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The Environmental Impact Model for measuring the maritime activities

A. Elentably[1,*], K. Fisher [1], A. Alghanmi[1], S. Alhrbi[1]

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ABSTRACT

The EIM, a commonly utilized instrument, is utilized to evaluate the effects of different actions on the environment. It is becoming more prevalent in evaluating the effects of fleet and harbor operations on the ecosystem of Saudi Arabia. This piece will delve into the EIM and its applicability in quantifying the environmental consequences of fleet and dock operations in Saudi Arabia, including the model equations, current data collections, and scientific resources that validate its usage. Recent data collections show the substantial environmental impact of maritime operations in Saudi Arabia, emphasizing the urgency for successful measures to mitigate these effects.

1. Introduction.

Evaluating the operations of fleets and harbors in Saudi Arabia is of utmost importance due to the country's unique and fragile ecosystem. With a diverse array of flora and fauna spanning its vast territory, this ecosystem holds significant ecological value and is highly vulnerable to human activities within its borders, including fleet and harbor operations. These activities, which encompass transportation of goods, fishing, mining, and oil extraction, have the potential to exert significant environmental impacts. The use of an environmental impact model is crucial in measuring the effects of a specific activity or system on the environment. This mathematical tool allows for the assessment of potential environmental impacts of projects, such as large-scale developments or fleets, and aids in determining sustainable and cost-effective project management strategies [5]. The assessment of the effects of actions and structures on the environment, such as the ecology of Saudi Arabia, often involves the use of environmental impact modeling. A specific model used for this purpose is the fleet and berth model, which is tailored to evaluate the impact on the Saudi Arabian ecosystem. In this article, we examine the fleet and berth model as an environmental impact model and explore its application in measuring the effects on the Saudi Arabian ecosystem. We will outline the model, analyze its equations, and demonstrate its application with recent data. Finally, the article will conclude with a discussion on the findings.

1.1. Fleet and Berth Model.

The utilization of the Fleet and Berth Model (FBM) in Saudi Arabia offers significant advantages for decision-makers and stakeholders in effectively managing maritime operations and mitigating their ecological effects. This segment highlights the various potential uses and advantages of FBM.

1.1.1. Applications:

- The use of FBM can facilitate the execution of thorough environmental impact assessments for various maritime activities in Saudi Arabia, aiding decision-makers in comprehending the potential ecological and financial repercussions of different fleet and berth operations.
- FBM data and insights can assist in the formulation of policies and regulations to mitigate the environmental impact of maritime operations. This could involve establishing emission standards, defining sustainable practices, and creating guidelines for fleet management.
- FBM can enable decision-makers to effectively allocate resources by identifying areas with a higher environmental impact, enabling them to prioritize interventions and

[1]Maritime Studies College. King Abdul-Aziz University. Saudi Arabia.
[*]Corresponding author: A. Elentably. E-mail Address: akramelentably@hotmail.com.

investments in pollution control, habitat restoration, or sustainable technologies.

- FBM results can inform operational planning for fleet and berth operations stakeholders. For instance, shipping companies can modify vessel routes or adopt cleaner technologies to reduce their environmental footprint, based on FBM insights.

1.1.2. Benefits:

- FBM enables decision-makers to proactively protect Saudi Arabia's delicate ecosystems, promoting environmental protection. By identifying and addressing environmental concerns, the model helps minimize harm to air and water quality, habitats, and biodiversity.
- Stakeholders can utilize FBM to ensure the long-term sustainability of maritime activities, promoting sustainability. This includes reducing pollution, conserving resources, and preserving the ecological balance of the region.
- FBM can lead to cost savings for both public and private entities by facilitating efficient resource allocation and pollution control measures. This can result in reduced environmental impact and lower clean-up and restoration costs.
- Decision-makers can enforce environmental regulations and standards with the help of FBM, promoting compliance. By ensuring that maritime activities adhere to established guidelines, the model reduces the risk of legal and reputational consequences.
- FBM provides scientifically supported data, enhancing the credibility of decision-making processes and promoting data-driven decisions. Stakeholders can make informed choices based on quantitative assessments of environmental impact.

To summarize, the Fleet and Berth Model is a highly beneficial resource that can be utilized in a wide range of decision-making and environmental management scenarios regarding maritime operations in Saudi Arabia. Its usefulness and advantages go beyond theoretical evaluations, offering tangible solutions for preserving the environment while maintaining vital economic and industrial activities [7].

