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Pandemic Marine Risks Assessment for Marine Spatial Planning (MSP): A Case Study of Northport, Malaysia

Ayati Parmen[1,2], Nazirah Mohamad Abdullah[1,3*], Badrul Hisham Ismail[4] Yusuf Drisu Opaluwa[5]

[1] *Center of Applied Geomatics and Disaster Prevention (CAGeD), Faculty of Civil Engineering and Built Environment (FKAAB),*
Universiti Tun Hussein Onn Malaysia, 86400 Parit Raja, Batu Pahat, Johor, MALAYSIA
[2] *Department of Polytechnics and Community College Education,*
Ministry of Higher Education, 62100 Putrajaya, MALAYSIA
[3] *Faculty of Applied Sciences and Technology (FAST),*
Universiti Tun Hussein Onn Malaysia, Pagoh Branch, KM1, Jalan Panchor, 84600 Muar, Johor, MALAYSIA
[4] *Marine Operation, Hydrographic Unit,*
Port Klang Authority (PKA), Jalan Pelabuhan Utara, 42005 Pelabuhan Klang, Selangor, MALAYSIA
[5] *Department of Surveying and Geoinformatics*
School of Environmental Technology Federal University of Technology Minna, NIGERIA

*Corresponding Author: nazirah@uthm.edu.my
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Abstract

The pandemic outbreak has emphasized the necessity of incorporating pandemic marine risk assessment as a critical component of marine spatial planning (MSP). The purpose of this study was to utilize the Risk Assessment Matrix (RAM) methodology to determine the most severely impacted zone at Northport, Port Klang. 31 senior management personnel at Northport, Port Klang were involved in a survey to assess the pandemic's severity in various zones. According to the findings, the Vehicle's Terminal zone had the highest score of 17.72, indicating it to be the most severely impacted zone, followed by the Passenger's Terminal zone (15.88), Distribution Centre zone (14.62), Bulk zone (14.52), Dangerous Good zone (14.13), Free Zone (14.10), Ancillary Service zone (13.65), and Container zone (13.39). These results can be integrated into Geographical Information System (GIS) and Multi Criteria Decision Analysis (MCDA) to convert them from numerical values to spatial data, and visualize them hierarchically. Additionally, this study's findings can contribute to enhancing MSP practices, not only at Northport, Port Klang, but also at other ports facing similar challenges. By including pandemic risk assessment as a crucial part of MSP, ports can develop effective pandemic response plans that prioritize the health and safety of port workers and visitors, as well as ensure the continuity of trade and economic activities.

1. Introduction

Pandemic marine risk assessment is a specialized area of risk assessment that concentrates on identifying and assessing the risks linked with infectious disease outbreaks in marine operations. The pandemic has underscored

the importance of incorporating pandemic marine risk assessment as part of marine spatial planning (MSP) to guarantee the continuity and resilience of marine operations (Charles Ehler, 2019). The primary objective of pandemic marine risk assessment is to evaluate the risks associated with infectious disease outbreaks on diverse aspects of marine operations, such as the safety and well-being of personnel, the supply chain, and the environment.

Pandemic marine risk assessment is an essential element of MSP, which is the process of planning and managing the utilization of marine resources to attain ecological, economic, and social objectives (Kirkfeldt et al., 2020). MSP strives to balance conflicting uses of marine resources (Aziz et al., 2019) and ensure the sustainable utilization of marine ecosystems (Yatim et al., 2018). Pandemic marine risk assessment aids in integrating the risks related to infectious disease outbreaks into MSP and guiding decision-making for pandemic response planning (Cormier et al., 2010). By identifying and prioritizing high-risk zones and operations, pandemic marine risk assessment can help to ensure the continuity and resilience of marine operations during and after a pandemic.

2. Literature Review

Pandemic outbreak has brought to the forefront the importance of pandemic preparedness and response in all sectors, including the marine transport sector (Alamoush et al.,2021; Abdullah et al., 2020; Savulescu et al., 2020; Shrestha et al., 2020; Stuchtey et al., 2020; Van Wee & Witlox, 2021). The pandemic has caused significant disruptions to global trade and supply chains, including marine operations (Atalan, 2020; Oyenuga, 2021; Shukla, 2020), which has highlighted the need for Marine Spatial Planning (MSP) that incorporates pandemic marine risk assessment.

MSP is the process of planning and managing the use of marine resources to achieve ecological, economic, and social objectives (Gimpel et al., 2018). MSP aims to balance competing uses of marine resources and ensure the sustainable use of marine ecosystems (Charles Ehler, 2019; Abdullah et al., 2016). Pandemic marine risk assessment helps to integrate the risks associated with infectious disease outbreaks into MSP and to inform decision-making for pandemic response planning.

Recent studies have highlighted the importance of pandemic marine risk assessment in MSP. For example, a study by (Saumweber & Lehr, 2020) emphasized the need for MSP that incorporates pandemic risk assessment to ensure the resilience of marine operations. The study recommended the use of RAM methodology for pandemic risk assessment in MSP.

Another study by Sackey et al. (2021) applied RAM methodology to assess the risks associated with the COVID-19 pandemic on marine operations in Africa. The study identified high-risk areas, such as cruise terminals and passenger ferry terminals, and recommended measures for pandemic response planning and mitigation.

In addition, pandemic marine risk assessment is a critical component of MSP that helps to ensure the continuity and resilience of marine operations during and after a pandemic. The RAM methodology is a useful tool for pandemic marine risk assessment, and its application in MSP can inform decision-making for pandemic response planning and resource allocation.

