Research

Tourism intensity and plastic waste management insights from European capital cities

Eleonora Foschi[1,4] · Jelena Barbir[2] · Luigi Mersico[1] · Zaneta Stasiskiene[3]

Abstract

The surge in demand for plastic materials, coupled with the rising trend of out-of-home food consumption, has posed significant challenges to urban waste management systems. These challenges are intensified in touristic cities where touch-and-go tourism leads visitors to spend most of the day outside, resulting in a high generation of waste in urban areas. While existing research focuses predominantly on the hospitality sector, the role of public administrations remains underexplored. This study addresses this gap by surveying city managers from ten European capitals, providing a comprehensive overview of plastic waste management and prevention patterns. Results reveal that legislative measures and plastic bans are effective, but local initiatives and social programs require further support. Waste generated in public areas is less scrutinized than residential waste, and differences in municipal waste collection schemes hinder proper sorting. Findings underscore the need for collaborative efforts in both waste prevention and management to strengthen partnerships with hotels, restaurants and shopkeepers, as well as the proper design of waste logistics and infrastructure and dedicated communication campaigns in tourist hotspots.

Keywords Plastic waste management · Plastic waste prevention · EU capital cities · Public administrations · Cities

1 Introduction

Plastic production has increased dramatically since 1950 [1, 2]. This growth is primarily driven by increasing consumer demand across all markets, with packaging emerging as the most demanding sector [2].

However, preventing excessive plastic packaging consumption and ensuring its efficient valorization when reaching the end-of-life (EoL), remain a challenge. This is especially acute in urban settings where urbanization has led to massive and diverse packaging waste streams [3], outpacing the corresponding development of waste management infrastructure [4].

This issue is exacerbated in cities with a tourism vocation. The hospitality industry alone generates approximately 35 million tons of solid waste annually [5], with an average value of 1,67 kg of waste produced per tourist per day [6]. Most are small-sized plastic packaging with limited lifespan, generally called single-use-plastics (SUPs) [7]. SUPs are galvanized by out-of-home food consumption and on-the-go lifestyles, with volumes of takeaway food and

✉ Jelena Barbir, jelena.barbir@haw-hamburg.de; Eleonora Foschi, eleonora.foschi3@unibo.it; eleonora.foschi@enea.it | [1]Department of Management, Bologna University, Via Capo Di Lucca 34, 40126 Bologna, Italy. [2]Faculty of Life Sciences, Research Transfer Centre & Sustainable Development & Climate Change Management, Hamburg University of Applied Sciences, Ulmenliet 20, 21033 Hamburg, Germany. [3]Institute of Environmental Engineering, Kaunas University of Technology, Gedimino Str.50, 44239 Kaunas, Lithuania. [4]Department for Sustainability, Italian National Agency for New Technologies, Energy and Sustainable Economic Development, Via Dei Mille, 21, 40121 Bologna, Italy.

Discover

fast-moving consumer goods (FMCGs) strongly influenced by the popularity of street and local foods to consume on the go [8, 9]. Tourism is also identified as one of the key sources of urban littering [10, 11], mainly caused by the missing sense of place [10, 12–14], combined with the lack of knowledge about local waste collection and segregation practices [15] and the diverse behaviors of visitors [16]. Seasonal variations and local dynamics for attractions and points of interest are additional elements that can massively undermine waste recycling performance in touristic-oriented cities [13, 17].

While the literature has examined tourism's impact on local waste infrastructure [18–22], it predominantly focuses on the perspective of business actors (e.g., hotels and resorts), tending to circumscribe the research debate to the hospitality industry [23–31]. Furthermore, the literature stream on hospitality management has mainly addressed the problem from the perspective of visitors, limiting the analysis to the investigation of attitudes and behaviors [32–37]. Thus, the perspective of local institutions and more in general, the role of policies, have been timidly scrutinized [38], with most studies focusing on popular destinations in developing [22, 39, 40] and small islands [5, 41–43]. However, this topic is increasingly recognized as a concern, even in urban destinations, emerging as a priority of many political agenda [23]. While hotels and accommodation facilities may anticipate tourist flows, set up well-structured waste collection systems, actively engage visitors in waste reduction initiatives, and essentially have superior control over the types and amount of waste generated [24, 25, 30], this is more challenging for those managing a city. Waste produced in public areas can fluctuate significantly, with higher concentrations in key tourist spots and dining areas [13, 29]. Effective waste management also depends on various factors, including age, cultural differences, and individuals' level of concern for environmental issues [13, 14, 16, 32]. Additionally, city managers must prioritize clear communication and accessibility to waste segregation infrastructure to maximize tourist participation. Furthermore, local waste management systems should be designed to accommodate seasonal variations in tourism flows and prevent situations where waste infrastructure capacity is exceeded [44–46].

European (EU) capital cities, despite being among the top urban destinations worldwide, have received little recognition in tourism and waste literature streams [6, 44, 45]. When done, studies are limited to monitoring waste management performance, without deepening the impact of tourism-driven consumption patterns on urban waste systems. [46–48]. Moreover, while most of the research on tourism focuses on food waste [27, 31, 49, 50], there is a shortage of studies examining the impact of plastics which today represents a big issue for their massive use in FMCGs. This is even more urgent in light of the increasing urban littering trend, the plastics dispersion into the environment and the recent evidence about the presence of microplastics in the food chain and human body [10, 11].

Although urban waste management planning is a relevant research topic in waste-oriented literature, there is a knowledge gap in how city managers perceive and address the challenges caused by the tourism effect, which is becoming increasingly relevant considering the overtourism shift. Yet, although the literature has evidence of the link between tourism flow and plastic waste increase [17], only few studies investigated plastic waste management at touristic cities and the role of city managers in properly valuing plastic waste streams in those hotspots. Furthermore, to the author's knowledge, there are no studies investigating management of compostable and biodegradable plastic waste in EU capital cities.

The present study aims to fill these gaps by investigating how city managers in European capitals [45, 51] address the challenges of plastic waste management associated with tourism. Specifically, to achieve this objective, the study seeks to answer the following Research Question: *How do city managers in European capitals perceive and address the challenges of plastic waste management related to tourism intensity?*

Particular attention is dedicated to the plastic materials that today characterize the on-the-go style of urban areas. This paper contributes to advancing research on the interplay between waste management and tourism by investigating measures and actions implemented by municipalities of EU capital cities to optimize plastic waste management and promote plastic waste prevention initiatives. Unlike extant literature, this study addresses the topic from the perspective of city managers, thus contributing to extending the research knowledge on waste management systems in urban areas with tourist destinations. The study also contributes to providing recommendations for policy in light of the normative pressure on SUPs.

