

Article

# Solid Waste Management Key Indicator Development for Hotels: A Tunisian Case Study Analysis

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**Abstract:** The main objective of this research was to provide suitable technical, organizational, financial, legal, and social indicators for solid waste management (SWM) systems, which can be used to diagnose the current situation faced by tourist destinations (TD) in Tunisia. To this end, 33 interviews and field visits to hotels in Tunisia were carried out. Specifically, the study covers tourist municipalities, private companies, and environment and tourism authorities. A characterization analysis and a quantification of the solid waste (SW) generated by hotels were also performed. It was found that hotels generate large amounts of mixed SW, especially during the summer period. It represents, for example, 45.5% of the total SW generated per year in Hammamet, and can reach 54.2% during the summer. The interviews indicated that 83% of the hotels collect mixed waste, which is then sent to landfills. The characterization of the SW shows that hotels generate about 58% organic waste, and a minimum of 36% of recyclable waste could be valorized. From a financial point of view, the results indicated that the collected taxes from hotels do not cover the municipalities' expenses. The findings of the research reported in this paper can be used as a decision-making support.

**Keywords:** solid waste management; key indicators; tourist destinations; hotels; decision-making; Tunisia

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## 1. Introduction

The rapid development of the tourism industry has a direct impact on the increase in the amount of solid waste (SW) in tourism areas [1,2] and has a negative impact on the environment [3], namely in the form of higher operational costs [4], blight owing to litter and contaminated water, and a reduction in the touristic value of otherwise attractive locations [5]. This has increased pressure on public authorities to develop accurate municipal solid waste management (MSWM) policies and systems to deal with the impacts on services related to solid waste (SW) generation in tourism destinations [6–8].

A clean beach is the main indicator of coastal environmental quality. However, coastal regions are susceptible to litter accumulation, and marine litter has become a global problem [9]. Solid waste management (SWM) systems in touristic regions have their own rules, not only concerning waste collection from hotels, but also beach and street cleaning, infrastructure, etc. Moreover, these systems generally become more concentrated during the summer, putting even more stress on the authorities [10,11]. The increase in the number of tourists, therefore, increases the amount of waste generated [12,13] and makes the waste management operation even more complex [14]. It should be noted that quantities of SW generated by tourism enterprises are large in absolute terms—reaching 35 million tons of SW per year globally [15]—and that a tourist may generate up to twice as much SW per capita as local residents [16]. Moreover, in several zones of high touristic interest, visitor amounts can even overcome the volume of wastes generated by the local population during the ‘high

season' [17]. This is also the case in Langkawi Island in Malaysia, where tourists generate double the amount of SW per capita compared to local residents [18].

Good waste management in hotels could be among the solutions to improve the sector. In fact, around 30% of a hotel's SW can be sorted, reused, recycled, or recovered [19]. For example, as reported by Bohdanowicz [20], 80% of hotels in Sweden and 30.6% of hotels in Poland have active waste sorting and recycling programs. On the other hand, the composition of the waste generated depends on the tourist area. For example, in Hoi An in Vietnam, the waste composition of hotels was 58.5% for biodegradable waste, 25.8% for recyclables, and 15.7% for other [21]. Another study in Djerba showed that the organic fraction in one of the hotels represented more than 71% [22]. Contrariwise, the composition in the UK was 37% for food waste, 50% for recyclables, and 13% for other [23]. This difference influences the way of managing and treating waste generated between different countries.

SWM in tourism destinations in developing countries still represents a big problem. For example, Ghadban et al. [24] presented the SWM crisis in Lebanon in 2015, in which hotels were the main producer of SW. Furthermore, Djerba Island in Tunisia, where hotels generate 45% of the total waste (according to the Ministry of Local Affairs and the Environment), has been experiencing a major waste management crisis since 2012 [25]. The increase in the quantities of waste necessarily causes the increase of the costs of the collection. Malaysia, for example, spends 75% of municipal budgets for waste collection [26].

In Tunisia, tourism is an industry which has seen continuous development and will reach 8 million tourists by the end of 2018, according to the Tunisian Ministry of Tourism. Such an evolution must be associated with good organization and the management of the large amounts of SW generated [27], which requires concrete data for decision-making.

Indicators are considered as a tool with which more information can be obtained. The Rio Conference on Environment and Development in 1992 recognized the need for better and more knowledge and information about environmental conditions. To achieve this, it was necessary to collect new and better data, as well as to promote new thinking and research with regard to indicator frameworks. The selection criteria ensure that the indicators are useful and effective in their provision of information to the decision-makers [26]. However, and as reported by Bahia Sergio [28], 39% of indicators can be easily accessed, another 39% present moderate difficulties in obtaining data, and the remaining 22% are classified as being difficult to answer. On the other hand, Rosenstrom [29] found that environmental indicators do not steer decision-making in Finland, but rather supply background information.

The lesson learned from this work is to take into consideration the importance of developing different indicators for different audiences, contexts, and ends. As well, special attention should be paid to interpreting the collected and developed indicators to transform this into information. This can be used as a tool to support local authorities in decision-making, planning, monitoring, and judging specific policies, as well as to improve the SWM sector in tourism zones [30].

The objective of this paper was to provide a core set of organizational, technical, financial, legal, and social indicators that have the greatest influence on decision-making. The most important indicators for the Tunisian context were employed to diagnose the SWM situation in the tourism sector.

## 2. Results

Table 1 presents the indicators developed with regard to SWM in tourism zones, classified as follows:

- (a) Technical indicators: This box concerns general data related to tourism establishments, their classification, and other information that concerns quantitative and qualitative indicators related to SWM operations (separation, collection, recycling, etc.);
- (b) Organizational indicators: These indicators are mainly related to national and local SWM institutional frameworks, to the structures and tasks of the different actors;

- (c) Financial indicators: These are linked principally to the current financial framework, taxes paid by hotels, and whether these adequately cover municipal SWM costs;
- (d) Legal indicators: These concern regulations and SWM laws at the national and local levels.
- (e) Social indicators: these indicators concern the social issues related to SWM in hotels or in public areas (beaches, parks, streets, etc.), such as the motivation of the hotel team, the education of the staff, guest satisfaction, etc.

**Table 1.** Key indicators classification for solid waste management (SWM) in tourist destinations.

<b>Indicators</b>	
<b>Technical indicators</b>	General information (No. of beds, rooms, occupancy rate, etc.)
	SW generation in the hotel (kg/day)
	SW generation by tourists/guests (kg/day)
	SW composition and characteristics
	Types of SW generated in different hotel departments
	SWM practices in hotels (landfilling, recycling, etc.)
	Sources and characteristics of SW generated from kitchens
<b>Financial indicators</b>	SW reduction activities in hotels
	Frequency of SW collection from hotels
	SWM costs per guest per night
	SWM general costs paid by hotels
	Taxes paid by hotels for SW collection
<b>Organizational indicators</b>	SW collection costs (per ton)
	Adequacy of taxes paid for SWM
	Role of different actors in SWM in tourism regions
	Percentage of tourist destinations (TD) covered by SW collection services
<b>Legal indicators</b>	Types of SW collection services in TD (public or private)
	Number of collection and recycling facilities installed in the tourist municipality
	SWM law in tourist areas
	National laws regarding the environment
<b>Social indicators</b>	Control law for hotels
	Requirements of the municipalities on SWM in hotels
	Municipal SWM plans and local objectives
	Employee involvement in separation and recycling activities
	Hotel satisfaction (concerning cleanliness)
	Customer satisfaction (concerning cleanliness)
	Responsibility for the assigned area
	Motivation of the hotel
	Education on SWM in the hotel

Based on the developed indicators, some were selected to report on the SWM situation in the tourism sector, especially for hotels in Tunisia.

### 2.1. Technical Indicators

#### 2.1.1. Composition and Characteristics of SW Generated by Hotels

This indicator should always be included in any decision-supporting process. It furthers the understanding of the characteristics of the waste generated and allows decision-makers to define laws and actions to orient the campaigns to increase sensitivity, etc. The composition of SW from hotels is similar to that of household waste but varies somewhat depending on the services offered by the establishment. For example, those hotels that have restaurants have a higher share of organic waste [31].

Figure 1 presents the results of the SW sorting analysis on Gammarth and Hammamet, which aims to determine the amounts of different waste fractions generated by hotels.

