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EVALUATION OF PRIORITY ENVIRONMENTAL ISSUES IN PORT OPERATIONS USING THE q-ROF-SWARA METHOD: THE CASE OF SAMSUN

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Abstract

In this context, the increasing environmental pressures on a global scale highlight the importance of environmental responsibility in the long-term strategies of businesses. When examining port activities and operations, environmental issues such as climate change, global warming, air and water pollution, noise pollution, waste management, and energy consumption stand out. Therefore, identifying environmental problems in port operations and developing effective management strategies to address them is of great importance for enhancing both business performance and societal and environmental well-being. To detect and address the relevant environmental problems, the q-ROF-SWARA method was utilized. Within the scope of the study, "Energy Consumption" was identified as the most significant environmental issue, whereas "Noise" was found to be the least important.

Keywords: *Port Operations, Priority Environmental Issues, Multi-Criteria Decision Making (MCDM), q-ROF-SWARA Method*

1. INTRODUCTION

Carrying out sustainable development and environmental protection activities is one of the greatest challenges faced by societies and economies today. Throughout history, humanity has perceived natural resources as if they were unlimited, which has led to environmental problems taking on a global dimension. The international nature of these problems has made it necessary for countries to develop joint policies and create implementation plans accordingly [1].

In maritime transport, the concept of sustainability regulates maritime activities in a way that minimizes harm to the marine ecosystem by reducing negative environmental impacts, such as emissions across the supply chain, while maintaining economic interests. Reducing the environmental impacts of ports and promoting a lasting ecological balance are also among the objectives of this concept [2]. In particular, to prevent the degradation of natural resources and ensure environmental sustainability, ports must continuously improve their quality, enhance their technical capacity, and develop their operational management in order to increase their competitiveness.

On the other hand, establishing a strong connection with their hinterland, maintaining relationships with nearby ports, and integrating available resources into the port system to create a highly efficient port network are critical factors for ensuring the sustainability of ports [3]. However, the rapid development of ports also brings certain environmental problems; pollution has become increasingly widespread, and environmental concerns are growing [4].

Today, businesses are under social pressure to adopt an environmentally oriented approach. These pressures have led to increasing concern that businesses must take sustainability and environmental factors into account in their production models and business operations [5]. Accordingly, port authorities aim to find a balance between economic, social, and environmental dimensions in order to ensure the sustainable development of the local community surrounding the port [6].

In this sense, sustainability in ports has been expanded to mean balancing business systems and practices that protect people and the environment while also supporting enterprises and their stakeholders [7]. There are three main sources of environmental risks in ports: risks arising from port operations, risks originating from ships, and risks caused by off-port vehicles in intermodal transportation networks. Some of the problems caused by these sources include air pollution, habitat degradation and loss, harm to biological species, pollution from various waste sources (oils, wastewater and stormwater discharges, hazardous material waste, bilge water, ballast water, waste from ship paint maintenance, solid waste, and waste from port infrastructure and superstructure maintenance, etc.), traffic congestion, noise and light pollution, loss of cultural resources, soil and water contamination, oil spills, and soil erosion [8].

From this perspective, the major environmental issues arising in ports should not be viewed merely as factors affecting operational activities, but as multidimensional and dynamic parameters with broad impacts ranging from ecological balance to social welfare. These issues are directly related to environmental components such as air and water pollution, noise, waste management, energy consumption, degradation of marine ecosystems, and carbon emissions. Therefore, managing these environmental impacts within the framework of sustainability is of great importance for port authorities not only in terms of economic efficiency but also with respect to social responsibility and environmental justice principles.

Consequently, the systematic identification, analysis, and prioritization of key environmental problems arising in ports are of critical importance for building a sustainable society.

Identifying these environmental issues stands out as a strategic requirement for transforming business processes into a sustainable structure. Minimizing the major environmental problems in ports helps optimize resource use while simultaneously generating economic and social benefits for society.

In line with all these considerations, this study aims to identify the major environmental issues encountered in port operations located in the province of Samsun. Within the scope of the research, the identified challenges were evaluated using multi-criteria decision-making (MCDM) methods and classified according to their level of importance. Furthermore, the study provides a comprehensive examination of the key environmental issues arising in ports, their related concepts, and the approaches presented in the existing literature, which together constitute the theoretical foundation of the research. In the final section, the results obtained from the analysis are presented, the potential contributions of the findings to industry practices are discussed, and recommendations for future research are proposed.