The paper is structured as follows: First, the outcomes of a literature review on waste management in tourist-oriented cities are provided to offer a broad overview of existing dynamics, challenges and opportunities. Then, plastic waste recycling and prevention initiatives are discussed to provide evidence of the most common practices in tourist destinations. Later, the research design is introduced (Sect. 3), while the results of a survey conducted in the EU capital cities are elaborated in Sect. 4, followed by discussion and conclusion sections.

2 Theoretical background

2.1 The contribution of tourism to waste generation in Europe

Tourism is one of the fastest-growing industries in the world [17]. In 2019, 745 million tourist arrivals were recorded in Europe, accounting for 50% of the international market [52]. Among the destinations, urban areas, including capital cities, have received discrete attention in the literature [44, 53, 54].

However, [55] confirm that EU urban destinations have recently surpassed coastal ones in popularity. This shift may be attributed to the rise in business trips [56] and/or cultural tourism trends [54, 57] where tourists and business travellers typically spend most of their day outdoors, thereby accelerating waste generation patterns. In this regard, very recent literature has also scrutinized the impact of overtourism in cultural cities [58–60], highlighting as waste represents one of the most critical externalities of mass tourism phenomena in urban hotspots.

Tourism is associated with high waste production rates: as evidenced by [18, 19], the number of tourist arrivals positively correlates with the amount of waste generated, confronting tourist cities with challenges regarding waste disposal and littering [41]. The situation is then aggravated by the massive use of street food [63], often packaged in SUPs, small toiletries in hotel bathrooms or single servings of butter or other spreads at breakfast buffets [62, 64]. Additionally, the emerging on-the-go lifestyle, especially in some EU countries [8], has contributed to generating an alternative waste stream, mainly composed of biodegradable and compostable materials.

Thus, the substantial and diverse urban waste volumes created by tourism often overload local waste management systems [61]. For example, in the Carpathian region of Ukraine, the country's most popular tourist area, almost 69% of the urban waste originates from tourism. Recreational and tourism centers in this region were generally developed without considering the infrastructure needed to process the additional waste generated [22]. Moreover, most landfills in the region, being over 30 years old and at 90% or higher capacity, are posing tremendous threats to the environment and human health in the region [22].

The seasonal nature of tourism adds another layer of complexity, making it difficult for local waste management systems to adapt [61]. For instance, the city of Bled in Slovenia experiences sharp annual increases in urban waste from June to September, with waste volumes nearly doubling compared to other months [62]. Additionally, tourists often lack knowledge of local waste separation and collection systems, resulting in improper waste disposal [61]. Separate collection of recyclables is especially critical on small islands, which are more vulnerable to adverse environmental effects [41]. On the Spanish Island of Menorca, residents collected nearly 50% more separated recyclables than tourists on average [41], illustrating the potential for the hospitality industry to enhance waste separation practices.

2.2 Recycling vs prevention measures: from private to public sector efforts

Tourist cities typically generate waste comprising conventional plastics [26], and, more recently, biodegradable and compostable plastics, commonly referred to as bioplastics [64]. From the perspective of city managers, an appropriate integrated waste management infrastructure is essential for tourist sites. Existing literature in the hospitality industry reveals that composting programs are commonly implemented in hotels to divert organic material streams from landfills [65]. However, the optimization of organic waste collection schemes and the increase in recycling capacities remain high priorities on local political agendas [4, 66, 67]. Behavioral factors, spurred by economic incentives (e.g., deposit systems) and penalties, also play a crucial role in promoting high participation rates in collection systems, correct source separation practices, and efficient recycling processes [2].

Yet, studies reveal that during high tourist seasons, the amount of waste generated by visitors often exceeds that of the local population. Furthermore, the composition of waste may vary depending on the lifestyle of visitors [41, 68–70]. These aspects highlight the need for municipalities to complement traditional urban waste management plan with tailored strategies that account for seasonality, type of tourism, and tourists' behaviour. Such strategies require strengthening waste infrastructure capacities, often involving higher operational costs [17], and recognizing tourists as critical stakeholders in the implementation of local waste management roadmaps [36].

Prevention measures, aimed at reducing waste quantity and minimizing environmental and human health impacts [71], are among the most discussed research topics in circular economy literature [75–77]. Common examples include the elimination of drinking straws [65], the replacement of bottled water with filtered water [72], the use of alternative

serving styles [73] and the introduction of refillable food and detergent packaging [74]. Waste prevention, as the top priority in the EU waste hierarchy, delivers multiple benefits, such as cost savings, pollution reduction, natural resource conservation, and the promotion of sustainable consumption patterns [78]. However, waste prevention is demonstrated to be much more complex than recycling because of the profound changes in consumers' behaviours it requires [79]. This issue is further complicated in cities with high tourism volumes, where engaging the entire tourism ecosystem, ranging from temporary visitors to hotels owners and shopkeepers, presents significant challenges.

Yet, waste prevention is strongly interconnected with waste management practices. Based on six pilot cases in coastal cities, the study of [6] reveals that the impact of waste prevention measures depends on the waste management system already in place. In most pilot cases, recyclables are collected as a co-mingled fraction of varying composition. That said, prevention measures are mainly activated by hotels and restaurants, calling for major involvement of local institutions. Similar results have been detected by [5] in four Mediterranean tourist islands, where findings confirm the limitless waste minimization initiatives in resorts and the widespread use of waste-to-energy plants and sanitary landfills as end destinations of municipal waste.

3 Materials and methods

3.1 Research design

Following a literature review on the impact of tourism on urban waste management, this study relies on an online survey aimed to examine the role of city managers of EU capital cities in addressing waste-related issues arising from local tourism dynamics.

Europe is the world's most visited regional destination [80]. In 2022, the travel and tourism industry's direct contribution to the EU GDP was approximately €1,37 trillion, representing 8,7% of the total GDP [81].

Given the lack of detailed information and the existence of disaggregated data on waste management in tourist hotspots at the urban level [82], this study primarily relies on data collected through an online survey. In order to guarantee the reliability and validity of the questionnaire, all the measurement items have been adapted from extant studies on waste management and tourism. The initial version of the questionnaire has been pre-tested by a panel of academics and experts engaged in the H2020 BIO-PLASTICS EUROPE consortium and amended based on their feedback [32]. Specifically, the questionnaire consisted of 13 questions focused on three key constructs. Items on waste management and prevention have been adapted from the works of [34] and [83]. The first construct regards the general information about the participating cities. The second is about current plastic waste streams and areas to be attended. The third section explores measures and actions implemented for waste prevention. Closed questions are employed by using the Likert scale, ranking scale and/or multiple choice based on a range of statements [84]. To reduce response bias, the closed questions include "don't know" and "not applicable" options [85].