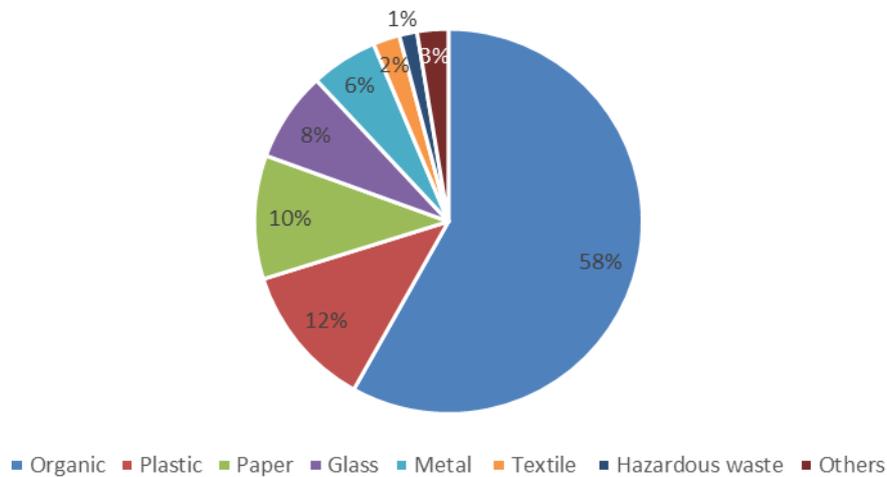


Figure 1. Characteristics of the solid waste (SW) generated by hotels in Gammarth and Hammamet.

The results indicate that a minimum of 36% of the SW generated by hotels could be valorized and recycled, if proper sorting at the source in hotels was performed to separate glass, metal, and mainly plastics and papers, which represent 22% of the total waste. Moreover, the results indicate that biodegradable waste accounted for the highest percentage of 58%, including kitchen waste and green waste.

The results of Figure 2 show that a higher level of organic waste was generated during the summer period and only small differences were observed for the other fractions. These differences correlate with the findings of Gidarakos et al. [32], who revealed that municipal SW generation and composition depends on the flow of tourists throughout the year.

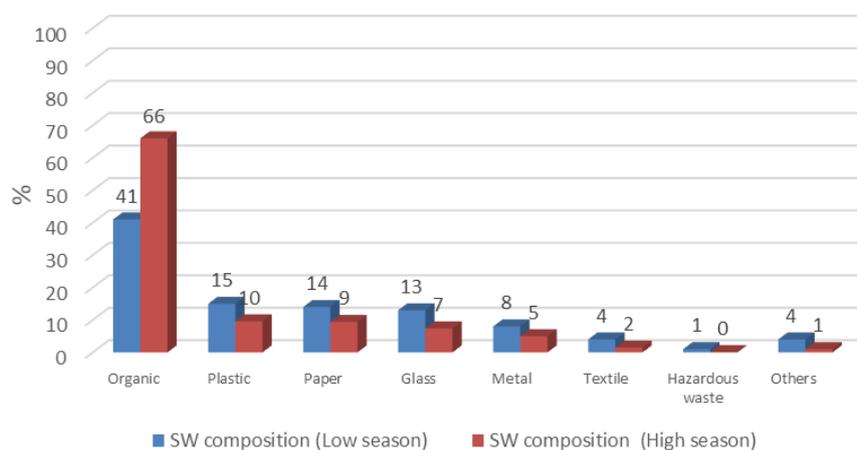


Figure 2. SW characteristics comparison in Gammarth between low and high seasons.

### 2.1.2. Streams of SW Generated per Department

SW is generated from different departments of hotels, such as rooms, kitchens, gardens, restaurants, administration, etc. This indicator allows the investigation of where and how waste arises. The process helps to prioritize areas where simple actions can be taken. Table 2 represents the sources of different types of waste generated in different hotel departments. The responsible (Hotel, Guest) for the different types of waste have been identified.

**Table 2.** Principal types of solid waste (SW) generated from different hotels departments.

Department/zone of the hotel	Types of waste	Responsible	
		Guest	Hotel
Beach	Paper, plastic, carton	100%	0%
Wellness area	Wipes, diaper, waste resulting from personal hygiene (bathroom kit, soap remainders)	100%	0%
Outdoor area (park, pool, garden, golf course)	Garden waste, paper, plastic	10%	90%
Kitchen	Food preparation waste, carton packing, metal packing, paper, textile	0%	100%
Local restaurant and bar	Meal remains (bio-waste), glass, plastic and metal packaging	95%	5%
Laundry service	Tablecloths, towels, clothes, rags	0%	100%
Furniture and stock	Plastics, paper, cardboard	0%	100%
Maintenance service	Paint remains, cans, light bulbs, paper, plastic	0%	100%
Offices and administrative activities	Cardboard packaging, plastic bottles, glass, paper, ink cartridges, batteries	0%	100%
Conference rooms	Paper, plastic, meal remains, glass	90%	10%
Lifts and stairs	Paper, plastic	100%	0%
Rooms	Metal, plastic and glass packaging (minibar), paper and newspapers, plastic cups, layer, wipes, personal hygiene waste (toilet bag, soap remainders), courtesy waste (slippers, shower cap, disposable products), batteries, medical waste	100%	0%

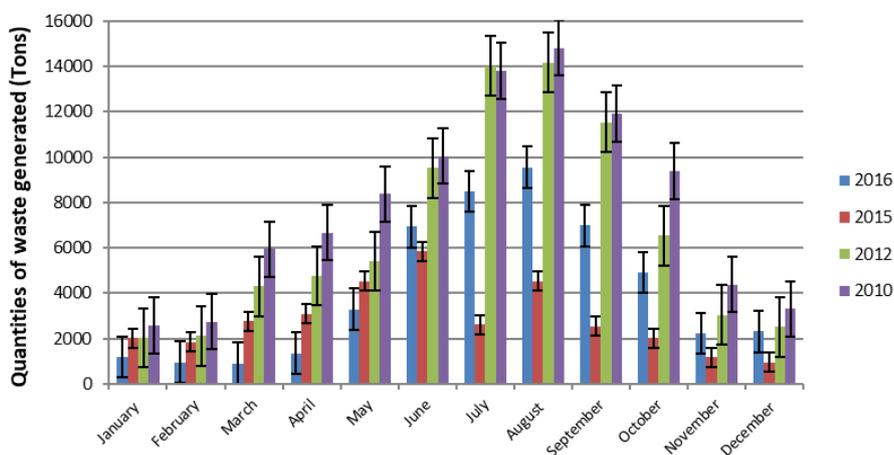
It should also be noted that other types of waste are generated occasionally from hotels in Tunisia, having mainly hotels as a source:

- (a) Bulky waste (supply, chairs, desks, sofas, etc.);
- (b) Demolition and renovation waste (concrete, stone, brick, plaster, glass wool, ceramic, glass, treated wood, pipes, etc.);
- (c) Hazardous waste (used electrical and electronic equipment, fluorescent lamps, batteries, discarded refrigeration equipment such as refrigerators, freezers).

2.1.3. SW Attributable to Tourism (Tons/Month)

Tourist zones generate different amounts of SW, given the difference in terms of the number of hotels and the number of tourists and visitors [33]. The presented methodology refers to the waste generated by tourists at the hotel.

The variables of  $N_n$ ,  $N_a$ , and  $N_t$  were collected based on the statistics of the Ministry of Tourism. The formula was used to estimate and compare the waste generated in Tunisia (tons/months) for the years 2010, 2012, 2015, and 2016 (See Figure 3).



**Figure 3.** SW generation from accommodation establishments between 2010 and 2016 in Tunisia.

The above figure shows a progressive increase in generated waste from hotels during the summer period, with a peak during July and August. The quantity decreased during the years 2015 and 2016.

Figure 4 shows the increase in the quantities of SW generated in hotels in Hammamet during the summer period in 2017. This period begins with a first increase in May, and peaks during June, July, and August (between 2500 tons and 3000 tons).

