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Leisure Boating Environmental Footprint: A Study of Leisure Marinas in Palermo, Italy

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Abstract: Ports have played a significant role in the touristic development and further economic growth of Italy. It is the country with the highest number of berths among the nations in the Mediterranean Sea; over time, Italy has created ports with a range of functions. Therefore, it is of vital importance to evaluate the potential pollutants generated from these docks and propose ways to eliminate those problems. A survey that asked about the carbon footprint and the quality of the water in the water footprint calculation was created and distributed to the management of the marinas' operations. After receiving the completed surveys, the data were analyzed and translated using emission factors into tons of CO_2 equivalent. The amount of greenhouse gases generated by the investigated marinas was determined by calculating the carbon and water footprints of five representative Palermo marinas, and we aimed to better understand how these port-related operations affect the environment. To pinpoint the pollutant sources within the investigated marinas, an original P-Mapping/Pareto ratio approach was performed as supported by Pareto's principle. The findings indicated that the primary operations of the marina sector are the main sources of pollution. However, a sizable portion of the emissions were also caused by pollution from supporting operations. Based on the study, the origins of CO_2 and pollution in marina operations were clarified. The results obtained enable the authors to make recommendations that all recreational boating activities should be closely supervised in order to reduce CO_2 emissions and their input in relation to environmental degradation.

Keywords: leisure boats; marina operation; pollution; tourism; value chain

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1. Introduction

Italy's most popular tourist destinations are home to some of the country's top marinas. With a coastline over 7500 km in length, Italy has 537 tourist ports. The pinnacle locations in Italy include Venice, Sardinia, Sicily, the Amalfi Coast, and Naples. Leisure boat marina companies operate in an increasingly competitive environment, where environmental impact becomes a unique point of sale criterion. Similarly, the international development of the sector is also considered an indicator for the effectiveness of promotional strategies and the promotion of marina berth. In this sense, current studies on marina management are not sufficient to support operations regarding the CO_2 emissions because they lack a clear classification of pollution sources in terms of type of operations related to pollutant activity. Sustainability is defined in a business context as *"an organization's ability to make profits, as well as sustaining the environment at the same time"* [1]. Sustainable marina management is related, first and foremost, to the environmental impact generated by marina operations, thus to the pollution sources [2,3].

Green P-Mapping (i.e., Process Mapping) is a technique that incorporates the identification of environmental wastes [4] and provides an appropriate analysis for marinas. Nevertheless, relatively similar approaches are Lean and Green and the GBPM (*Green Business Process Management*) that arose from conventional *Business Process Management* (BPM), which was 'born' when *"instead of blaming people for underperformance, they started to blame the process"* [4–6]. The extension of BPM to a green context (GBPM) is an example of the growing interest in environmental impact studies of business activities [6]. It is also due to increasingly stringent environmental requirements as well as consumers' growing concerns about sustainability [7]. However, this is still a young discipline, and the approaches that the literature classifies as GBPM are very fragmented; they lack generality and are strongly related to specific fields of application [6]. The literature emphasizes that strategy should be the first aspect to be considered when planning an environmental approach in a company [7]. It is necessary to develop a green strategy that is consistent with a company's business strategy [8,9]. In this context, a Porter's value chain helps in strategic decision making by highlighting the core and support activities for value creation. Subsequently, decision making concerning this chain can be oriented to a sustainable direction. Another recurring topic is the GBPM life cycle [10,11]. Several life cycle models are proposed, and they are basically green adaptations of the BPM life cycle. The steps in BPM, for the continuous improvement of processes, start with a definition of a strategy and then follow with the design and/or redesign of processes and finally continue with monitoring and control.

Many approaches are based on the Business Process Model and Notation (BPMN) or similar techniques and then add information related to environmental sustainability [12]. For example, one of the approaches [13] uses both a BPMN mapping technique and symbols that identify the type, the point of origin of resources consumed (such as fuel or paper), and indicators that quantify CO_2 and greenhouse gas emissions related to activities. The previously mentioned article by Houy [3] highlights another interesting case [14] on the mapping of a process carried out through the Event-driven Process Chain (EPC) technique. In the mapping process, the activities are linked to annotations that report ideal values of indicators referring to the consumption of resources (fuel, electricity) or emissions (CO_2).

The exploration of this field also reveals works by Caldera et al. [15,16] as excellent sources of information. Lean Manufacturing is a strategy that includes several methods and aims to *"deliver the same output while utilizing fewer inputs"* [15]. In other words, transferring value to the customer while minimizing any waste of resources. Moreover, the Lean philosophy, as it is for BPM, fits well with the context of greater attention to sustainability, which has increasingly become a driver to improve organizations' efficiency and competitiveness [15]. Evidence of this is the rise in the number of publications, highlighted by Caldera et al. [16]. It has also been demonstrated that these methods are effective in reducing pollution, including emissions [17,18].

The Italian marine industry is world leading, especially concerning yacht production. In 2018, 54,685 motorboats were registered in Italy in 395 marinas, of which 148 were classified as high-quality marinas [19,20]. Based on research [21], in Sicily there are 4038 registered motorboats. There are 53,835 quality berths with an average of 364 per marina. What makes Italian marinas attractive to visitors and berth residency is the coastal marina density. Italy has 20.8 km coast per marina, and this rises to 55.4 km for high quality marinas which subsequently comes to 6.6 km quality marina berths per km of coast. According to the Superyacht Intelligence Quarterly [22], Italy has 2900 berths for superyachts. A total of 162 marinas are capable of berthing yachts larger than 24 m and, respectively, 83 marinas are capable of berthing yachts larger than 40 m.

In the Mediterranean basin, Italy has the most berths (2900), followed by Spain (2300), with Slovenia (30 berths) in bottom place [22]. Additionally, Italy has 57 shipyards, which account for 21% of the global market. There were reportedly 661 yachts being built in Italy in the past 10 years. Moreover, Italian shipyards have refitted 278 yachts in 2020 and

285 in 2021, respectively [22]. The forecast indicates a growth between 18.8% and 23.8% for 2021 respectively: a global output of around 6 billion Euros compared to 4.66 billion Euros in 2020. In Sicily there are 31 shipyards, with Yam Marine (Palermo) specialized in yacht design.

Given the intensive leisure boating in Italy, it was hypothesized that these increased activities during the last decade would contribute to greater CO_2 emissions and environmental pollution levels. Therefore, investigation on the environmental impact of marinas, particularly for Italy, is a pressing issue. The aim of this study was to identify the pollution sources for five Italian marinas located in Palermo using a P-Mapping approach and identify the environmental footprint of the leisure boating sector.