3.2 Data collection and analysis

The study focuses on one city from each EU Member State, selecting capital cities due to their association with urban and over-tourism dynamics, as well as their roles as cultural, political, and economic hubs that inherently attract tourists and temporary visitors in varying intensities [44, 45, 86, 87]. A total of n.27 capital cities have been considered in the study [88].

Data were collected via Computer Assisted Web Interviewing (CAWI) from July 19, 2021, to June 9, 2022, using Qualtrics. The survey has targeted city managers responsible for leading environmental departments or urban waste management services. These senior executives oversee day-to-day waste management operations and have comprehensive access to relevant data management systems, policies, and operational insights on urban waste collection and disposal. Yet, city managers play a substantial role in local policymaking, contributing to the wider urban planning process and ensuring responses based on informed decision-making and factual records rather than subjective opinions. While only one respondent per city was surveyed, this approach has been chosen to engage city managers with the highest level of expertise and responsibility within their administrations.

The primary data from the survey were supplemented with secondary data from Eurostat, covering population statistics and tourism occupancy rates [89, 90].

Quantitative data from closed questions were analyzed using Microsoft Excel (365) and SPSS (v.27). Yet, data analysis entailed both an individual question-level analysis employing descriptive statistics (frequency and percentage of responses) to assess participant responses and secondary data collected from the Eurostat database.

To detect tourism intensity and seasonal trends in each surveyed city, monthly data on nights spent at tourist accommodation establishments ($N_{i,j}$) [90] and the latest available population and housing census data (N_{2021}) [89] were utilized.

A tourism intensity rate ($P_{i,j}$) [91, 92] was calculated with monthly frequency according to (1) as:

$$P_{i,j} = \frac{N_{i,j}}{N_{2021}} \qquad (1)$$

Considering tourism seasonality [80, 93], seasons were defined as Winter (W): December, January, February; Spring (S): March, April, May; Summer (Su): June, July, August; Autumn (A): September, October, November. Monthly tourism data were averaged into seasonal values [80] according to (2), (3), (4), (5) as:

$$\overline{P}_{i,W} = \frac{1}{3}\sum_{j\in W}P_{i,j} \qquad (2)$$

$$\overline{P}_{i,S} = \frac{1}{3}\sum_{j\in S}P_{i,j} \qquad (3)$$

$$\overline{P}_{i,Su} = \frac{1}{3}\sum_{j\in Su}P_{i,j} \qquad (4)$$

$$\overline{P}_{i,A} = \frac{1}{3}\sum_{j\in A}P_{i,j} \qquad (5)$$

The peak tourism season for each city i was determined by identifying the season with the highest average tourism intensity (6), and the standard deviation σ ≥ 10% compared to the other months.

$$Peak\ season_i = \underset{X\in\{W,S,Su,A\}}{\arg\max}\ \overline{P}_{i,X} \qquad (6)$$

Finally, data were clustered into two groups: (a) capital cities with a high tourism intensity rate during the tourist season and (b) capital cities with a low tourism intensity rate during the tourist season.

To compare the tourism intensity during touristic season across cities, the Kruskal–Wallis's test, a non-parametric method, was employed to determine if there were statistically significant differences between the groups. The outcomes demonstrated significant divergence at a 95% confidence level (p ≤ 0.05), suggesting that the population changes during touristic seasons significantly differ between these growth categories.

4 Results

4.1 Characterization of the sample

N.10 responses (representing n.10 EU capital cities) are collected in total, achieving a 40% response rate (Table 1). The surveyed cities are distributed across four EU regions, with a predominant presence in Central and Eastern Europe (40%), followed by Northern Europe (30%), Southern Europe (20%), and Western Europe (10%). This distribution indicates diverse geographical coverage with a notable concentration in Central and Eastern Europe.

In terms of population size [94], the cities predominantly fall into larger categories, with the majority classified as Extra Extra Large (70%) and none having populations below 250.000 inhabitants. The survey also includes a significant representation of Extra Large (10%) and Large (20%) cities, while no capital cities are categorized as Small or Medium.

Regarding tourism dynamics, all surveyed cities are cultural capitals [44]. However, Lisbon, Tallinn, and Riga are distinct due to their seaside characteristics.

Table 1 Breakdown of the sample, including name of Country, Capital City, Population, Dimensional class, Total nights spent at tourist accommodations, Tourist season and Tourist intensity—2022. Source: authors elaboration on survey results and [89, 90] data