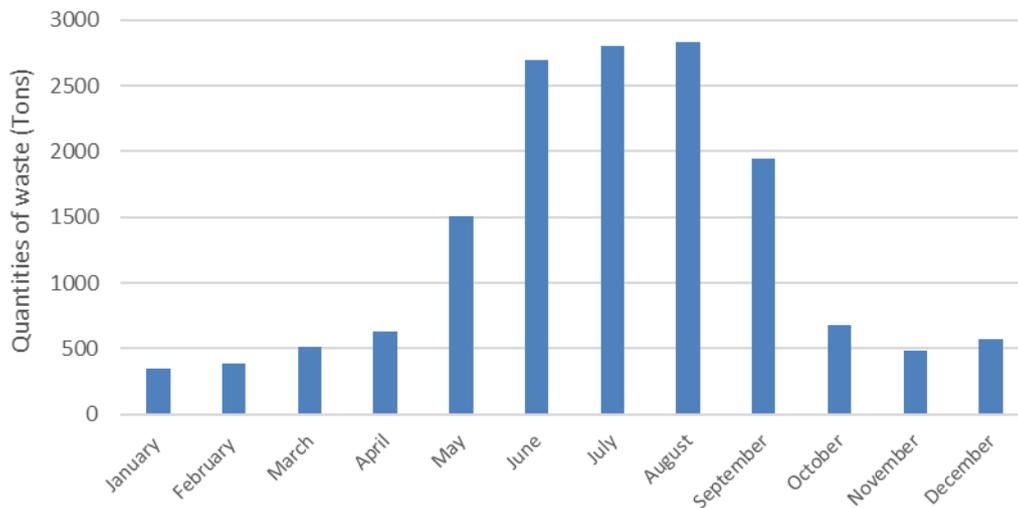


Figure 4. Evolution of SW attributable to tourism (tons/month) in Hammamet (2017).

Taking into account the results of the estimation, and to understand the role of tourism in SW generation in Hammamet, a comparison with household waste generation was performed. Figure 5 represents the contribution of the hotels in Hammamet to the total quantities generated. The estimated amount of SW generated by hotels in Hammamet in 2017 was as much as 15,394 tons, which represents 45.5% of the total SW generated for the year (33,840 tons). The contribution of hotels was higher during July and August, representing 54.2% and 49.5%, respectively, of the total waste generated by the tourism sector in that municipality.

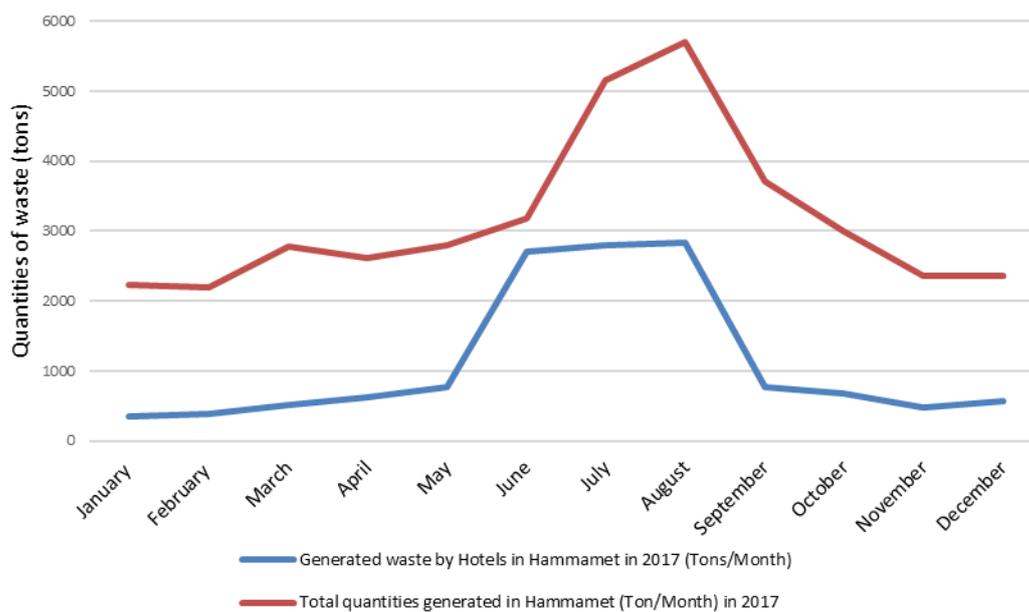


Figure 5. Comparison of SW generated in Hammamet by tourism and households in 2017 (Tons/Month).

### 2.1.4. SWM Practices in Hotels

SW generated by hotels can be treated with different manners. In Tunisia, hotels themselves actually decide on their SWM management strategies, since laws are not sufficiently enforced by municipalities. Based on the questionnaire undertaken by 33 hotels in Tunisia, the results in Figure 6 indicate that 83% of hotels generate mixed waste to be landfilled, whereas only 17% of hotels are developing small recycling and composting initiatives. At that level, recycling means sorting different materials at the source (plastic PET, PEHD, paper and cardboard, glass, bread). On the other hand, the option of energy recovery is not currently on the table.

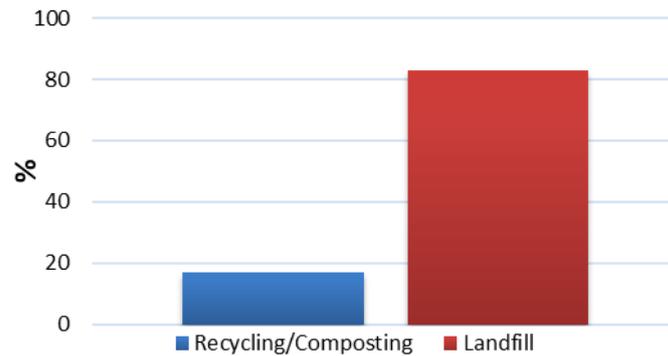


Figure 6. Solid Waste Management (SWM) practices in hotels in Tunisia.

In the case of mixed SW generation, the municipality is responsible for collection and transportation. This collection does not include hazardous waste, green waste, electronic waste, or chemical waste, etc. (see Figure 7). In this case, waste pickers collect the recyclable materials from the landfills to be sold and recycled.

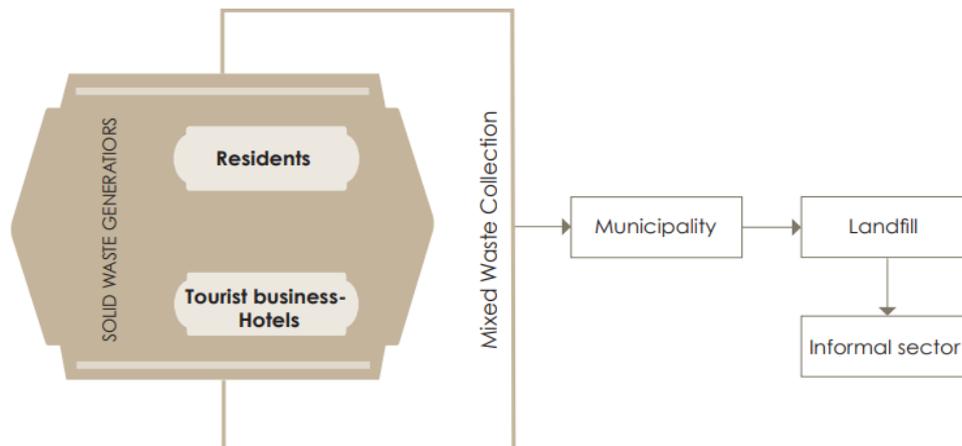


Figure 7. Case of mixed waste generation in hotels in Tunisia.

In the case where hotels sort their waste, two types of SW are eliminated: mixed waste (collected by the municipality) and recyclable waste such as paper, cardboard, plastics, metals, and glass, which are collected by private companies and informal collectors (see Figure 8).

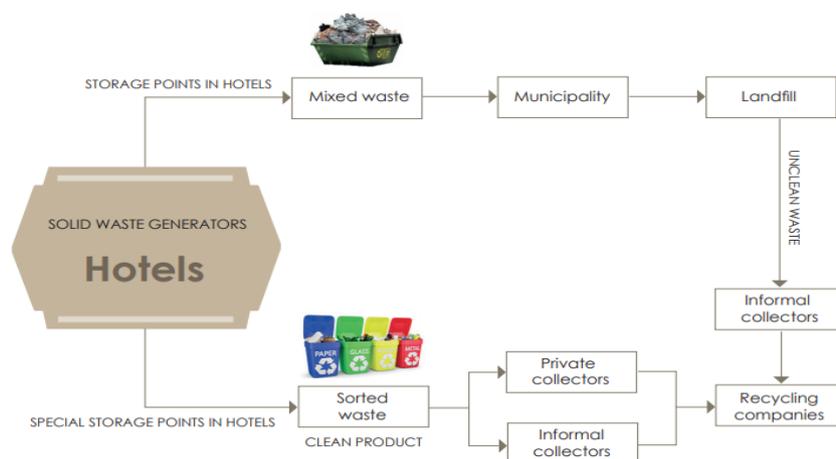


Figure 8. Case of SW sorting at the source in hotels in Tunisia.