2. Methodology

2.1. Study Area

Palermo is an Italian city on the island of Sicily with a great maritime tradition and a large number of ports both for goods and cruise liners and designated marina berths [23]. Based on the Italian legislation (D.P.R 509 of 2 December 1997 and Law 84 of 28 January 1994), there are three main port facilities for pleasure boating:

1. Tourist port: complex of removable and immovable structures built with facilities on land and at sea in order to serve only or mainly pleasure boating and yachting, also through the provision of complementary services;
2. Tourist landing place: portions of multipurpose ports intended to serve pleasure boating and yachting, including the provision of complementary services;
3. Mooring points: maritime state property areas and water bodies equipped with facilities that are not difficult to remove and are intended for the mooring, launching, and storage of small boats and pleasure crafts.

Small ports (marinas) located within the urban area of the city of Palermo were selected for analysis. The goal was to determine the marinas' water and carbon footprints for the year 2021 as well as any operational management variations. The authors of this study aimed to examine the environmental effects of recreational marinas from the standpoints of carbon footprint and water footprint. Most of the known research currently being undertaken on marinas is mainly concerned with water quality as a result from port operations, emerging pollutants, waste management, and the impact on local marine life [24]. However, from an all-encompassing environmental perspective, there is still no comparable study that looks at greenhouse gas emissions and the implicit carbon footprint from Italian marinas. In total, five marinas were selected for analysis (Figure 1) with emphasis on core activities carried out by marina companies that were relevant to the environmental impact. These marinas had a range of water depth of 4–8 m, with well-equipped marinas able to accommodate about 600 yachts up to 70 m long.

The main features of each studied marina are indicated in Table 1. According to the analysis, marina companies focused on two main aspects: (i) the typical activities of charter and (ii) leisure boating and the ship-repairing industry (i.e., caring and maintenance of pleasure boats).

2.2. Measuring Carbon and Water Footprints

There are two fundamental methodological approaches that can be used to calculate carbon footprints. The first is the business-oriented approach, which entails gathering information on an organization's direct and indirect energy and material consumption and converting it into CO_2 equivalent emissions and subsequently to generate an emissions inventory. The Green House Gas Protocol, created by the World Business Council for Sustainable Development, is the most extensively used manual for businesses of all kinds to construct an inventory of their GHG emissions and determine their carbon footprint. This procedure is significant since it served as the foundation for numerous other techniques and programs. A second instrument, the ISO 14064: 2006 standard, is used by companies (parts 1 and 3). Compared to the GHG Protocol, the ISO standard provides an internationally accepted means of verification guides for enterprises to build and report on their greenhouse gas inventory. Beside these approaches, there is one more that is product-focused. Product-focused tools track the amount of resources and energy consumed throughout a product's life cycle, up until it is released onto the market. Additionally, after all the data is available, it is converted into CO_2 emissions. The composite accounting technique, often known as MC3, is a hybrid approach that is focused on both the organization and the product. In contrast to the earlier techniques, the information used in the composite method comes from the books of the organization.

Figure 1. The selected marines in the study are shown in red dots.

Table 1. Functions and main features of the studied marinas.

Marina	Main Function	Employees	Main Company Operations
Arenella	Dry port	8	Management of the piers, maintenance, management of storage of boats
Palemo Nautica Galizi	Ship repair	5	Maintenance of hulls
Si. Ti. Mar Srl	Management of piers	3	Management of piers and assistance of customers
Centro velico Siciliana	Dock management	3	Mooring, management, and maintenance
Salpancore Srl	Ship repair yard	6	Management of piers and maintenance

Three categories can be used to categorize GHG emissions. Scope 1 emissions, also known as direct emissions, are those caused by the fuels an organization uses in its operations or for transportation. Scope 2 emissions, also known as indirect emissions, are those that are connected to the organization's purchase and generation of electricity. The third category of emissions is known as "other indirect emissions" or "Scope 3 emissions", and it includes all forms of indirect emissions as well as electricity. The process is finished if the register covers the carbon footprint of all fixed assets, works, and capital goods.

Leisure marinas and freight ports operate differently, which results in variances in the pollutants they produce. Additionally, the logistics and industrial support provided by freight ports significantly enhance their carbon footprint. Another reason why GHG emissions are higher in freight ports than in leisure ports is the way that ships acquire energy when they are berthed. In the past, cargo ships have used generators while at anchor, which produces Scope 1 greenhouse gas emissions.

The usage of drinking water necessary for an activity's proper growth is taken into account by the water footprint, along with the investigation of water pollution. Three parts make up the water footprint: the blue, grey, and green parts. Green water is precipitation that is absorbed into the soil or plant life rather than being lost through runoff. The portion of the hydrological cycle that is converted into surface or subway runoff and consumed by incorporation or evaporation in the evaluated process is referred to as blue water. It can be intentionally caught by building reservoirs, and it feeds the flow of rivers and aquifer reserves. Finally, the term "grey water" relates to the resource's pollution in theory. It represents the amount of water necessary to lessen the load of contaminants and meet the standards for existing water quality. According to the water footprint, the main contaminants identified in the waters of recreational marinas are suspended particles, heavy metals, and residues of antifouling coatings. Direct water consumption by the marina is another crucial aspect of recreational marina management that is pertinent to this study and also gives an idea of the potential amount of water that could be contaminated by activities there.

The blue, green, and grey water footprints' calculations are used to quantify the overall direct water use. The direct water footprint of sports marinas has been calculated using only blue water (drinking water supplied from a supply source), leaving out the amount of green and grey water. The amounts of green and grey water were dumped for the following reasons: incorporated rainfall is measured by "green water," which is particularly significant when agricultural goods are being investigated but becomes unimportant in other situations; grey water accounts for the volume of water that would, in theory, dilute the pollutants produced as a result of the procedure that has subjected the blue water to concentrations lower than its maximum allowable concentration in accordance with the most stringent regulations currently in effect.

2.3. P-Mapping

The P-Mapping (i.e., Process Mapping) aims to identify wastes by decomposition of processes into activities [24]. The classical P-Mapping technique was extended to highlight unnecessary sources of pollution. For each activity, sub-activities were classified as value-adding (operations, inspections) and non-value-adding (transports, storage, delays). In Table 2, the decomposition highlights a consumption of fuel and production of dirty isopropanol that needs to be disposed (a Pareto is also needed to quantify wastes).

