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Measuring the Level of Environmental Performance on Coastal Environment before and during the COVID-19 Pandemic: A Case Study from Cyprus

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Abstract: Tourism activities are considered, among others, the backbone of the local economies. However, tourism activities lead to adverse environmental impacts, especially in coastal zones. Coastal areas are considered and recognized as of strategic importance due to the fact that several activities take place, from leisure to business. At the same time, coastal areas are under pressure from tourist activities, and the waste generated is a very serious issue. Therefore, there are limited studies related to the environmental dimensions of the COVID-19 pandemic in the coastal environment. This paper provides answers to the hypothesis that the pandemic lockdown scenario would improve environmental performance due to reduced usage and, therefore, waste, taking into account specific key performance indicators (KPIs) as these KPIs are used to evaluate the performance of an area. The results showed that the study area improved, as did the selected KPIs, i.e., clean coast index (CCI), waste accumulation rate (WAR), and waste accumulation index (WAI). Additionally, according to the final results, the concentration of micro-, meso- and macroplastics on the beach reduced, and the main issues remained the solutions on cigarette butts, straws, and other plastic containers. Furthermore, the final results are considered very useful to local authorities, stakeholders, consultants, policymakers, and any other competent authorities, to reschedule their waste management strategies, to improve waste infrastructures and their level of services (LOS), as well as, to suggest frequent awareness-raising activities to their visitors on how to protect the coastal environment, taking into account a pandemic scenario, as well as, the policy alternative impacts on EU coastal zones 2000–2050.

Keywords: COVID-19; key performance indicators; waste strategies; clean coast index; waste accumulation index; waste accumulation rate; waste strategies; microplastics; level of services

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Citation: Loizia, P.; Voukkali, I.; Chatziparaskeva, G.; Navarro-Pedreño, J.; Zorpas, A.A. Measuring the Level of Environmental Performance on Coastal Environment before and during the COVID-19 Pandemic: A Case Study from Cyprus. *Sustainability* **2021**, *13*, 2485. https://doi.org/10.3390/su13052485

Academic Editor: Ashraf Dewan

Received: 10 January 2021
Accepted: 18 February 2021
Published: 25 February 2021

1. Introduction

By definition, according to WHO (World Health Organization), a pandemic is considered as "an epidemic occurring worldwide, or over a very wide area, crossing international boundaries and usually affecting a large number of people". The conventional pandemic classification does not cover or relate to population immunity, virology, or disease severity. Therefore, with this definition, seasonal epidemics are not considered pandemics, but pandemics can be considered to occur annually in each of the temperate southern and northern hemispheres, as seasonal epidemics cross international borders and affect a large number of people [1].

During the coronavirus disease 2019 (COVID-19) period, as announced [2], almost the entire planet was locked down (either from fear or to prevent the worst health effects). At the same time, the major fundamentals of human rights and human activities (such as free movement), the structures of the entire world health system, and the structures of the economies worldwide have been tested without any successful result. During May 2020 [3], the total number of confirmed positive cases of COVID-19 was almost 3.4 million [4]. According to the European Centre for Disease Prevention and Control [5], there were 15.7 million cases of COVID-19 on the 25th of July 2020 (in agreement with the applied case definitions and testing strategies in the affected countries), and the reported deaths were equal to 4.07% (equal with 639,273). At the same time, according to WHO [1], the deaths from pollution were estimated to be more than 12 million inhabitants per year. Every year, 1.5 million people die from inhaling indoor pollutants that often exceed accepted guideline limits for outdoor air. In the case of fine particles, the limit is exceeded by 100 times or more. Children and women are disproportionately affected, with nearly 800,000 deaths attributable to indoor air pollution occurring among children under five years of age and more than 500,000 such deaths occurring among women. And for these reasons, there is a huge debate whether or not COVID-19 is a pandemic. However, according to Ilyas et al. [6], the pandemic started in China (Hubei and Wuhan) in December 2019, and at the beginning was known as new pneumonia diseases. Deeper investigation indicated a novel coronavirus, which was named 2019 novel coronavirus (SARS-Cov-2), that caused clusters of fatal pneumonia with clinical presentation greatly resembling SARSCoV according to Huang et al. [7] and Wang et al. [8].

Zambrano-Monserrate et al. [9] mentioned that COVID-19 generates several indirect and direct effects on the environment. It is true, that to the best of our knowledge the direct and long-term effects of the COVID-19 pandemic on solid waste management systems' climate changes, waste production, coastal environment, and, furthermore, on the waste accumulation and clean coast index are still not well known [10]. However, as the planet was entirely in lockdown, the greenhouse gases (GHGs) were reduced (along with CO_2 emissions) due to the fact that there were strict measures on movement globally (almost zero cars on the roads—much fewer accident—and only the most necessary flights were made). Le Quéré et al. [10] mentioned that before the COVID-19 pandemic, the emissions of CO_2 were increasing by about 1% on a yearly basis [11–13], while there was limited progress in 2019 [13]. Considering that COVID-19 was first acknowledged in December 2019 [1] and confirmed as a global pandemic by the WHO on 11 March 2020, Le Quéré et al. [10] indicated that the day-to-day global CO_2 releases decreased by −17 (−11 to −25) $MtCO_2/d$, or −17% (−11 to −25%) by April 2020, taking into account the emissions realized on 2019. Janssens-Maenhout et al. [14] provided evidence that CO_2 minimization within the COVID-19 pandemic period had a large variation, which was similar to the seasonal CO_2 production. Globally, according to Le Quéré et al. [10], CO_2 emissions from the transportation sector reduced by −36% (equal to −7.5 $MtCO_2/d$), −7.4% (equal to −3.3 $MtCO_2/d$) from the power sector, and the manufacturing division, the reduction was −19% (equal to −4.3 $MtCO_2/d$), on 7 April 2020. Furthermore, until the end of April 2020, the minimization of CO_2 was nearly −1048 $MtCO_2$ (equal to −8.6% compared with the period of January to April 2019). In the reverse series, major variations were mentioned in China, with the reduction estimated to be up to −242 $MtCO_2$, followed by the USA with the reductions estimated to be up to −207 $MtCO_2$, then for Europe −123$MtCO_2$, and India with a reduction up to −98$MtCO_2$. Hence, Zand and Heir [15] mainly investigated the direct health issues associated with Covid-19 rather than environmental aspects. On the other hand, the financial crisis interconnected with COVID-19 was noticeably different from other former crises.

The COVID-19 pandemic has created an interesting and challenging condition from many angles. From a scientific point of view, the COVID-19 pandemic has a clear impact on social, economic, and environmental dimensions globally. To date, there are limited studies related to the direct effects of COVID-19 on waste production, management, and treatment, and as well, there is almost zero research on the impact on coastal areas. Worldwide, an unprecedented challenge to fight COVID-19 along with the myriad COVID-19 waste products that are being produced, i.e., personal protective mask, gloves, napkins etc., are vital, as indicated by Ilyas et al. [6]. Testa et al. [16] indicated that several studies stress the examination of the impact of a single policy on environmental performance, while Klemes et al. [17] studied the short and long-term variations in plastic waste management. Nghiem et al. [18] investigated the impact of the pandemic on the sewage sector and showed that COVID-19 can be transmitted through non-hazardous waste from healthcare facilities. Vaka et al. [19] investigated the status of solar energy systems in Malaysia and the effects on waste-to-energy and waste investment taxes. Moreover, Zambrano-Monserrate et al. [9] focused on challenges faced by the waste management system in Teheran and highlighted the amount that health care waste had increased, as well as the illegal separation and recycling of wastes. Additionally, Saadat et al. [2] discussed the environmental aspects and socioeconomic characteristics of the COVID-19 pandemic. Kulkarni and Anantharama [3] proposed an alternative approach to Municipal Solid Waste (MSW) treatment during the pandemic, and they indicated that waste-to-energy could be a valuable solution, as the proposed technology could reduce their volume by 80–95%. During Pyrolysis (which usually take place at 350–550 °C) [20] and the Gasification process, in which waste decomposed at temperature up to 850 °C or more [3], a few more benefits are included, such as energy recovery [20], mineralization, control and immobilization of hazardous substances, and resource preservations [21]. Hence, Di Maria et al. [22] reported that the EU states that there is no scientific evidence of the transmission of the virus through household waste management.