By implementing pandemic risk assessment into MSP, decision-makers can make more informed decisions about how to manage marine operations during and after a disaster. This integration improves the resilience of marine operations by including public health, safety, and continuity factors into spatial planning (Sutrisno et al., 2018). Furthermore, MSP frameworks that integrate pandemic risk assessment help to support adaptive management techniques, allowing for more flexible responses to changing conditions and emergent threats in marine ecosystems. MSP is an important platform for addressing the complex and interconnected issues confronting marine ecosystems and human societies. The stakeholders also can collaborate to create more resilient and sustainable marine systems that can withstand a variety of threats, including infectious disease outbreaks, while also promoting the long-term health and well-being of marine ecosystems and communities.

Marine Spatial Planning (MSP) emerges as a critical technique for the comprehensive management of maritime habitats, balancing ecological preservation, economic development, and social stability. MSP aims to bring together the many human activities within maritime spaces while protecting ecosystem integrity. This paper provides a thorough review of MSP, highlighting its major components and importance in modern marine governance (Frazão et al., 2018). The inclusive inclusion of diverse stakeholders is central to MSP, ensuring that multifaceted perspectives are considered in decision-making processes. MSP uses rigorous data gathering and geographical analysis to designate marine resources, assess anthropogenic impacts, and identify conservation priorities.

MSP develops spatial planning and zoning regulations to allocate maritime area for various purposes, thereby simplifying dispute resolution and environmental preservation. Embracing adaptive management principles, MSP encourages ongoing assessment and change of plans in response to changing conditions and stakeholder feedback. MSP implementation is underpinned by legal and institutional frameworks, which provide the appropriate regulatory processes and governance structures (Depellegrin et al., 2017). Finally, MSP provides as a foundation

for long-term marine governance by combining ecological, economic, and social factors to promote resilience and balance in marine ecosystems.

2.1 Port Klang Northport, Malaysia

The study has been choosing Port Klang because MSP is a new for them and Port Klang is the pulse of Malaysian economy. As we know, Port Klang is located on Peninsular Malaysia's west coast, approximately 40 kilometers from Kuala Lumpur. Due to its closeness to the border of Klang Valley, the country's industrial and commercial hub and its most populous region play a critical role in its economic development. Port Klang is continuously being built as the National Load Centre and ultimately as a regional hub in response to a 1993 Government decision (Wani, 2021).

Since 1993, various cargo-centering and hubbing tactics have been implemented, and Port Klang's facilities and services have become synonymous with world-class ports. The port maintains commercial ties with more than 120 nations and conducts business with more than 500 ports worldwide. Due to its advantageous geographical location, it serves as the first port of call for ships sailing eastbound and as the final stop port for ships traveling westbound on the Far East-Europe trading port. The Malayan Railway Administration relinquished control of Port Klang to the Port Klang Authority (PKA), a statutory corporation founded on July 1, 1963 (Liyana, 2020).

The Port Klang Authority is responsible for administrating three ports in the Port Klang area: Northport, Southpoint, and Westport. Southeast Asia's first and only port, South Port, was operated by the Malayan Railway Administration until the Port Klang Authority was established in 1997 to oversee all ports in the region (Soon & Lam, 2013). Each port, Westport and Northport, has been privatized and is now run as independent enterprises. In 2005, the port's overall cargo capacity was 109,700,000 tons, a significant increase from the port's 1940 capacity of 550,000 tons (Jeevan et al., 2015). Figure 1 below shows the location of Port Klang's docks. The ideal place for anchoring and being the primary destination for traders demonstrates PKA's success in operating and managing the port and the study only focus on NorthPort.

Northport is a wholly owned subsidiary of Northport (Malaysia) Sdn Bhd and consists of specialized multifunctional port facilities and amenities. Northport was formed by consolidating two companies: Klang Container Terminal (KCT) and Klang Port Management (KPM). Its operations include South Port, named Southpoint for traditional cargo handling, and the logistics division purchased Northport Distripark Sdn. Bhd. (NDSB) (Salleh, Zulkifli, & Jeevan, 2021).

The port has been privatized and operated by Northport (Malaysia) Bhd, MMC Corporation Berhad group member. MMC Corporation's Ports and Logistics Division manages the port operations and activities of Pelabuhan Tanjung Pelepas Sdn Bhd, Johor Port Berhad, Northport (Malaysia) Bhd, Penang Port Sdn Bhd, Tanjung Bruas Port Sdn Bhd, and logistics provider Kontena Nasional Berhad. MMC's worldwide presence is represented through the Red Sea Gateway Facility Company Limited, which operates a container port terminal within the Jeddah Islamic Port (Northport Malaysia, 2021).

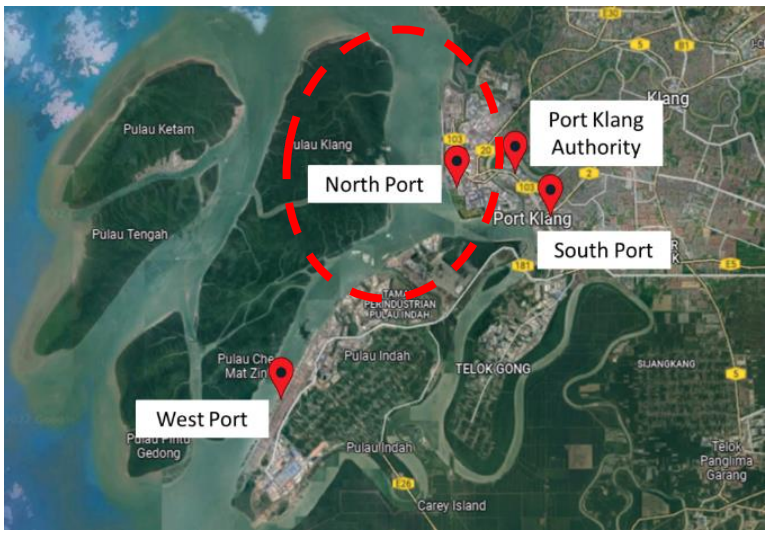

Fig.1 *Location of ports in Port Klang (Google Earth, 2022)*

PKA functions as a body that oversees these three ports. As a prominent port and an international focus, privatization has been done on Northport and Westport to further facilitate each port's management. Therefore,