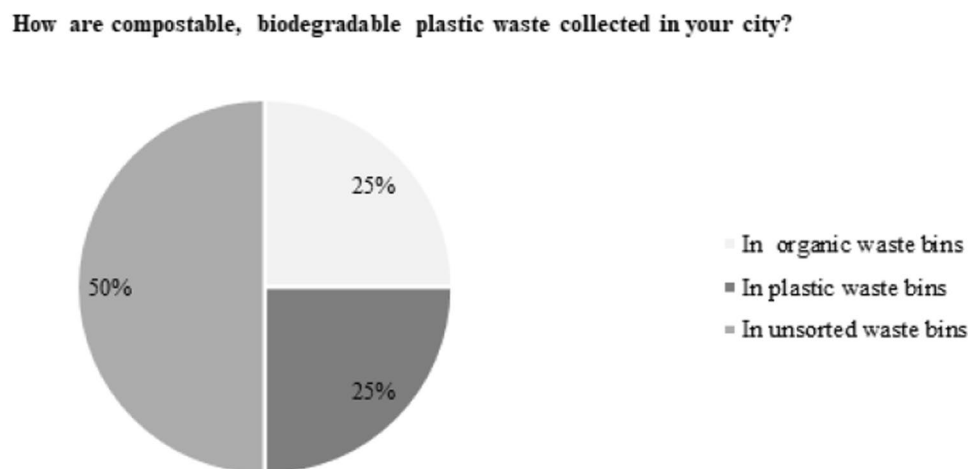| Country	Capital	Population	Dimensional class	Total Nights spent at tourist accommodations	Tourist season	Tourist intensity
Austria	Wien	1.915.422	XXL	12.624.154	Summer	Low
Czech Republic	Prague	1.300.297	XXL	13.398.104	Summer	High
Estonia	Tallinn	431.285	L	5.950.873	Summer	High
Greece	Athens	3.249.067	XXL	10.313.319	Summer	Low
Hungary	Budapest	1.705.425	XXL	8.722.977	Entire year	Low
Latvia	Riga	611.599	XL	3.882.922	Summer	Low
Poland	Warsaw	1.865.602	XXL	8.773.703	Entire year	Low
Portugal	Lisbon	1.872.764	XXL	19.390.987	Summer	High
Slovenia	Ljubljana	280.000	L	10.438.837	Summer	High
Sweden	Stockholm	1.899.560	XXL	14.307.916	Summer	Low
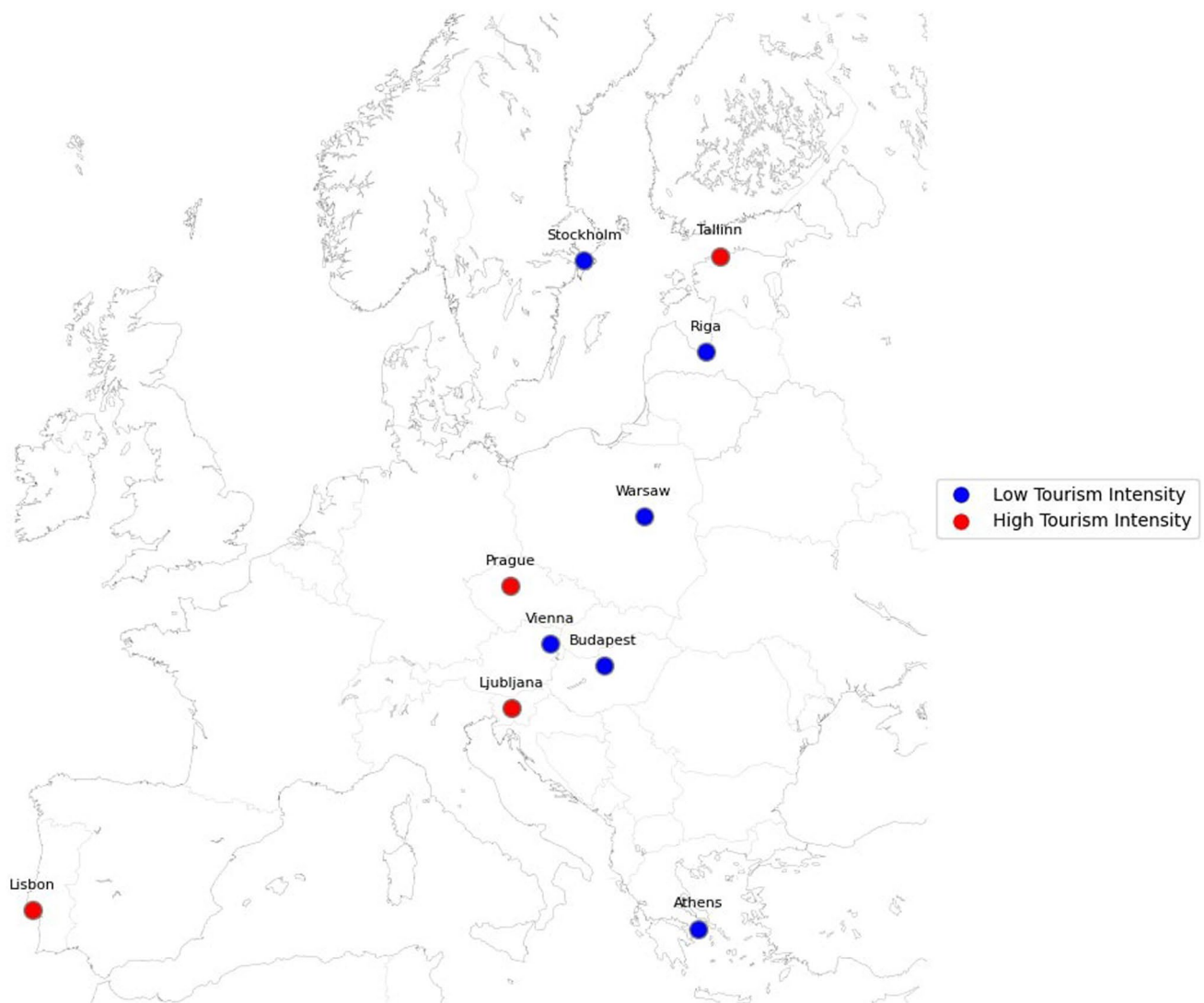
Fig. 1 Tourism intensity in EU capital cities. Source: authors elaboration on [90] data

Fig. 2 Plastic waste streams that need to be attended in EU capital cities

Regarding the plastic waste management, which waste streams need to be attended in your city?
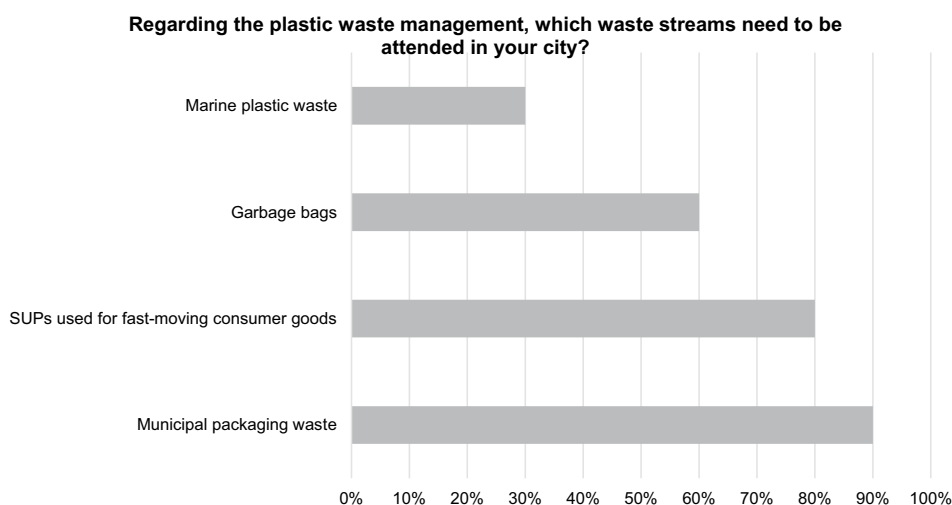
Fig. 3 Compostable and biodegradable plastic waste collection in EU capital cities

How are compostable, biodegradable plastic waste collected in your city?