Without a doubt, with or without a pandemic, waste (in the strict sense of the definition) will continue to grow internationally [23–27], and according to many researchers [27–31], there are plentiful explanations related to the production of waste from citizens (i.e., advertising effects, absence of educational programs, level of incomes, and quality of life, etc.). However, to the best of our knowledge, there is no other paper related to the estimation and the assessment of the waste accumulation rate and clean coast index during the planet lockdown in any coastal area. The number of arrivals, as indicated in Figure 1, has continually increased since 1995 for the entire tourist destinations, and this expansion is considered vital for many economies. The hospitality industry makes significant contributions to local economies creating employment and investment prospects, but rapid growth has been a major cause of many adverse environmental issues [30,32]. In addition, according to many studies [33–36], pollution in the coastal environment is a serious and an important issue for many tourist destinations due to the massive tourist activities. Rangel-Buitrago et al. [33] mentioned that the distribution of plastics, and their relative negative effects, have been documented in all coastal and marine environments. Rapp et al. [34] declared that large quantities of exogenous plastics waste had been recently detected in the Canary Islands due to illegal dumping at sea. Moreover, the pressure in the coastal zones [34] is mostly affected by the citizen density, which has a direct consequence on waste accumulation. Paler et al. [35] concluded that marine litter in coastal areas is a global problem, as it has also affected coastal areas in the Philippines. The Clean Coast Index (CCI) was used to assess several kinds of waste litter, such as wooden, biodegradable, on the beach. Pervez et al. [36] indicated that solid waste debris is considered a serious environmental aspect for any coastal environment. On the other hand, China has given limited attention to the impact of solid waste debris on coastal zones compared with Australia and the USA [36]. Pervez et al. [36] mentioned that tourist activities have a direct effect on waste accumulation and highlight that higher population density leads to a higher amount of waste.

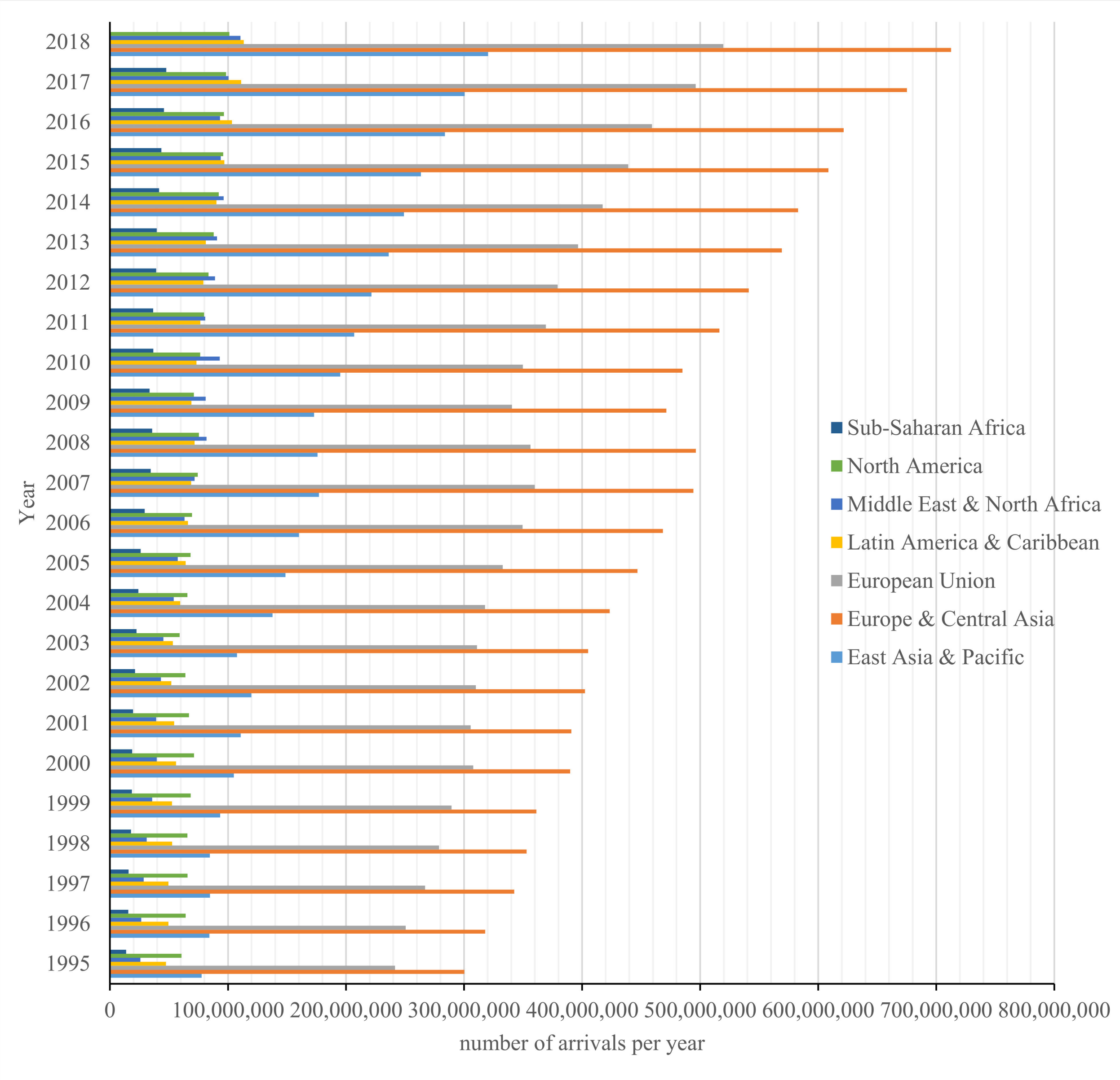


Figure 1. Expansion of tourism (number of arrivals in million).

When holidays come to mind, for most people, the destination is located somewhere near a beautiful beach and coastal areas worldwide, in hotels, which are considered one of the most auspicious and at the same time sustainable businesses in the world. Historically, according to Ling [37], the development of Island resorts for holiday destinations was first established almost 2000 years ago, and more specifically, when the Isle of Capri was suggested by Romans [38]. However, the rapid evolution of tourist activities has totally changed, modified, and metabolized several areas over the last century with direct and indirect effects, either on social, financial, or environmental dimensions. In terms of metabolism, tourist services have transformed a strong local agricultural economy into a strong tourism economy in 40 years. As shown in Figure 2, the whole area was considered agricultural, and the most popular crops included potatoes, tomatoes, cucumbers, watermelon, etc. Within about 10 years (1985–1995), the rapid and massive expansion of tourism resulted in the metabolism of the entire area, as many services and infrastructures appeared (i.e., hotels, apartments, restaurants, shops, road infrastructures, etc.) to support the hospitality industry.

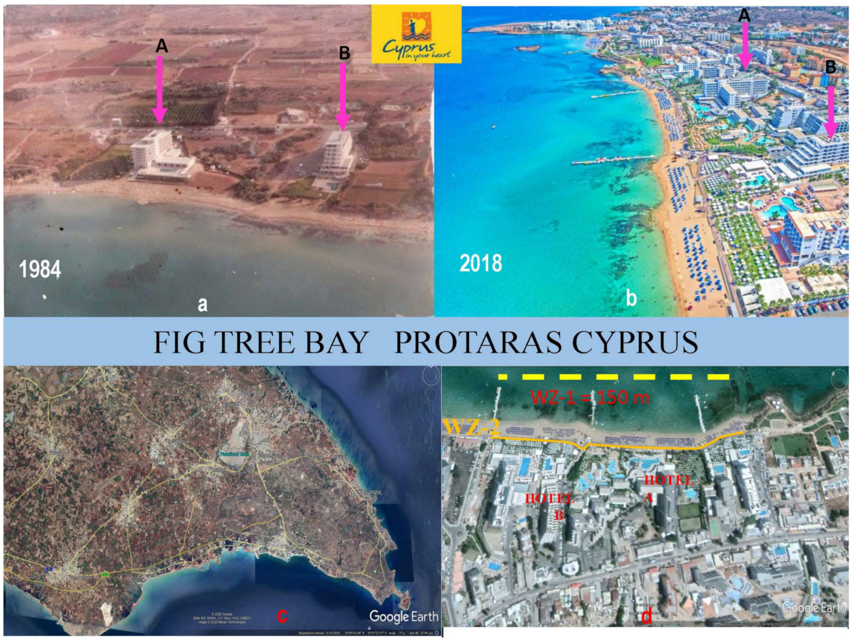


Figure 2. Study Area. (**a**) the area as was on 1984; (**b**) the expansion of the area on 2018; (**c**) the map the Easter region of Cyprus; (**d**) study area.

This paper focuses on the evaluation of one of the most popular and famous tourist areas on the island of Cyprus (Protaras) during the COVID-19 pandemic through the implementation of key performance indicators (KPIs). The KPIs applied were clean coast index (CCI); waste accumulation rate (WAR); waste accumulation index (WAI); waste compositional analysis of the municipal solid waste (C-MSW); the level of services (LOS); waste generation rate (WGR); waste recovery rate (WRR); recycle bins per population density (RPB); waste infrastructure (WI); waste bin capacity (WBC); micro-, meso- and macroplastics concentration. Moreover, a SWOT (S: Strength, W: Weaknesses: Opportunity, T: Threats) and PESTEL (P: Political, E: Economy, S: Social, T: Technical, E: Environment, L: Legislation) analysis was applied to evaluate key strategic approaches, using an internal and external matrix, considering (having in mind today's surroundings) strengths and weakness.