### 2.1.5. Source and Characteristics of SW Generated by Kitchens in Hotels

Food waste is defined as “any by-product or waste product from the production, processing, distribution, and consumption of food” [34]. In hotel kitchens, food waste could be the result of food preparation and processing, from serving dishes or from the guests’ plates [35].

In this study, it was found that about 39% of the waste was from food preparation, 59% from guests’ plates, and 2% from non-consumed food. On the other hand, the characterization of the kitchen waste in these establishments showed that 83% of the generated waste was bio-waste. The remaining 17% included paper (6%), plastic (5%), glass (3%), and metal (3%). In fact, all fractions are mixed with other types of waste from other departments. This indicator could help hotels to identify possible actions to minimize the generated food waste.

## 2.2. Organizational Indicators

### 2.2.1. SWM Actors and Responsibilities

In Tunisia, several actors take part in SWM in tourist areas. The municipality, the private sector, tourist businesses including hotels, the Ministry of Local Affairs and the Environment, the Ministry of Tourism, and the Ministry of Finance are basically the main active stakeholders in this process. Table 3 presents the classification of their responsibilities.

Table 3. Role of different stockholders in SWM in tourist destinations.

Institution	Role
Municipalities	Waste collection and transfer; cleaning the streets and beaches; SW collection infrastructure
Hotels	SW storage and preparation for collection; responsibility of cleaning the surrounding beaches and supporting the efforts of the municipality
Ministry of Local Affairs and the Environment (MLAE)	Special cleaning actions; planning and coordination of cleaning actions
Ministry of Tourism	Support for special cleaning actions; discussing with municipalities and the MLAE about the plan of the Tourist Destinations Protection Fund
Private sector (collectors and recyclers)	Participation in collection and cleaning efforts; recycling activities
Coastal Protection and Development Agency (APAL)/National Agency of Waste Management (ANGed)	Organizing special cleaning actions

These actors engage in SWM without any special strategy, which results in large quantities of waste generated during the summer period from tourist establishments. It should also be noted that no program for sorting at the source for hotels nor for the recycling of waste is scheduled by the authorities at the moment.

### 2.2.2. Types of SW Collection Services in Tourism (Public or Private)

In Tunisia, municipalities are responsible for SW collection, and they can also delegate this task to the private sector. One hundred percent of tourist zones are covered by a collection system, but the quality of the service differs from one area to another. Municipalities tend to privatize the collection of waste from hotels, given the low price and the quality of service. This sector is also involved in terms of mechanical or manual cleaning activities (streets, beaches, etc.) during the high seasons.

Table 4 presents some examples of the service providers within four tourist municipalities.

**Table 4.** Intervention of private and public sectors in waste management (WM) services (%).

Tourist Municipalities	% of Public Services	Type of Services	% of Private Services	Type of Service
Marsa-Gammarth	50%	SW collection from	50%	SW collection from
Hammamet	25%	households and	75%	households and
Sfax	70%	hotels; street	30%	hotels; street and
Bizerte	100%	cleaning	0%	beach cleaning

### 2.2.3. Number of Collection and Recycling Facilities Installed in Tourism Municipalities

Private collection and recycling facilities are important actors with regard to SWM in tourism. Their presence in tourist municipalities can open the doors to new waste sorting and recycling initiatives in hotels. Table 5 presents the existing companies in six tourist areas in Tunisia. They offer different services for several types of waste. The table also indicates the difference between existent aggregated companies (small companies for collection) and active companies.

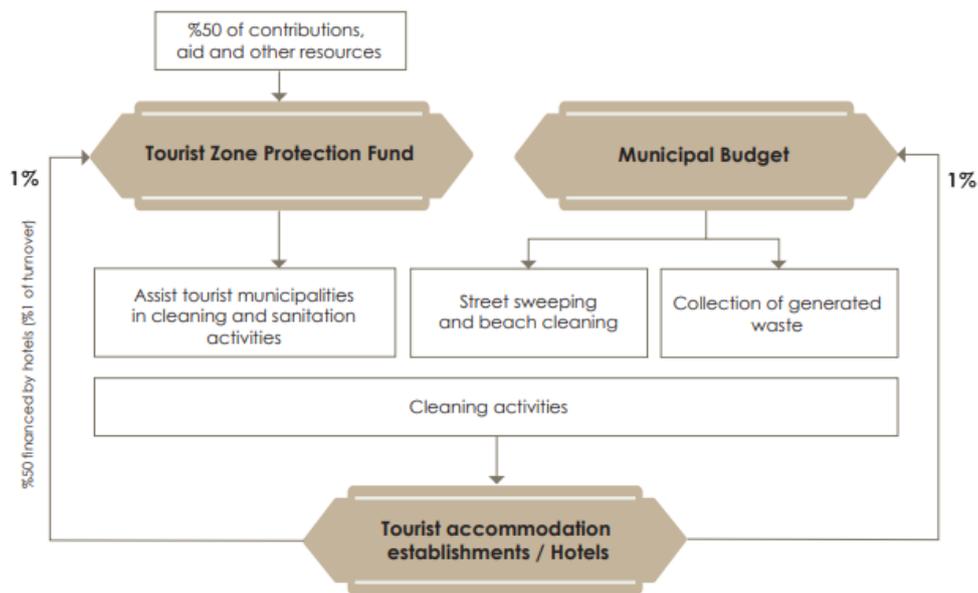
**Table 5.** Existing collection and recycling companies in six tourist destinations (source: National Agency of Waste Management (ANGeD)).

Tourist Destination	Aggregated Collection Companies	Aggregated Recycling Companies
Tunis	37 (25 active)	15 (PET, film, sacs, membranes)
Nabeul/Hammamet	7 (4 active)	4 (PET, film, sacs, membranes)
Sfax	25 (15 active)	8 (PET, film, sacs, membranes)
Sousse		16 (PET, film, sacs, membranes)
Mounastir	42 (30 active)	6 (PET, film, sacs, membranes)
Mahdia		2 (PET, film, sacs, membranes)

## 2.3. Financial Indicators

### 2.3.1. Taxes Paid by Hotels for SW Collection (Tunisian Dinars (TND)/Year)

In Tunisia, hotels pay taxes for general services, including SWM. These taxes amount to 2% of their turnover per year—1% for the municipality and 1% for the fund for the protection of tourist destinations (TD) (the allocated budget is decided after discussion with the tourism authorities). The activities relate to SW collection and transfer, road sweeping, beach cleaning, etc. (see Figure 9).

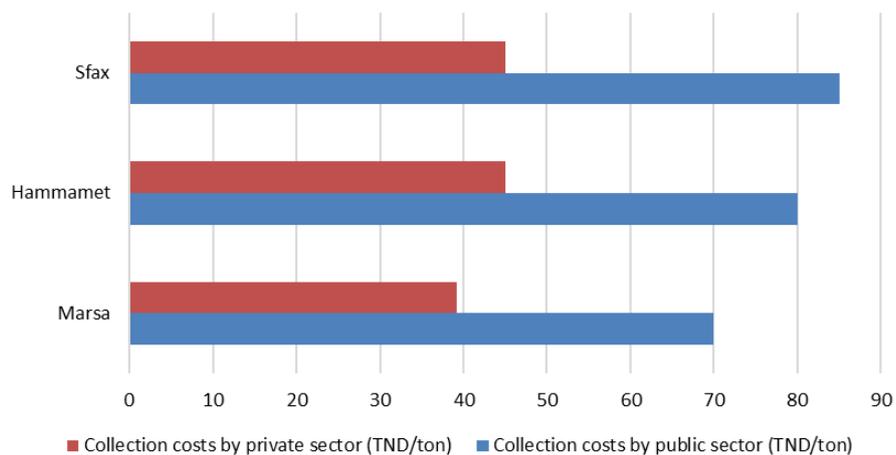


**Figure 9.** Financial system of SWM in tourist zones in Tunisia.

It should also be noted that the fund, financed by hotels, is also used to finance other activities, such as security in tourist areas. Municipalities say that the aid received from the fund is not sufficient, and does not cover the costs of waste management, especially for large tourist municipalities.