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the port is too broad, and for the study to facilitate the supervision of zones at Port Klang, the study has made focusing and zoning based on eight (8) areas. They are as follows:

i. Bulk
ii. Container
iii. Passenger Terminal
iv. Distribution Centre
v. Free Zone
vi. Dangerous good
vii. Vehicle Terminal
viii. Ancillary Service

2.2 Pandemic Marine Risk Assessment

Pandemic marine risk assessment is a specialized field of risk assessment that focuses on the risks associated with infectious disease outbreaks on marine operations (Alamoush et al., 2021; Atalan, 2020; Riley, 2007; Stuchtey et al., 2020). The goal of pandemic marine risk assessment is to identify and assess the risks associated with infectious disease outbreaks on different aspects of marine operations, including the health and safety of personnel, the supply chain, and the environment (Kao et al., 2020).

Risk Assessment Matrix (RAM) is a widely used tool for pandemic marine risk assessment. It is a qualitative risk assessment technique that helps to prioritize risks based on their likelihood and severity (Bai & Jin, 2016). The RAM approach involves scoring risks on a matrix with two axes: likelihood and severity as shown in Table 1. The score for each risk is calculated by multiplying the scores for likelihood and severity (Jensen et al., 2022; Liu & Chang, 2020; Lorenz & Kneitz, 2019; Suppiah et al., 2020). The resulting score can then be used to prioritize risks and allocate resources for mitigation and response.

Table 1 *The Risk Assessment Matrix (Source: TMS-Outsource, 2019)*

Severity/ likelihood	Very Low severity (1)	Low severity (2)	Medium severity (3)	High severity (4)	Very High severity (5)
Highly Unlikely (1)					
Unlikely (2)					
Possible (3)					
Likely (4)					
Very likely (5)					

3. Methodology

In order to gauge the severity of the pandemic in Northport, Port Klang, the study employed a systematic method. This involved several key steps: first, the development of a questionnaire; next, ensuring content validity through expert assessment; followed by a pilot study to refine the questionnaire. Subsequently, a survey was conducted with 31 participants. Finally, data analysis was carried out to assess risks and determine the extent of the pandemic's severity in the Northport area of Port Klang. This structured approach provided a comprehensive understanding of the pandemic's impact in the specified region.

3.1 Develop A Questionnaire

Questionnaire was designed to gauge respondents' knowledge on level of severity of pandemic risk at Northport. The respondents were requested to tick each risk based on its likelihood and severity on a s understanding of the severity level of pandemic risks at Northport scale of 1 to 5, with 1 being the least score and 5 being the highest score. The likelihood score reflected the probability of the risk occurring, while the severity score reflected the potential impact of the risk (**Table 1**). The scores for each risk indicator (likelihood and severity) were then multiplied to obtain the score for each risk. The resulting scores were then used to rank the risks in order of severity.

3.2 Content Validity

Before the questionnaire is distributed to respondents, validation must be conducted to assure its reliability. Face validity and pilot study are two (2) crucial elements in verifying the questionnaire. Face validity necessitates

experts attempting to complete a questionnaire and provide feedback on its contents. Therefore, one expert in Northport management confirmed the questionnaire created for this study.

During the phase a preliminary study is carried out to confirm the questionnaires validity with a group of participants. Questionnaires covering the previously identified issues were distributed to management to measure whether the questions were understandable and reliable (Kaiser, 2016). Thus, the questionnaire designed for this study was tested and approved by two experts from Universiti Technology Malaysia (UTM). Associate Professors Dr Abdullah Hisam bin Omar and Dr Muhammad Hafiz bin Mohd Yatim were chosen to validate the instrument. Their expertise in maritime spatial planning in Malaysia stems from almost a decade of experience in this field.

3.3 Conducting A Pilot Study

The pilot test involved KMO and Bartlett's Test in measuring the question suit for factor analysis (Kaiser, 1974). Therefore, a survey was disseminated to 15 out of 31 respondents among the top management familiar with the environment of Port Klang. The pilot study sample size was based on the previous researcher's recommendation, which included 10% of the total sample number of respondents (Connelly, 2008). In contrast to another researcher who believes that a pilot test requires 10 to 30 samples (Sim & Lewis, 2012), this study considers all theories by using half of the sample size as a pilot study.

3.4 The Survey

Following all of the previously indicated procedures were finished, a group of thirty-one respondents received the completed questionnaire. These responders have been selected to precisely represent Northport, Port Klang's top management in all zones. To ensure a thorough and reliable assessment of the pandemic's intensity in the port region, this decision was made with great care. The questionnaire aimed to gather feedback from people who had a thorough awareness of Northport's operational dynamics and general situation by focusing on top management executives from each zone. Their managerial positions gave them a great deal of insight into the different facets of the port's operations, such as logistics, safety procedures, and people management.

In addition to ensuring an elevated level of knowledge among the respondents, this strategic approach offered a comprehensive picture of the pandemic's effects throughout Northport's many operational zones. The purpose of the questionnaire was to obtain detailed information from respondents about the severity of the pandemic. This information would allow for a thorough evaluation of the situation and assist in the formulation of well-informed decisions that would address any obstacles brought about by the ongoing health crisis in the port environment.

