011*	n/a	994	million [€]	[38]
Municipal expenditures for cleaning of public spaces	8,07M	n/a	20.569	2,51M	2,96M	n/a	740.071	601.578	17,50M	3,85M	n/a	[€]	[19]
Population	580.295	122.568	378.174	70.501	504.471	536.327	55.014	68.768	173.957	122.503	n/a	[number]	[36]
Total number of tourist arrivals at tourist accommodation establishments	8,50M	n/a	3,59M	165.499	3,78M	2,264M	85.407	294.570	1,76M	214.278	n/a	[number]	[43]

Based on these data it is possible to calculate some very simple **ratios to describe the economic importance of the tourism industry relative to waste management costs** in the pilot areas: The turnover in tourism industry

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

per capita, the ratio of tourism industry turnover relative to GDP, turnover in the tourism industry per tourist arrival at accommodation establishment, municipal costs for cleaning of public spaces per capita and the ratio of municipal expenditures for cleaning public spaces relative to the tourism industry turnover (Table 21).

Table 21: Ratios to describe the economic importance of the tourism industry relative to waste management costs in the 11 URBANWASTE pilot cases. [1)]Italic indicates national level values, i.e. local data are not available

Indicators	Copenhagen	Dubrovnik	Florence	Kavala	Lisbon	Nice	Nicosia	Ponta Delgada	Santander	Syracuse	Tenerife	Unit	Used pilot survey data ID
Turnover of the tourism industry per capita	4.997	*1.872*[1)]	n/a	167	5.368	9.574	*2.494*	549	*2.562*	n/a	n/a	[€ per capita]	[38] ------- [36]
Ratio of tourism industry turn-over relative to GDP	7,9%	18,4%	n/a	1,2%	8,4%	n/a	12,0%	3,6%	12,3%	n/a	n/a	[%]	[30]*[36] ------------- [38]
Turnover in tourism industry per tourist arrival at accommodation establishment	341	n/a	n/a	71	716	2.586	n/a	128	n/a	n/a	n/a	[€ per arrival]	[38] -------- [43]
Expenditures for cleaning of pub-lic spaces per capita	14	n/a	n/a	36	6	n/a	13	9	101	31	n/a	[€ per capita]	[19] --------- [36]
Ratio of expendi-tures for clean-ing of public spaces relative to tourism indu-stry turnover	0,3%	n/a	n/a	21,2%	0,1%	n/a	0,5%	1,6%	3,9%	n/a	n/a	[%]	[19]*[36] --------- [38]

As visible in Table 21, the importance of tourism relative to GDP varies from 1,2 % (Kavala) to 18,4 % (Dubrovnik). In general, **tourism has a relatively high economic impact in more pronounced tourist areas** such as Dubrovnik, Nicosia and Santander **compared to capital areas** such as Copenhagen and Lisbon.

Differences are also seen in the ratio of expenditures for cleaning of public spaces relative to the tourism industry turnover. It is noted that particularly Kavala holds very high cleaning expenses relative to the tourist industry turnover (21,2%). As possible explanation for this result it could be suspected that since Kavala's (and for that matter Greece's) GDP per capita is in the lower end of the European spectrum and the fact that the tourism industry traditionally is a low wage area, consequently, Kavala has the lowest turnover in tourism industry of all URBANWASTE pilot cases. Further, Kavala's waste management system is adjusted throughout the year in order to catch up with the fluctuations between high and low season for tourists, i.e. extra waste workers and equipment are hired for the summer season, which may be relatively costly. Also 57 % of the Kavala area is beach, which may mean that cleaning is relatively laborious.

Due to lack of data, identification of EE relationships between the cost of the waste management systems and the amount of waste fractions collected was very difficult. It has only been possible to express an eco-efficiency ratio in terms of collected street sweeping and expenditures for cleaning of public spaces in Copenhagen, Florence, Ponta Delgada and Santander. The ratios vary from 0,02 kg per € in Santander to 2,55 kg per € in

This project has received funding from the European Union's Horizon 2020 research
and innovation programme under grant agreement No 690452

Florence. One reason for the significant difference could be that Florence is characterized as metropolitan area, whereas 83 % of Santander is beach area which probably makes street sweeping considerably more laborious. However, the amount of collected street sweeping waste is not the best environmental indicator because it does not reflect to what extent the resources in the waste are preserved. For a more nuanced insight into the eco-efficiency (EE) of the waste systems in the pilot areas it would be necessary to have more specific economic data on reused and recycled waste fractions as well.

Although eight of the pilot cases could provide data on the waste management tax, the **tourism industry's costs in connection with waste management** could only be estimated for Nicosia stating an average cost of € 2.000 per tourist establishment. The reason why it has not been possible to estimate the tourism industry's costs in connection with waste in the other seven pilot cases is because **variable and widely different assessment basis units are used in the pilot areas for settling waste taxes for business customers**, e.g. container size [m^3], number of bins, waste volume [m^3], area of property [m^2], value of buildings per square meter, type of tourist establishment/with or without restaurant and even water consumption [m^3] and such specific data about tourist establishments were not collected. Consequently, it has only been possible to assess the municipalities' expenditures, hence the taxpayers' costs of cleaning of public spaces.

In addition, waste treatment costs, which also form a significant part of the waste management system, would be useful for assessing the economic impacts of waste generation related to touristic activities, but such data were not available from the status quo surveys (WP 2, WP 3). Further, for analysing these costs one has to bear in mind that these costs typically fluctuate more than costs for waste collection as especially market prices for recyclables tend to vary over time due to quality, supply and demand.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

9. Concluding Remarks

One issue arising within this Work Package was the issue of **reliable data**. In order to use the data of the pilot cases adequately, it is necessary to have reliable data. If such data are not available, those pilot cases had to be excluded from the evaluations within WP 2. Nevertheless, this procedure has no influence on the whole project as the implementation of pilot actions in the URBANWASTE pilot cases is not directly connected to the waste generation in the pilot case. What will be needed in later project stages is an estimation of the changes reached by the implemented pilot action. However, this aspect is relevant only for the pilot action and not for the whole city/municipality.