### 2.3.2. SW Collection Costs (TND/Tons)

The collection process is a high priority in the management of SW in tourist areas. This operation has a direct effect on the cleanliness of the destination. It may be ensured by the municipality or delegated to the private sector. Human resources, maintenance, fuel, and other operations cost money. Data collected from private companies and municipalities allowed us to compare public and private sector costs in three tourist cities (La Marsa, Hammamet, and Sfax), revealing that public costs are greater than those of the private sector (Figure 10).

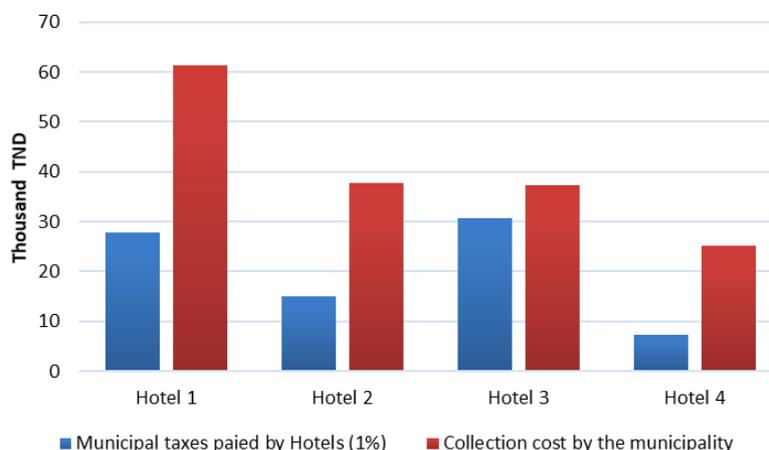


**Figure 10.** Comparison between SW collection costs from hotels by the private and public sectors.

This difference is due to competition between local companies. On the other hand, the results of the questionnaire carried out by hotels indicated that 100% of the questioned municipalities are more satisfied with the private collection services since they are well equipped and better organized than the services provided by municipal authorities. This is especially the case with regard to big waste management companies.

### 2.3.3. Adequacy of Taxes Paid with Regard to SWM

With regard to SWM, hotels pay taxes for the provision of services, such as collection and transportation to landfills, provided by the municipality. Figure 11 provides a comparison between the taxes paid by four Tunisian hotels for general municipal services and the municipal costs for the collection of different mixed waste amounts.



**Figure 11.** Comparison of the taxes paid by hotels to municipalities (1%) and the municipal collection costs from hotels.

## 2.4. Social Indicators

### 2.4.1. Employee Involvement in Separation and Recycling Activities

Hotel owners, managers, and employees must make a commitment to SWM in their establishments, through waste reduction and sorting and recycling initiatives, if these programs are to be successful [36]. Hotels staff should be included at all stages of the program so that they understand and support the waste management strategy in the hotel.

The questionnaire results show that 70% of hotels do not have any apprenticeship programs for staff to learn appropriate collection/sorting of waste.

### 2.4.2. Hotel and Customer Satisfaction

A questionnaire was undertaken in six tourist areas (Hammamet, Sfax, La Marsa-Gammarth, Sousse, Mahdia, and Djerba) with 50 hotel guests of different nationalities from Europe, America, Africa, and Asia (see some questions in Table 6).

**Table 6.** Interview questions involving hotel guests.

Questions	Number and Categories of Guests Questioned
Are you interested in the question of “waste management” and “cleanliness” in tourist destinations?	50 guests: 30 guests (20–40 years old) and 20 guests (40–60 years old), from Europe, America, Africa, and Asia
What do you think of the cleanliness/hygiene/quality of the hotel?	
How do you evaluate cleanliness around the hotel?	
Do you think that the number of garbage cans around the hotel is sufficient?	
What do you think of the cleanliness in the tourist area generally?	

The questionnaire results showed that all guests were interested in a clean destination, and were also satisfied with the cleanliness and the hygiene in the hotel. However, 90% of the guests were

somewhat dissatisfied about the cleanliness of the streets around the hotel, while 50% were unhappy about the cleanliness of the tourist area generally. All guests who completed the questionnaire complained about the lack and/or insufficiency of bins. On the other hand, we asked the hotels responsible in a separate questionnaire about their opinion regarding the cleanliness of the TD. Eighty-eight percent of the hotels were not satisfied with the cleanliness of either the tourist area or the locality of the hotel, or of the beaches.

### 3. Discussion

This study agrees with the findings of Reference [37], that tourism structures produce different waste types, which mainly belong to the categories of organic waste, cardboard, paper, glass, tins, plastic, and packaging. The indicator, which aims to identify the sources of waste by department and manager, shows that the hotel and the visitor are both responsible for the generation of waste. As can be seen in Table 2, organic waste is generated mainly in the kitchen and restaurant, and other types of waste are generated from different departments unequally.

In the tourism sector in Tunisia, organic waste represents the main generated fraction, similar to the case of Vietnam [21], and its percentage depends on many parameters, such as the type of tourism and the season. To confirm this, the result of the study shows a difference of the composition of the waste between two seasons in Gammarth. This could be the result of a change in terms of the type of tourism (more beach tourism than business tourism during the summer), and consequently a change in the type of service provided in the hotel restaurants, such as more buffet service in restaurants, which generates more food waste [38]. Furthermore, this study found that 83% of the generated kitchen waste was bio-waste. It was sourced mainly from guests' plates, food preparation, and non-consumed food. The large amount of organic waste present in hotel SW has the potential to cause environmental problems, and at the same time could be a great potential for resource recovery, through compost production. Given these points, it is recommended for hotels to use "A la carte" service more than Buffet in their restaurants, which could reduce waste from guests' plates [39].

On the other hand, the calculation of the quantities of waste generated represents an important indicator to better planning the municipal SW collection, personnel, and equipment utilization, etc. The results of the theoretical quantification of SW generation in Tunisia in Figure 3 coincide with the case of the Galapagos Islands [12], indicating a strong seasonal pattern linked to tourism seasonality and revealing that SW generation has recorded peaks especially for the years 2010 and 2012. The figure also shows a decrease in these quantities in 2015. This was due to the tourism crises in the country after the terrorist attacks at Bardo and Sousse. The practical quantification in Hammamet served to confirm the difference of the quantities generated between the seasons, which is due to the increase of the number of the tourists and the reopening of closed hotels during the winter. This amount can reach more than half (54.2%) of the total generated waste in Hammamet, which confirmed the idea reported in Reference [17]. The increase in SW quantities during the summer season represents a problem for municipalities in terms of the availability of resources and the costs of collection. Furthermore, the study found that 83% generate mixed waste, without any sorting, which ends up in the landfill. In this case, only a portion of the non-clean recyclable waste is recovered by waste pickers from the landfills.

On the other hand, the private sector should also play an important role in this process. This study showed that the costs of collection by the private sector are less than those incurred by the municipality, with hotels being satisfied overall with the offered service. In the same way, the existence of collection and sorting companies of recyclable materials represents a motivation to launch sorting at source in hotels, since a potential of 36% of recyclable materials generated by hotels exists. Recyclable materials collected directly from hotels are clean and available to private collectors. The main barriers to collaboration in the form of "collection companies/hotels" are related to the costs and the profitability of the operation. Some companies also require the payment of transportation costs to make the collection of recyclable materials profitable. However, some hotels consider it as a resource and charge

a fee for collecting it. Apart from that, and following our discussion with hotels and private collection companies, other points are taken into consideration when developing this collaboration, such as types of materials accepted by the collector, materials preparation requirements (clean sorted materials, clean commingled materials, etc.), the supply of collection containers by the collector, possibility of monitoring and documentation of the collected quality, etc. The local authority could also be included to organize this collaboration.

Undoubtedly, the development of the sector must be accompanied by the improvement of the financial framework of waste management in tourist destinations. Actually, Figure 11 shows that taxes paid by hotels do not cover the costs of collection and cleaning the streets and beaches. On another hand, the municipality pays more money by collecting increased quantities of waste by hotels. To address this, the creation of a specific tax for residual waste generated per ton is recommended. In this way, hotels will conduct appropriate and effective sorting to minimize the waste collected by the municipality. As well, the local authority may charge additional fees on hotels to cover the costs of the collection operation.