Table 2. Extended process mapping [4]. Note: O—operations, I—termed inspections, T—transports, S—storage, D—delays, G—green waste, n.a.—not applicable.

Activity	O	I	T	S	D	G	Notes
Load	n.a.	n.a.	10 sec.	n.a.	n.a.	n.a.	n.a.
Process	60 sec.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Check thickness	n.a.	20 s	n.a.	n.a.	n.a.	n.a.	n.a.
Clean	n.a.	5 s	n.a.	n.a.	n.a.	n.a.	n.a.
Unload	n.a.	n.a.	10 sec.	n.a.	n.a.	Disposal of dirty isopropanol (100 L per week)	1 in 5 require isopropanol cleaning
Warehouse	n.a.	n.a.	100 m	<48 h	WTG forklift, 30 min	Diesel fuel (100 L per day) and forklift emissions.	Forklift being refilled; 1000 L in storage.
Paareto ratio	-	-	99.6%/0.4%	99.8%/0.2%	98%/2%	99%/1%	-

The Pareto principle focuses on how a small number of causes are likely to manifest more frequently than others when examining the underlying causes of a problem. This concept acts as an all-encompassing reminder that inputs and outputs frequently do not have a balanced connection. For example, a business' profitability may be driven by a reduced percentage of efforts, and vice versa. Most of the time spent by managers is typically insufficiently allocated to activities that have little to no impact on achieving business objectives. In any case, many diverse fields, including economics and environmental sciences, are subject to Pareto's 80:20 rule [25]. For instance, even though China and India are two of the countries responsible for 20% of the global emissions, remedies seem to be centered on the 80% of countries responsible for the remaining 80% of the problem. According to the Pareto principle, 20% of causes account for about 80% of the effects for many events. This also holds true for global CO_2 emissions. If China and India, the two largest CO_2 emitters, do not act, the rest of the world can preserve resources and reduce CO_2 emissions, but the world will follow the Pareto principle. The relative contributions of the different marine operation processes to the pollution level were calculated and expressed as Pareto ratios for the total mixture and for the mixtures for each operation group. Adopting the idea makes decision-making more effective by allowing it to concentrate on important tasks (business drivers). The fundamental tenet of the few vital and many trivial concepts underlie the entire idea.

Within the map, the value stream was represented but information relevant for cost efficiency (crucial for "classic" value stream mapping) was substituted by environmental sustainability indicators (i.e., that define the level of sustainability). This enables us to understand where the waste is generated, and the amount of waste connected to each activity. The value chain represents the activity that generates value in the company, which is subsequently taken into consideration. The green approach consists of adding relevant information from an environmental point of view. This allows us to link value-adding activities with the amount of pollution generated by each of them or resources used. For example, the map highlights that the activities performed in the *painting station* produce 0.7573 metric tons of CO_2 and consume 170 kWh of energy and 700 liters of water every day.

2.4. Data Collection and Analysis

Marina operations supervisors were asked to complete a web-based questionnaire (Table 3) to provide information on: (i) fossil fuel consumption for vehicles and fixed installations; (ii) electric energy consumption; (iii) fuel consumption related to waste management, movement of working labor, suppliers; (iv) water consumption and waste management. The structure of the interviews followed the P-mapping and the Porter's model [20] and focused on environmental topics to determine the carbon and water footprints [26]. The aim of the study was to obtain a concrete view of the operation of marinas as relates to the impact on environment as well as to identify all sources of pollution. The Porter's value chain was applied as an exploratory instrument because the model is generally used to map the activities that create value. Then, a green perspective was adopted, highlighting the sources of pollution and environmental issues.

Table 3. Questionnaire sent to selected marinas.

Question	General Information	Unit	Indicator
	Questionnaire		
Q1.1	Type of port	Transit/Base	–
Q1.2	Number of workers	n°	–
Q1.3	Average daily commute of workers to the marina	km	Carbon
Q1.4	Average daily commute of tourists to the marina	km	Carbon
Q2	Number of berths	n°	–
Q3	Vessel dimensions	m × m	–

Table 3. *Cont.*

Question	General Information	Unit	Indicator
Q4	Activities most frequently carried out by ships	Open-ended question	Carbon/Water
Q5.1	Separate waste collection	Yes/No	–
Q5.2	Frequency waste collection	Times/Year	Carbon
	Maintenance activities		
Q6	Developed by who	Open-ended question	–
Q7	Frequency of these tasks	Times/Year	Carbon
Q8	Hot water production system	Open-ended question	Carbon
	Consumptions		
Q9	Electric	kWh	Carbon
Q10	Diesel fuel	litres	Carbon
Q11	Water	m3	Water
	Suppliers		
Q12	Number of suppliers	nº	Carbon
Q13	Frequency of visits	Times/Year	Carbon
Q14	Type of vehicle	Open-ended question	Carbon
	Office		
Q15	Number of people working	nº	Carbon
	Restaurants		
Q16	Bar, Cafeteria, Restaurant, etc	Type	Carbon/Water
Q17	Quantity	nº	–
Q18	Energy source	Type	Carbon
	Visitors		
Q19.1	Quantity	nº	Carbon
Q19.2	Vehicle	Type	Carbon

A methodical approach to data gathering is necessary to ensure the accuracy and completeness of the information. Following this idea, a web-based survey has been created, with most of the inquiries being prime and open-ended. Three questions are multiple choices: Scope 1 is covered by question 10, which deals with the marina's use of fuel; scope 2 is covered by questions 8, 9, and 18, which deal with the marina's overall use of electricity; finally, scope 3 is covered by the remaining questions, which provide an approximation of the fuel used by the visitors', suppliers', and waste manager's vehicles.

2.5. Model Adaptation

A yacht charter company in the original model (Figure 2) was represented as a set of activities (or processes), each contributing to create value that is ultimately transferred to the customer. The activities were grouped into two categories [27]: (i) Primary Activities and (ii) Support Activities. The adaptation proposed here excluded services (e.g., launching dock, winter storage, short repairs and maintenance) from the value chain because services are not a component of the value flow, but are the value itself. Because logistics and marketing activities are in common among the various flows, it was decided not to duplicate them, but to diversify the flows only within the operations box according to the type of service offered.