Additionally, the study helps to classify the measures to be taken in real-time, for the Local Authorities to be able to monitor the coastal areas in a sustainable way and to control the waste production, including the concentrations of micro-, meso- and macroplastics.

2. Material and Methods

The survey started between June and July 2019 as well as between June and July 2020 to find out how tourist activities, as well how tourist attitudes affect waste generation in coastal areas.

2.1. Area Description

The Municipality of Paralimni is based on the Eastern Region of Cyprus (Figure 2) and taking into account the last inventory review, which was carried out by the Cyprus Statistical Services in November 2011, the permanent population is 40,000 [32]. Figure 2a shows the area during 1984; Figure 2b is the same area in 2018. Figure 2c indicates the entire area, while Figure 2d indicates the study area. Moreover, Paralimni (as well as Agia Napa) is considered from the economic point of view the lungs of the island due to the fact that, it can accommodate nearly 30–35% of the tourists vising the island. The equivalent population is up to 75,000 (during the tourist period, which starts after 15 of March concludes at the end of October). The tourist services include approximately 120 large Hotels and other apartments, 1000 (more or less) restaurants, bars, shops, etc. [39–41].

The particular study area (Figure 2d) is situated between Hotel A and Hotel B, which operated close to 1984. The selected area was divided into Zones (Waste Zone 1: WZ-1 and WZ-2). WZ-1 covered the creation of waste at the front beach, and WZ-2, the creation of waste in the pedestrian precinct.

The surface area of WZ-1 is around ~3500 m^2, and the surface area of WZ-2 is around ~450 m^2. Additionally, the waste infrastructures in 2019 comprised 32 bins every 30 m in WZ-1 (56 L each) and 5 waste bins every 30 m (70 L each) in WZ-2.

The visitors entering WZ-1 were calculated by applying a theoretical grid for the number of people at the beach (Figure 3). Each grid was a theoretical square of 10 m^2.

Figure 3. Theoretical grid (each square was approximately 10 m^2) to measure visitors at the beach.

2.2. Sampling Period

The sampling period lasted for 2 months for each year. The first sampling period was from the 1st of June until the end of July of 2019, and the second period was between 1st June and the end of July of 2020. It is important to note that, until the end of June 2020, Cyprus was totally locked down (due to the COVID-19 pandemic), and strict measures had been applied. However, given all these measures, there is no any tangible scientific evidence that they have had a positive effect on combating the pandemic and that citizens paid somehow the hidden political success story. There was no tourist activity in the study area, and all tourist services were closed (including hotels, restaurants, shops, etc.). Limited tourist activities started in the 2nd week of July, mainly with local visitors during weekends and only for swimming (while few restaurants and hotels open, taking into account specific hygiene rules). The sampling covered the collection of waste from WZ-1 and WZ-2 every morning (between 08:00–09:00), every mid-day (between 13:00–14:00), and early afternoon (between 17:00–18:00) because at those hours the cleaning department of the municipality collected the waste from bins to avoid littering the sea. The samples were analyzed and categorized into the following: plastics, paper, glass, wooden, edible food waste (EFW) and inedible food waste (IFW), textiles, WEEE (waste electrical and electronic equipment), green waste, clinical waste, hazardous waste, dust, metals, PMD (packaging waste), batteries, other. In addition, the guests on the beach were calculated for the WZ-1.

2.3. Key Performance Indicators (KPIs)

The following KPIs were used to test the research hypothesis that the pandemic lockdown scenario would improve environmental performance due to reduced usage.

2.3.1. Waste Compositional Analysis

Equation (1) indicates how the separated waste streams were calculated through the waste compositional analysis (C–MSW: Compositional Analysis of Municipal Solid Waste).

Waste analysis delivers valuable evidences related to the social dimension of the waste origins [27,29,42–44]:

$$C - MSW = \frac{Q_{Known\ MSW}t}{Q_{Total\ MSW}t} \quad (1)$$

2.3.2. Clean Coast Index (CCI), Waste Accumulation Index (WAI), Level of Services (LOS), Waste Accumulation Rate (WAR)

The CCI is presented in Equation (2) [27]. The indicator was first proposed by Alkalay et al. [45] as a tool to estimate the level of the dirtiness (or the cleanliness) of the coastal beaches. It can be used to estimate the concentration mainly of plastic debris or other waste as an indicator of the cleanliness of the examined area. On the other hand, this indicator does not directly highlight the LOS, although the results could be used for this purpose. The LOS are correlated with CCI using the matrix of Tables 1 and 2.

$$CCI = \frac{NIcol}{Sur} K \quad (2)$$

Sur: is consider in m^2 the examined area; NIcol is the amount of the collected waste spread anywhere within the examined area. The constant K is equivalent to 20. This was suggested by Alkalay et al. [45] to ensure that the values generated do not fall between 0 and 1. The quantitative approach in Table 1 estimated the level of the study area [45].

Table 1. Clean index identification.

Quality	Level of Services	CCI	Classification
Very clean	1 (A)	0–2	No waste is observed
Clean	2 (B)	2–5	No waste is observed over a large area
Moderate	3 (C)	5–10	A few items of waste can be observed
Dirty	4 (D)	10–20	A lot of waste exists
Very dirty	5 (E)	20+	Most of the area is covered with waste

Table 2. Waste Accumulation Rate (WAR) and Index classification.

	Extremely Low	Very Low	Low	Moderate	High	Very High	Extremely High
Level of services	1	2	2 to 3	3	4	4 to 5	5
WAI	≤1	1 to 2	2 to 3	3 to 4	4 to 5	5 to 6	≥6
WAR (items/m^2/day)	10^{-6}	10^{-5}	10^{-4}	10^{-3}	10^{-2}	10^{-1}	1
WAR (items/km^2/day)	1	10	10^2	10^3	10^4	10^5	10^6

The classification of the level of services is presented in Table 1.

Equations (3) and (4) were used to calculate WAR and WAI, respectively [27].

$$WAR = Nicol/S/T \quad (3)$$

$$WAI = \log 10\ (AR \times 1{,}000{,}000) \quad (4)$$

WAR was used to estimate the accumulation of waste litter of a certain item per unit of surface and per unit of time rate (items/m^2/day), T is considering the time between two different samplings. It is important to mention that the time passed from the last cleaning links to the number of days gone since the last cleaning completed by the competent authorities. By multiplying the results of Equation (4) by one million (1,000,000), the WAI was calculated (items/km^2/d).

2.3.3. Waste Generation Rate (WGR), Waste Recovery Rate (WRR)

The WGR (Equation (5)) provides details on waste formation in a selected area at a specific time (i.e., in one day [27,43]. Equation (6), according to Urban Wins [46], took into account C-MSW and R-MSW and calculated WRR, which provided useful information related to which waste stream can be recovered and at what rate.

$$\text{WGR} = (\text{Production of the waste in kg}) \times \text{Inhabitants (in the selected area in one d)} \quad (5)$$

$$\text{WRR} = \frac{\text{Recoverd Waste}}{\text{P} - \text{MSW}} \quad (6)$$

2.3.4. Recycle Bins per Population (RBP)

The indicator (Equation (7)) was first proposed by Zorpas [27] and quantifies the quantity and the capacity of recycling bins (and or waste collection bins in general) per resident density. RBP is a very important indicator [27,42,47], as it distributes useful information to the policymakers regarding the resident density and the current waste infrastructure. The indicator is directly correlated with the LOS as specified in Tables 1 and 2, taking into account other indicators, i.e., the WGR, WRR, WAI, WAR, CCI, WI, WBC, and P-MSW.

$$\text{RBP} = \frac{\text{Number of Recycle Bins}}{\text{Population Density}} \quad (7)$$

$$\text{WI} = \frac{\text{Number of Bins}}{\text{Population Density}} \quad (8)$$

$$\text{WBC} = \frac{\text{total volume of bins in one area in Lit or t}}{\text{Population Density}} \quad (9)$$

$$\text{P} - \text{MSW} = \frac{Q_{\text{Total MSW}}\,t}{Q_{\text{POP}}\,t} \quad (10)$$

where WBC = waste bins capacity in L; WI = waste infrastructure per resident; P-MSW provide detail related to the amount of MSW formed to the population at a given time in any selected area.