- In organic waste bins
- In plastic waste bins
- In unsorted waste bins

Tourism patterns reveal that 80% of the capitals are destinations throughout the summer. A smaller fraction of capitals is primarily visited throughout the entire year (20%). Tourism intensity shows notable variations across capital cities, with 60% of them experiencing a low tourism intensity level. In contrast, 40% of the capitals (including Prague, Tallinn, Lisbon, and Ljubljana) witnesses a high tourism intensity level, underscoring the significant impact of overtourism on urban demographics, especially during peak seasons (Fig. 1).

## 4.2 Plastic waste management in European capital cities

To contextualize the survey, respondents were asked about the various plastic waste streams requiring attention in their cities. A significant 90% of city managers identified plastic packaging waste generated from accommodations, commercial and residential activities (i.e. urban waste) as the most prevalent type of plastic waste stream to be addressed in their waste management systems (Fig. 2).

Other notable sources of plastic waste streams that need attention include SUP items used for FMCGs (80%), followed by garbage bags (60%), thus reflecting the growing on-go style and the resulting need to address plastic overconsumption and subsequent issues in urban waste management.

Furthermore, the results show that 70% of the cities identify waste collection as the area to be attended, while 30% focus on waste treatment.

Shifting the focus on innovative materials emerging in urban waste streams (Fig. 3), results show a lack of harmonization for the collection of compostable and biodegradable plastic waste, with the most common method being collection

Fig. 4 End-of-life treatment in place in EU capital cities for compostable and biodegradable plastic waste

Which waste treatment mainly occurs when compostable, biodegradable plastic waste are disposed of in your area?
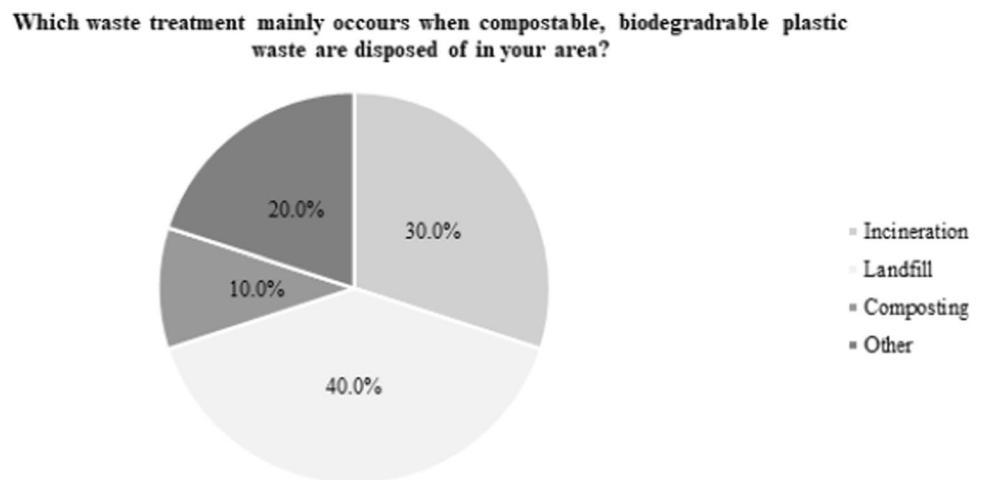
in unsorted waste bins (50%), followed by plastic waste bins (25%) and organic waste bins (25%), with no differences between high-intensity tourist cities and low-intensity touristic cities (p ≥ 0.05).

When dealing with waste treatment scenarios (Fig. 4), respondents report that landfill represents the most common disposal method (40%), followed by incineration (30%) and other EoL treatments (20%) such as anaerobic fermentation (10%). Only a small fraction of capitals reports the use of industrial composting as end-of-life treatment (10%).

4.3 Plastic waste prevention in European capital cities

All the capital cities report active engagement in measures and actions oriented to reduce plastic waste and relative negative impacts on the environment and human health. Notably, 90% of these cities have integrated plastic waste prevention targets into their waste management roadmaps. When asked about the implementation level of measures and actions (Table 2), results record discrete attention for initiatives promoting tax and penalties for unsustainable waste treatment as well as bans for specific SUPs. When comparing measures in high and low-tourism-intensity cities (Table 2), overall results indicate that high-tourism-intensity cities demonstrate a more advanced approach towards waste prevention measures, with well-established levels recorded. In contrast, cities with low tourism intensity primarily focus on exploratory measures.

In terms of actions (Fig. 5), Fig. 5 home composting shows the most substantial commitment in 80% of the cities surveyed. Relatedly, the cross-group comparison shows that among the high tourism-intensity cities, 50% has implemented actions at a well-established level, while low tourism-intensity cities are still in an exploratory phase (50%). Then, 70% of respondents have reported the establishment of recycling infrastructure at least at the exploratory level with a peak of 100% among high tourism intensity cities, thus diverting materials from incineration and landfill. Promoting compostable and biodegradable plastic packaging emerges as a priority among the surveyed cities. However, the engagement is at the design level (50%), followed by the exploratory (20%) while well-established actions are detected in one city only.

An analysis of the barriers (Fig. 6) reveals that the most significant challenge is the poor enforcement of legislation, as highlighted by 70% of city managers. This suggests that existing policies are either not being implemented effectively or are not stringent enough to drive significant changes in tourists' behaviour. Nevertheless, a significant portion of respondents (60%) identify a lack of awareness and insufficient knowledge as key barrier to stimulate alternative behaviors among tourists. Insufficient participation from key stakeholders and the general public is another crucial barrier, noted by 40% of respondents.