From an institutional vision, it should be pointed out that municipalities need specific organizational, technical, and financial solutions to manage SW sustainably. For many reasons (financial, technological, know-how, etc.), municipalities cannot ensure that this task is carried out properly in such a way as to satisfy tourists. Hotels are not sufficiently experienced and, while local private collecting companies can do this work efficiently on a technical level, they are not able to ensure organizational decisions. The main actors of the tourism sector (Tunisian Federation of Hotels, National Office of Tourism, etc.), in cooperation with the municipalities and SWM authorities, must work together to provide a sustainable solution based on organizational issues, involving local businesses and experts. The sorting of the generated SW at the source is a solution that can reduce the quantities of waste to be landfilled, and increase the availability of clean products for collection and recycling companies.

Among the identified social indicator, two were taken into account. They concern the satisfaction of hotels guests about the cleanliness and the involvement of the hotel's staff in waste management initiatives. Findings of these indicators indicate the dissatisfaction of guests and hotels owners about the cleanliness around the hotel, as well as in the tourist destinations. They also show a weak integration of workers in the waste management operations. These results confirm the importance of the improvement of the SWM concept to improve the cleanliness of the tourist destinations. Moreover, the results stress the importance of the integration of the hotel through waste minimization, waste sorting at source, beach cleaning, etc.

## 4. Materials and Methods

### 4.1. Data Collection and Indicators Development

As a first step, and to further identify more drivers, a review of 50 relevant papers, reports, and doctoral theses on SWM in tourism was undertaken [1–25,27–30,32,34–38,40–54]. The literature review acted as a base to learn from other researchers, best practices, and international studies to better prepare all the possible items contained in the paper and questionnaires (see the questionnaires directed to hotels and municipalities in the Supplementary Materials).

Both questionnaires were structured to support the collection of appropriate indicators, and to collect more data on the Tunisian context. The first questionnaire concerns hotels and covers questions on the satisfaction of the establishment in terms of waste management in the zone, as well as technical aspects, including storage, collection, sorting, composting, etc. In addition, the questions affect the contribution of the hotel and its staff to the waste management system.

The second questionnaire concerns municipalities, which are considered to be the first parties responsible for waste collection and the cleanliness of tourist destinations. Questions include the

role of public and the private sectors, the type of waste collected, and the financial aspects of waste management (collection costs, taxes paid by hotels, role of the tourism fund, etc.).

As a second step, the employed methodology for the development of the indicators was based on a participatory process [26]. First, the framework was developed, agreed upon, and harmonized to structure what is to be monitored. Then, the selection criteria, indicator sets, and analytical tools were defined to establish a clear initiative that can be communicated to various stakeholders. Finally, the practical phase was initiated to collect data through questionnaires, visits, and analytical tools.

The most important indicators for the Tunisian context were selected, based on the country's current framework, and the ability of the indicators to influence decisions and to improve the sector was analyzed. To this end, key individuals from hoteliers, private companies, and national and local authorities were employed to identify current SWM practices.

#### 4.2. Study Area

Tunisia was selected for this case study. Tunisia is a small country on the North African coast with 1300 km-long coastline, holds a central position in the Mediterranean and has a very important mass tourism activity [55], which represents a major source of environmental pressure on the natural resources and coastal areas (water, waste pollution) [56]. Tourism in Tunisia has undergone major changes in recent years, and sustainable solutions must be put in place to ensure clean destinations. The country has undertaken many scientific researches to understand the potential and problems of the environment and to try to find suitable solutions for the posed problems. The study also focused on Hammamet and Gammarth, which represent some very important tourism zones in terms of the number of tourists arriving each year, whether for business or holidays.

In Tunisia, SWM is mainly the responsibility of municipalities [57]. SW generated from hotels is mostly mixed and sorting collection initiatives are infrequent. This causes an increase of collection costs and reduces the life of landfills. After the first municipal elections in May 2018, following a revolution with the aim of decentralization, municipalities held more power and financial independence to make decisions. Furthermore, they need reliable data to diagnose SWM situations and to make good decisions.

#### 4.3. Theoretical Quantification

The annual quantities of waste generated by the tourism sector in Tunisia were calculated based on estimating the amounts of SW generated by tourists (Qwt). First, the average lengths of stay in accommodation units for a city and a commune were calculated using the following formulas, developed by Reference [33]:

$$D_s = N_n / N_a \quad (1)$$

where  $N_n$  = number of overnight stays;  $N_a$  = number of arrivals.

Then, the amount of SW generated by tourists was calculated based on the formula:

$$Q_{wt} = N_t \times I_{twg} \times D_s / 1000 \text{ (t/year)} \quad (2)$$

where  $Q_{wt}$  = amount of waste generated by tourists;  $I_{twg}$  = tourist waste generation rate (kg/capita/day);  $N_t$  = number of tourists;  $I_{twg}$  = intermediate value compared to rural and urban areas provided in regional and local SWM plans [33]. In this paper,  $I_{twg} = 1$  kg/guest/day.

#### 4.4. Collected Samples Composition and Experimental Quantification

The first sorting analysis was planned during one week for each tourist destination (Gammarth and Hammamet), and during the winter and summer periods in Gammarth. The operation was limited to SW generated from hotels and quantities were provided by municipalities and the private sector. One percent of the waste generated from hotels per day (in February 2017) was sorted. This represents 150 kg in the case of Gammarth and 160 kg for Hammamet. Another sorting analysis

was realized in August 2017 in Gammarth to compare the composition of the waste between the winter and summer periods.

The waste is fractionated before sorting with two sieve cuts, thus, resulting in three screen fractions. The movement of waste is important to separate waste components from each other. The sieve cuts take place at 100 and 30 mm. Only the coarse fraction and the medium fraction (>100 mm and 100 mm to 30 mm) are fully sorted. From the fine fraction (<30 mm) only 10% are sorted.

The operations were conducted in covered and flat areas which belong to both municipalities. All necessary tools were available (screens, sorting table, equipment, scales, protective work clothing).

Figure 12 shows the methodology of the elaboration of the sorting analysis.

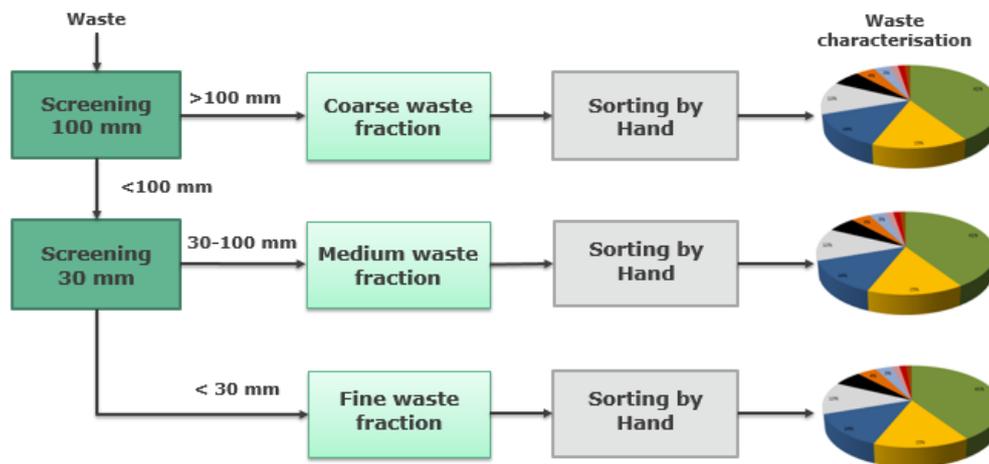


Figure 12. Sorting analysis methodology.

Furthermore, the amount of waste generated by hotels in Hammamet was also estimated. The estimation method was executed in the field. During 2017, knowing the lack of means available by the municipality, the amount of waste collected from hotels was weighted during three days in each month. The average represents an estimation of the quantities of waste generated in a month.

The identification of the streams of SW generated per hotels departments is realized within 4 hotels in Gammarth. All hotels departments were visited to note the generated waste in each of them and to identify those possibly responsible.

Regarding the characterization of the waste generated in hotel kitchens, a sorting analysis was realized which involved the collection of food waste in three separate bins in four hotels in Gammarth: one bin for waste from food preparation and processing, one for waste from serving dishes, and one for waste from guests' plates. The workers in the kitchen represented the strong point during this operation. After sorting the total amount generated in the kitchen, a weighing step is required to calculate the percentage of each fraction.

## 5. Conclusions

It has been increasingly expressed that SW represents a key concern in the hospitality industry and that city clean-ups are among the elements of sustainable tourism [58]. Improving the SWM system in tourist areas in Tunisia could consequently enhance the satisfaction of hotels and guests concerning the cleanliness of the TD, as well as create a suitable environment for more tourist arrivals, strengthening the Tunisian economy.