3.5 Risk Analysis

The last step is data analysis, which used Risk Assessment Matrix (RAM) method. RAM is the probability and severity risk matrix designed to help minimize the likelihood of potential risk to optimize project performance (Zhao et al., 2019). The result of this analysis methods is a hierarchy that shows the zones most influenced by the pandemic in Port Klang.

The RAM is a qualitative risk assessment technique that involves scoring risks based on their likelihood and severity (Kadir et al., 2020). In this study, the RAM methodology was used to assess the risks associated with the pandemic on marine operations at Northport, Malaysia. To conduct the RAM assessment, questionnaire was distributed on 31 top management staffs at Northport. The questionnaire contained a list of potential risks associated with the COVID-19 pandemic on different aspects of marine operations, including the health and safety of personnel, the supply chain, and the environment.

The RAM methodology aids the identification and prioritization of the most severe zones influenced by the pandemic at Northport, Port Klang. Some examples of how your references should be listed are given at the end of this template in the 'References' section, which will allow you to assemble your reference list according to the correct format and font size.

4. Finding and Analysis

This part discusses the findings of the research and highlights the areas in Northport, Port Klang, that were hit the hardest by COVID-19. It looks closely at the data to see how the pandemic affected different parts of the area. It explains things like how people's jobs, health, and daily routines were impacted. By doing this, it helps us see which areas faced the most difficulties and which ones managed better during the pandemic. This helps us understand the challenges people encountered and the strategies they used to overcome them amid the COVID-19 outbreak. The following subsection elaborates on the findings in detail, providing a thorough analysis of the data and uncovering significant insights into the impacts of the COVID-19 pandemic on Northport, Port Klang

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4.1 Pilot Study

A subset of 15 of the 31 top management respondents who are familiar with the specifics of the Northport zones were given the survey to complete as part of the project's pilot study. All of the respondents were cooperative in answering the questions. Based on the proposal of the previous researcher, 10% of the overall sample number of respondents comprised the size of the pilot study sample (Connelly, 2008). Unlike Sim and Lewis (2012), who contend that a pilot test needs between 10 and 30 samples, this study considered all theories by utilizing half of the sample size for the pilot study. In this section, the results of this pilot study are described.

The Kaiser-Meyer-Olkin (KMO) test value of over 0.5 and the significance level of less than 0.05 for the Bartlett's test indicate a high degree of correlation among the data (Kaiser Meyer Olkin, 2016). This correlation among variables is known as variable collinearity.

The primary purpose of a pilot study is to ensure that survey questions are intelligible and easy for respondents to answer. To measure the questions appropriate for factor analysis, the pilot test uses the KMO and Bartlett's Test (Kaiser, 1974). The results in Table 2 indicate that the KMO test conducted on all the questions in the questionnaire is acceptable, with the lowest KMO value of 0.657, which is still above the minimum level of 0.5. This suggests that the pilot test was successful and that the survey is appropriate for distribution to actual respondents.

Table 2 *KMO Test*

Variable	No. Of Item	Kaiser-Meyer-Olkin (KMO)	Bartlett's Test of Sphericity	Sig
The Need for MSP At Port Klang	10	0.780	300.272	0.000
Formation And Implementation of MSP	7	0.841	387.433	0.00
Pandemic Risk at Port Klang	10	0.657	247.078	0.00
Risk Assessment Matrix	8	0.834	202.857	0.00

This indicates that the initial trial run of the survey was successful, suggesting that it's ready to be distributed to the intended participants for further assessment. The positive outcome of the pilot test signifies that the survey instrument is reliable and suitable for gathering data from the target population. It provides confidence that the survey methodology is sound and that the responses collected will be meaningful and valuable for the study. This validation of the survey's effectiveness in the pilot phase assures researchers that they can proceed with confidence in utilizing the instrument to gather insights from the broader respondent pool in the study's main phase.

4.2 Questionnaire Survey

4.2.1 Demographic Information General Guidelines

The demographic information gathered from the survey participants is summarized in Table 3. The data reveals that 58 percent of the respondents identified as female, whereas 42 percent identified as male. A substantial portion of the participants, accounting for 48 percent, reported having attained education up to the degree level. Further analysis indicates that 23 percent of respondents had pursued education beyond the bachelor's level, holding master's degrees. Moreover, approximately 16 percent of participants possessed a certificate in port management, coupled with extensive practical experience in the field.

Notably, a significant proportion of respondents, totaling 69 percent, reported having over a decade of experience working within Northport. This extended duration of engagement underscores the reliability and relevance of the feedback provided by these individuals for the study's objectives. Their wealth of experience within the port environment enhances the credibility of their perspectives and insights, thereby enriching the depth and breadth of the study's findings. This comprehensive demographic profile of the survey participants not only highlights the diversity within the respondent pool but also underscores the robustness of the data collected, strengthening the validity and applicability of the study's outcomes within the context of Northport's operations and management.

Table 3 *Demographic Data from Respondents*

Demography	Number of Respondent	Percent (%)
Gender		
Male	13	41.9
Female	18	58.1

Total :	31	100
Education		
Certificate	5	16.1
Diploma	4	12.9
Degree	15	48.4
Master	7	22.6
Total :	31	100
Working Experience		
1 To 5 years	5	16.1
5 To 10 years	4	12.9
10 To 15 years	12	38.7
15 years above	10	32.3
Total :	31	100

4.2.2 Reliability Test

Subsequently, the evaluation turned to the application of the Cronbach Alpha coefficient (α) to gauge the internal consistency and reliability of the survey instrument, as outlined by Kennedy (2022). This statistical measure is pivotal in determining the extent to which the survey items effectively capture the intended construct, namely, the assessment of pandemic risk within the Maritime Security Planning (MSP). A higher Cronbach Alpha value signifies a greater degree of consistency among the survey items, thereby reinforcing the validity of the instrument in measuring the targeted phenomenon. Conversely, a lower Cronbach Alpha indicates inconsistencies among the survey items, suggesting potential discrepancies or deviations from the intended purpose.