When asked about the main target stakeholders (Fig. 7), city managers indicate the civil community as a priority (60%), followed by commercial activities and students in schools and universities, with 40% reporting moderately high and 30% slightly higher involvement. Accommodation facilities are not considered relevant target objects, showing slightly to moderately high engagement levels in 20% of respondents with no engagement in 10% of the sample.
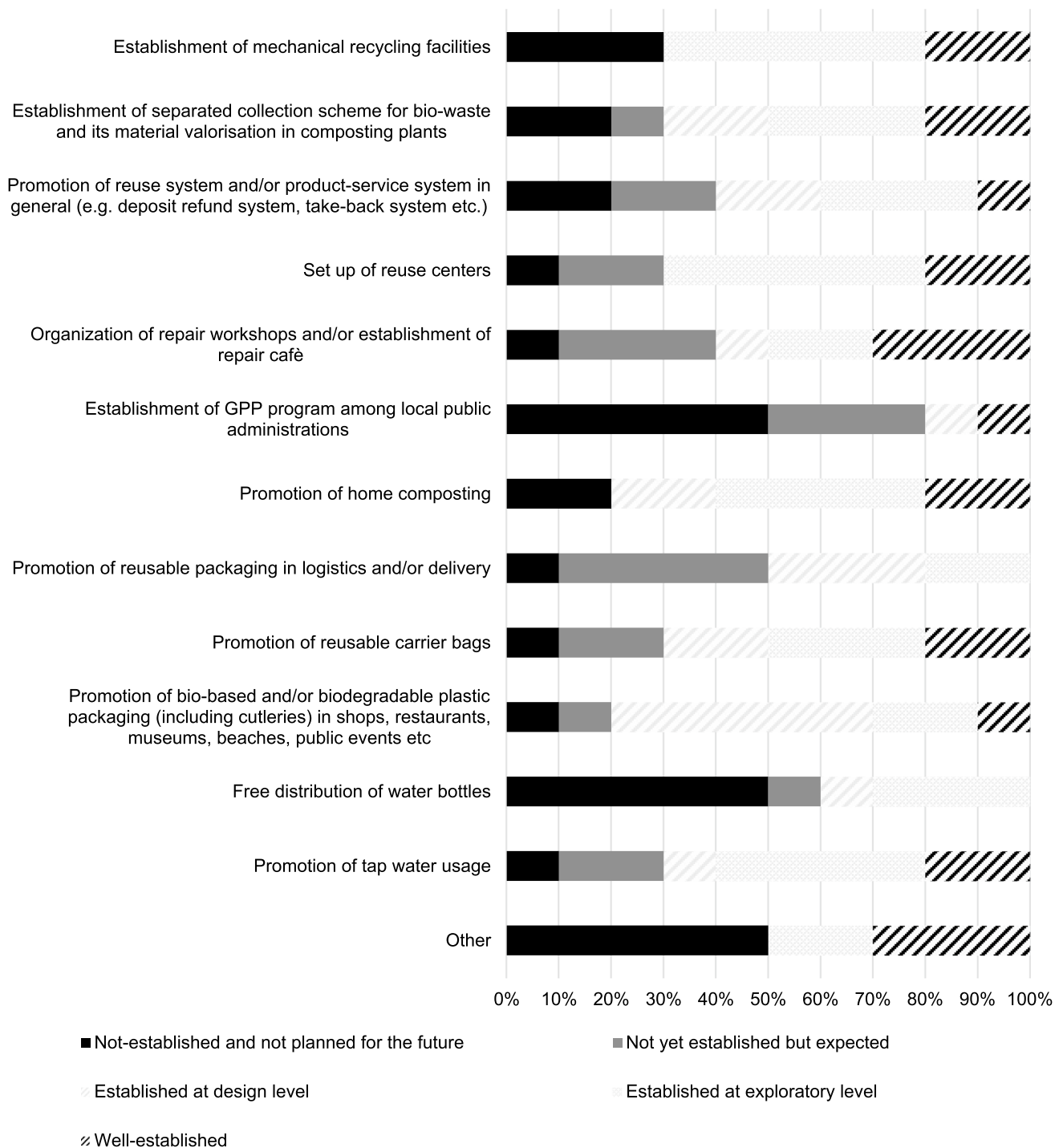
Table 2 Level of implementation of waste prevention measures in EU capitals, distinguishing high from low-intensity cities

Level of implementation Measure	High Tourism Intensity (n = 4)					Low Tourism Intensity (n = 6)				
	Not established and not planned for the future	Not yet established but expected	Established at design level	Established at exploratory level	Well-established	Not established and not planned for the future	Not yet established but expected	Established at design level	Established at exploratory level	Well-established
Introduction of economic incentives on green purchasing and sustainable consumption patterns	25%	25%	0%	25%	25%	50%	17%	33%	0%	0%
Establishment of market-based instruments (including taxes and penalties) on unsustainable waste treatment	0%	0%	0%	75%	25%	17%	17%	17%	50%	0%
Establishment of legislative targets on plastic waste collection and/or recycling	0%	0%	25%	25%	50%	33%	0%	17%	50%	0%
Promotion of product-service system	50%	0%	25%	0%	25%	33%	50%	17%	0%	0%
Establishment of ban on specific plastic products	0%	0%	0%	50%	50%	33%	0%	17%	50%	0%
Establishment of waste prevention program and/or zero waste strategy	0%	0%	0%	75%	25%	17%	50%	17%	17%	0%
Promotion of local initiatives on sustainable behavior	0%	0%	0%	50%	50%	17%	17%	33%	33%	0%
Set up of training programs and/or information campaigns on proper waste collection	0%	25%	0%	25%	50%	17%	17%	17%	50%	0%

Table 2 (continued)

Level of implementation	High Tourism Intensity (n=4)					Low Tourism Intensity (n=6)				
Measure	Not established and not planned for the future	Not yet established but expected	Established at design level	Established at exploratory level	Well-established	Not established and not planned for the future	Not yet established but expected	Established at design level	Established at exploratory level	Well-established
Support to R&D activities	25%	25%	0%	0%	50%	50%	33%	17%	0%	0%
Support to innovative start-ups	25%	25%	0%	25%	25%	50%	17%	17%	17%	0%
Use of metrics monitoring market trends and/or waste management	0%	0%	25%	0%	75%	33%	17%	17%	33%	0%
Other	50%	0%	0%	25%	25%	67%	0%	0%	17%	17%

Which actions have you established in your city to prevent plastic waste?
Please, include the level of implementation for each action you established

Fig. 5 Level of implementation of waste prevention actions in EU capital cities

5 Discussion

This study shows that waste is a significant concern in EU capital cities, particularly in those with high tourism intensity, as highlighted by [5] and [37]. Capitals such as Prague, Lisbon and Ljubljana exemplify these challenges. While it is not entirely possible to isolate the tourism dimension from other urban dynamics [95], the results reveal the substantial

Fig. 6 Barriers related to waste prevention activities implemented in EU capital cities