2. LITERATURE REVIEW

Below are some studies in the national and international literature addressing the major environmental issues emerging in ports.

- Wiegmans & Geerlings (2010) examined sustainable port innovations and the barriers and facilitating factors affecting the successful implementation of port practices [9].
- Battistelli et al. (2011) analyzed the existing regulations in port areas and proposed sustainable actions to address the environmental impacts of maritime activities [10].
- del Saz-Salazar et al. (2012) emphasized the necessity of measuring the adverse effects resulting from port growth [11].
- Pozo (2013) investigated the recurring atmospheric emission problems caused by maritime activities at the Port of Santos [12].
- Murphy & King (2014) studied the noise exposure levels of residents living around Dublin Port in Ireland [13].
- Gómez et al. (2015) proposed a standardized and integrated procedure to assess environmental risks at the level of pollutant sources in port water systems [14].
- Sislian et al. (2016) conducted a literature review on port sustainability and the ocean carrier network issue [15].
- Venturini et al. (2017) examined the Berth Allocation Problem, an optimization issue that assigns berthing times and locations to ships at container terminals [16].
- Abbasi & Pishvaee (2018) proposed a two-stage optimization model for the dry port location problem in Iran [17].
- Lagoudaki et al. (2019) conducted an environmental risk assessment for ports and provided various recommendations[18].
- Çalışkan (2020) compiled potential challenges in smart port transformation and developed a hierarchical model to analyze the relationships among these challenges [19].
- Čurović et al. (2021) investigated the impact of COVID-19 on environmental noise generated from ports [20].
- Tok & Bucak (2022) examined the effects of port congestion on sustainability and evaluated its potential impacts on port operations and the supply chain [21].
- Zeng et al. (2023) analyzed carbon emission reduction within the scope of integrated logistics at the Port of Shanghai [22].
- Ayaz & Bucak (2024) investigated the causes and most frequent periods of port congestion, as well as measures to mitigate congestion and strategies that could be developed [23].
- Yuan et al. (2025) conducted a bibliometric analysis focusing on port emission reduction [24].

A detailed literature review reveals that research on the challenges faced in ports is quite limited. Most existing studies are confined to specific sectors or countries, and comprehensive analyses that examine the causes of barriers, their interrelationships, and their impacts in depth are insufficient. This indicates a significant gap in the literature. Conducting such a study could provide a valuable resource by addressing existing knowledge gaps, enabling the classification and prioritization of barriers, and developing practical solutions.

3. METHODOLOGY

It is common for decision-making problems to involve conflicting criteria and uncertainties. In such problems, there are differences in the priority or importance levels of the criteria considered. Weighting techniques are used in the process of determining the importance levels of criteria. Among the methods used for this purpose, SWARA has a structure easily understandable and applicable. In this study, an extension of SWARA, defined under q-ROFSs, enables the determination of criteria weighting coefficients using uncertain information. In the following section, information about q-ROFSs will be presented first. Then, the q-ROF-SWARA process steps will be presented.

Let X be a discourse universe. A q-ROFS A of X is provided in Eq. (1), where $a_A(\mathrm{x})$ denotes the membership degree and $\mathrm{b(x)}$ depicts the non-membership degree.

$$A = \{\langle x, (a_A(\mathrm{x}), b_A(\mathrm{x}))\rangle | \mathrm{x} \in \mathrm{X}\} \quad (1)$$

There are the following conditions regarding membership level and non-membership level in q-ROFSs: $a_A(\mathrm{x}) \in [0,1]$, $b_A(x) \in [0,1]$, $0 \leq (a_A(x)^q + b_A(\mathrm{x})^q) \leq 1, (q \geq 1)$. Also, the uncertainty membership degree can be written as $\pi_A(\mathrm{x}) = (a_A(x)^q + b_A(\mathrm{x})^q - a_A(x)^q b_A(\mathrm{x})^q)^{1/q}$.