The significance of establishing high internal consistency lies in ensuring the accuracy and reliability of the survey results. A robust Cronbach Alpha coefficient reinforces confidence in the survey's effectiveness as a reliable tool for assessing pandemic risk within the MSP context. Conversely, if the Cronbach Alpha coefficient indicates poor reliability, it raises concerns regarding the survey's validity in capturing the intended construct accurately. In such instances, further refinement or reassessment of the survey instrument may be warranted to enhance its alignment with the research objectives and improve its efficacy in yielding meaningful insights into pandemic risk management within the MSP framework.

Table 4 displays the outcomes of the reliability assessment performed on the questionnaire items. Each variable in the survey has surpassed the minimum reliability threshold of 0.7, with Cronbach's alpha values spanning from 0.893 to 0.980. This signifies a robust level of reliability in evaluating the MSP requirements, as well as the formation, implementation, and assessment of pandemic risks, along with the risk assessment matrix, all of which are crucial components for accomplishing the study's aims. The uniformity in reliability scores across the questionnaire items not only validates the survey's effectiveness but also facilitates in-depth analysis and interpretation of the data, fostering confidence in the conclusions drawn from the study.

Table 4 *Reliability Test*

Reliability Statistics			
Variables	**Cronbach's Alpha**	**Cronbach's Alpha Based on Standardized Items**	**N of Items**
The Need of MSP At Port Klang	0.924	0.926	10
Formation And Implementation Of MSP	0.980	0.981	7
Propose of PMRA at Port Klang	0.893	0.896	10
Risk Assessment Matrix	0.946	0.944	8

4.2.3 Normality Distribution Test

The objective of this analysis is to determine whether the complete dataset obtained from the respondents exhibits a normal distribution or deviates from it. In order to accomplish this, the collected data underwent a Normality Test, which provides insights into the distribution pattern of the dataset. The results of this test are pivotal in understanding the statistical characteristics of the data and assessing its suitability for further analytical procedures.

Displayed in Table 5 are the distributions of the data, encompassing responses from a total of 31 respondents. It's important to note that this survey questionnaire comprises 48 questions in total. By scrutinizing the distribution of responses across the questionnaire items, researchers can gain a comprehensive understanding of the dataset's distributional properties and identify any potential deviations from normality. This analysis not only aids in determining the appropriateness of parametric statistical methods but also informs subsequent data interpretation and decision-making processes.

Furthermore, the examination of data distribution serves as a foundational step in ensuring the robustness and validity of subsequent statistical analyses. By assessing the normality of the dataset, researchers can make informed choices regarding the selection of appropriate analytical techniques and mitigate potential biases or inaccuracies that may arise from violating the assumption of normality. Thus, this analysis constitutes a crucial aspect of the research methodology, laying the groundwork for rigorous and reliable data analysis and interpretation.

Table 5 *Test of Normality*

A. Severity level of pandemic's impact on port zones	**Skewness**	**Kurtosis**
	Normal	**Normal**
A1.Bulk zones.	0.5	-0.70
A2.Containers zones.	0.3	-0.48
A3.Passenger's terminal zones.	-1.2	1.65
A4.Distribution centers zones.	0.0	-0.30
A5.Free zones	-1.2	-0.48
A6.Dangerous goods zones.	-0.4	-0.43
A7.Vehicle terminals zones.	-0.6	-0.26
A8.Waste management zones	-0.7	0.03
B. Likelihood of the most likely consequence occurring	**Skewness**	**Kurtosis**
	Normal	**Normal**
B1.Bulk zones	0.69	-1.05
B2.Containers zones	0.31	-0.91
B3.Passenger's terminal zones	-0.99	-1.37
B4.Distribution centers zones	-1.59	0.57
B5.Free zones	-0.58	-0.49
B6.Dangerous goods zones	-0.13	-0.58
B7.Vehicle terminals zones	-0.89	-0.02
B8.Waste management's zones	-0.58	-0.49

The analysis of the data presented in Table 5 suggests that the overall dataset conforms to a normal distribution, as indicated by the skewness values falling below the threshold of 2.0, as proposed by Demir (2020). Skewness measures the symmetry of the distribution, with values closer to zero indicating a more symmetrical distribution. In this case, the skewness values within the dataset did not exceed the designated threshold, affirming the normality of the data.

Moreover, the examination revealed that each of the survey's questions, organized into distinct sections, exhibited a normal distribution pattern. This finding is significant as it indicates that the responses collected across various aspects covered by the questionnaire are consistent with the assumptions of normality. This consistency across different sections of the survey enhances the robustness of the dataset, making it suitable for inferential analysis techniques such as hypothesis testing and regression analysis.

The confirmation of normal distribution across the dataset and its constituent sections is crucial for ensuring the validity and reliability of subsequent statistical analyses. When data adheres to the assumptions of normality, it allows researchers to confidently apply parametric statistical tests, which rely on such assumptions for accurate interpretation of results. Additionally, normality assures researchers that the dataset accurately reflects the underlying population characteristics, thereby enhancing the generalizability of study findings.

Overall, the findings from the analysis of Table 5 provide assurance regarding the suitability of the dataset for inferential analysis, affirming the reliability of conclusions drawn from subsequent statistical tests and reinforcing the validity of research findings.