Where the level of services is decoded as:

1. (Class A): Outstanding collection of waste at least three times per day (early morning, the middle of the day, and late afternoon); waste bins exist at least every 20–30 m, and the waste bins capacity is at least in the range of 1.5–2.5 L/guest; other waste infrastructures (i.e., separated bins per waste stream, awareness and information boards) were observable, as well as, there was mechanical cleaning of the sand, such as in situ sievings at least twice a week (if the coastal line was more than 1000 m).
2. (Class B): Acceptable to very good collection of waste, at least twice a day (early morning and late afternoon); waste bins capacity to be at least 1.0–1.4 L/visitor, and there were bins every 25–40 m and/or other waste infrastructure (separated bins per waste stream, etc.) in place; awareness and information boards were observable, as well as, once per week there was a mechanical cleaning of the sand.
3. (Class C): Average collection of waste, 2–3 times per week but once per day; average waste bins or other waste infrastructures (waste bin capacity varies from 0.5–1.4 L/visitor) with limited awareness and information boards, and periodically the implementation of mechanical cleaning of the sand, such as in situ sieving.
4. (Class D): Periodically collection of waste once a week; limited waste bins or other waste infrastructure (waste bin capacity varies from 0.5–1.4 L/visitor) and there was no mechanical cleaning of the sand, such as in situ sievings, with extremely limited information boards.

5. (Class E): There were no cleaning programs for the specific area in place; the waste infrastructures were not established, and there was no mechanical cleaning of the sand, such as in situ sievings, while there are no information boards.

Classification of LOS may subject to change in case of further research.

2.3.5. Micro-, Meso-, Macroplastics

Micro-, meso-, and macroplastics concentrations, were calculated using 13 sand samples that were collected from a selected area (Figure 4). Ten samples were taken at the high-water mark, 15 from the middle of the beach, and another 10 fronts of the pedestrian. To float microplastics, a known quantity of sand sample (100 ± 1 g) was mixed with a known quantity of hypersaline solution (250 ± 0.01 mL in 10% *v/v* NaCl) for 7 min. After natural drying, the samples were passed through separated sieves. The sieving samples were classified as macroplastics if the diameter was between 2.5–50 cm, mesoplastics if the diameter was between 0.5–2.5 cm, and microplastic if the diameter was less than 0.5 cm. With this method, when samples were decanted into high-density solutions, plastic particles float on the surface of the solution. However, the denser sample materials remain at the bottom of the solution gradient [48]. It is important to note that, with this method, we were not estimating any light density plastics, i.e., PP (polypropylene), PE (poly-ethylene), but only general concentrations.

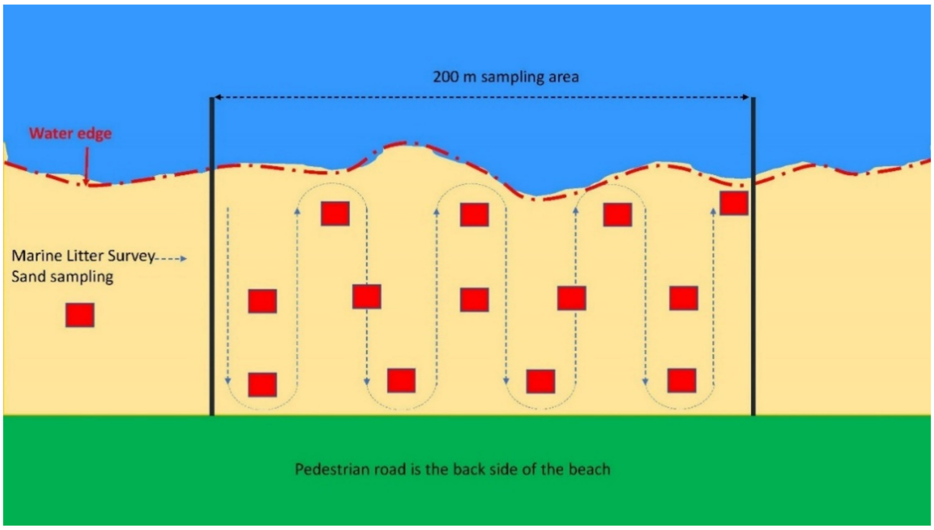
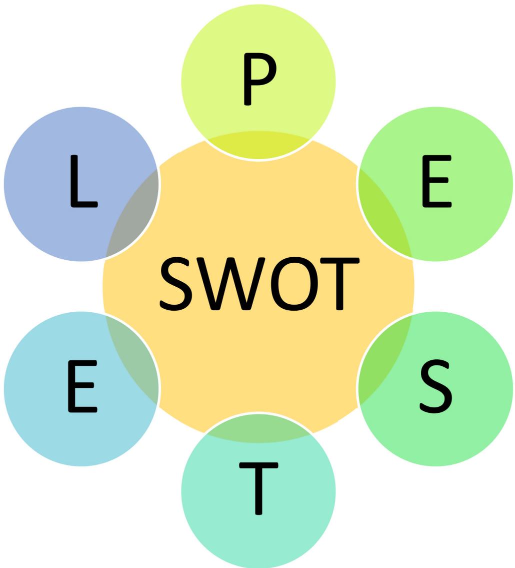


Figure 4. Sand sampling for microanalysis.

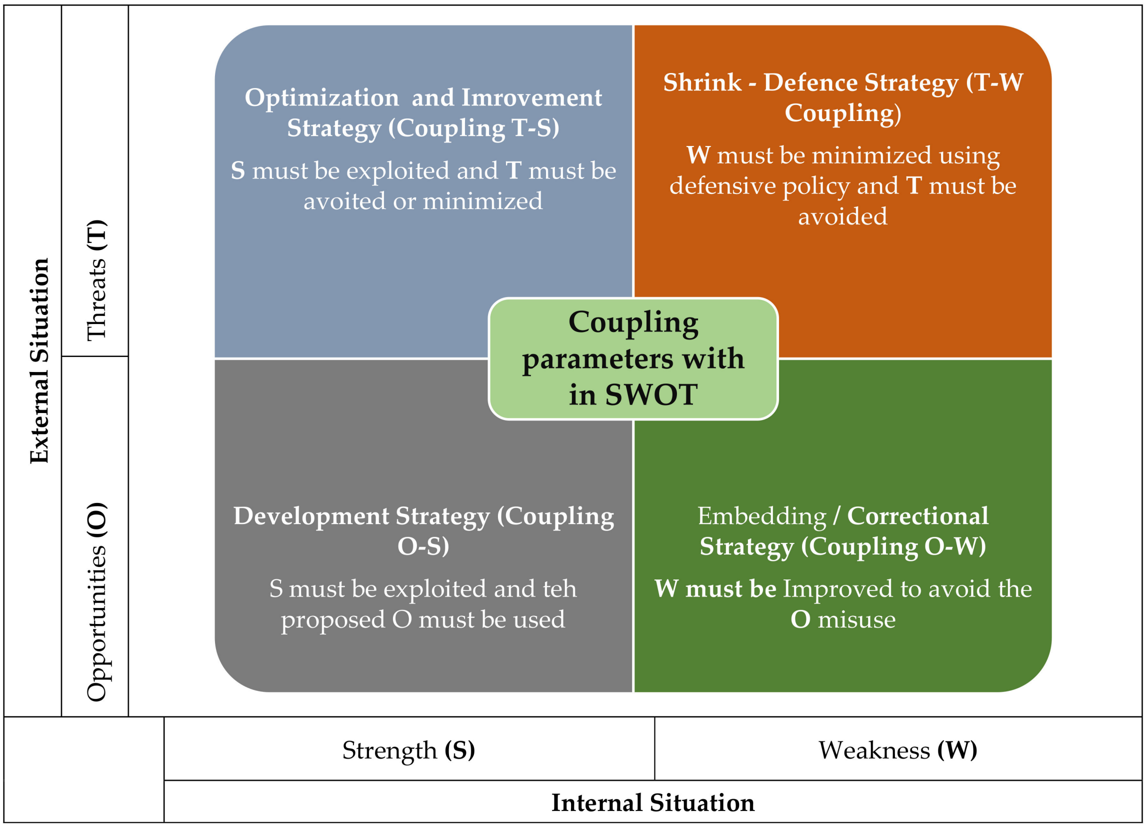
2.4. *SWOT (S: Strength, W: Weaknesses: Opportunity, T: Threats) Analysis*

Islam and Mamum [49], Symeonides et al. [50], Tsangas et al. [51], Voukkali et al. [52] mentioned that SWOT analysis is considered a useful tool to be used for strategic assessment and strategic improvement as it can associate external (Opportunities and Threats) and internal (Strengths and Weaknesses) aspects of any organization (from the public to private sector). Without limitation, SWOT matrix analysis supports any organization to define any key strategic features using internal and external matrix, taking into consideration any strengths and weaknesses, taking into account the up-to-date circumstances. The link between PESTEL (P: Political, E: Economy, S: Social, T: Technical, E: Environment, L: Legislation) and SWOT was effectively used for other research, i.e., to assess renewable energy establishment and natural resource [49,51], to control end of life tire management in insular communities [52], as well as for the monitoring of any waste strategy development [27].