1.2. Environmental Impact Model.

The EIM is a comprehensive model that measures and predicts the impact of maritime activities on the environment. It takes into account various environmental factors and combines them in a thorough evaluation. Through the examination of key parameters and their interactions, this model systematically evaluates the potential effects on the Saudi Arabian ecosystem. It uses interconnected equations to assess environmental impacts, considering factors such as fleet size and composition, vessel types, berth operations, and specific impact factors. These equations quantify the potential effects on elements like air and water quality, noise levels, and habitat disturbance. Using these equations, the model is able to compute the overall environmental consequences of maritime operations, encompassing emissions of pollutants, duration, toxicity, energy usage, and land utilization. The outcome is a thorough evaluation that offers a comprehensive understanding of the combined effects of fleet and dock activities in Saudi Arabia. The integration and assessment of various environmental factors by the EIM make it a reliable tool for decision-makers and environmental planners, equipping them with the necessary information to make informed decisions regarding the management and mitigation of environmental impacts related to maritime operations in the region [8]. This all-encompassing approach guarantees a more precise depiction of the intricate relationships between human actions and the environment, ultimately promoting sustainable and responsible practices in the maritime industry.

1.2.1. Background.

Saudi Arabia's ecosystem is unparalleled in its diversity and distinctiveness, encompassing a vast range of plant and animal species [3]. However, human activities have posed significant environmental challenges in the region. These activities span various industries, including transportation, fishing, mining, and oil extraction, each with its own set of obstacles and environmental impacts. Consequently, there is a pressing need for accurate and thorough environmental impact assessments in Saudi Arabia. For example, the widespread transportation of goods, both domestically and internationally, has raised concerns about air and water pollution. The shipping industry, in particular, has been a major focus due to its potential to release harmful substances into the marine environment [16]. Moreover, the cornerstone of the Saudi economy, oil extraction, has also faced scrutiny for its detrimental effects on the local ecosystem, such as the risk of oil spills and destruction of habitats [9]. Furthermore, fishing practices have also been a source of environmental worry, with issues such as overfishing and bycatch threatening the delicate balance of marine life [3]. Similarly, mining operations have raised questions about the disturbance of terrestrial ecosystems, soil erosion, and the potential contamination of water bodies [5]. These instances highlight the critical importance of robust environmental impact assessment models, such as the Environmental Impact Model (EIM), in comprehensively evaluating and mitigating the environmental consequences of various activities in Saudi Arabia [8]. By understanding and quantifying the ecological impacts of these activities, we can strive towards more sustainable practices that protect the region's unique natural heritage.

2. Findings.

2.1. Fleet and Berth Model.

Environmental Impact Modeling is a technique utilized in evaluating the influence of a fleet or terminal on the surrounding environment. It follows sustainability guidelines and is employed to evaluate the potential harm that could be inflicted on

the ecosystem. By analyzing the correlation between human actions and the environment, the model determines the overall effect they may have. This includes examining the possible ecological consequences on water and air quality, as well as land usage. Additionally, the model takes into account potential economic consequences, like expenses for pollution management, and social consequences, such as the displacement of nearby communities [6].

2.2. Environmental Impact of a Particular Activity or System.

The mathematical model known as the fleet and berth model is utilized for evaluating the environmental consequences of a specific activity or system. This model is formulated through the following equations [10]:

1. Fleet size: $S = N + M$, where S is the fleet size, N is the number of ships in the fleet, and M is the number of berths available for the ships. e.g., $S = 5 + 2$, $S = 7$ considering no: of ships (N) 5 & no: of berths available (M) 2.

2. Fleet capacity: $C = S * V$, where C is the fleet's total capacity, and V is the average vessel size. e.g., $C = 7 * 5$, $C = 35$ considering average vessel size (V) 5.

3. Impact on the Environment: $I = S * C * E$, where I is the total environmental impact of the fleet, and E is the environmental impact factor. e.g., $I = 7 * 35 * 2$ considering environment impact factor (E) 2.

2.2.1. Applications:

The Saudi Arabia Ecosystem's environmental impact can be assessed using the fleet and berth model [2]. This requires gathering information on the fleet size, berth availability, average vessel size, and environmental impact factor. With this data, the fleet's size, capacity, and overall environmental impact can be determined [11].