Trying to **analyse tourism's impact on waste generation** for all URBANWASTE pilot cases revealed that effects on waste generation caused by touristic activities only were visible when **monthly data** was used. Annual data might only be suitable for such an analysis in case available time series data covers a (much) longer period that only 2000 to 2015. For most pilot cases it was not possible to get reliable data for this period but only for a shorter time span starting 2004, 2008 or later. Thus, the number of data points was too small using annual data for identifying significant trends. Further, the influence of tourism on waste generation may be less visible in annual data. Especially for regions with a strong seasonality in tourism, the effect touristic activities have on waste generation is clearly visible in monthly data, whereas in annual data this effect is levelled out by aggregating data for both high and low tourism season.

Analysing tourism's impact on waste generation further highlighted the **importance of having data representing** (at least a high share of) **waste generated by tourist establishments such as hotels and restaurants**. Only for those URBANWASTE pilot cases where the available (monthly) data not only covered waste collected from households and public spaces, but also waste generated by tourist establishments was it possible to perform analyses to identify the impact of tourism on a region's waste generation by correlating waste amounts with the number of nights spent by tourists. For pilot cases providing monthly municipal waste collection data representing no or only a small share of all hotels in the pilot case area (e.g. Lisbon), the visible variation in waste generation is due to changes in behaviour of local residents or can be explained by a high number of local residents going on holidays in a specific month.

In general, monthly variation in waste generation may be caused by various reasons and not only tourist related factors. Changes in waste generation caused by local resident population (especially if the intensity of tourism compared to local resident population is low) often outweigh waste generation caused by tourists. This is even more the case if the analysed data does not cover hotels etc. as it can be assumed that the major part of tourists' waste generation occurs in tourist establishments. This insight is in line with the findings presented in URBANWASTE report "D2.1 - Literature Review on Urban Metabolism Studies and Projects" which identified "accommodation" and "food & beverage provision for tourists" as hotspots in terms of waste generation through touristic activities. Therefore, it can be concluded that **analysing tourism's impact on waste generation without having data covering waste generation in hotels seems to be difficult**.

Concerning **environmental impacts** caused by tourist waste generation it turned out that especially the **separate collection and treatment of food waste** is a major topic to reduce greenhouse gas emissions. Especially for pilot cases where no separate collection of organic waste is foreseen at the moment and residual waste is landfilled without prior treatment, focus of waste prevention and treatment activities has to be laid on food waste.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

The much better way of course would be to focus on **food waste prevention** which might be implemented by measures described in Gruber & Obersteiner (2017). Connected to activities concerning food waste are all measures reducing mixed packaging waste that normally cannot be recycled very well like "to go" cups or other disposable tableware.

Depending on existing separate collection of plastic, waste measures should focus either on the prevention of **PET bottles** e.g. by the installation of public drinking water fountains (and accompanying information measures) or reusable packaging or in optimising the separate collection (depending on relevant fractions) at least in tourist areas. As it could be shown especially the generation of glass packaging waste seems to be influenced by tourism. Implementation of re-useable packaging (if available) especially for restaurants could be a promising measure beside optimisation of separate collection.

Concerning **social and economic impacts** of tourists, the pilot case level seems not reasonable to be used as especially social impacts are only relevant on a smaller scale which would be relevant only after the implementation of waste prevention and management measures. Because variable and widely different assessment basis units are used in the pilot cases for settling waste taxes for business customers, it has not been possible to estimate the tourism industry`s costs in connection with waste in a satisfying way for all pilot cases.

10. References

Ahlgren, S., Bernesson, S., Nordberg, Å., Hansson, P.-A., 2010, Nitrogen fertiliser production based on biogas – Energy input, environmental impact and land use, Bioresource Technology 101, 7181–7184.

Alvarez, H, 2010, Energiteknik, Studentlitteratur, Lund.

Andersen, J., 2010, Composting of organic waste: quantification and assessment of greenhouse gas emissions, PhD thesis, Department of Environmental Engineering, Technical University of Denmark, Copenhagen.

Arcese, G. et al (2013): Social life cycle assessment as a management tool: Methodology for application in tourism, Sustainability 2013:5 pp. 3275-3287, DOI: 10.3390/su5083275

Beigl, P., Mackow, I., Mrowiski P., Salhofer, S., Schneider, F., Wassermann, G., 2003, Deliverable Report on D2.1: Draft Waste Generation Prognostic Model (Work package 2) of LCA-IWM - The Use of Life Cycle Assessment Tool for the Development of Integrated Waste Management Strategies for Cities and Regions with Rapid Growing Economies. FP7Project EVK4-CT-2002-00087

Björklund, A., 1998, Environmental systems analysis of waste management with emphasis on substance flows and environmental impact, Licentiate thesis, Department of Chemical Engineering and Technology/Industrial Ecology, Royal Institute of Technology, Stockholm.

Bjørn Olsen, T., de Luca, C., Eriksson, M., Große, J., Gruber, I., Kazeroni, M., Kovacs, E., Mayerhofer, J., Obersteiner, G., Ramusch, R., Romein, A., Zapata Aranda, P., 2017, Compendium of waste management practices in pilot cities and best practices in touristic cities, Urban Strategies for Waste Management in Tourist Cities, Government of Canary Islands, Las Palmas.