The proposed methodology is presented in the flowchart of Figure 5 [50–52], which is based on the identification of internal features to analyze the topics of strengths and weaknesses, as well as to clarify the opportunities and threats based on external features.



(**a**)



(**b**)

Figure 5. (**a**). SWOT (S: Strength, W: Weaknesses: Opportunity, T: Threats) and PESTLE (P: Political, E: Economy, S: Social, T: Technical, E: Environment, L: Legislation) analysis. (**b**). SWOT Matrix.

Table 3 provides details related to how PESTEL pillars had been encoded, taking into account the external and the internal features, as well the significance coefficient (1 to 5).

Table 3. Encoding of SWOT (S: Strength, W: Weaknesses: Opportunity, T: Threats) and PESTLE (P: Political, E: Economy, S: Social, T: Technical, E: Environment, L: Legislation).

	Internal Aspects (int)		External Aspects (ext)	
SWOT	**S (+)**	**W (−)**	**O (+)**	**T (−)**
		PESTEL		
Political	Pol, int, +	Pol, int, −	Pol, ext, +	Pol, ext, −
Economic	Eco, int, +	Eco, int, −	Eco, ext, +	Eco, ext, −
Social	Soc, int, +	Soc, int, −	Soc, ext, +	Soc, ext, −
Technological	Tec, int, +	Tec, int, −	Tec, ext, +	Tec, ext, −
Legal	Leg, int, +	Leg, int, −	Leg, ext, +	Leg, ext, −
Environmental	Env, int, +	Env, int, −	Env, ext, +	Env, ext, −

Each feature was rated with a significance coefficient, from 1 to 5, with 1 (one) being minor, 2 (two) less important, 3 (three) average, 4 (four) important, and 5 (five) very important. In front of each significance coefficient, the symbol "+" or "−" demonstrates whether it was a positive (in the case of internal aspect) or a negative characteristic (in the case of the external aspect).

Figure 5b [27] provides details related to the strategy that must be followed to optimize the existing strategy that was applied and/or to boost the performance of the area in the environmental sense. Using the sensitive analysis software [53–56], the selected strategy was evaluated.

3. Results and Discussions

3.1. Study Area Assessment

Creating the right balance between the welfare of tourists, host communities, and the environment, reducing conflict, and recognizing mutual dependency, requires a special approach to the management of destinations [57–62]. The number of international tourist arrivals during 2017 [63] was almost 1.32 billion worldwide (+7%), 671 million of which, or 51% of the market (+8%), were in Europe. At the same time (without the assumption of the pandemic), the World Tourism Organization (WTO) estimated that at the end of 2030, European tourism will grow to an estimated 744 million tourists (+1.8%), or 41.1% of the global market.

However, in the outline of waste management, there was no mandatory legislation to elaborate an environmental impact assessment study (during the tourist activities rapid expansion on the study area), as well as there was no waste management strategy in place (the early 1980s). No data were available on waste generation at that time in the study area, but according to information collected by the municipality, the waste was collected once a day and transported to a typical landfill site, which has now been restored, taking into account the requirements of the 1999/31/EC [64] directive and the amended Directive 2018/850/EC [65]. Currently, in the entire area, according to Zorpas et al. [59,66], waste management comprises a door-to-door collection of household waste 2 to 5 time per week (depends on the area) and their transmission for mechanical treatment. Additionally, several waste recycling bins that collect PMDs, papers, glass, clothes, etc., exist. In 2011, the waste production was 15,100 t, at the end of 2012, it was up to 16,250 t, at the end of 2013, it was 16,865 t, while at the end of 2014, the amount was nearly 16,505 t [66]. The tourist area was served more often, as the waste was collected at least once a day, while in the coastal areas (front beach), 2–3 times per day, to avoid littering at sea.

3.2. CCI, WAI, WAR, WRR, LOS, WI, RBP, WBC, P-MSW

Taking into account that (to the best of our knowledge), there were no relevant scientific data for the study area in the early 1980s, we considered that (Table 4) the CCI was less than 1 (in fact, it could be equal to zero), as the two first hotels did not use any other plastic beside straws (in the pool bar), while visitors avoided carrying anything to the beach. Therefore, there was no significant evolution and use of plastics at that time. The F&B (Food and Beverage) department used glass containers (glasses, cups, etc.) instead of plastic, and all products, such as beers, water, wines, soft drinks, were served in glass containers. Due to the fact that there were no other facilities in the area, such as shops, supermarkets, etc., the tourist did not have the opportunity to buy something that could be transferred to the beach. All services were provided by the hotels, which were responsible for cleaning the beach, along with their own common public areas. Similar to CCI, we felt that it was also the same for WAI and WAR.

Table 4. Clean coast index (CCI), waste accumulation rate (WAR), and waste accumulation index (WAI).

	1984 *	**2019**	**2020 (during the COVID-19 Pandemic)**
CCI	<1	3.94	0.9–2.6
WAI	<0.5	3.4–4.6	0.8–2.2
WAR	<0.000001	0.1–0.001	0.001–0.0001
LOS		2	1–2
WBC		1.33 ± 0.31 L/Guest	1.57 ± 0.36 L/Guest
WI		0.023 ± 0.009	0.031 ± 0.015
RBP		1/1600 guest	3/1600 quest
LOS		Category B to A	Category A

* An assumption was considered for the data on 1984 due to the limited tourist activity in the entire area.

The volume of waste generation (WGR) at the beginning of the tourism industry was estimated between 500 and 1000 kg per day. This estimation was made taking into account that each guest produces up to 1 kg of waste per day [40] and taking into account that the visitors in both hotels numbered between 500 and 1000. However, the WRR could not be zero, although there were not any quantified data, as the supplier policy at that time was to collect all empty bottles of wines, beers, and soft drinks for refilling. Years later, due to the massive and rapid expansion of tourism in the area, significant infrastructure related to waste management was required.

By observing (Figure 6) the waste infrastructure (waste bins in general and other cleaning activities and facilities) on the beach, as well as in the surrounding areas, valuable information can be extracted for policymakers and other stakeholders to redesign their waste management strategy.

The capacity of the existing waste bins (in 2019) in WZ-1 and WZ-2 was 2142 L. There were (in 2019) only 32 waste bins per 30 m in WZ-1 (56 L each) and 5 waste bins per 30 m (70 L each) in WZ-2, to serve 1600 ± 300 visitors (but there was not any separated bin to collect recycling materials for both WZs), and the WBC = 1.33 ± 0.31 L/Guest, and WI = 0.023 ± 0.009 (Table 4). After recommendations, the waste bins in WZ-1 were increased to 45 (56 L each), while in WZ-2 continued the same (and a separated recycling bin was added, mainly to collect PMDs). The WBC in 2020 improved to 1.57 ± 0.36 L/Guest. The RBP was 1/1600 per guest in 2019 and 3/1600 per guest in 2020. In 2019, the WGR in the WZ-1, as indicated in Table 5, varied between 18.65 and 182.84 kg. In one week, the WBCaverage was 0.5561 ± 0.045, the WGRaverage was 102.61 ± 70.49 kg, while the P-MSWaverage was 0.03 ± 0.021. In 2019, the WRRPMD was 0.28, the WRRGlass was 0.12, and the WRRpaper was 0.08.

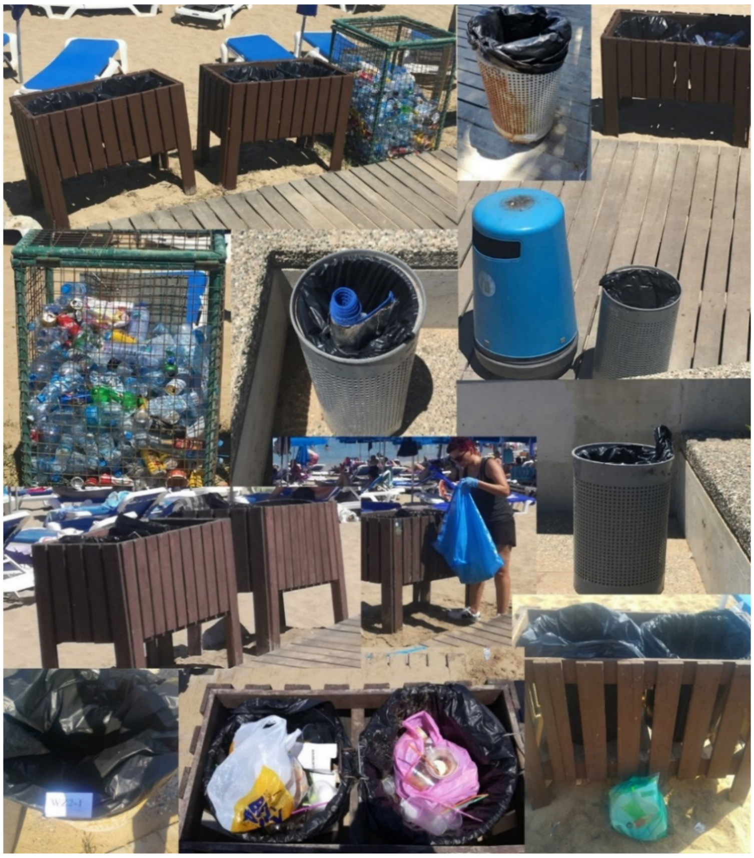


Figure 6. Infrastructure in Waste Zone 1 (WZ-1) and Waste Zone 2 (WZ-2).