4.3 Risk Assessment Matrix (RAM)

The utilization of the Risk Assessment Matrix (RAM) served as a pivotal tool in evaluating the repercussions of the pandemic on marine risk assessment within the context of Port Klang. The primary aim of conducting the RAM survey was to gauge the extent of the pandemic's impact on diverse activities within the port area. This

involved assessing the severity of these impacts across various zones within the port, encompassing a range of critical operations and logistical functions. The insights gleaned from the RAM survey are crucial for identifying vulnerabilities, mitigating risks, and devising effective strategies to enhance resilience in the face of future crises.

Table 6 provides a comprehensive overview of the results derived from the respondents, shedding light on the degree of severity attributed to the pandemic's impact on different zones within Port Klang. By delineating the severity levels across distinct areas of the port, this analysis facilitates a nuanced understanding of the localized effects of the pandemic and enables stakeholders to prioritize response efforts accordingly. Meanwhile, Table 7 offers insights into the perceived likelihood of the pandemic affecting various activities conducted within Northport, Port Klang. This assessment of likelihood aids in anticipating potential risks and enables proactive measures to be implemented to mitigate their impact.

The utilization of RAM surveys underscores the importance of adopting systematic approaches to risk assessment and management within maritime operations. By integrating both severity and likelihood assessments, stakeholders can develop comprehensive risk profiles, thereby enhancing their capacity to anticipate, prevent, and respond effectively to emerging threats. Furthermore, the findings from these surveys serve as valuable inputs for strategic decision-making processes, enabling port authorities and relevant stakeholders to allocate resources judiciously and implement targeted interventions to safeguard critical infrastructure and ensure the continuity of maritime operations amidst the challenges posed by the pandemic.

Table 6 *Descriptive Statistics of severity level*

	n	Very Low	Low	Medium Low	High	Very High	Mean	Std. Error	Std. Dev Statistic
A1	31	0	0	10	17	4	3.81	0.117	0.654
A2	31	0	2	13	12	4	3.58	0.145	0.807
A3	31	1	0	13	3	14	3.94	0.16	0.893
A4	31	0	1	11	15	4	3.71	0.133	0.739
A5	31	0	4	6	15	6	3.74	0.167	0.93
A6	31	0	1	9	15	6	3.84	0.14	0.779
A7	31	0	2	5	9	15	4.19	0.146	0.815
A8	31	0	2	10	16	3	3.65	0.136	0.755

Table 7 *Descriptive Statistics of likelihood in every zone*

	n	Highly Unlikely	Unlikely	Possible	Likely	Very Likely	Mean	Std. Error	Std. Dev Statistic
E1	31	0	0	11	15	5	3.81	0.126	0.703
E2	31	0	1	12	12	6	3.74	0.146	0.815
E3	31	0	0	12	6	13	4.03	0.137	0.762
E4	31	0	2	5	17	7	3.94	0.146	0.814
E5	31	0	2	9	14	6	3.77	0.152	0.845
E6	31	0	2	11	13	5	3.68	0.149	0.832
E7	31	0	2	5	8	16	4.23	0.126	0.703
E8	31	0	2	9	15	6	3.74	0.146	0.815

The analysis of Table 6 reveals important insights into the perceived impact of the pandemic across different zones within Port Klang. Notably, the A7 vehicle terminal zone emerges as having the highest mean score, indicating a perceived severity of 4.19, while the A2 containers activity zone records the lowest mean score of 3.58. However, it's imperative to exercise caution in interpreting these mean scores as definitive indicators of the severity of the pandemic's impact on each zone.

The mean scores merely reflect the average severity ratings provided by respondents for each zone. While they offer valuable information regarding the perceived severity of the pandemic's impact within specific areas of the port, they do not provide a comprehensive assessment of overall impact severity. This is because severity alone does not account for the likelihood of an event occurring, which is equally crucial in determining risk levels.

To gain a more accurate understanding of the severity of the pandemic's impact on each zone, it's necessary to consider both severity and likelihood scores. Multiplying the severity score by the likelihood score, as discussed previously, yields a composite risk score that accounts for both the severity of the impact and the probability of occurrence. This approach provides a more nuanced and comprehensive assessment of risk, enabling stakeholders to prioritize response efforts based on the zones most vulnerable to significant impact.

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Therefore, while the A7 vehicle terminal zone may have the highest mean severity score, its overall risk level could vary depending on the associated likelihood score. Similarly, the A2 containers activity zone, despite having a lower mean severity score, may exhibit a higher overall risk level if the likelihood of pandemic-related disruptions is significantly higher in that area.

Table 7 offers valuable insights into the perceived likelihood of the pandemic affecting various activities conducted within Northport, Port Klang. Notably, the A7 vehicle terminal zone emerges with the highest mean likelihood score, standing at 4.23, while the E6 dangerous goods zone records the lowest mean score of 3.68. These mean scores provide an initial indication of the perceived vulnerability of different zones to the potential impact of the pandemic. However, it's essential to interpret these scores within the broader context of risk assessment and management.

The mean likelihood scores in Table 7 represent the average ratings provided by respondents regarding the likelihood of pandemic-related disruptions occurring within each zone. While they offer valuable insights into the perceived vulnerability of each zone, they do not provide a comprehensive assessment of overall risk levels. Like mean severity scores, mean likelihood scores should be considered in conjunction with severity scores to gain a more holistic understanding of risk levels.

By combining severity and likelihood scores, stakeholders can calculate a composite risk score that accounts for both the potential impact and the probability of occurrence. This approach enables a more nuanced and comprehensive assessment of risk, facilitating informed decision-making and resource allocation. Therefore, while the A7 vehicle terminal zone may have the highest mean likelihood score, its overall risk level could vary depending on the associated severity score. Similarly, the E6 dangerous goods zone, despite having a lower mean likelihood score, may exhibit a higher overall risk level if the severity of potential impacts is significantly higher in that area.