Caramiello, C., Fabbri, L., Marzi, M., Tatàno, F., 2009. Tourism impact on municipal solid waste: Elaborations for the case study "Adriatic Riviera" (Province of Rimini, Italy). WIT Transactions on Ecology and the Environment 122, 471-482.

Carlsson, M., Uldal, M., 2009, Substrathandbok för biogasproduktion [Substrate handbook for biogas production]. Report SGC 200, Svenskt Gastekniskt Center, Malmö.

Castellani, V., Sala, S., 2012. Ecological Footprint and Life Cycle Assessment in the sustainability assessment of tourism activities. Ecological Indicators 16, 135-147.

European Commission, 2010. International Reference Life Cycle Data System (ILCD) Handbook - General guide for Life Cycle Assessment - Detailed guidance. Joint Research Centre - Institute for Environment and Sustainability, Luxembourg.

De Camillis, C., Raggi, A., Petti, L., 2010. Tourism LCA: state-of-the-art and perspectives. International Journal of Life Cycle Assessment 15, 148-155.

De Luca, C., Perello, M., Romein, A., Louw, E., Fertner, C., Große, J., Buckingham, S. (2017): D3.2 - Situation and behavioural analysis of consume and waste behaviour and patterns. Report of the project URBANWASTE. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452, p. 119.

Denafas, G., Ruzgas, T., Martuzevicius, D., Shmarin, S., Hoffmann, M., Mykhaylenko, V., Ogorodnik, S., Romanov, M., Neguliaeva, E., Chusov, A., Turkadze, T., Bochoidze, I., Ludwig, C., 2014. Seasonal variation of municipal solid waste generation and composition in four East European cities. Resources Conservation and Recycling 89, 22-30.

Ecoinvent, 2017, Ecoinvent database version 3, Ecoinvent, Zürich.

EEA (2015) *EEA coastline for analysis*. https://www.eea.europa.eu/data-and-maps/data/eea-coastline-for-analysis-1. Accessed 1 June 2017

EEA (2016) *Corine Land Cover inventory Version 18.5*. http://land.copernicus.eu/pan-european/corine-land-cover/view. Accessed 8 April 2016

EEA (2017) *Natura 2000 data - the European network of protected sites*. Data reported in 2016. https://www.eea.europa.eu/data-and-maps/data/natura-8. Accessed 1 June 2017

Eriksson, M., 2015, Supermarket food waste - Prevention and management with the focus on reduced waste for reduced carbon footprint, Thesis 2015:119, Swedish University of Agricultural Science, Uppsala.

Eriksson, M., Ahlgren, S., 2013, LCAs for petrol and diesel - a literature review. Report 058, Department of Energy and Technology, Swedish University of Agricultural Science, Uppsala.

Eriksson, M., Strid, I., Hansson, P-A., 2015, Carbon footprint of food waste management options in the waste hierarchy – a Swedish case study, Journal of Cleaner Production, 93, 115-125.

EU Commission, D.E., Unit A4, 2017. Energy datasheets: EU-28 countries, in: EU Commission, D.E., Unit A4 (Ed.), <p class="MsoNormal" style="margin-bottom:0cm;margin-bottom:.0001pt;line-height: normal"> https://ec.europa.eu/energy/sites/ener/files/documents/CountryDatasheets_July2017.xlsx.

Eurostat (2015) *GEOSTAT 2011, GEOSTAT_grid_POP_1K_2011_V2_0_1.* http://ec.europa.eu/eurostat/web/gisco/geodata/reference-data/population-distribution-demography/geostat. Accessed 1 June 2017

Eurostat (2017): Annual data on trips of EU residents (tour_dem). Reference Metadata in Euro SDMX Metadata Structure (ESMS). Eurostat, the statistical office of the European Union. Available from: http://ec.europa.eu/eurostat/cache/metadata/en/tour_dem_esms.htm.

Fertner, C. & Große, J. (2017) *Ecosystem services and tourism in the URBAN WASTE pilot cities*. URBAN WASTE Deliverable Report 2.6.

Geofabrik (2017) *Data extract from OpenStreetMap project*. http://download.geofabrik.de. Accessed 16 June 2017

Gode, J., Martinsson, F., Hagberg, L., Öman, A., Höglund, J., Palm, D., 2011, Miljöfaktaboken 2011 - Estimated emission factors for fuels, electricity, heat and transportation in Sweden, Värmeforsk Service AB, Stockholm.

Gruber, I.; Obersteiner, G. (2017): D2.7 – Compendium of waste management practices in pilot cities and best practices in touristic cities. Report of the project URBANWASTE. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452, p.138.

Gruber, I.; Obersteiner, G.; Ramusch, R. (2016): D2.3 – Report on indicator sets and touristic processes. Report of the project URBANWASTE. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452, p. 68.

ITEP (2015): Report on Greek Tourism Hotel Performance 2014 (in Greek). Institute for Tourism Research and Forecasts (ITEP), Athens. Available from: http://www.grhotels.gr/GR/xee/ITEP/DocLib2/Greek-tourism_Hotel-performance_2014_Nov2015-Final.pdf (last accessed: 20.06.2017).

Jørgensen, A. et al (2008): Methodologies for social life cycle assessment, Journal of Life Cycle Assessment 13:2 pp. 96-103, DOI: 10.1065/lca2007.11.367

Laurent, A., Bakas, I., Clavreul, J., Bernstad, A., Niero, M., Gentil, E., Hauschild, M.Z., Christensen, T.H., 2013a. Review of LCA applications to solid waste management systems – Part I: lessons learned and perspectives. Waste Management, 34, 573-588.

Laurent, A., Clavreul, J., Bernstad, A., Bakas, I., Niero, M., Gentil, E., Christensen, T.H., Hauschild, M.Z., 2013b. Review of LCA applications to solid waste management systems – Part II: Methodological guidance for a better practice. Waste Management, 34, 589-606.