For convenience, let $g_1 = \langle a_1, b_1 \rangle$ and $g_2 = \langle a_2, b_2 \rangle$ be two q-ROF numbers (q-ROFNs). Eq.s (2)-(6) displays the fundamental operations, Eq. (7) represents the score function ($\mathcal{S}(g_1)$), and Eq. (8) gives the accuracy function ($\mathcal{A}(g_1)$) [25], [26] and [27].

$$g_1 \oplus g_1 = \left(\sqrt[q]{(a_1)^q + (a_2)^q - (a_1)^q (a_2)^q}, b_1 b_2\right) \quad (2)$$

$$g_1 \otimes g_2 = \left(a_1 a_2, \sqrt[q]{(b_1)^q + (b_2)^q - (b_1)^q (b_2)^q}\right) \quad (3)$$

$$\xi g_1 = \left(\sqrt[q]{1 - (1 - (a_1)^q)^\xi}, (b_1)^\xi\right), \xi \geq 0 \quad (4)$$

$$g_1{}^\xi = \left((a_1)^\xi, \sqrt[q]{1 - (1 - (b_1)^q)^\xi}\right), \xi \geq 0 \quad (5)$$

$$(g_1)^c = (b_1, a_1) \quad (6)$$

$$\mathcal{S}(g_1) = \frac{1}{2}((a_1)^q - (b_1)^q + 1), \qquad \mathcal{S}(g_1) \in [0,1] \quad (7)$$

$$\mathcal{A}(g_1) = (a_1)^q + (b_1)^q, \qquad \mathcal{A}(g_1) \in [0,1] \quad (8)$$

Let $g_j = \langle a_j, b_j \rangle$ be a collection of q-ROFNs, where $j = 1, \dots, \mathrm{n}$. Eq. (9) gives the q-ROF weighted arithmetic average (q-ROFWAA) operator and Eq. (10) provides the q-ROF weighted geometric average (q- ROFWGA) operator [25], [26] and [27].

$$\mathrm{q-ROFWAA}(g_j) = \langle \left(1 - \prod_{\mathrm{j}=1}^{n} \left(1 - a_j^q\right)^{w_j} \right), \prod_{\mathrm{j}=1}^{n} b_j^{w_j} \rangle \quad (9)$$

$$\mathrm{q-ROFWGA}(g_j) = \langle \prod_{\mathrm{j}=1}^{n} a_i^{w_j}, \left(1 - \prod_{\mathrm{j}=1}^{n} \left(1 - b_j^q\right)^{w_j} \right) \rangle \quad (10)$$

where $W = (w_1, \dots, w_n)^T$ is the weight vector, $0 \leq w_j \leq 1$, and $\sum_{j=\mathrm{n}}^{n} w_i = 1$. The following steps gives details of q-ROF-SWARA [28], [29], [30].

Step 1. The sets of criteria and experts are determined. $C = \{C_1, \dots, C_j, \dots C_n\}$ denotes the set of criteria, while $E = \{E_1, \dots, E_k, \dots E_z\}$ depicts the set of experts.

Step 2. The weight coefficients of experts λ_k are determined, where $k = 1, \dots, z$, $0 \leq \lambda_k \leq 1$ and $\sum_{k=1}^{z} \lambda_k = 1$.

Step 3. Experts evaluate the importance of criteria using linguistic expressions provided in Table 1.

Table 1. The linguistic expressions and their corresponding q-ROFNS equvalients.

Linguistic Expressions	Notations	q-ROFNs *a*	*b*
Extremely High	EH	0.99	0.20
Very Very High	VVH	0.90	0.25
Very High	VH	0.80	0.30
High	H	0.70	0.40
Medium High	MH	0.60	0.45
Medium	M	0.50	0.50
Medium Low	ML	0.45	0.60
Low	L	0.40	0.70
Very Low	VL	0.30	0.80
Very Very Low	VVL	0.25	0.90
Extremely Low	EL	0.20	0.99

As a result, $\iota_j^{(k)} = \left(a_j^{(k)}, b_j^{(k)}\right)$ denotes the importance ratings of k-th expert for j-th criterion.

Step 4. Eq. (9) is employed to produce the q-ROF integrated importance of j-th criterion ι_j.

Step 5. Eq. (7) is used to determine the crisp values of ι_j.

Step 6. The criteria are ranked in descending order according to their $\mathcal{S}(\iota_j)$ values. After that, the comparative importance score of each criterion is determined. In this context, $c_1 = 1$ is assigned to the most important criterion.