(D) It is important to note that just four (4) of the value chain activities made a significant contribution to the environmental pressure seen in the current case study. (R) The associated Pareto ratios for transports (99.6/0.4), storage (99.8/0.2), delays (98/2) and green waste (99/1) found throughout our analysis are listed in Table 3. (D) Conceptually, this pattern should be expected from the probability calculation underpinning the environmental pressure derivation of the Van Straalen–Aldenberg integral (overlaps of tails of distributions). This statistical cause is still undiscovered. It would have been unexpected to find non-skewed results in hindsight given that Newman's study [29] reported comparable outcomes for a number of scenarios. The situation where mixes in the field are composed so that all primary activities contribute equally to the mixing impact everywhere, or where they are equal in significance, would be the most improbable. For the present results and accuracy level, we suggest using the outcomes in practice by considering 3 classes: even despite some uncertainties, the method can help us to identify a class of chemicals unlikely to pose harm in the European Union water body, a class for which this is possible (and depending on circumstances), and a class that likely poses harm.

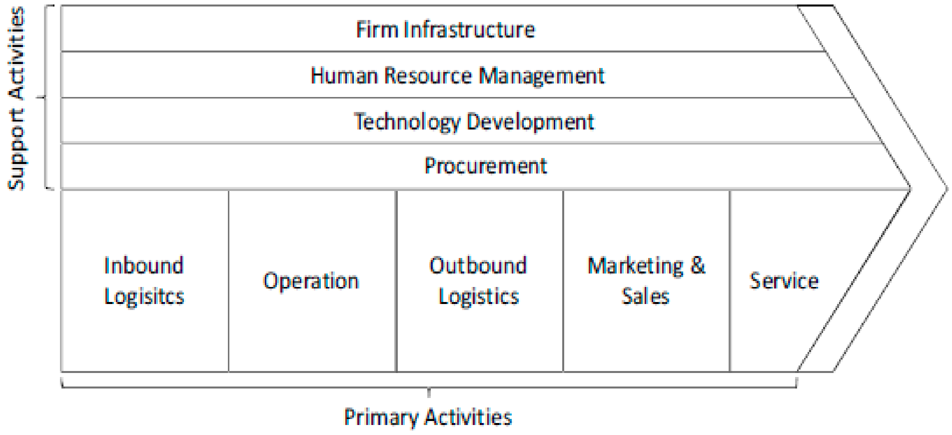


Figure 2. The Porter's Value Chain [28].

2.6. Analysis

The operation performance as per P-mapping and Porter's Value Chain endeavor to demonstrate how will positively determine carbon reduction value chain adoption in leisure boat marinas. The measurement model is tested by examining validity and reliability before the structural model is tested. As a result, the construct reliability, convergent validity, and discriminant validity were evaluated for each indication. The Composite Reliability (CR) coefficient was used to verify the construct reliability.

Indicators were ranked by individual reliability using Partial Least Square (PLS). Composite reliability was used to assess the constructs' reliability. The path association used was therefore statistically significant because all values for the standardized regression weights were more than 0.1. Thus, it can be inferred that the primary and supporting activities were crucial for attaining the adoption of a value chain with a lower carbon footprint, and that the factors that influence strategic environmentalism can forecast the adoption of a sustainable value chain.

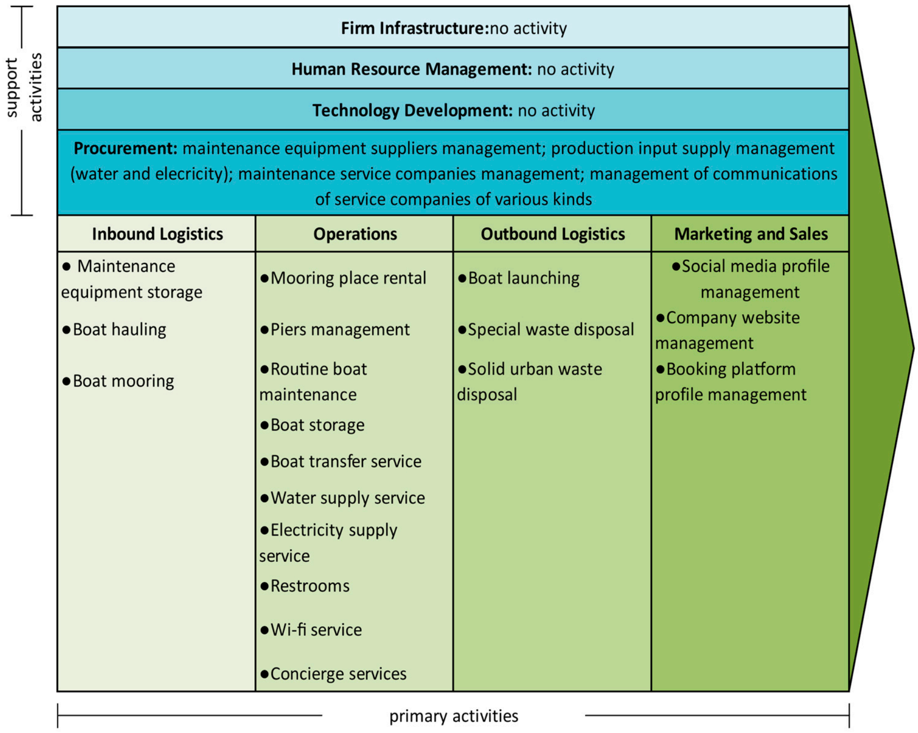
3. Results

The results of the questionnaire on the carbon and water footprints are presented in Table 4.

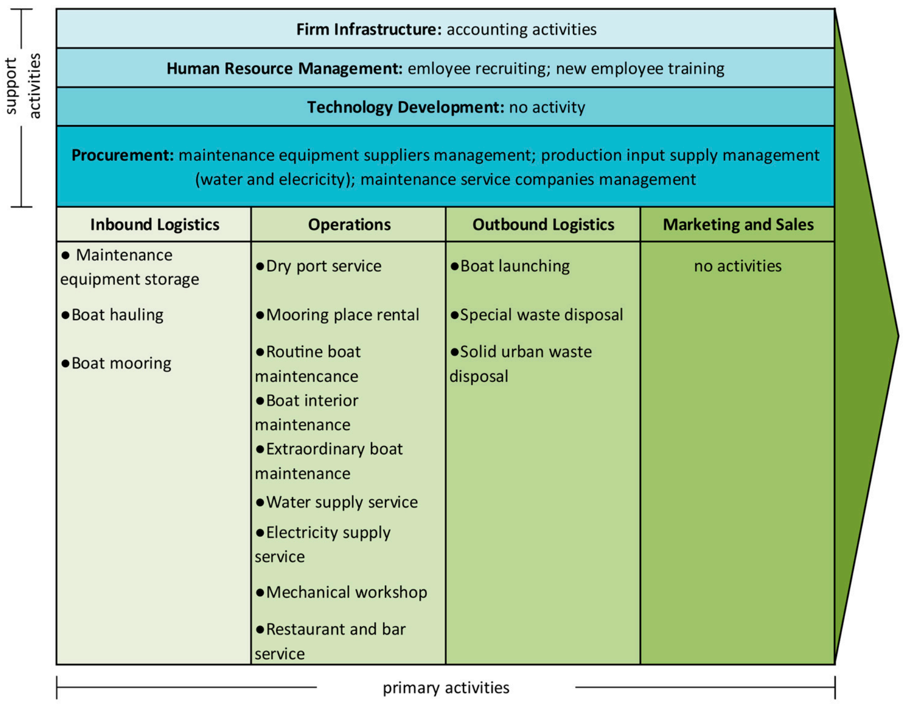
Table 4. Carbon and water footprints of the 5 studied marinas.