Linderholm, K., Tillman, A-M., Mattsson, J.E., 2012, Life cycle assessment of phosphorus alternatives for Swedish agriculture, Resources, Conservation and Recycling, 66, 27–39.

Nilsson, H., 2012, Integrating Sustainability in the Food Supply Chain - Two Measures to Reduce the Food Wastage in a Swedish Retail Store, Master thesis in Sustainable Development Nr. 94, Uppsala University and the Swedish University of Agricultural Science, Uppsala.

Ofner, H., 2011. Abfallaufkommen und Abfallsammlung in historischen Städten mit Tourismus. Diploma Thesis. University of Natural Resources and Life Sciences (BOKU), Vienna.

Ramusch, R.; Gruber, I.; Obersteiner, G. (2016a): D2.2 - Methodology framework document as guidance for accompanying assessment. Report of the project URBANWASTE. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452, p. 119.

Ramusch, R.; Obersteiner, G.; Gruber, I. (2016b): D2.1 - Literature Review on Urban Metabolism Studies and Projects. Report of the project URBANWASTE. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452, p. 135.

RHYNER, C., 1992. MONTHLY VARIATIONS IN SOLID-WASTE GENERATION. Waste Management & Research 10, 67-71.

Sala, S. et al (2015): Social Life Cycle Analysis – State of the art and challenges for supporting product policies, JRC Technical Reports, DOI:978-92-79-54055-4

Salhofer, S., Schneider, F., Obersteiner, G., 2007. The ecological relevance of transport in waste disposal systems in Western Europe. Waste Management 27, S47-S57.

Sammito, F. (2017): Written information received on 8th May 2017.

Sundquist, J-O., Baky, A., Carlsson, M., Eriksson, O., Granath, J., 2002, Hur ska hushållsavfallet tas omhand? – Utvärdering av olika behandlingsmetoder, B1462, IVL Swedish Environmental Research Institute, Stockholm.

UNEP & SETAC (2009): Guidelines for social life cycle assessment of products, United Nations Environmental Programme

UNEP & SETAC (2013): The methodological sheets for subcategories in social life cycle assessment (S-LCA), United Nations Environmental Programme

Uppsala Vatten, 2013, Miljörapport 2013 Biogasanläggningen vid Kungsängens gård [Environmental report 2013 for the biogas plant at Kungsängens gård], Uppsala Vatten, Uppsala.

Vinyes, E. et al (2013): Application of LCSA to used cooking oil waste management, Journal of Life Cycle Assessment 18 pp. 445-455, DOI: 10.1007/s11367-012-0482-z

Wikipedia (2017): Map of the municipalities of Kavala and Thasos. Available from: https://upload.wikimedia.org/wikipedia/commons/8/81/2010_Dimi_Kavalas_numbered.svg (last accessed: 03.07.2017).

Zhang, H., & Malczewski, J. (2017). Quality Evaluation of Volunteered Geographic Information: The Case of OpenStreetMap. In *Volunteered Geographic Information and the Future of Geospatial Data* (pp. 19-46). IGI Global.

Zhang, R., El-Mashad, H., Hartman, K., Wang, F., Liu, G., Choate, C., Gamble, P., 2007, Characterization of food waste as feedstock for anaerobic digestion, Bioresource Technology, 98, 929–935.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

11. Annex

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

11.1 Calculation of tourism adjusted resident population

Table 22: Details: Calculation of tourism adjusted resident population

2015	Number of tourism nights	National population	Number of residents' nights at home	National Ratio for residents' nights at home
Source	Eurostat [tour_dem_tntot]	Eurostat [demo_pjan]	National population * 365 - Number of tourism nights	National population * Number of residents' nights at home / Total resident nights per year
Denmark	5.627.235[1)]	5.659.715	1.940.908.706	93,95%
Germany	1.311.808.356	81.197.537	28.325.292.649	95,57%
Greece	57.439.268	10.858.018	3.905.737.302	98,55%
Spain	583.440.923	46.449.565	16.370.650.302	96,56%
France	1.113.942.857	66.488.186	23.154.245.033	95,41%
Croatia	42.224.340	4.225.316	1.500.016.000	97,26%
Italy	292.218.810	60.795.612	21.898.179.570	98,68%
Cyprus	16.157.068	847.008	293.000.852	94,77%
Austria	105.812.584	8.576.261	3.024.522.681	96,62%
Portugal	65.317.948	10.374.822	3.721.492.082	98,28%
Switzerland	132.166.305	8.237.666	2.874.581.785	95,60%