Step 7. The comparative importance of each criterion's score value (c_j) is calculated using the importance ranks of the criteria. c_1 represents the comparative importance score of the most important criterion, and c_n represents the comparative importance score of the least important criterion. The c_2 value is calculated by subtracting the $\mathcal{S}(\iota_j)$ value of the most important criterion from the $\mathcal{S}(\iota_j)$ value of the second most important criterion. A similar procedure is followed for the other criteria. On the other hand, $c_1 = 1$ is allocated to the most crucial criterion.

Step 8. Eq. (11) produces the comparative coefficient (h_j) of each criterion:

$$h_j = \begin{cases} 1, & \text{if } j = 1, \\ c_j + 1, & \text{if } j > 1. \end{cases} \quad (11)$$

Step 9. Eq. (12) gives the recalculated coefficients (q_j).

$$q_j = \begin{cases} 1, & \text{if } j = 1, \\ \dfrac{h_{(j-1)}}{h_j}, & \text{if } j > 1. \end{cases} \quad (12)$$

Step 10. Eq. (11) is employed to calculate weight coefficients of criteria.

$$w_j = \frac{q_j}{\sum_{j=1}^{n} q_j} \quad (13)$$

where $0 \leq w_j \leq 1$ and $\sum_{j=1}^{n} w_j = 1$.

4. FINDINGS

Six operations managers rated the importance of the criteria. These evaluations are shown in Table 2.

Table 2. The Linguistic Importance Evaluations of Criteria Provided by Experts.

Criteria	Source	Criteria
Climate Change	[24], [31]	C1
Air and Water Quality	[16]	C2
Energy Consumption	[1]	C3
Noise	[1] and [15]	C4
Ship-Generated Waste	[31]	C5
Relations with Local Communities	[31]	C6
Port Development Related to Land and Water	[31]	C7
Solid Waste / Port Waste	[1]	C8

Experts evaluated the importance of criteria using linguistic expressions in Table 1. These evaluations are displayed in Table 3.

Table 3. The Linguistic Importance of Criteria.

	C1	C2	C3	C4	C5	C6	C7	C8
E1	M	M	H	M	M	H	H	M
E2	H	H	VH	L	M	M	M	M
E3	M	M	H	M	M	M	M	H
E4	M	M	H	M	M	M	H	M
E5	H	M	H	M	H	M	M	H

The calculations regarding q-ROF-SWARA was carried out, and the results displayed in Table 4 were obtained.

Table 4. The weighting results of q-ROF-SWARA.

Criteria	ι_j		$\mathcal{S}(\iota_j)$	c_j	h_j	q_j	w_j	Rank
	a	b						
C3	0.724	0.377	0.663	0.000	1.000	1.000	0.181	1
C1	0.603	0.457	0.562	0.101	1.101	0.907	0.165	2
C7	0.603	0.457	0.562	0.000	1.000	0.907	0.165	2
C8	0.603	0.457	0.562	0.000	1.000	0.907	0.165	2
C2	0.558	0.478	0.532	0.029	1.029	0.881	0.160	5
C5	0.558	0.478	0.532	0.000	1.000	0.881	0.160	5
C6	0.558	0.478	0.532	0.000	1.000	0.881	0.160	5
C4	0.483	0.534	0.480	0.052	1.052	0.837	0.152	8

The most important criterion is “C3-Energy Consumption.”

5. CONCLUSION

In a globalized world, maritime transport has become one of the key drivers of international trade and the global economy. However, the rapid growth of this sector also brings significant environmental challenges. Waste generated by ships, greenhouse gas emissions, and other pollutants exert considerable pressure on ecosystems, particularly in coastal areas. In this context, the role of ports extends beyond the mere handling of vessels and cargo; it also encompasses environmental management, sustainability, and energy efficiency. Therefore, identifying the major environmental issues in ports and developing sustainable strategies to address them is critical for both environmental protection and the competitive performance of ports. In this regard, the present study analyzed the primary environmental issues in ports operating in the province of Samsun. The findings revealed that “Energy Consumption” is the most critical factor among the environmental impacts. This is attributed to the high energy demand of port operations, the limited implementation of energy efficiency measures, and insufficient use of renewable energy. Consequently, improving energy management and developing sustainable port policies are considered essential for enhancing environmental performance. Conversely, “Noise” was identified as the least significant priority environmental issue. This is linked to the relatively remote location of ports from residential areas and the fact that port activities are confined to limited areas. However, the low priority of noise does not imply that its impact can be entirely disregarded in terms of occupational health and environmental sustainability.