	Units	Marina1	Marina 2	Marina3	Marina4	Marina5
		Value	Value	Value	Value	Value
Carbon Footprint	t CO_2 eq	63.1	687.1	5937.2	156.5	25.9
Water Footprint	m^3	2720	0	10,668	1500	500

As a result, the two representative marinas (1 and 5) findings demonstrate that all constructions have CR values above 0.7, proving their dependability. Finally, the standard deviation (SD) number is less than 1 and the mean score for each construct is higher than 2.5 on a scale of 5, indicating that the respondents' responses were close. The degree of significance of the path coefficients and percentage of variance R^2 measurements were used to evaluate the structural model. Accordingly, R^2 is 0.748 (74.8%) for operational performance for adopting a reduced carbon value chain. PLS does not require a large sample size and can be used for data validation [30]. As can be observed in Figure 3, SmartPLS3 was utilized to produce path coefficients, R^2, t-values, and p values.



(a)



(b)

Figure 3. Porter's value chain for two of the most representative marinas in this study; Arenella marina (**a**) and Salpancore Srl marina (**b**).

Additionally, operational performance had the largest impact on the leisure marinas' adoption of the low-carbon value chain at (0.865), indicating that operational use can help them achieve lower energy use, lower CO_2 emissions, and other goals.

The information collected was synthesized and the value-chain-adapted models were built (Figure 3). In some cases, the value chain model reported "no activities" as the type of activity in question is either performed by third parties or not performed at all (this is the case for technology development activities in all five marinas).

This study looked at factors that influence marinas' adoption of the value chain as sustainable options for carbon reduction operations.

The sources of pollution identified are presented in Table 5. The main sources of pollution originate in the primary activities, related to exhaust gases and also to antifouling paint toxic liquids (Table 5).

Table 5. Sources of pollution in the studied marinas of Sicily.

Source of Pollution	Origin	Notes
Exhaust gas	Handling of boats through lifting vehicles; engines of boats turned on during mooring phase	-
Antifouling paint	Boat's hull while it is anchored in the marina	Boat's hull needs this paint to prevent biofouling damage
Toxic liquids (like oil or fuel)	Leakages from the boat while it is anchored in the marina	-
Liquid in the maintenance yard	Maintenance activities	It contains dusts, oil and toxic substances, it should be stored or filtered for correct disposal
Dust in the maintenance yard	Maintenance activities	It is considered a hazardous waste
Maintenance activities wastes (like used rags, used sandpaper or zinc plate)	Maintenance activities	They are considered a hazardous waste
Solid wastes	Customer boats	They are not a hazardous waste
Bilge water	Customer boats' bilge	It should be correctly stored since it can contain toxic substances
Sewage	Customer boats' sewage tank	it should be correctly stored

Table 6 present the main characteristics of the 5 marinas in relation their annual day to day operation which are contributor to their carbon and water footprint.

Table 6. Main Characteristics of the five marinas studied.

Marina	1	2	3	4	5
Number of boats	60	80	155	80	30
Diesel Consumption (L)	1188.3	0	1491	0	0
Electricity consumption (kwh)	14,368	19,377	46,296.40	11,506.00	15,000
No of suppliers	70	5	72	130	40
No of workers	15	10	7	7	2

Besides identification of pollution sources, the current analysis adds useful information and proposes sustainability-driven reflections to provide a better understanding of the impact of identified pollution sources. The description is focused on the common aspects of marina companies' operations that are considered typical of the sector:

Maintenance equipment storages: This is the set of activities that are linked to the reception and storage of equipment that is essential to carry out maintenance activities. Storage operations do not seem to have much impact on the environment because of the low figures reported per storage operation. However, storage operations do use forklifts and heavy vehicles to deliver goods. In this case, the use of electric forklifts and supply management aimed at reducing CO_2 emissions (e.g., less frequent orders) could reduce the environmental impact of these activities. It should be noted that almost all the material stored can be a source of pollution in case of its dispersion. It is also necessary to ensure the traceability of goods according to the pertinent regulations.

Boat mooring: The mooring process consists of the boat reception activities and assistance during the actual mooring phase. It must be noted that during the whole operation, boats' engines generally remain switched on, so the longer the operation goes on, the more pollution will be produced. Therefore, practices that facilitate mooring and the use of experienced personnel is certainly very advantageous. In addition to this, there are activities that could be defined as bureaucratic, such as the verification of the port of departure or the boat's registration. This type of activity also reveals potential sources of pollution. If, for example, the verification operations are prolonged for a long time, the customer will not be able to moor while waiting. In addition, if the mooring has not yet been assigned or has not been vacated yet, the customer's waiting time will increase, as will CO_2 emissions.

Boat hauling: This consists of lifting the boat out of the water generally before maintenance or storage activities. It is carried out using a crane or a forklift. In this case, the main impact is related to emissions from lifting equipment. Therefore, the use of more environmentally friendly vehicles would certainly result in less pollution. Another possible source of pollution could come from the internal handling of ships that have been taken on shore. If this does not appear to be relevant for a small shipyard, it could have more of an impact on a larger structure or dry dock.