[1)] Data on number of tourism nights for DK from 2014

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

11.2 Waste generation in the pilot cases (2010 - 2015)

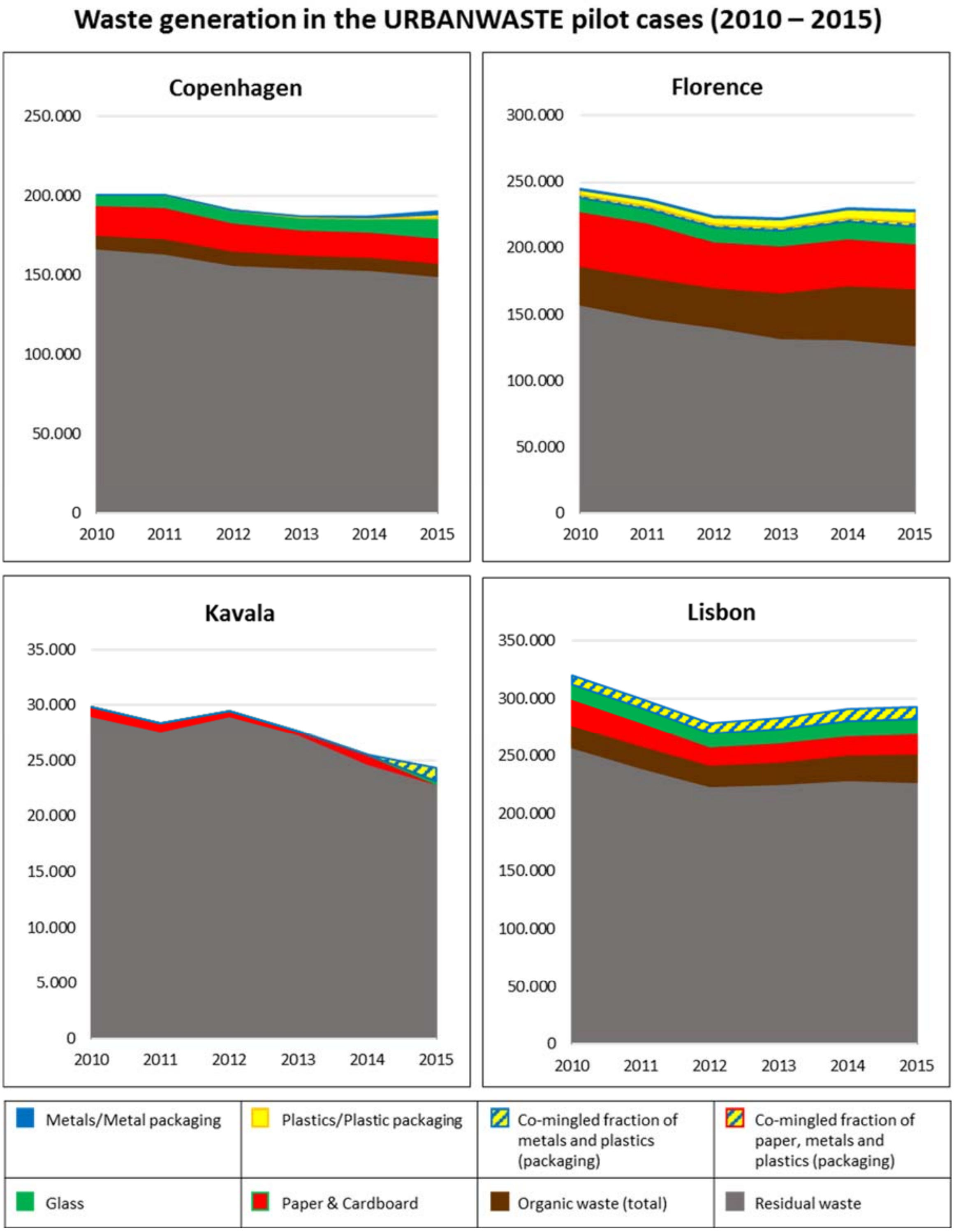


Figure 60: Waste generation in Copenhagen, Florence, Kavala and Lisbon (2010-2015)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