Overall, this study can be regarded as a guiding effort that addresses a notable gap in the literature regarding the major environmental issues in the specified ports. The findings contribute to the development of environmental sustainability policies for ports and provide strategic insights for decision-makers to prioritize environmental concerns effectively.

In future research, the topic can be examined more comprehensively using different multi-criteria decision-making (MCDM) methodologies. This would allow for comparisons between various analytical approaches, enabling an assessment of the consistency of the results obtained. Additionally, existing analyses could be extended and redefined under alternative fuzzy logic-based methods or hybrid multi-criteria models. Such studies would provide a more in-depth and comparative perspective on the environmental performance evaluation of ports, making a significant contribution to the literature on sustainable port management..

REFERENCES

1. Korucuk, S., & Memiş, S. (2019). Yeşil Liman Uygulamalari Performans Kriterlerinin DEMATEL Yöntemi Ile Önceliklendirilmesi: İstanbul Örneği. *Avrasya Uluslararası Araştırmalar Dergisi*, *7*(16), 134-148.
2. Wang, L., Yao, J., Zhang, H., Pang, Q., Fang, M. (2023). A Sustainable Shipping Management Framework In The Marine Environment: Institutional Pressure, Eco-Design, And Cross-Functional Perspectives. Fronties Maritime Science, 9, 1070078. https://doi.org/10.3389/fmars.2022.1070078.
3. Zhao, C., Li, R., Wang, Y., Yu, H. & Gong, Y. (2021). “Study on the Propagation of Sustainable Development Concept Among Gulf Ports Based on Complex Network.” Maritime Policy and Management, 478-496. doi : 10.1080/03088839.2020.1783466
4. Wang, L & Zhou, Z. & Yang, Y. & Wu, J. (2020). Green Efficiency Evaluation and Improvement of Chinese Ports: A Cross-Efficiency Model, Transportation Research Part D, 88, pp. 1-15. https://doi.org/10.1016/j.trd.2020.102590.
5. Bu, X. & Dang, W. V. T. & Wang, J. & Liu, Q. (2020). Environmental Orientation, Green Supply Chain Management, and Firm Performance: Empirical Evidence from Chinese Small and Medium-Sized Enterprises”, International Journal of Environmental Research and Public Health, 17(1199): 1-17. https://doi.org/10.3390/ijerph17041199.
6. Lam, S. L. L. ve Li, K. X. (2019). Green port marketing for sustainable growth and development. Transport Policy, 84, 73-81.doi:10.1016/j.tranpol.2019.04.011.
7. Hiranandani V. (2014). Sustainable Development In Seaports: A Multi-Case Study, WMU Journal Of Maritime Affairs, 13(1), 127-172. https://doi.org/10.1007/s13437-013-0040-y.
8. Badurina, P., Cukrov, M. ve Dundovic, C. (2017). Contribution to the implementation of “Green Port” concept in Croatian seaports, Scientific Journal of Maritime Research, 31 10-17.
9. Wiegmans, B. W., & Geerlings, H. (2010). Sustainable port innovations: barriers and enablers for successful implementation. World Review of Intermodal Transportation Research, 3(3), 230-250. https://doi.org/10.1504/WRITR.2010.034664.
10. Battistelli, L., Coppola, T., Fantauzzi, M., & Quaranta, F. (2011). Evaluation of the environmental impact of harbour activities: Problem analysis and possible solutions. In IMAM 2011 Conference, Genoa (Italy). ISBN 978-0-415-62081-9
11. del Saz-Salazar, S., García-Menéndez, L., & Feo-Valero, M. (2012). Meeting the environmental challenge of port growth: A critical appraisal of the contingent valuation