Mooring place rental: Mooring place rental concerns the set of activities starting with the bookings from boatowners. It concerns the management of reservations, the preparation of the contract, and the subsequent assignment of a mooring place, as well as the possible rearrangement of the disposition of boats in the marina. A crucial element in this process is to ensure that the berth assigned to a boat is free and ready to accommodate the incoming boat. These activities are generally carried out with the support of information systems. Simple platforms to manage bookings up to more sophisticated mooring assignment systems are used. An inefficient process could be problematic from a CO_2 emissions point of view. An incoming boatowner who does not find the assigned position already vacated would have to wait with the risk of increasing emissions. As mentioned, another important aspect concerns the rearrangement of boats within the marina. An inefficient layout can increase the number of boat movements necessary to find a suitable configuration.

Pier management: These activities are necessary to ensure that boats moored remain in a safe condition. For this purpose, companies use video surveillance systems. This prevents vandalism or theft and is also a useful tool for monitoring the condition of boats. This is not only useful for the protection of customers' property, but also from an environmental point of view. In fact, a moored boat can be considered a potentially polluting element. Adverse weather conditions could damage the boat, causing the dispersion of pollutants such as fuel, oils, or bilge content into the sea.

Boat maintenance: Activities concerning boat maintenance are certainly the most relevant from the point of view of environmental impacts for the type of company in question. Both for the dangerous nature of the waste produced and for the frequency with which the maintenance activities are carried out. Ordinary maintenance concerns the control, cleaning, potential repairs and replacement of parts of various kinds (such as zinc plate or sea cocks) that must be disposed as hazardous waste. The main focus is on the boat's hull; however, the entire boat is inspected. Another common activity is a treatment necessary to eliminate and prevent damage caused by water osmosis between the layers of fiberglass. In most cases, maintenance work involves abrasion of the layers (on the entire hull or on portions) of old paint and ends with painting (which requires different types of products). These repair and cleaning activities produce waste that has a high environmental impact. In particular, dust and liquid waste containing oils and other pollutants are produced. These are collected in special tanks and subsequently disposed of. In addition, objects used during the activities such as gloves, brushes, rags, or safety masks and containers of used chemical products must also be disposed of as hazardous waste. In addition, very basic maintenance on the engine is often executed, and they generally change the engine oil.

Boat storage: This covers the transfer of boats to storage and the activities related to the assignment and traceability of the assigned spaces. Therefore, hauling the boat and storing it eliminates the risk of the boat being damaged and therefore reduces the potential dispersion of polluting material. Another advantage of keeping the boat out of the water is that no vegetation forms on the hull. This reduces the need to apply antifouling paint, which is a pollutant. In this sense, the use of a dry dock rather than a classic marina is advantageous.

Boat launching: This consists of positioning the boats in the assigned mooring place and in the preparation of boats so that they can be used by their owners. This is essentially the reverse process to boat hauling. It also requires the use of a lifting vehicle, thus the previous considerations regarding the use of electric lifting vehicles apply.

Waste disposal: Waste disposal may concern both solid waste and hazardous waste of various kinds. These are produced either by cleaning marina areas or by customers, who collect waste while they are onboard their boats and have to dispose of it once landed. This waste is simply placed in the containers used for collection and then collected by Palermo's port authority that manages the service.

The disposal of hazardous waste is a process that presents a high degree of complexity, as each type of waste has its own disposal channel. This involves activities related to tracking, storage in the correct container, and the disposal of hazardous waste. In fact, since this kind of waste often has very significant environmental impacts, there are very precise regulations regarding disposal and each type of waste presents specific problems. In all cases, it is necessary to store the waste in containers that are appropriate for each type of substance, and it is necessary to ensure traceability until the waste is delivered to a specialized disposal company. Waste from maintenance activities has already been discussed. In addition to this waste, there is also water that has accumulated in the bilge that may contain pollutants, and the sewage tank.

Other activities: It is useful to mention that other maintenance activities are not carried out by the marina's employers. From interviews, it emerged that marinas need external specialized companies for vehicle maintenance (like forklifts) and pier maintenance. Customers instead may need the intervention of specialized companies for a boat's engine maintenance, sails maintenance, electrical system, water system, or mechanical components. Those activities may have a significant environmental impact, but the company that performs the activity is generally in charge of the waste disposal.

Policy framework: It is necessary to mention the policy framework in which marinas operate for the sake of completeness. As part of the European Union, Italian's policy is very influenced by EU policy. It has been observed that 80% of Italian environmental legislation "on an institutional level" is derived from the EU. In this case, to focus on a European framework makes sense. The activity analysis shows that the main sources of pollution generated are maintenance wastes. Those are considered hazardous wastes and they are affected by Directive 2008/98/EC of the European Parliament and of the Council. As previously stated, they need to be properly disposed of. Incorrect disposal or "discharging, emitting or otherwise releasing dangerous materials into air, soil or water" is recognized as an environmental crime (Directive 2008/99/EC). Concerning other sources of pollution, including emissions, marinas have no specific obligations other than to purchase equipment and use products that comply with European standards.

Socio-economic aspects: Implementation of new environmental policies can have a wide impact on the communities affected by this choice from economic and social points of view. In addition, the United Nations' Sustainable Development Goals (SDGs) [31] were consulted. Interesting information were collected from interviews, even if they can be strongly influenced by perception of stakeholders. Conversely, when addressing the social impact, people's perceptions become a relevant factor [32]. Stakeholders report that the cost of careful environmental management is by no means insignificant. Regulations require plant upgrades, processes modifications, and the purchase of sustainable products and equipment. When an environmental inspection occurs, marinas must demonstrate, through logs, that they have properly stored the waste and delivered it to a licensed company that collects it. Stakeholder reports covering these "additional" costs is a burden and companies sometimes struggle to cover these costs. Though compliance is experienced with grievance, awareness of environmental risks on the part of the interviewees was detected. Economic efforts are needed to obtain long-term benefits on the environment and the people's well-being. However, while efforts are absorbed by a small group of people, benefits can be shared by society [33]. In addition, investment on new methodologies could generate long term savings thanks to reduced public spending for citizen care [34]. Returning to marinas, a strict environmental policy could help in building a good reputation considering that customers are becoming more environmentally conscious. It would improve the marina's environmental conditions and the health of local citizens. In addition, the application of environmental regulations would allow the construction of a supply chain for waste disposal and environmental management that could distribute wealth in the territory.

For the environmental footprint, there are just two scopes, Scopes 1 and 2, for which the carbon footprint assessment is required. However, it is strongly advised to calculate Scope 3 while researching service providers, such as marinas, because it offers fascinating details about the processes involved in our activities and their effects on the environment. This is due to the fact that a port's presence increases the amount of connected road travel, which raises Scope 3 emissions.