Which barriers have you met in implementing the above mentioned plastic waste prevention activities?
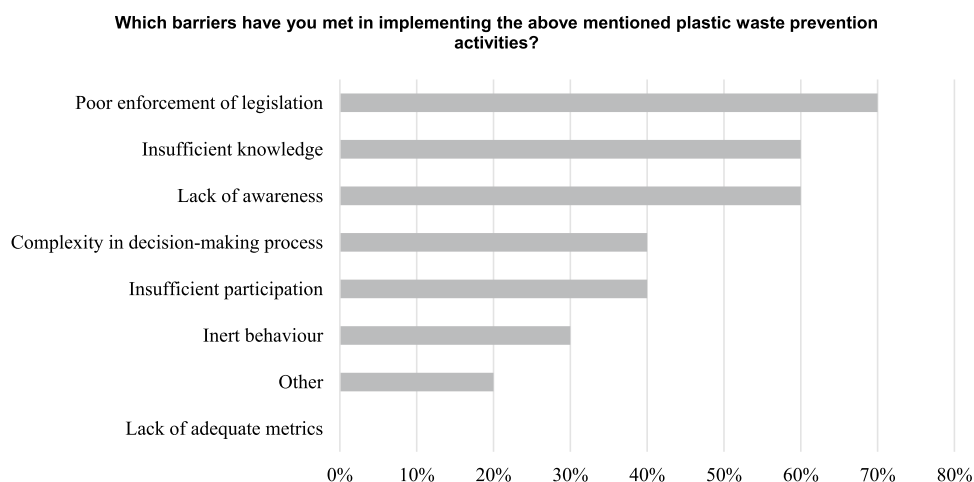
impact of plastic waste streams on local waste management systems [7, 8]. This issue is accentuated by the penetration of compostable and biodegradable plastics into the packaging market. As evidenced in cities like Budapest, Lisbon and Athens, structured separate collection systems for biodegradable and compostable plastic packaging waste still do not exist everywhere. Where dedicated collection routes are in place, missing harmonization is detected: while organic waste bins are used in Prague and Ljubljana, cities like Warsaw still rely on plastic waste bins to dispose of their biodegradable and compostable plastic waste. This situation, when not well documented and informed, causes reluctance among tourists to properly sort the waste they generate. The problem is even reiterated during the EoL treatment since 40% of city managers report that landfilling is the primary method for disposing of compostable, biodegradable plastic waste in their areas, followed by incineration (30%) while industrial composting accounts for 10% only. This lack of harmonization in disposal routes highlights the complexities of managing these materials effectively [4]. This issue is exacerbated in tourist cities where the lack of knowledge about the material composition (especially from tourists coming from countries where bioplastics are not on the market) and, even more, the diverse ways to dispose and valorize them across the globe may cause contamination and, in some case, the potential for littering.

Moving from waste generation to waste management, the advanced separate collection techniques implemented in the EU should make the waste management system less problematic compared with cities outside Europe [96]. In [4], authors demonstrate how rapid economic growth in middle-income countries like China and Indonesia has outpaced the development of waste management infrastructure, leading to significant environmental leakage. However, plastics remain a major issue in Europe due to variations in waste management infrastructure and governance across EU Member States. According to [47], integrated municipal waste collection systems exist in Riga, Wien, Ljubljana, Lisbon, Stockholm, Tallinn, Athens, Warsaw and Budapest, while in Prague, bring-points are still prevalent. However, results show that waste collection needs more attention than waste treatment in the surveyed capitals. Specifically, this is true for all the cities except for Stockholm, Budapest and Ljubljana, where incineration and landfilling are still the prevailing EoL treatment options for plastic materials [2]. That said, while plastic waste treatment basically implies investments in logistics and technologies [79], effective waste collection involves managing socio-economic and cultural factors [33, 34]. For instance, cities with high tourism intensity, like Prague, report that tourists' inert behavior represents a key challenge. Despite these behavioral challenges, research findings highlight the existence of other motivations, mainly political-oriented. While the EU Commission has introduced ambitious measures, such as the revision of the Waste Framework Directive, and municipalities have incorporated waste prevention targets into local waste management roadmaps, disparities persist across Europe [97]. In the study, this is evidenced by the divergent approaches undertaken by cities: while Ljubljana has a well-implemented zero-waste strategy, Warsaw is still in the exploratory phase of applying such measures. This is also demonstrated by poor legislation enforcement, which appears to be the key barrier among the municipalities surveyed.

Regarding waste prevention, all the surveyed capital cities (100%) show commitment to reducing waste generation and its negative impacts. However, most measures remain at the design level. The results also indicate limited engagement with key stakeholders of tourism ecosystem, including owners of accommodation facilities, commercial activities, food shops, and restaurants. This aligns with other relevant studies [32, 43] that highlight the role of business actors in one side and the lack of cooperation between public and private sectors in the other side. It follows that when waste prevention is included in urban waste management plans, roadmaps cannot

Which are the main targets of your measures? Please, include the level of engagement for each potential category.

Legend: ■ Much lower ■ Moderately lower ■ Slightly lower ▨ About the same ▨ Slightly higher ■ Moderately higher ■ Not engaged
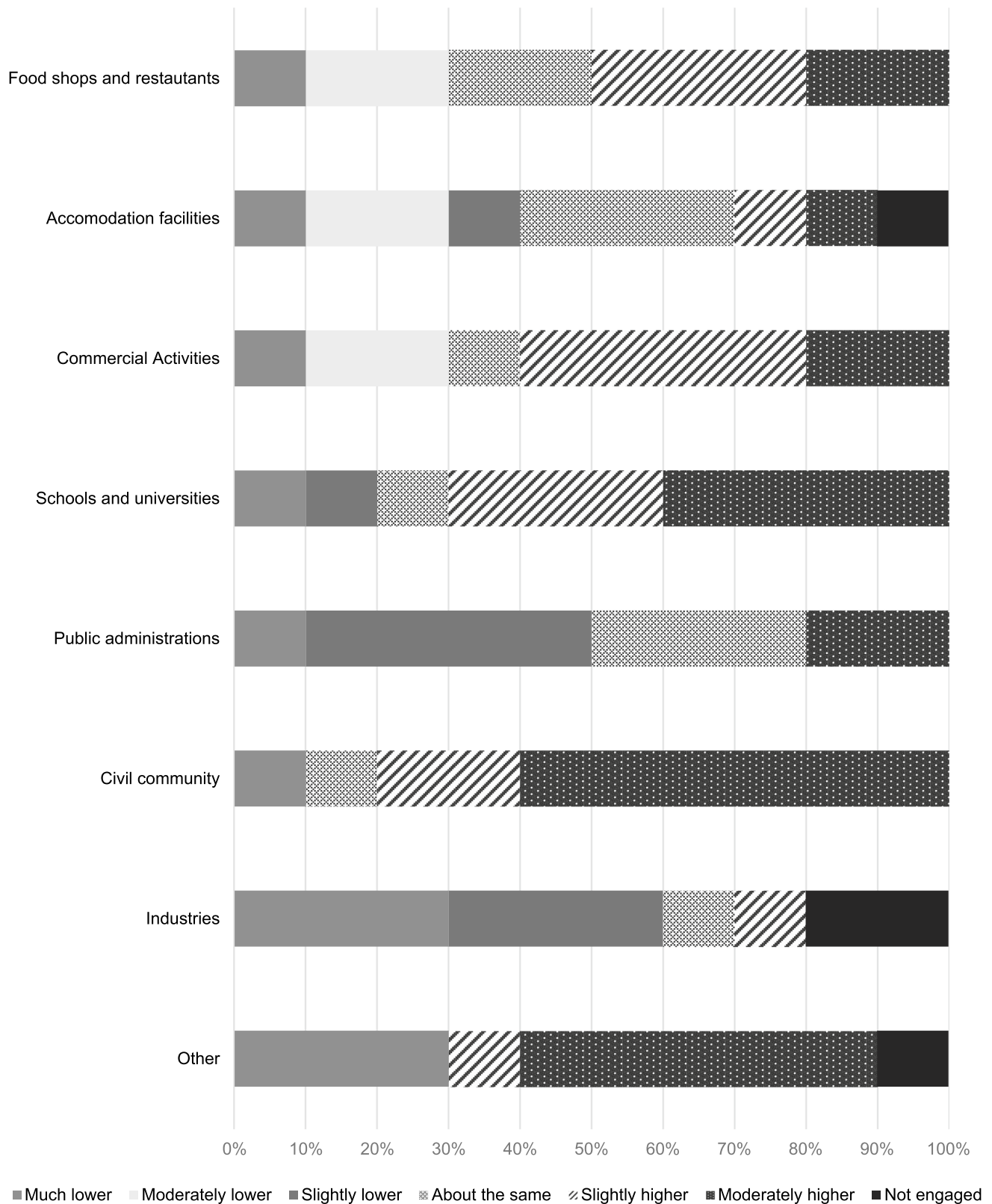
Fig. 7 Target stajeholders related to waste prevention activities implemented in EU capital cities