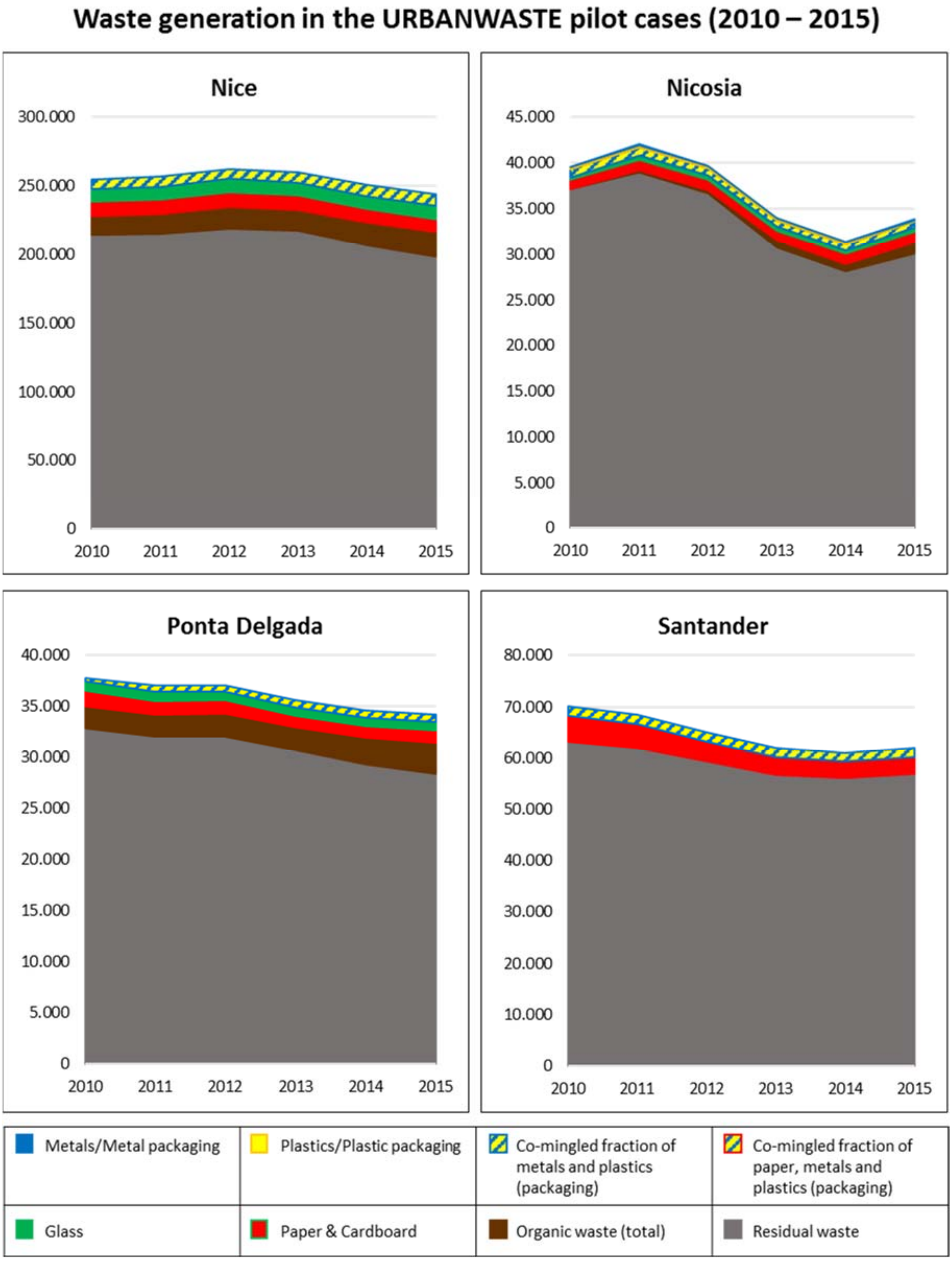


Figure 61: Waste generation in Nice, Nicosia, Ponta Delgada and Santander (2010-2015)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

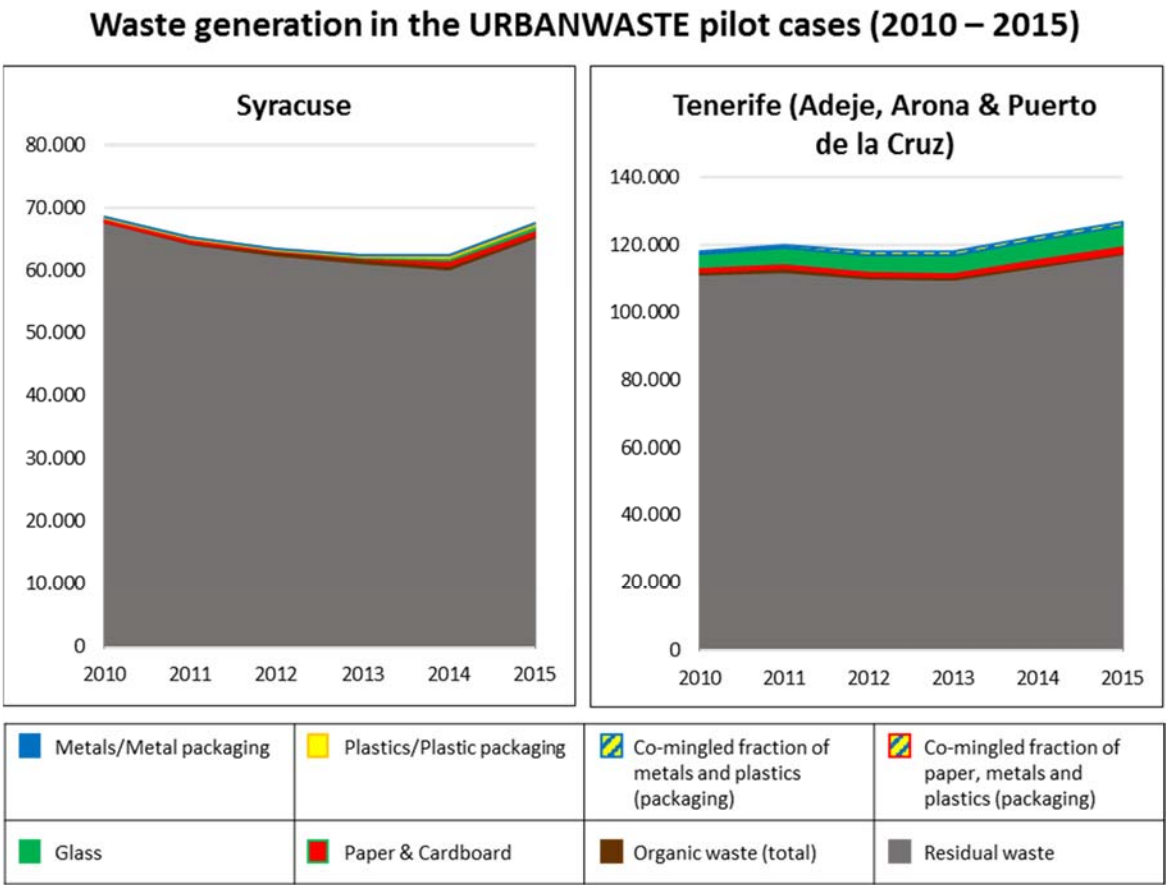


Figure 62: Waste generation in Syracuse and Tenerife (Adeje, Arona, Puerto de la Cruz) (2010-2015)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

11.3 Overview: availability of data on waste generation, local resident population and overnight stays

Table 23: Summarizing overview on data sets used for Benchmarking and analysis of tourists' impact on waste generation (incl. additional information on the spatial and temporal scales)