Due to the importance of the transportation of commodities in commercial ports, various environmental studies have been conducted on this topic. Due to the fact that Scope 3 is typically higher than Scopes 1 and/or 2 in marinas, we have discovered that their impact there is also noticeable.

Therefore, we can conclude that marinas entirely rely on an outside chain of supply for their customers' provision of high-quality service. The need to make marinas into places where circular economy ideas are introduced stems from the fact that doing so not only boosts the local economy of the area in which they are located but also significantly raises CO_2 emissions from the vehicles that regularly travel to the marinas to support their daily operations. The usage of electric vehicles, which we have noticed is happening more frequently but is still far from where it needs to be to get the desired results in the regions analyzed, would be one of the solutions that could resolve this situation. As a result, the number of employees and suppliers has a direct impact on Scope 3 of the carbon footprint, with the marinas with the highest footprint having the highest numbers of suppliers and employees (considering the typical everyday journeys made in their own automobiles).

Only two marinas, Arenella and Salpancore Srl, have carbon footprints under 100t of equivalent CO_2. Among other things, they both do not use fossil fuels (there is no Scope 1) and consume relatively little electricity. As a result, one of the elements that clearly identifies the amounts of emissions in the atmosphere is the direct consumption of fuel or oil by the marina. So long as the port reduces its dependency on fossil fuels and sources all of its electricity from renewable sources, scopes 1 and 2 can be eliminated. In other words, the port would be able to entirely stop the emissions of greenhouse gases brought on by this activity.

High electricity usage is seen in Marina 3 (Si. Ti. Mar Srl) which is likely due to berths management. One of the main components of the Energy-Climate Package for the European Union in terms of power is the ecological transition within the energy sector. In fact, the EU has set a goal for itself to reduce the emissions the continent produces to produce power by 27% by 2030. A higher emphasis on renewable energy sources would logically offset a huge portion of Scope 2 emissions and drastically cut activity-related greenhouse gas emissions.

Water-intensive activities in Sicily and water withdrawal in any of the studied marinas, such as hotels, agriculture, and urban consumption, do not appear to be excessive. The port area suburb populations drank the same amount of water in 2021 as all marinas put together, 118, 566 m^3. For the first time, the water footprint for marinas enables the evaluation of water consumption in a context, particularly in Sicily where water resources are scarce, and droughts have a significant negative impact on the environment and socioeconomic development. Sicily's freshwater resource is predicted to be problematic by current warming projections.

It should be noted that we only looked at drinking water use for this activity, and that green and grey water were not considered. Because all the marinas under consideration pumped their wastewater beyond the port facilities, they complied with waste management rules, and the analysis of seawater pollutants in the port was therefore excluded from the study. Additionally, there is an association between water and energy usage. Marinas that have a significant water footprint generation also have high carbon footprint generation. This may be caused by a variety of factors, including the energy source used to heat the shower and restroom water in the marinas.

4. Conclusions

The implementation of a P-Mapping and Pareto ratio approach to these marinas is substantial in achieving a sustainable management. It has been revealed that the main sources of pollution are linked to the core activities of the marina sector. Essentially, there are three main types: the maintenance waste, the direct CO_2 emissions, and the potential dispersion of pollutants in water. The results of our study confirm the Pareto principle, namely that few causes often explain a large part of the result. In environmental pressure calculation, this goes well beyond the classical Pareto 80:20 rule. We observed Pareto ratios (Table 3) that were systematically larger (e.g., for green waste a 98–1 ratio was found, whereas for the "ordinary", transports, storage, and delays, the ratios were even greater). A more narrow and detailed approach able to look closely at individual processes, or a statistical study able to obtain information that is statistically significant, could "bring to light" new details, as well as help assess the extent of what has been highlighted herein.

The creation of a managerial tool specialized in sustainable management of marinas would make it possible to bring together all the specific skills required in one person. This person can both boost a culture of sustainable management within a company and be the best process owner for sustainability-related processes.

The following recommendations emerged from the results of our study:

1. Encouraging the exchange of opinions and sharing knowledge between marinas could improve the management of environmental issues;
2. A good communication with customers, including information about regulations, could foster the growth and establishment of a common culture of sustainability;
3. Investing in process innovation could make environmental management more efficient;
4. In order to reduce emissions, it would be useful to adopt layouts that minimize the movement of boats both in water and on the yard;
5. Increasing the time boats remain on the yard could reduce the risk of accidents and dispersion of pollutants into the water.

Some of the other clusters or marinas on the Italian mainland could be used as test sites for this strategy and its recommendations.