Discover

be limited to technological investments or financial means but expanded to turism ecosystem engagement and behavioural change initiatives [98, 99]. On this regard, Ljubljana is recognized at the forefront among the EU capital cities for its zero-waste commitment, operationalized in the promotion of packaging-free shops, investment in public procurement of sustainable products, and establishment of public awareness campaigns with various stakeholders, including businesses, NGOs, and citizens [100]. Similarly, the Smart Prague Concept [101] and the packaging-Free Shopping initiative [102] make the city a frontrunner in the integration of waste management with digital technologies [103]. With the same aim in mind but different actions, city managers from Lisbon have largely invested in the hospitality industry to ensure zero-waste goals. Finally, Lisbon introduced a package of measures including the promotion of waste separation in hotels - where individual bins in guest rooms and common areas are provided to sort plastic, glass, paper, and organic waste fractions and the replacement of single use toiletry containers with dispensers [6].

When tourists are engaged in waste prevention practices, dynamics for better waste sorting appear facilitated, thus stimulating active behaviour which simultaneously promotes shared responsibility, closeness towards the place, and tourist satisfaction with the place and the travelling experience [10]. That said, measures should be designed to encourage shopkeepers, hotels, resorts and general holders of tourist accommodations to minimize waste. In tandem, municipalities should combine responsible tourism aspirations with reliable waste infrastructure to ensure that reliable consumption behaviours are supported by well-functioning disposal patterns. It follows that local institutions should better enforce public–private partnerships to ensure the efficacy of waste prevention measures while it is their responsibility to design and implement infrastructure able to react to waste diversity in terms of material compositions and volumes. This is also encouraged by the EU policies [104] which targets are mostly oriented towards reuse rather than recycling only.

6 Conclusion

6.1 Concluding remarks

Acknowledging that the challenges posed by plastic waste in urban environments with high tourism intensity are multi-dimensional, requiring a comprehensive approach that encompasses technological innovation, legislative actions, behavioural changes, and cooperation among multiple stakeholders [17], this study discusses the perspective of municipalities in managing and minimizing waste in EU capital cities, by considering plastics and bioplastics as material streams to be attended.

The contribution of tourism to waste generation has been here scrutinized, highlighting how high tourism intensity exacerbates the strain on waste segregation, especially in cities that lack adequate waste management infrastructure. The influx of tourists, coupled with the high consumption of SUPs, leads to significant environmental challenges that, if not properly managed, can challenge local municipal waste management systems.

Several barriers to effective waste management were identified, including poor legislation enforcement, lack of public awareness, insufficient knowledge and missing harmonization in waste collection practices when dealing with innovative materials like biodegradable and compostable plastics. These issues are particularly pronounced in high tourism intensity cities, where seasonal variability adds to the complexity of maintaining consistent waste management programs [46]. Despite these challenges, some cities have demonstrated advanced levels of implementation for waste prevention measures, which effectiveness is ensured by the engagement of all stakeholders, including tourists.

To address these challenges, urban waste management plans must extend beyond technological investments and financial resources. A holistic approach that includes tourism ecosystem engagement, policy development, and behavioural change initiatives is essential [98]. The findings of this study advance the research landscape by merging waste management and tourism literature streams. By providing insights from the perspective of city managers, the research highlights how a well-coordinated combination of prevention and recycling initiatives, supported by public–private partnerships [106], is crucial in addressing overgeneration and mismanagement of urban waste.

The empirical research undertaken in this paper has various policy implications. Municipalities characterized by high tourism intensity must prioritize developing waste prevention campaigns that involve all the actors of the tourism ecosystem. A reuse pathway is not only preferred but also encouraged by EU policies.

Considering practical implications, city managers need to design and implement programs that educate and engage the hospitality industry about proper waste management practices. Simultaneously, they must invest in robust waste infrastructure capable of responding to diverse material streams. Increasing public awareness about proper waste disposal helps residents and tourists to understand the importance of waste segregation [105].

6.2 Limitations of the study and further research agenda

This study does not come without limitations. First, the study focuses primarily on EU capital cities. The exclusive focus on capital cities limits the generalizability of the findings on tourist hotspots, as waste management challenges in smaller cities or rural areas may differ significantly. Second, only city managers of the environmental department and/or in charge of waste management services have been engaged. In order to avoid a response bias, further research may extend to other departments (like the tourism department) and other cities (like regional cities) with different tourism dynamics. Finally, the role of city managers and the contribution of waste management in advancing smart and carbon neutral city initiatives would benefit the literature stream on public management, urban development and sustainable development.

Declarations

Ethics approval and consent to participate There is no Italian legal basis for Ethics Committees to review qualitative research with interviews, quantitative research using questionnaires or internet-based surveys, unrelated to clinical trial. This type of research is free in agreement with the Italian Law.

Informed consent Informed Consent was obtained from all the participants involved in the study. The consent to participate in the survey was written and aligned with EU data policy regulation. Data are not based on individual persons.

Competing interests The authors declare no competing interests.

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