This study revealed that Tunisian hotels generate large amounts of mixed SW, mainly during the summer period, which ends up as landfill. It contributes significantly to the total waste generated in the destination during the year, and especially during the high seasons. This is the case for hotels in Hammamet, which generate 45.5% of the total waste in the city, and that could reach 54.2% during July. In hotels, waste is produced from different departments, and the responsibility is shared between

guests and the enterprise. In addition, it can be concluded that the composition of the waste generated from hotels is dominated by the organic fraction (58%), which is similar to the composition of waste generated from households. Therefore, the separation at source in hotels would allow clean organic and recyclable materials to be obtained which could be composted and recycled.

The top-down waste hierarchy is difficult to be applied directly to hotels. Actually, a bottom-up approach could be a solution for the case of Tunisia. Municipalities could temporarily continue the landfill operation, but this process should be accompanied by increasing financial pressure on hotels by charging taxes on residual waste collected.

This study also developed twenty-nine indicators between technical, organizational, financial, legal, and social. These indicators have the greatest influence on decision-making. Decisions should be based on concrete data, which is the most basic component of indicator work and represents the basis of the information.

This study has some limitations which have to be pointed out. This study did not assess useful indicators for SW generated by restaurants since they are also considered as potential waste generators in tourist destinations [59]. On the other hand, the survey did not obtain the determined sample size, because some hotels declined to answer the survey. Out of the 33 organizations who were selected for the sample, 27 respondents refused to participate in the study. Similarly, the difficulties encountered in collecting more information from the official level cannot be ignored.

With this paper, new lines of research are opened in the area of SWM in tourist regions in Tunisia. First, this will mainly involve the diagnosis of the identified indicators in other tourism municipalities. Second, to use these indicators and to develop others with the aim of controlling and monitoring SWM. Additionally, the implementation of an extended producer responsibility (EPR) system in Tunisia could be a solution, especially with regard to financing SWM activities in tourism destinations.

**Supplementary Materials:** The following are available online at <http://www.mdpi.com/2313-4321/3/4/56/s1>: Q1: Questionnaire for hotels, Q2: Questionnaire for municipalities.

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## References

- Giurea, R.; Precazzini, I.; Ragazzi, M.; Achim, M.I.; Cioca, L.I.; Conti, F.; Torretta, V.; Rada, E.C. Good practices for a sustainable municipal solid waste management. *Resources* **2018**, *7*, 51. [[CrossRef](#)]
- Arbulu, I.; Lozano, J.; Rey-Maqueira, J. Waste Generation Flows and Tourism Growth: A STIRPAT Model for Mallorca. *J. Ind. Ecol.* **2017**, *21*, 272–281. [[CrossRef](#)]
- Murava, I.; Korobeinykova, Y. The analysis of the waste problem in tourist destinations on the example of Carpathian region in Ukraine. *J. Ecol. Eng.* **2016**, *17*, 43–44. [[CrossRef](#)]
- Greco, G.; Cenciarelli, V.G.; Allegrini, M. Tourism's impacts on the costs of municipal solid waste collection: Evidence from Italy. *J. Clean. Prod.* **2018**, *177*, 62–68. [[CrossRef](#)]
- Edmundo, M.; Rodrigo, N. Waste management in touristic regions. *Waste Manag. Res.* **2015**, *33*, 593–594.
- Al-Khatib, I.; Monou, M.; Abu Zahra, A.; Shaheen, H.; Kassinos, D. Solid waste characterization, quantification and management practices in developing countries. A case study: Nablus district–Palestine. *J. Environ. Manag.* **2010**, *91*, 1131–1138. [[CrossRef](#)] [[PubMed](#)]
- Foo, T. Recycling of domestic waste: Early experiences in Singapore. *Habitat. Int.* **1997**, *21*, 277–289.
- Bartone, C. Economic and policy issues in resource recovery from municipal solid wastes. *Resour. Conserv. Recycl.* **1990**, *4*, 7–23. [[CrossRef](#)]

9. Liu, T.-K.; Wang, M.-W.; Chen, P. Influence of waste management policy on the characteristics of beach litter in Kaohsiung, Taiwan. *Mar. Pollut. Bull.* **2013**, *72*, 99–106. [[CrossRef](#)] [[PubMed](#)]
10. Estay-Ossandon, C.; Mena-Nieto, A. Modelling the driving forces of the municipal solid waste generation in touristic islands. A case study of the Balearic Islands (2000–2030). *Waste Manag.* **2018**, *75*, 70–81. [[CrossRef](#)] [[PubMed](#)]
11. Styles, D; Schönberger, H.; Galvez, M. *Best Environmental Management Practice in the Tourism Sector*; European Commission: Brussels, Belgium; Luxembourg City, Luxembourg, 2013.
12. Torretta, V.; Salazar-Valenzuela, X. Management of municipal solid waste in one of the Galapagos Islands. *Sustainability* **2014**, *6*, 9080–9095.
13. Rada, E.C.; Zatelli, C.; Mattolin, P. Municipal solid waste selective collection and tourism. *WIT Trans. Ecol. Environ.* **2014**, *180*, 187–197.
14. Ranieri, E.; Rada, E.C.; Ragazzi, M.; Masi, S.; Montanaro, C. Critical analysis of the integration of residual municipal solid waste incineration and selective collection in two Italian tourist areas. *Waste Manag. Res.* **2014**, *32*, 551–555. [[CrossRef](#)] [[PubMed](#)]
15. Gutierrez, E.; Lamoureux, K.; Matus, S.; Sebuya, K. *Conservation International, Linking Communities, Tourism & Conservation: A Tourism Assessment Process*; Conservation International, George Washington University: Washington, DC, USA, 2005; ISBN 1-8811 73-43-7.
16. IFC Environmental, Health, and Safety Guidelines for Tourism and Hospitality Development IFC, Washington D.C. 2007. Available online: <https://www.ifc.org/wps/wcm/connect/e9f48800488559c0840cd66a6515bb18/Final++Tourism+and+Hospitality+Development.pdf?MOD=AJPERES> (accessed on 28 November 2018).
17. DO, T.T.T. A study of solid waste generation from commercial and institutional sectors and its potential for recovery in Vietnam. PhD Thesis, Graduate School of Environmental and Life Science, 2016, Okayama University. Available online: [http://ousar.lib.okayama-u.ac.jp/files/public/5/54659/20170309184851938253/O0004462\\_fulltext.pdf](http://ousar.lib.okayama-u.ac.jp/files/public/5/54659/20170309184851938253/O0004462_fulltext.pdf) (accessed on 6 October 2018).
18. Shamsiry, E.; Nadi, B.; Mokhtar, B.M.; Komoo, I.; Hashim, S.H.; Yahaya, N. Integrated Models for Solid Waste Management in Tourism Regions: Langkawi Island, Malaysia. *J. Environ. Public Health* **2011**, *9*, 709549. [[CrossRef](#)] [[PubMed](#)]
19. Bohdanowicz, P. Environmental awareness and initiatives in the Swedish and Polish hotel: Industries—Survey results. *Hosp. Manag.* **2006**, *25*, 662–682. [[CrossRef](#)]
20. Mohan, V.; Deepak, B.; Mona, S. Reduction and Management of Waste in Hotel Industries. *Int. J. Eng. Res. Appl.* **2017**, *7*, 34–37. [[CrossRef](#)]
21. Phu, P.; Hoang, M.G.; Fujiwara, T. Analyzing solid waste management practices for the hotel industry. *Glob. J. Environ. Sci. Manag.* **2018**, *4*, 19–30.
22. Ghribi, K. *Programme Pilote de Gestion Intégrée des Déchets à l'île de Djerba (PGIDID): Analyse déchets de l'hôtel Dar Djerba*; ACR&MED: Djerba, Tunisia, 2012.
23. Parfitt, J.; Eatherley, D.; Hawkins, R.; Prowse, G. *Waste in the UK Hospitality and Food Service Sector*; Technical Report No. HFS001-00 6; Waste and Resources Action Programme (WRAP): Banbury, UK, 2013.
24. Ghadban, S.; Shames, M.; Mayaleh, H.A. Trash Crisis and Solid Waste Management in Lebanon—Analyzing Hotels' Commitment and Guests' Preferences. *J. Tour. Res. Hosp.* **2017**, *6*, 1–18. [[CrossRef](#)]
25. Kapitalis. Available online: <http://kapitalis.com/tunisie/2018/06/24/djerba-houmt-souk-ville-devastee-par-les-dechets/> (accessed on 30 September 2018).
26. Segnestam, L. *Indicators of Environment and Sustainable Development*; Theories and Practical Experience, PAPER NO. 89; The World Bank: Washington, DC, USA, 2002.
27. Sophie, C.; Gouin, S. Observatoire des Multinationales. Available online: <http://multinationales.org/Dechets-la-face-cachee-du-tourisme-de-masse-en-Tunisie> (accessed on 26 October 2018).
28. Bahia, S.R. Sustainability Indicators for a Waste Management Approach. Master's Thesis, University of Leeds, Leeds, UK, 1995.
29. Rosenstrom, U. The potential for the use of sustainable development indicators in policy making in Finland. *Futura* **2002**, *2*, 19–25.
30. Ristić, G. Basic Indicators of Integrated Solid Waste Management, Faculty of Occupational Safety Niš. *Facta Universitatis, Series: Work. Living Environ. Protection* **2005**, *2*, 383–392.