Table 5. Waste Zone 1 characteristic (2nd week of July 2019).

	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Visitors 08:00–09:00	734	615	671	467	635	703	699
WGR WZ-1 in kg	25.344	5.985	0	5.7015	63.702	27.612	28.404
P-MSW (08:00–09:00)	0.0345	0.0097	0.0000	0.0122	0.1003	0.0393	0.0406
WBC (08:00–09:00)	0.3427	0.2871	0.3133	0.2180	0.2965	0.3282	0.3263
Visitors (13:00–14:00)	1662	1547	1549	1489	1398	1527	1603
WGR WZ-1 in kg	71.046	21.177	0.783	15.471	41.661	18.882	63.189
P-MSW (13:00–14:00)	0.0427	0.0137	0.0005	0.0104	0.0298	0.0124	0.0394
WBC (13:00–14:00)	0.7759	0.7222	0.7232	0.6951	0.6527	0.7129	0.7484
Visitors (17:00–18:00)	1509	1362	1472	1237	1147	1489	1499
WGR WZ-1 in kg	86.454	11.448	17.874	26.2575	49.536	46.926	90.819
P-MSW (17:00–18:00)	0.0573	0.0084	0.0121	0.0212	0.0432	0.0315	0.0606

Table 5. *Cont.*

	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
WBC (17:00–18:00)	0.7045	0.6359	0.6872	0.5775	0.5355	0.6951	0.6998
Total WGR WZ-1 in kg	182.84 ± 31.78	38.61 ± 7.70	18.65 ± 10.10	47.43 ± 10.28	154.89 ± 11.17	93.42 ± 14.35	182.41 ± 31.28
P-MSW	0.045 ± 0.012	0.011 ± 0.003	0.004 ± 0.007	0.015 ± 0.006	0.058 ± 0.037	0.028 ± 0.014	0.047 ± 0.012
WBC	0.6077 ± 0.23	0.5484 ± 0.23	0.5745 ± 0.22	0.4969 ± 0.24	0.4949 ± 0.18	0.5787 ± 0.21	0.5915 ± 0.23

The WGR during the COVID-19 pandemic ranged from 2.41 to 29.12 kg (the main reason was the fact that construction workers in the wider area and some visitors who used the pedestrian walk disposed of their wastes, which were mainly plastic water bottle, and other plastic packaging materials). The WBC was very high, as the total visitors in WZ-1 and WZ-2 was less than 100 per day, and the WRRPMD (2020) was greater than 0.6.

In 2019, there were 32 waste bins per 30 m in WZ-1 (56 l each) and 5 waste bins per 30 m (70 l each) in WZ-2, to serve 1600 ± 300 guests. WBC was equivalent to 1.33 ± 0.31 L/Guest and WI 0.023 ± 0.009 (Table 4). In 2020, the waste bins in WZ-1 upgraded to 45 (56 L each). The WBC in 2020 increased to 1.57 ± 0.36 L/Guest. The RBP was 1/1600 visitors in 2019 and 3/1600 in 2020.

The CCI is a direct, measurable index, which links to the LOS, in addition to the cleanliness (or dirtiness) of a beach. The CCI, as indicated from Table 4, was 3.94 during 2019, and the LOS was equal to 2 (or class B as indicated from Table 1). Class B means that the waste services in the study area were characterized as Acceptable to very good. According to the report of Blue-island (2019), CCI in other beaches is higher. For example, in Mallorca, it was found to have a value of 19, which means that the beach was dirty, while in Crete, it was found to be almost 11, and which is characterized as moderate. In the study area and during the COVID-19 pandemic, CCI ranged from 1.0 to 2.6. This was considered to be the same during the low tourist season in a normal period. The items found on the beach during the COVID-19 pandemic were mostly transported by the air, and tourist activities, or visitors to the front beach did not add any pressure on the environment. On the other hand, the WAI during June and July 2019 was found to be 3.4 and 4.6, respectively, while the WAI during the COVID-19 pandemic varied from 0.8 to 2.2. The Blue-island report [67] indicated that the WAI for Mallorca was almost 5.5 and Crete was 3.8. During June and July 2019, the WAR was found to be between 10^{-1} and 10^{-3} items/m^2/d, while at the same period during 2020 (during the COVID-19 pandemic period), WAR was found to be between 10^{-3}–10^{-4} items/m^2/d. In general, the selected study area can be considered in a normal high season period as moderate to clean. The WAR and the WAI can be considered from moderate to very low, and the LOS is characterized as acceptable to very good, considering the pressure from the tourist activities that the specific beach receives on a daily basis.

3.3. *C-MSW (Quantitative and Qualitative)*

The C-MSW for 2019 for WZ-1 is shown in Figure 7, and it can be said that the recognized waste streams (such as PMD, plastics, etc.) were directly related to what visitors can find nearby to buy, and, in addition, were related to what they can find from their hotels and which can be easily transported to the beach. The waste compositional analysis of July (2019) in the reverse series was PMD (33.13%) > FW (24%) > glass (12.7%) > mixed municipal (8.8%) > other metals (7.9%) > paper and paper carboard (6.7%), while for June in the reverse series was FW (33.3%) > PMD (19.91%) > glass (10.3%) > paper and paper carboard (11.2%) > mixed municipal (9.2%).

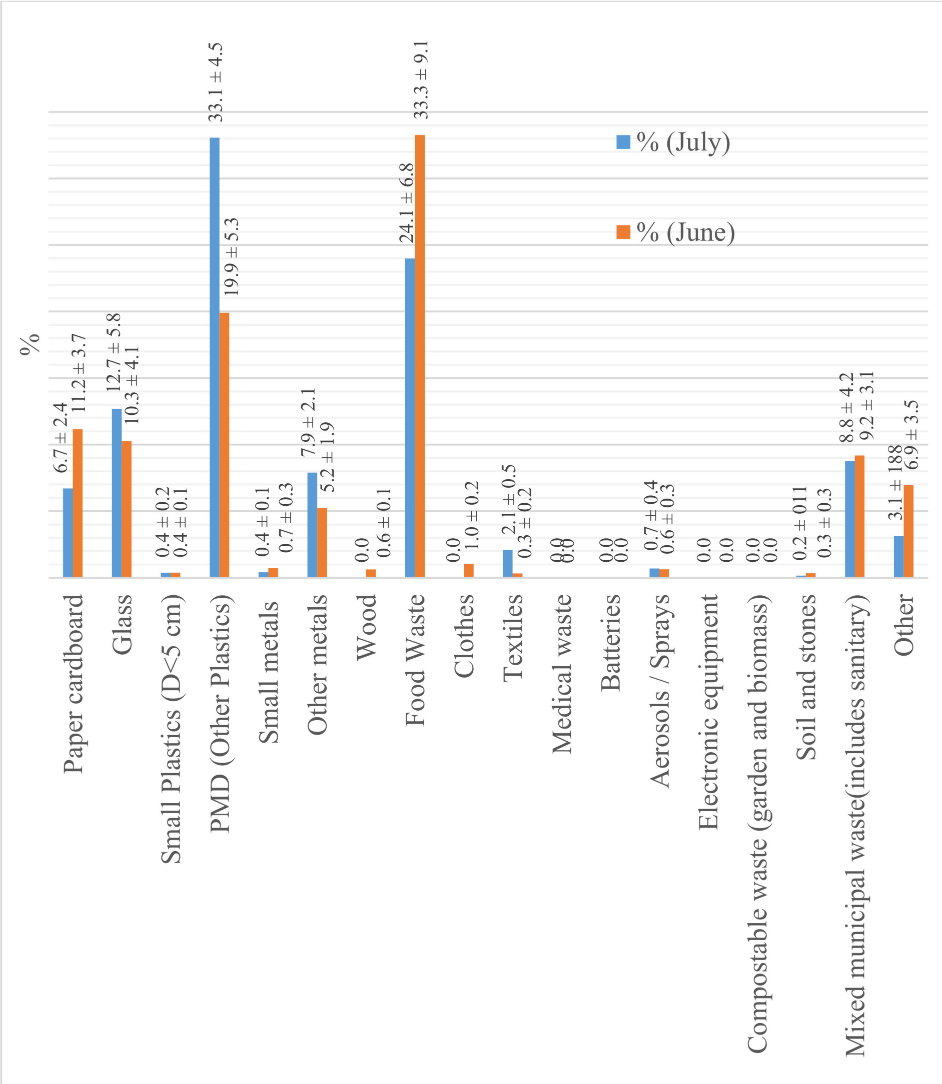


Figure 7. Waste compositional analysis in WZ-1 (for June and July 2019).