Pilot Case	Data set		Temporal Scale			Comments
			No data	Annual	Monthly	
Copenhagen	Waste Generation	Organic waste		2008-2012	2013-2015	
Copenhagen	Waste Generation	Residual waste		2008-2012	2013-2015	
Copenhagen	Waste Generation	Metal packaging	x			no separate data
Copenhagen	Waste Generation	PET bottles	x			no separate data
Copenhagen	Waste Generation	Paper and cardboard		2008-2012	2013-2015	
Copenhagen	Waste Generation	Glass		2008-2012	2013-2015	for some glass packaging there is a refund system; data for refund system only for 2015
Copenhagen	Waste Generation	Metals		2008-2012	2013-2015	for some metal packaging there is a refund system; data for refund system only for 2015
Copenhagen	Waste Generation	Plastics		2008-2012	2013-2015	for some plastic packaging there is a refund system; data for refund system only for 2015
Copenhagen	Waste Generation	Co-mingled recyclables	x			no collection of co-mingled fractions
Copenhagen	Local resident population			2000-2015		
Copenhagen	Overnight stays			2008-2015		
Dubrovnik	Waste Generation	Organic waste	x			no reliable data
Dubrovnik	Waste Generation	Residual waste	x			no reliable data
Dubrovnik	Waste Generation	Metal packaging	x			no separate data
Dubrovnik	Waste Generation	PET bottles	x			no separate data
Dubrovnik	Waste Generation	Paper and cardboard	x			no reliable data
Dubrovnik	Waste Generation	Glass	x			no reliable data
Dubrovnik	Waste Generation	Metals	x			no reliable data
Dubrovnik	Waste Generation	Plastics	x			no reliable data
Dubrovnik	Waste Generation	Co-mingled recyclables	x			no collection of co-mingled fractions
Dubrovnik	Local resident population			2001; 2011		REGIONAL scale, Census data for 2001 and 2011; remaining years estimated; no estimation of data for pilot case scale
Dubrovnik	Overnight stays			2004-2012	2013-2015	NATIONAL scale; no estimation of data for pilot case scale

This project has received funding from the European Union's Horizon 2020 research
and innovation programme under grant agreement No 690452

Pilot Case	Data set		Temporal Scale No data	Annual	Monthly	Comments
Florence	Waste Generation	Organic waste		2000-2015		
		Residual waste		2000-2015		
		Metal packaging	x			no separate data
		PET bottles	x			no separate data
		Paper and cardboard		2000-2015		
		Glass		2000-2015		
		Metals		2000-2015		single stream collection targeted at large utilities or domestic users
		Plastics		2000-2015		single stream collection targeted at large utilities or domestic users
		Co-mingled fractions		2000-2015		road collection of mixed packaging
	Local resident population			2000-2015		
	Overnight stays			2003-2015		
Kavala	Waste Generation	Organic waste	x			no organic waste collection
		Residual waste		2002-2012	2013-2015	monthly data of summer months not reliable
		Metal packaging	x			no separate data
		PET bottles	x			no separate data
		Paper and cardboard		2009-2012	2013-2014	for 2015 separate collection only from Jan.-March
		Glass			2015 (June-Dec.)	separate collection only starting with June 2015
		Metals	x			no separate data
		Plastics	x			no separate data
		Co-mingled fractions			2015 (April - Dec.)	collection started April 2015
	Local resident population			2001;2011		Census data for 2001 and 2011; remaining years estimated
	Overnight stays				2013-2015	Original data only on regional scale. Data from www.trivago.com and OpenStreetMap used to estimate the number of overnight stays on pilot case scale (Municipality).
Lisbon	Waste Generation	Organic waste		2005-2015	2013-2015	
		Residual waste		2000-2012	2013-2015	
		Metal packaging	x			no separate data
		PET bottles	x			no separate data
		Paper and cardboard		2000-2012	2013-2015	

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

Pilot Case	Data set		Temporal Scale No data	Annual	Monthly	Comments
		Glass		2000-2012	2013-2015	
		Metals	x			no separate data
		Plastics	x			no separate data
		Co-mingled fractions		2000-2012	2013-2015	
	Local resident population			2001-2002; 2004-2011; 2015		Missing years estimated
	Overnight stays			2000-2012	2013-2015	
Nice (MNCA)	Waste Generation	Organic waste		2004-2015		
		Residual waste		2004-2015		
		Metal packaging	x			no separate data
		PET bottles	x			no separate data
		Paper and cardboard		2004-2015		
		Glass		2004-2015		
		Metals	x			no separate data
		Plastics	x			no separate data
		Co-mingled fractions		2004-2015		
	Local resident population			2005-2015		
	Overnight stays			2012-2015		
Nicosia	Waste Generation	Organic waste		2011-2012	2013-2015	
		Residual waste		2009-2012		
		Metal packaging		2008-2015		%-age of total PMD (co-mingled recyclables) available
		PET bottles		2008-2015		%-age of total PMD (co-mingled recyclables) available
		Paper and cardboard		2008-2012	2013-2015	
		Glass		2008-2012	2013-2015	
		Metals	x			no separate data
		Plastics	x			no separate data
		Co-mingled fractions		2008-2012	2013-2015	
	Local resident population			2001;2011		Census data for 2001 and 2011; remaining years estimated

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

Pilot Case	Data set		Temporal Scale: No data	Temporal Scale: Annual	Temporal Scale: Monthly	Comments
	Overnight stays			2009-2015		
Ponta Delgada	Waste Generation	Organic waste		2008-2012	2013-2015	
Ponta Delgada	Waste Generation	Residual waste		2008-2012	2013-2015	
Ponta Delgada	Waste Generation	Metal packaging	x			no separate data
Ponta Delgada	Waste Generation	PET bottles	x			no separate data
Ponta Delgada	Waste Generation	Paper and cardboard		2008-2012	2013-2015	
Ponta Delgada	Waste Generation	Glass		2008-2012	2013-2015	
Ponta Delgada	Waste Generation	Metals	x			no separate data
Ponta Delgada	Waste Generation	Plastics	x			no separate data
Ponta Delgada	Waste Generation	Co-mingled fractions		2008-2012	2013-2015	
Ponta Delgada	Local resident population			2001, 2011		Census data for 2001 and 2011; remaining years estimated
Ponta Delgada	Overnight stays			2001-2012	2013-2015	Estimation of overnight stays at municipality scale by using regional data (Sao Miguel island) and the share of the island's hotels and other accommodations that is located in Ponta Delgada (www.booking.com)
Santander	Waste Generation	Organic waste	x			no reliable data
Santander	Waste Generation	Residual waste		2008-2012	2013-2015	
Santander	Waste Generation	Metal packaging	x			no separate data
Santander	Waste Generation	PET bottles	x			no separate data
Santander	Waste Generation	Paper and cardboard		2008-2012	2013-2015	
Santander	Waste Generation	Glass			2016	???
Santander	Waste Generation	Metals	x			no separate data
Santander	Waste Generation	Plastics	x			no separate data
Santander	Waste Generation	Co-mingled fractions		2008-2012	2013-2015	
Santander	Local resident population			2000-2016		
Santander	Overnight stays			2006-2012	2013-2016	
Syracuse	Waste Generation	Organic waste		2008-15	3b: 20130und 2015; 3a: nur als Pilot für 2013	monthly data only for 2013 (pilot phase of collecting organic waste from households; monthly data on green garden waste only for 2013 and 2015
Syracuse	Waste Generation	Residual waste		2005-2015	2013	
Syracuse	Waste Generation	Metal packaging	x			no separate data
Syracuse	Waste Generation	PET bottles	x			no separate data