In conclusion, mean likelihood scores in Table 7 offer valuable insights into the perceived vulnerability of different zones within Northport, Port Klang to pandemic-related disruptions. However, to accurately assess risk levels, it's essential to consider these scores alongside severity scores and calculate composite risk scores. This holistic approach ensures that response efforts are targeted towards mitigating risks effectively and safeguarding critical port operations against the potential impacts of the pandemic.

4.4 The Indicator of Severity

In order to determine the severity level of an activity accurately, it is necessary to multiply the mean severity score by the mean likelihood score. This calculation is crucial for obtaining a comprehensive understanding of the potential impact and likelihood of pandemic-related disruptions. As emphasized by Baybutt (2018), the formula for this calculation plays a pivotal role in risk assessment and management, enabling stakeholders to prioritize response efforts and allocate resources effectively based on the combined severity and likelihood of potential risks.

Severity=mean of severity x mean of likelihood	(1)

The data presented in Table 8 provides crucial insights into the severity of pandemic-related impacts across different zones within Northport, Port Klang. It reveals that the vehicle terminal zone exhibits the highest severity score of 17.72, indicating the perceived severity of potential disruptions in this area. Following closely is the passenger terminal zone with a severity score of 15.88, suggesting significant potential impacts on passenger-related activities. Conversely, the container zone records the lowest severity score of 13.39, indicating relatively lower perceived severity of disruptions in this zone. These severity scores offer valuable information for stakeholders to prioritize response efforts and allocate resources effectively based on the severity of potential risks in each zone.

Table 9 complements the severity scores presented in Table 8 by hierarchically ranking the zones from the most severe to the least severe. This hierarchical ranking enables stakeholders to identify the zones that warrant immediate attention and intervention due to the perceived severity of potential impacts. By prioritizing response efforts based on this hierarchical ranking, stakeholders can focus resources and implement targeted measures to mitigate risks effectively in the most vulnerable zones. This hierarchical approach to ranking zones facilitates a structured and strategic response to pandemic-related disruptions, ensuring the resilience and continuity of critical port operations amidst evolving challenges.

Table 8 *The severity of each activity zone at Port Klang*

Zones	Mean of severity	Mean of likelihood	Severity
1. Vehicle terminals	4.19	4.23	17.72
2. Passenger's terminal	3.94	4.03	15.88
3. Distribution centers	3.71	3.94	14.62
4. Bulk	3.81	3.81	14.52
5. Dangerous goods	3.84	3.68	14.13
6.Free duty	3.74	3.77	14.10
7.Ancillary Service	3.65	3.74	13.65
8. Containers	3.58	3.74	13.39

Table 9 *Level Indicator of Severity (source: Lee et al., 2020)*

Score	Indicator of severity
1-4	Very low
5-8	Low
9-12	Medium
13-16	High
17-25	Very High

The analysis of Table 8 offers critical insights into the severity of pandemic-related impacts across various zones within Northport, Port Klang. The zone with the highest severity score, the vehicle's terminal, records a score of 17.72, categorizing it under the "Very High" severity level. This designation suggests an extremely significant risk in terms of pandemic transmission, necessitating urgent attention and decisive action from port authorities and stakeholders to mitigate potential impacts effectively. Conversely, the container zone, with a severity score of 13.39, falls under the "High" severity level, indicating a lower but still notable risk level that warrants proactive measures to address potential disruptions.

Further analysis in Table 9 provides additional context by hierarchically ranking the severity levels of different zones within Northport, Port Klang. The passenger's terminal, with a severity score of 15.88, is classified under the "High" severity level, indicating a substantial risk level similar to that of the container zone. Additionally, the distribution center, bulk, dangerous goods, free zone, and ancillary service zone also fall under the "High" severity level, with severity scores ranging from 14.10 to 14.62. While these zones may not exhibit the highest severity scores, they still represent significant risks in terms of potential pandemic transmission, underscoring the importance of implementing proactive measures to mitigate risks effectively.

Table 10 serves as a visual representation of the severity zones within Northport, Port Klang, offering stakeholders a clear overview of the risk landscape and aiding in strategic decision-making processes. By identifying and categorizing zones based on severity levels, port authorities and stakeholders can prioritize response efforts, allocate resources efficiently, and implement targeted interventions to safeguard critical port operations and mitigate the impacts of pandemic-related disruptions. This comprehensive approach to risk assessment and management ensures the resilience and continuity of port operations amidst evolving challenges posed by the pandemic.

Table 10 *The severity zones at Northport, Port Klang*

No	Zone	Level of Severity	Indicator
1	Vehicle's Terminal	17.72	Very High
2	Passenger's Terminal	15.88	High
3	Distribution Centre	14.62	High
4	Bulk	14.52	High
5	Dangerous Good	14.13	High
6	Free Zone	14.10	High
7	Ancillary Services	13.65	High
8	Container	13.39	High

The Marine Pandemic Risk Assessment outcomes underscore the significance of understanding and addressing the potential risks of pandemic transmission within different zones of Northport, Port Klang. Notably, the Vehicle's Terminal and Passenger's Terminal zones emerge as having the highest risk levels, indicating a heightened susceptibility to pandemic transmission. These zones are characterized by the movement and storage

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of vehicles and passengers, respectively, which may entail interactions among numerous individuals, thereby creating conducive conditions for the spread of infectious diseases.

The elevated risk levels assigned to the Vehicle's Terminal and Passenger's Terminal zones necessitate a deeper examination of the underlying factors contributing to the heightened risk of pandemic transmission. Possible contributing factors may include the nature and frequency of interactions, the volume of traffic, effectiveness of control measures, and adherence to safety protocols. Additionally, the specific operational dynamics and logistical activities within these zones may further amplify the risk of transmission.