The micro qualitative analysis (Figure 8) showed that the main PMD streams consisted of 0.5–1.5 L of plastic bottles (waters and soft drinks mainly) and tetra packs. FW was mostly corn (as during summer, there are many sellers of roasted corn on the beach) and leftovers from snacks (i.e., pizza, sandwiches, seasonal fruits, mainly melon and watermelon). The glass fraction consisted mainly of wine and beer bottles. It was very disturbing that many plastic items were found, i.e., straws, small pieces from broken plastic of food containers, that were easily transported by air to the front beach and finally to the sea. This resulted in an increase in the concentration of micro-, meso-, and macroplastics in the beach sand.

Figure 8. Qualitative compositional analysis.

3.4. Macro-, Meso-, and Microplastics

According to Figure 9, cigarette butts and straws were considered to be the most significant waste, from those found on the beach (beside debris and stones that exist in the sand). However, macroplastics (which are the easiest to collect) consisted of PMD, i.e., plastic bottles, tetra packs, aluminum cans, toys, etc. During the tourist season (June and July 2019), the concentration of almost all the waste accumulation, was higher than in the same period of 2020. In addition to the minimum pressure that the study area received at the beginning of the season (March to April), the municipality has a strong policy, which deals with an in-situ cleaning technique through mechanical sieving (Figure 9). Taking into account the cleaning of the sand (through the mechanical sieving), the minimum tourist activities in the area, and the almost zero pressure on the beach (due to the strict measures taken and established on the COVID-19 pandemic), the waste accumulation of micro-, meso-, and macroplastic, decreased significantly. However, (in general), a pandemic scenario cannot be the panacea solution to control and reduce the environmental impact and the carbon footprint of the planet. It is obvious that if the pressure received by an area due to tourism activities can be controlled through the development and implementation of a strategic plan [27,52], then the negative effects on the environment can be minimized. However, a strategic approach requires political decisions that may be contrary to economic growth.

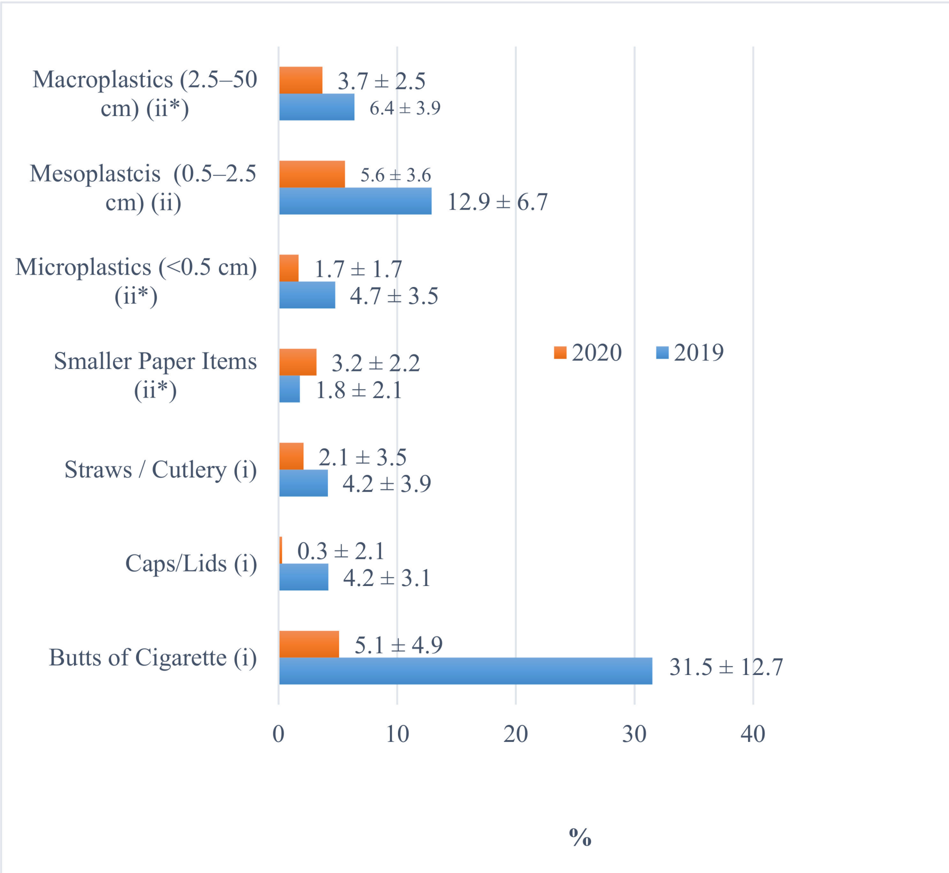


Figure 9. Waste accumulation, waste infrastructure (LOS), and qualitative analysis (The probable source is specified as: (i) = coastline, including poor waste management, tourism and recreational activities; and (ii) = non-sourced. The symbol (*) associated to the non-sourced items (ii) shows that this specific item is strongly related to seasonality).

3.5. SWOT-PESTEL Analysis

Table 6 presents the SWOT analysis, and Table 7, the SWOT coupling matrix. According to the result of Table 7, there were 24 links between T-S, 25 between T-W, 27 between O-W, and 29 links between O-S. Considering Figure 5b and the outcomes from Table 7, the Development Strategy was chosen when "O-S" overcomes, which means that O were too many. At the same time, the organization had the potential, and the resources to make the most of it as any of the recognized weaknesses and/or threats can be easily controlled. It is obvious that the development of a holistic and appropriate strategy for the management of waste from coastal areas will contribute to the improvement and control of the environmental performance of the area. At the same time, littering to the sea will be minimized.

Table 6. The interaction of SWOT into a PESTEL analysis.

	External Aspects														
	Opportunities	**Pol**	**Eco**	**Soc**	**Tec**	**Leg**	**Env**		**Threats**	**Pol**	**Eco**	**Soc**	**Tec**	**Leg**	**Env**
O1	To improve the existing environmental performance	+2	+4	+5	+3	+5	+5	T1	Lack of public policy that is concerned with environmental issues	−3	−3	−4	−2	−1	−5
O2	To improve waste infrastructure	+1	+4	+5	+3	+3	+5	T2	Non-existence of any awareness activities related to waste strategies (i.e., reduce, reuse, recycling, prevention, etc.)	−2	−3	−4	−1	−4	−5
O3	To avoid littering in the sea (microplastics)	+3	+5	+4	+3	+5	+5	T3	Massive tourist activities (and seasonality)	−3	−5	−5	−1	−1	−5
O4	To change citizens attitude and behavior regarding waste disposal	+2	+3	+4	+3	+5	+5	T4	Pandemic announcement (i.e., COVID-19)	−3	−5	−4	−1	−1	−5
O5	To increase recycling index	+1	+3	+5	+1	+3	+5	T5	Not appropriate cleaning of the beach	−2	−5	−4	−2	−1	−5
O6	To turn the beach to a "Smart and Sustainable Destination"	+4	+4	+3	+2	+5	+5	T6	Pollution at the coastal areas and degradation of the marine ecosystem	−3	−5	−5	−3	−5	−5
	Internal Aspects														
	Strengths	**Pol**	**Eco**	**Soc**	**Tec**	**Leg**	**Env**		**Weaknesses**	**Pol**	**Eco**	**Soc**	**Tec**	**Leg**	**Env**
S1	Reputation of the area	+5	+5	+5	+2	+1	+5	W1	The absence of a holistic waste strategy	−2	−2	−4	−3	−3	−5
S2	Organized Beach	+3	+5	+5	+4	+4	+5	W2	Absence of waste management infrastructures	−2	−4	−5	−1	−1	−5
S3	Existing hospitality industry for many years	+4	+5	+5	+2	+3	+5	W3	Lack of Beach watchers (i.e., local police to monitor littering)	−2	−3	−4	−1	−2	−5

Table 6. *Cont.*

	Internal Aspects													
	Strengths	**Pol**	**Eco**	**Soc**	**Tec**	**Leg**	**Env**		**Weaknesses**	**Pol**	**Eco**	**Soc**	**Tec**	**Leg**	**Env**
S4	The expansion of tourism in the area and in the Country	+5	+5	+5	+3	+2	+5	W4	Minimum awareness activities, advertising, and marketing	−1	−2	−5	−1	−1	−5
S5	Strong government support behind the industry	+5	+5	+5	+1	+4	+5	W5	Lack of educational programs for the citizens	−1	−2	−5	−1	−1	−5
S6	LOS	+2	+3	+4	+2	+3	+5	W6	Lack of Technical standard	−1	−2	−3	−1	−1	−5

Each feature is rated with a significance coefficient, from 1 to 5, with 1 (one) being minor, 2 (two) less important, 3 (three) average, 4 (four) important, and 5 (five) very important. In front of each significance coefficient, the symbol "+" or "−" demonstrates whether it is a positive (in the case of internal aspect) or a negative characteristic (in the case of the external aspect).