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References

1. Mali, M.; Dell'Anna, M.M.; Mastrorilli, P.; Damiani, L.; Piccinni, A.F. Assessment and Source Identification of Pollution Risk for Touristic Ports: Heavy Metals and Polycyclic Aromatic Hydrocarbons in Sediments of 4 Marinas of the Apulia Region (Italy). *Mar. Pollut. Bull.* **2017**, *114*, 768–777. [CrossRef] [PubMed]
2. Marín, J.C.; Raga, G.B.; Arévalo, J.; Baumgardner, D.; Córdova, A.M.; Pozo, D.; Calvo, A.; Castro, A.; Fraile, R.; Sorribas, M. Properties of Particulate Pollution in the Port City of Valparaiso, Chile. *Atmos. Environ.* **2017**, *171*, 301–316. [CrossRef]
3. Houy, C.; Reiter, M.; Fettke, P.; Loos, P. Towards Green BPM—Sustainability and Resource Efficiency through Business Process Management. In Proceedings of the Business Process Management Workshops, Hoboken, NJ, USA, 13–15 September 2010; Springer: Berlin/Heidelberg, Germany, 2011; pp. 501–510.
4. White, G.; James, P. Extension of Process Mapping to Identify "Green Waste". *Benchmark. Int. J.* **2014**, *21*, 835–850. [CrossRef]
5. Windisch, J.; Röser, D.; Mola-Yudego, B.; Sikanen, L.; Asikainen, A. Business Process Mapping and Discrete-Event Simulation of Two Forest Biomass Supply Chains. *Biomass Bioenergy* **2013**, *56*, 370–381. [CrossRef]
6. Opitz, N.; Krüp, H.; Kolbe, L.M. Green Business Process Management—A Definition and Research Framework. In Proceedings of the Hawaii International Conference on System Sciences, Waikoloa, HI, USA, 6–9 January 2014.
7. Nowak, A.; Leymann, F.; Schumm, D. The Differences and Commonalities between Green and Conventional Business Process Management, Dependable, Autonomic and Secure Computing (DASC). In Proceedings of the IEEE Ninth International Conference, Bangkok, Thailand, 12–13 January 2011.
8. Ginevičius, R.; Ostapenko, A. A Quantitative Evaluation of the Company Environment for the Formation of Its Effective Expansion Strategy. *Intell. Econ.* **2015**, *9*, 130–137. [CrossRef]
9. Opitz, N.; Krüp, H.; Kolbe, L.M. Environmentally Sustainable Business Process Management—Developing a Green BPM Readiness Model. In Proceedings of the Pacific Asia Conference on Information Systems, Chengdu, China, 24–28 June 2014.
10. Von Rosing, M.; von Scheel, H.; Scheer, A.-W. *The Complete Business Process Handbook: Body of Knowledge from Process Modeling to BPM*; Elsevier Science & Technology: San Francisco, CA, USA, 2014; Volume 1, ISBN 9780128004722.
11. Gohar, S.R.; Indulska, M. Business Process Management: Saving the Planet? In Proceedings of the Australasian Conference on Information Systems (ACIS), Adelaide, Australia, 30 November–4 December 2015.
12. Mendling, J.; Weidlich, M. Business Process Model and Notation. In Proceedings of the 4th International Workshop Proceedings. Vienna, Austria, 1 March 2012.
13. Recker, J.; Rosemann, M.; Hjalmarsson, A.; Lind, M. Modelling and Analyzing the Carbon Footprint of Business Processes. In *Green Business Process Management—Torwards the Sustainable Enterprise*; Springer: Berlin/Heidelberg, Germany, 2012.
14. Scheer, A.-W. Business Process Engineering. In *Proceedings of the Reference Models for Industrial Companies*; Springer: Berlin/Heidelberg, Germany, 1994.
15. Caldera, H.T.S.; Desha, C.; Dawes, L. Exploring the Role of Lean Thinking in Sustainable Business Practice. In Proceedings of the Global Cleaner Production Conference, Barcelona, Spain, 1–4 November 2015.
16. Caldera, H.T.S.; Desha, C.; Dawes, L. Exploring the Role of Lean Thinking in Sustainable Business Practice: A Systematic Literature Review. *J. Clean. Prod.* **2017**, *167*, 1546–1565. [CrossRef]
17. King, A.; Lenox, M.J. Lean and Green? An Empirical Examination of the Relationship between Lean Production and Environmental Performance. *Prod. Oper. Manag.* **2001**, *10*, 244–256. [CrossRef]
18. Marimin; Darmawan, M.A.; Machfud; Islam Fajar, M.P.; Wjguna, B. Value Chain Analysis for Green Productivity Improvement in the Natural Rubber Supply Chain: A Case Study. *J. Clean. Prod.* **2014**, *85*, 201–211. [CrossRef]
19. Kurdve, M.; Shahbazi, S.; Wendin, M.; Bengtsson, C.; Wjktorsson, M. Waste Flow Mapping to Improve Sustainability of Waste Management: A Case Study Approach. *J. Clean. Prod.* **2015**, *98*, 304–315. [CrossRef]
20. EASME. *Study on Specific Challenges for a Sustainable Development of Coastal and Maritime Tourism in Europe, Final Report*; Executive Agency for Small and Medium-Sized Enterprises, European Union: New York, NY, USA, 2016.
21. Statista. Available online: https://www.statista.com (accessed on 12 June 2022).

22. The Superyacht Agency. *Superyacht Intelligence Consultancy Report: A Curation of Sample Projects*; The Superyacht Agency: London, UK, 2020.
23. Hung, R. Business Process Management as Competitive Advantage: A Review and Empirical Study. *Total Qual. Manag. Bus. Excell.* **2006**, *17*, 21–40. [CrossRef]
24. Cruz-Pérez, N.; Rodríguez-Martín, J.; García, C.; Ioras, F.; Christofides, N.; Vieira, M.; Bruccoleri, M.; Santamarta, J.C. Comparative study of the environmental footprints of marinas on European Islands. *Sci. Rep.* **2021**, *11*, 9410. [CrossRef] [PubMed]
25. Mozota, B.B. Structuring Strategic Design Management: Michael Porter's Value Chain. *Des. Manag. J. Former Ser.* **2010**, *9*, 26–31. [CrossRef]
26. Nicolini, E.; Pinto, M.R. Strategic Vision of a Euro-Mediterranean Port City: A Case Study of Palermo. *Sustainability* **2013**, *5*, 3941–3959. [CrossRef]
27. Couckuyt, D. An Overview of Challenges and Research Avenues for Green Business Process Management. In Proceedings of the OTM Confederated International Conferences "On the Move to Meaningful Internet Systems", OTM 2017 Workshops, Rhodes, Greece, 23–28 October 2017; Debruyne, C., Panetto, H., Weichhart, G., Bollen, P., Ciuciu, I., Vidal, M.-E., Meersman, R., Eds.; Springer International Publishing: Cham, Switzerland, 2018; pp. 270–279.
28. Porter, M.E. *The Competitive Advantage: Creating and Sustaining Superior Perfomance*; Free Press: New York, NY, USA, 1985.
29. Newman, M.E.J. Power laws, Pareto distributions and Zipf's law. *Contemp. Phys.* **2005**, *46*, 323–351. [CrossRef]
30. Vykoukal, J.; Beck, R.; Wolf, M. Impact of pressure for environmental sustainability on grid assimilation–empirical results from the financial services industry". *Australas. J. Inf. Syst.* **2011**, *17*, 5–28.
31. UN Sustainable Development Goals United Nations Department of Global Communications. *Guidelines for the Use of the SDG Logo Including the Colour Wheel, and 17 Icons*; United Nations Department of Global Communications: New York, NY, USA, 2019.
32. Stevenson, T.C.; Tissot, B.N.; Walsh, W.J. Socioeconomic Consequences of Fishing Displacement from Marine Protected Areas in Hawaii. *Biol. Conserv.* **2013**, *160*, 50–58. [CrossRef]
33. Akter, S.; Grafton, R.Q. Confronting Uncertainty and Missing Values in Environmental Value Transfer as Applied to Species Conservation. *Conserv. Biol.* **2010**, *24*, 1407–1417. [CrossRef] [PubMed]
34. Ballini, F.; Bozzo, R. Air Pollution from Ships in Ports: The Socio-Economic Benefit of Cold-Ironing Technology. *Res. Transp. Bus. Manag.* **2015**, *17*, 92–98. [CrossRef]

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