2.3. Impacts of a Fleet or Berth on the Environment.

The model contains multiple equations that are utilized to evaluate the environmental impact of a fleet or berth. These equations are outlined below:

1. Energy Consumption: This calculation determines the energy consumption of a fleet or berth, and is calculated using the following formula: Energy Consumption = Total Fuel Used / Total Distance Travelled.

2. Air Pollution: This calculation measures the amount of air pollution generated by a fleet or berth, and is calculated using the following formula [1]: Air Pollution = Total Fuel Used / Total Distance Travelled x Pollutant Emission Factor.

3. Water Pollution: This calculation determines the amount of water pollution produced by a fleet or berth, and is calculated using the following formula: Water Pollution = Total Fuel Used / Total Distance Travelled x Pollutant Emission Factor x Water Pollution Factor.

4. *Land Use*: This equation calculates the amount of land a fleet or berth uses. It is calculated using the following equation:

Land Use = Total Area Used / Total Distance Travelled

2.3.1. Applications:

The utilization of fleet and berth modeling can be employed to evaluate the ecological consequences of fleets and berths in Saudi Arabia using current data collections. In this particular study, the data collected is from the Saudi Navy's Annual Report on Ships, 2016-2017, which includes information on the number of ships operating in Saudi Arabian waters, vessel types, fleet sizes, and berth types. Utilizing the aforementioned equations, it is feasible to compute the energy consumption, air pollution, water pollution, and land use of ships operating in Saudi Arabia's waters. The calculated results reveal that the total energy consumption of the ships is 4,948.9 GWh, the total air pollution is 943.9 kg/year, the total water pollution is 1,065.6 kg/year, and the total land use area is 5,078.9 ha/year [12]. The Environmental Impact Model, known as a fleet and berth model, was chosen to assess its impacts on Saudi Arabia's ecology. The country and its citizens are greatly concerned about the environmental impact of industrial activities in Saudi Arabia. To aid in the evaluation and management of this impact, the Fleet and Jetty Model (FBM) was selected as the environmental impact model for the country. This article will provide an outline of FBM, its equations, and how it measures the environmental impact of industrial activities in Saudi Arabia.

2.4. Environmental Impact of a Given Industrial Activity.

FBM is a mathematical model used to assess the environmental impact of a given industrial activity. The model includes two equations:

Fleet equation and Berth equation. The fleet equation calculates the total pollutant discharge from a given fleet, while the dock equation calculates the pollutant concentration at a wharf or pier [13]. The Fleet equation is as follows:

The Fleet equation is as follows:

$$F = S \times P \times O \times E \tag{1}$$

Where F is the total amount of pollutants released from a given fleet of ships, S is the number of ships in the fleet, P is the pollutant emission rate per ship, O is the number of operating hours per ship per day, and E is the total number of days of operation.

The Berth equation is as follows:

$$B = F \times C \tag{2}$$

Where B is the concentration of pollutants at a given berth or dock, F is the total amount of pollutants released from a given fleet of ships, and C is the concentration factor.

2.4.1. Applications:

The utilization of FBM in Saudi Arabia is aimed at evaluating the environmental consequences of industrial operations through the analysis of data gathered from diverse sources such as satellite imaging, monitoring of air quality, and tracking of ship emissions. These sources are utilized to compute the total quantity of pollutants discharged by a specific fleet and the

concentration of pollutants at a designated jetty [14]. The successful implementation of FBM in Saudi Arabia has enabled the identification of regions with significant levels of pollutant emissions, as well as the development of strategies to mitigate these emissions. Moreover, it has been instrumental in pinpointing areas that require additional monitoring and enforcement measures [15]. This paper has presented a comprehensive overview of FBM, its mathematical equations, and its application in measuring the environmental impact of industrial activities in Saudi Arabia. FBM is a robust tool that facilitates the identification of high-pollution zones and provides guidance on reducing emissions in these areas.

2.5. Environmental Impact Model.

2.5.1. Identify the Environmental Factors to be Impacted.

The EIM consists of a dual-phase approach. Initially, the environmental elements that will be affected by the activity are determined. These may comprise of air and water pollution, noise levels, and the existence of harmful substances. The second phase entails computing the environmental consequences of the activity by considering the identified factors. This is accomplished through the use of equations that take into account the severity and duration of the impact, as stated by reference [17].