31. Styles, D.; Schönberger, H.; Martos, J.L. *Best Environmental Management Practice in the Tourism Sector*; European Commission: Luxembourg city, Luxembourg, 2013; pp. 318–319.
32. Gidakos, E.; Havas, G.; Ntzamilis, P. Municipal solid waste composition determination supporting the integrated solid waste management system in the island of Crete. *Waste Manag.* **2006**, *26*, 668–679. [[CrossRef](#)] [[PubMed](#)]
33. Florin, M. Tourism implications on local waste management: Case study: Neam County, Romania. *Present Environ. Sustain. Dev.* **2013**, *7*, 214–221.
34. Okazaki, W.K.; Turn, S.Q.; Flachsbart, P.G. Characterization of food waste generators: A Hawaii case study. *Waste Manag.* **2008**, *28*, 2483–2494. [[CrossRef](#)] [[PubMed](#)]
35. Pirani, S.I.; Hassan, A.A. Solid waste management in the hospitality industry: A review. *J. Environ. Manag.* **2014**, *146*, 320–336. [[CrossRef](#)] [[PubMed](#)]
36. Favro, S.; Brebbia, C.A. *Island Sustainability II, Second International Conference on Island Sustainability*; WIT Press: Southampton, UK, 2013.
37. JRC—EU. Available online: <http://ec.europa.eu/environment/emas/takeagreenstep/pdf/BEMP-6-FINAL.pdf> (accessed on 2 August 2018).
38. Hackes, B.L.; Shanklin, C.W.; Kim, T.; Su, A.Y. Tray service generates more food waste in dining areas of a continuing-care retirement community. *J. Am. Diet. Assoc.* **1997**, *97*, 879–882. [[CrossRef](#)]
39. Pirani, S.; Hassan, A.A. Reduction of Food Waste Generation in the Hospitality Industry. *J. Clean. Prod.* **2016**, *132*, 129–145. [[CrossRef](#)]
40. Kirk, D. Attitudes to environmental management held by a group of hotel managers in Edinburgh. *Hosp. Manag.* **1998**, *17*, 33–47. [[CrossRef](#)]
41. Erdogan, N.; Baris, E. Case study Environmental protection programs and conservation practices of hotels in Ankara, Turkey. *Tour. Manag.* **2007**, *28*, 604–614. [[CrossRef](#)]
42. María, D.L.; Enrique, C.C.; José, F.M.A. Environmental Perception, Management, and Competitive Opportunity in Spanish Hotels. *Cornell Hosp. Q* **2011**, *52*, 480–500.
43. Philips, A. Greening Hotels: The Case of Solid Waste Management by Chain Hotels and Individual Properties in Sofia. Master's Thesis, Cardiff Metropolitan University, Sofia, Bulgaria, 2014.
44. Tang, J. A Case Study of a Hotel Solid Waste Management Program in Bali, Indonesia. Master's Thesis, University of Waterloo, Waterloo, ON, Canada, 2004. Available online: <https://www.collectionscanada.gc.ca/obj/s4/f2/dsk3/OWTU/TC-OWTU-373.pdf> (accessed on 2 August 2018).
45. Murava, I.; Korobeinykova, Y. The Analysis of the Waste Problem in Tourist Destinations on the Example of Carpathian Region in Ukraine. *J. Ecol. Eng.* **2016**, *17*, 43–51. [[CrossRef](#)]
46. Ezeah, C.; Fazakerley, J.; Byrne, T. Tourism Waste Management in the European Union: Lessons Learned from Four Popular EU Tourist Destinations. *Am. J. Clim. Chang.* **2015**, *4*, 431–445. [[CrossRef](#)]
47. Walter, J.; Amit, K.; Sunalai, P.; Pallavi, M. *A Manual for Water and Waste Management: What the Tourism Industry Can Do to Improve Its Performance*; United Nations Environment Programme, Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH: Bonn, Germany, 2003; ISBN 92-807-2343-X.
48. WRAP (Waste & Resources Action Programme); Enviromentor Ltd.; Active Compost Ltd. Cost-Effective Management of Organic Waste from the Food and Drink and Hospitality Sectors, International Tourism Partnership, UK, 2018. Available online: <http://www.greenhotelier.org/wp-content/uploads/2014/09/Know-How-Guide-on-Managing-and-Reducing-Food-Waste.pdf> (accessed on 2 August 2018).
49. Gruber, I.; Obersteiner, G.; Ramusch, R. Urban Strategies for Waste Management in Tourist Cities, European Union H2020, 2016. Available online: <http://www.urban-waste.eu/wp-content/uploads/2017/09/Status-quo-baseline-assessment-report.pdf> (accessed on 28 November 2018).
50. Vilms, M.; Voronova, V. Non-deposit system option for waste management on small islands. *Waste Manag. Res.* **2016**, *34*, 748–754. [[CrossRef](#)] [[PubMed](#)]
51. Sherif, A.; Doumani, F.; Abdeljaouad, I. Cost of Environmental Degradation due to Solid Waste Management Practices, Case of Djerba Island. Unpublished work. 2015.
52. Alejandro, B.; Juan, D.H.; Macht, A.; Rodriguez, M. *Public-Private Partnerships as a Means to Consolidate Integrated Solid Waste Management Initiatives in Tourism Destinations: the Case of the Mexican Caribbean*; Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ): Bonn, Germany, 2008.
53. Cuellar, S. *Market Analysis of Solid Waste Collection, Recycling and Reuse in the Tourism Sector of the Municipalities of Benito Juárez and Solidaridad of the State of Quintana Roo*; GTZ: Quintana Roo, Mexico, 2008.

54. Antonis, A.Z.; Irene, V.; Pantelitsa, L. The impact of tourist sector in the waste management plans, Desalination and Water Treatment. *Desalin. Water Treat.* **2015**, *56*, 1141–1149.
55. Brini, B.; International Department Director of INSTM. Scientific Challenges in the Mediterranean Challenges and Scientific Priorities. Available online: [https://wwz.ifremer.fr/euro\\_mediterranee/content/download/22231/319274/file/abstract-brini.pdf](https://wwz.ifremer.fr/euro_mediterranee/content/download/22231/319274/file/abstract-brini.pdf) (accessed on 1 November 2018).
56. Switchmed.eu. Available online: <https://www.switchmed.eu/en/country-hubs/tunisia/actions/tunisia-ecotourism> (accessed on 30 October 2018).
57. SWEEP-Net Report. Report on the Solid Waste Management in Tunisia, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), 2014. Available online: [http://www.retech-germany.net/fileadmin/retech/05\\_mediathek/laenderinformationen/Tunesien\\_laenderprofile\\_sweep\\_net.pdf](http://www.retech-germany.net/fileadmin/retech/05_mediathek/laenderinformationen/Tunesien_laenderprofile_sweep_net.pdf) (accessed on 25 August 2018).
58. Radwan, H.R.I.; Jones, E.; Minoli, D. Managing solid waste in small hotels. *J. Sustain. Tour.* **2010**, *18*, 175–190. [[CrossRef](#)]
59. Tatàno, F.; Caramiello, C.; Paolini, T.; Tripolone, L. Generation and collection of restaurant waste: Characterization and evaluation at a case study in Italy. *Waste Manag.* **2017**, *61*, 423–442. [[CrossRef](#)] [[PubMed](#)]



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