Pilot Case	Data set		Temporal Scale: No data	Annual	Monthly	Comments
		Paper and cardboard		2005-2015	2013, 2015	
		Glass		2005-2015	2013,202	
		Metals		2005-2015		
		Plastics		2005-2015	2013, 2015	
		Co-mingled fractions	x			no collection of co-mingled fractions
	Local resident population			2002-2015		
	Overnight stays			2003-2015		estimated by using nr. of tourist arrivalsand average length of stay (estimated for several years); Nr. of tourist arrivals on provincial scale (45% of provincial arrivals can be allocated to pilot case area), since 2015 on municipality scale
Tenerife	Waste Generation	Organic waste		2004-2012	2013-2015	only partially available on monthly scale for pilot case area, the rest was estimated using data on monthly variation for whole island scale
		Residual waste		2004-2015	2013-2015	only partially available on monthly scale for pilot case area, the rest was estimated using data on monthly variation for whole island scale
		Metal packaging	x			no separate data
		PET bottles	x			no separate data
		Paper and cardboard		2006 (2008) - 2012	2013-2015	Adeje 2008-2012, Arona and PTO 2006-2012
		Glass		2000-2012	2013-2015	
		Metals	x			no separate data
		Plastics	x			no separate data
		Co-mingled fractions		2006 (2008) - 2012	2013-2015	Adeje 2008-2012, Arona and PTO 2006-2012
	Local resident population			2000-2015		
	Overnight stays			2009-2012	2013-2015	

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

11.4 Background information: Selected recyclables

Table 24: Overview on availability of data on selected separately collected recyclables (incl. background information on types of waste collected within these fractions)

Pilot case (Benchmark city) / Waste stream	Paper & Cardboard	Glass	Metals/Metal packaging	Plastics/Plastic packaging	Co-mingled fraction of Metals & Plastics (packaging)	Co-mingled fraction of Paper & Cardboard, Metals and Plastics (packaging)	Comments
Copenhagen	✓	✓	Metals collected from households (cans, old frying pans, …)	Rigid plastics (mostly packaging, but other types possible)	--	--	For most beverage containers (bottles, cans) there is a refund system in place. From May 1st 2017 the collection of soft and rigid plastics in the same bin at the households was introduced.
Dubrovnik	x	x	x	x	--	--	
Florence	✓	✓	metal packaging collected from large utilities or domestic users	plastic packaging collected from large utilities or domestic users	road collection of mixed packaging (bottles, bags, tetrapack, metal cans …)	--	Large users = malls, shops, supermarkets, …
Kavala	✓ (only until March 2015)	✓ (from June 2015 onwards)	--	--	--	all types of packaging materials, e.g. metal cans, metal bottle caps, plastic bags, plastic foils, plastic bottles etc.; no scrap metals (from April 2015 onwards)	
Lisbon	✓	✓	--	--	Metals and plastic packaging; compound packaging (tetrabricks), but also plastic cups, plastic hangers and plastic bags; Aluminium trays, metals hangers	--	

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

Pilot case (Benchmark city) / Waste stream	Paper & Cardboard	Glass	Metals/Metal packaging	Plastics/Plastic packaging	Co-mingled fraction of Metals & Plastics (packaging)	Co-mingled fraction of Paper & Cardboard, Metals and Plastics (packaging)	Comments
Nice	✓	✓	--	--	--	In some areas only plastics (PET and HDPE), in other areas in Nice there are trials to collect more type of plastic like PCT and LDPE), aluminium (cans), board packaging	
Nicosia	✓	✓	--	--	Plastic bottles and containers; Metal packages; paper-based Drink Packages (Tetra Pak type)		
Ponta Delgada	✓	✓	--	--	all metal and plastic packaging (no scrap metals)	--	Green Dot System for Paper & Cardboard, Glass and packaging waste
Santander	✓	n.a.	--	--	metal and plastic packaging, compound packaging (tetrabricks …)	--	
Syracuse	✓	✓	metals (packaging metals + scrap metals)	all plastics collected from citizens	--	--	the municipality does not collect scrap metals. The only ones collected are the ones find in the streets.
Tenerife	✓	✓	--	--	Metal, plastic and compound packaging	--	
Berlin	✓	✓	--	--	metal and plastic packaging and non-packaging waste from same materials	--	
Vienna	✓	✓	metal packaging	plastic and compound packaging	--	--	
Zurich	✓	✓	metal packaging	x	--	--	

n.a. … separate collection in place but data not available

x … separate collection in place in at least some parts of the pilot case but no data available

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690452

URBAN WASTE

URBAN STRATEGIES FOR WASTE MANAGEMENT IN TOURIST CITIES