Table 7. Correlations between strengths–opportunities (S-O), strengths–threats (S-T), weaknesses–opportunities (W-O), and weaknesses–threats (W-T).

THREATS	T.6	x	x	x	x		x	x	x	x	x	x	x
	T.5	x	x	x			x	x	x	x		x	x
	T.4	x						x					
	T.3	x	x	x	x		x	x	x	x	x		
	T.2	x	x	x			x	x	x			x	
	T.1	x	x	x	x		x	x	x	x	x	x	x
OPPORTUNITIES	O.6	x	x	x			x	x	x		x		x
	O.5	x	x	x	x		x	x	x		x	x	x
	O.4	x	x	x			x	x			x	x	
	O.3	x	x	x	x	x	x	x	x	x	x	x	x
	O.2	x	x	x			x	x	x				x
	O.1	x	x	x	x	x	x	x	x	x	x	x	x
SWOT MATRIX		S.1	S.2	S.3	S.4	S.5	S.6	W.1	W.2	W.3	W.4	W.5	W.6
		STRENGTHS						**WEAKNESSES**					

Sensitive analysis (Figure 10) indicated that the system under study did not face significant issues, and the O-S Development Strategy was the only option. As a result, the development of a holistic waste strategy must be a priority for the entire area. At the same time, the development of a department that will control the cleanliness of the beach on a daily basis is very important. Moreover, an awareness campaign to inform tourists and other guests to avoid littering on the beach or at sea, as well as to indicate the existing waste infrastructure and, furthermore, to promote any other prevention activities is also vital. This is directly related to the policy that the municipality wants to implement to improve its environmental performance.

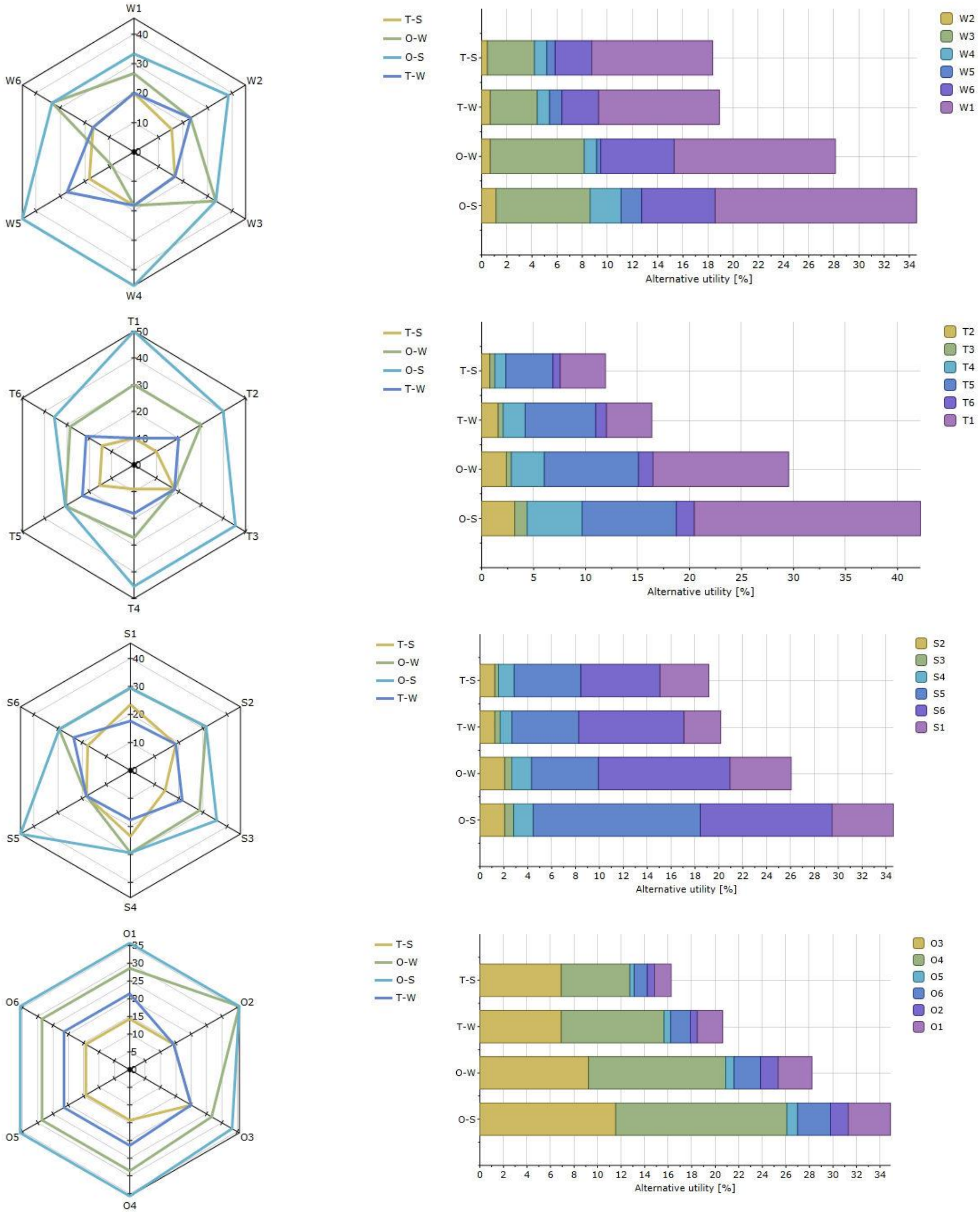


Figure 10. Sensitive analysis.

4. Conclusions

At present, it is unclear how long and deep the crisis will be (concerning the COVID-19 pandemic), and how the recovery path will look, and, therefore, how waste production, waste management, waste accumulation, clean coast index, CO_2 emissions, etc., will be affected or improved. Keeping track as it evolves, several KPIs can help to inform policymakers to be prepared for the next pandemic at all levels. Additionally, a pandemic (i.e., COVID-19) seems to temporarily improve all KPIs under examination, such as CCI, WAR, and WAI, etc. Nevertheless, a pandemic cannot be the panacea solution to control and minimize any environmental issue (i.e., waste, microplastics, CO_2, etc.), but the solution is the development of a waste strategy to address all environmental problems. The COVID-19 pandemic can help all the competent authorities to readjust, redesign, and even more, to start from scratch to propose a new strategy, targeting the improvement in LOS, including the development of an awareness strategy, with the aim of turning coastal zones into SMART zones, or to propose prevention activities, as well as zero waste approached. Hence, the COVID-19 pandemic can play a significant role in how our environment was before and how it looks now, to tackle ourselves on how we must act on environmental protection. Furthermore, COVID-19 may have implications for future management strategies. Further research is needed in the sense of the behavior of tourism regarding environmental performance, as well as a detailed strategy in the nearest future related to the minimization of single-use plastics by providing motivation measures to the stakeholders, and tourism is vital.

Author Contributions: Conceptualization, A.A.Z.; data curation, P.L., I.V., G.C., J.N.-P. and A.A.Z.; formal analysis, P.L., I.V., G.C., J.N.-P. and A.A.Z.; funding acquisition, A.A.Z.; investigation, P.L., G.C., J.N.-P. and A.A.Z.; methodology, P.L., I.V., G.C., J.N.-P. and A.A.Z.; project administration, I.V. and A.A.Z.; resources, P.L., I.V., G.C., J.N.-P. and A.A.Z.; software, A.A.Z.; supervision, J.N.-P. and A.A.Z.; validation, A.A.Z.; visualization, J.N.-P. and A.A.Z.; writing—original draft, J.N.-P. and A.A.Z.; writing—review & editing, J.N.-P. and A.A.Z. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Data Availability Statement: Not applicable.

Acknowledgments: Not applicable.

Conflicts of Interest: The authors declare no conflict of interest.

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