method and an application to Valencia Port, Spain. Ocean & coastal management, 59, 31-39. https://doi.org/10.1016/j.ocecoaman.2011.12.017.
12. Pozo, H. (2013). Recurrent atmospheric discharges from port operations: A problem of environmental management in the port of Santos, Brazil. *African Journal of Business Management*. doi: DOI: 10.5897/AJBM13.009.
13. Murphy, E., & King, E. A. (2014). An assessment of residential exposure to environmental noise at a shipping port. Environment international, 63, 207-215. https://doi.org/10.1016/j.envint.2013.11.001.
14. Gómez, A. G., Ondiviela, B., Puente, A., & Juanes, J. A. (2015). Environmental risk assessment of water quality in harbor areas: A new methodology applied to European ports. Journal of environmental management, 155, 77-88. https://doi.org/10.1016/j.jenvman.2015.01.042.
15. Sislian, L., Jaegler, A., & Cariou, P. (2016). A literature review on port sustainability and ocean's carrier network problem. Research in transportation business & management, 19, 19-26. https://doi.org/10.1016/j.rtbm.2016.03.005
16. Venturini, G., Iris, Ç., Kontovas, C. A., & Larsen, A. (2017). The multi-port berth allocation problem with speed optimization and emission considerations. Transportation Research Part D: Transport and Environment, 54, 142-159. https://doi.org/10.1016/j.trd.2017.05.002
17. Abbasi, M., & Pishvaee, M. S. (2018). A two-stage GIS-based optimization model for the dry port location problem: A case study of Iran. Journal of Industrial and Systems Engineering, 11(1), 50-73.
18. Lagoudaki, D., Nikitakos, N., & Papachristos, D. Port Environmental Risk Assessment, Case Study: Port of Perama. International Journal of Computer Applications, 975, 8887.
19. Çalışkan, A. (2020). Akıllı Liman Dönüşümünde Zorluklarin Yorumlayici Yapisal Modelleme İle Değerlendirilmesi. Beykoz Akademi Dergisi, 8(1), 305-320.https://doi.org/10.14514/byk.m.26515393.2020.8/1.305-320.
20. Čurović, L., Jeram, S., Murovec, J., Novaković, T., Rupnik, K., & Prezelj, J. (2021). Impact of COVID-19 on environmental noise emitted from the port. Science of The Total Environment, 756, 144147.
21. Tok, K., & Bucak, U. (2025). Liman Tıkanıklığının Liman Sürdürülebilirliğine Etkileri. Denizcilik Araştırmaları Dergisi: Amfora, 4(7), 57-74.
22. Zeng, Y., Yuan, X., & Hou, B. (2023). Analysis of Carbon Emission Reduction at the Port of Integrated Logistics: The Port of Shanghai Case Study. Sustainability, 15(14), 10914. https://doi.org/10.3390/su151410914.
23. Ayaz, İ. S., & Bucak, U. (2024). Liman Sıkışıklığı Faktörleri ve Çözümüne Yönelik Stratejilerin Analizi. Turkish Journal of Maritime and Marine Sciences, 10(2), 116-130. https://doi.org/10.52998/trjmms.1401523.
24. Yuan, K., Ma, L., & Wang, R. (2025). Research Hotspots and Evolution Trends of Port Emission Reduction: A Bibliometric Analysis Based on CiteSpace. Sustainability, 17(4), 1474. https://doi.org/10.3390/su17041474.
25. Yager, R. R. (2016). Generalized orthopair fuzzy sets. IEEE Transactions on Fuzzy Systems, 25(5), 1222–1230.
26. Pinar, A., & Boran, F. E. (2020). A q-rung orthopair fuzzy multi-criteria group decision making method for supplier selection based on a novel distance measure. International Journal of Machine Learning and Cybernetics, 11, 1749–1780.
27. Aytekin, A., İstanbullu, B., & Kara, K. (2025). Current Problems and Solutions of Certified Public Accountants in Türkiye. *Spectrum of Engineering and Management Sciences*, 3(1), 210-227.
28. Aytekin, A., Korucuk, S., & Görçün, Ö. F. (2024). Determining the factors affecting transportation demand management and selecting the best strategy: A case study. *Transport policy*, 146, 150-166.
29. Bakari, S. J., Bouraima, M. B., Aytekin, A., & Ntow-Gyan, K. (2025). Proposing appropriate strategies for domestic tourism promotion in developing country by fuzzy fermatean MCDM approach. *Journal of applied research on industrial engineering*, 12(2), 246-270.
30. Görçün, Ö. F., Aytekin, A., Korucuk, S., & Tirkolaee, E. B. (2025). Assessing the renewable energy sources for sustainable energy generation systems: Interval-valued q-rung orthopair fuzzy SWARA-TOPSIS. *Expert Systems with Applications*, 129735.
31. Puig M, Azarkamand S, Wooldridge C, Selén V., & Darbra R M (2021) Insights on the environmental management system of the European port sector. Science of the Total Environment, 806 (2022): 150-550.