For example, the equation for air quality impact is:

$$Air\ Quality\ Impact = Pollutant\ Emission\ Rate \times Emission\ Duration \times Pollutant\ Toxicity \quad (3)$$

2.5.2. Recent Data.

In Saudi Arabia, environmental impact assessments of fleet and berth operations have been conducted using recent data. One particular study utilized the Emissions Impact Model (EIM) to measure the effects of a fleet of oil tankers. The results revealed that the tankers were releasing air pollutants at a rate of 11.6 grams per second over a period of 7.5 days. These pollutants were found to be highly toxic, ultimately causing significant harm to the environment [16].

The Environmental Impact Model (EIM) utilizes multiple equations to assess the environmental effects of vessels. These equations encompass:

- Total fuel consumption: This calculates a vessel's overall fuel usage by taking into account its size and speed.
- Total emissions: This determines the total emissions of a vessel, factoring in its fuel consumption and the type of fuel utilized.
- Total noise: This calculates the noise levels produced by a vessel, considering its size and speed.
- Total habitat impacts: This evaluates the impact on habitats caused by a vessel, taking into consideration its type and activities.
- Total acumulative impacts: This computes the overall cumulative impact of a vessel, considering all factors such as fuel consumption, emissions, noise, and habitat impacts.

2.5.3. Applications:

Using this model, the environmental impact of ships operating in Saudi Arabia can be assessed by analyzing recent data collections. For instance, data from the Saudi Fisheries Authority (SFA) was utilized to evaluate the effect of vessels operating in Saudi waters on the surrounding environment and ecosystems. The data contains details about the types of ships in operation, their activities, and the environmental consequences of their operations [17]. With this data, the EIM model can be employed to compute the overall fuel consumption, emissions, noise levels, and habitat impact of ships operating in the region. By doing so, the EIM model can effectively determine the cumulative impact of ships and provide valuable insights on their impact on the environment and ecology of Saudi Arabia.

Conclusions.

Applying the fleet and berth model to the Saudi ecosystem yields significant insights into the environmental impact of maritime activities in the region. These findings have far-reaching implications for decision-making and policy development in Saudi Arabia.

Firstly, the fleet and berth model provides a robust framework for quantifying the environmental consequences of fleet and dock operations. By assessing key factors such as energy consumption, air and water pollution, and land use, decision-makers can understand the ecological footprint of these activities. This knowledge is essential for formulating targeted and effective environmental policies.

Additionally, the model presents a way to prioritize efforts in managing the environment. By pinpointing areas with high levels of pollutant emissions and potential ecological impacts, resources can be more efficiently allocated to mitigate the negative effects of industrial and maritime operations. This data-driven approach ensures that interventions are both cost-effective and ecologically beneficial. Furthermore, the data obtained from implementing the fleet and berth model can contribute to the long-term sustainability of Saudi Arabia's marine ecosystems. As the region continues to see growth in shipping, fishing, and industrial activities, understanding the environmental consequences becomes crucial. Policies and regulations based on the model's insights can help strike a balance between economic development and ecological preservation.

The study revealed the following numerical data:

- The ships had a total energy consumption of 4,948.9 GWh.
- The total air pollution emitted by ships was 943.9 kg/year.
- Ships also contributed 1,065.6 kg/year of water pollution.
- Their activity required a land use area of 5,078.9 ha/year.
- Oil tankers had an emission rate of 11.6 g/s for air pollutants.
- The duration of air pollution emitted from oil tankers was 7.5 days.

The Environmental Impact Model, utilized in this research, has practical implications for Saudi Arabia as it works to protect its unique and diverse ecosystems. It offers valuable information to aid in the decision-making process for port expansions, shipping routes, and pollution control measures. These informed decisions have the potential to mitigate the negative effects of maritime activities on the environment, promote sustainable practices, and contribute to the long-term well-being of Saudi Arabia's ecosystems. In conclusion, the application of the fleet and berth model to the Saudi ecosystem provides valuable insights into the environmental impact of maritime activities and serves as a powerful tool for developing policies and strategies that balance economic growth with environmental conservation. By utilizing the findings of this research, Saudi Arabia can take significant strides towards ensuring a sustainable and thriving ecosystem for future generations.

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