Given the complexity of factors influencing pandemic risk within the Vehicle's Terminal zone, further analysis is warranted to elucidate the underlying reasons for the high severity score assigned to this zone. Such analysis may involve conducting detailed assessments of operational practices, evaluating the efficacy of existing control measures, and identifying potential areas for improvement in mitigating pandemic-related risks.

Addressing the heightened risk levels identified within the Vehicle's Terminal and Passenger's Terminal zones requires a multifaceted approach that encompasses enhanced surveillance, rigorous adherence to safety protocols, and targeted interventions to minimize the risk of transmission. By gaining a deeper understanding of the factors contributing to pandemic risk within these zones, port authorities and stakeholders can implement tailored strategies to mitigate risks effectively and safeguard the health and well-being of individuals within the port environment.

To enhance the clarity and interpretability of the research findings, Geographic Information System (GIS) technology was employed to visualize the severity levels of pandemic risk within Northport, Port Klang. GIS serves as a powerful tool designed to collect, organize, process, analyze, manage, and display geographical or spatial data. In simpler terms, GIS allows users to visualize, analyze, and understand information related to specific locations on the Earth's surface. This technology enables researchers to overlay various data layers, such as severity scores of pandemic risks, onto geographical maps, providing a spatial context for the analysis.

The research utilized GIS to classify the severity scores obtained from the risk assessment into five categories, based on the severity levels outlined in Table 10. These categories ranged from the lowest score of 13.39 to the highest score of 17.72. By employing this classification approach, researchers were able to create a hierarchical representation of the zones within Northport, prioritizing those with the highest pandemic risk. This hierarchical representation enables stakeholders to identify and prioritize areas requiring immediate attention and intervention to mitigate potential risks effectively.

The results of this spatial analysis are presented in Figure 2, which provides a visual representation of the distribution of pandemic risk severity across different zones within Northport, Port Klang. By visualizing the severity levels on a map, stakeholders gain valuable insights into the spatial patterns of pandemic risk, allowing for informed decision-making and targeted allocation of resources. GIS-based visualization not only enhances the communication of research findings but also facilitates the identification of spatial trends and patterns that may inform future risk management strategies and interventions within the port environment.

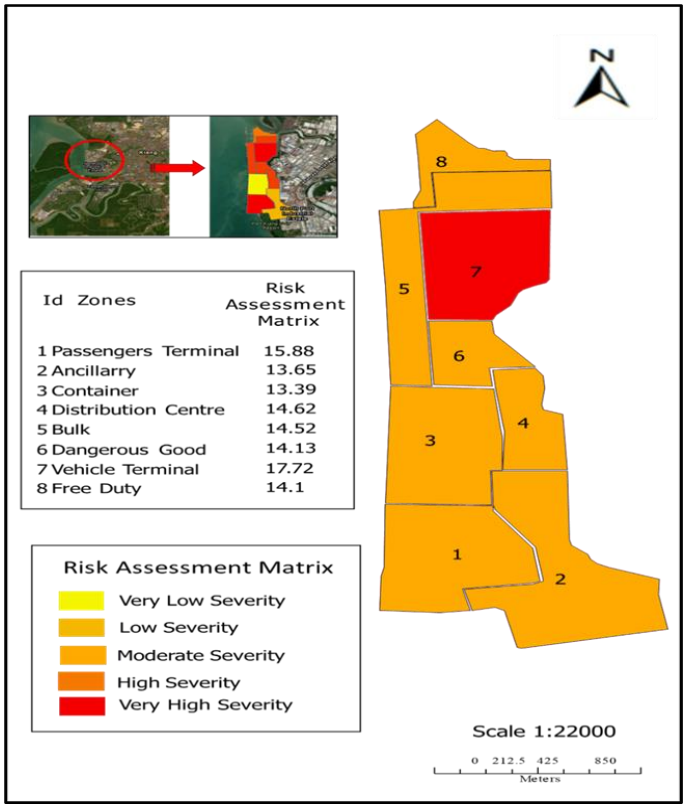

Fig.2 *Map of the severity of pandemic at Northport*

The findings depicted in Figure 2, derived from Geographic Information System (GIS) analysis, align closely with the outcomes obtained through the Risk Assessment Matrix (RAM) methodology. Both approaches concur in identifying the vehicle terminal as the zone with the highest pandemic risk within Northport, Port Klang. This consistency between GIS-based visualization and RAM methodology underscores the robustness and reliability of the risk assessment findings.

The identification of the vehicle terminal as the most pandemic-risky zone can be attributed to several factors. Firstly, the zone is characterized by a high volume of human and vehicular traffic, creating conditions conducive to the transmission of infectious diseases. The frequent interactions among individuals involved in vehicle movement and storage activities increase the likelihood of viral spread, particularly in situations where physical distancing measures may be challenging to enforce effectively.

Additionally, the vehicle terminal's role as a hub for transportation and logistics activities further amplifies the risk of pandemic transmission. The convergence of vehicles and personnel from various locations heightens the potential for virus introduction and dissemination within the terminal area. Moreover, the nature of activities conducted within the vehicle terminal, such as loading and unloading operations, may necessitate close proximity between individuals, increasing the risk of viral transmission.

Overall, the identification of the vehicle terminal as the zone with the highest pandemic risk underscores the importance of implementing targeted interventions and control measures to mitigate the risk of transmission within this critical area of Northport, Port Klang. Strategies such as enhanced hygiene protocols, increased surveillance, and strategic allocation of resources are essential for minimizing the impact of pandemic-related disruptions and safeguarding the health and well-being of individuals operating within the vehicle terminal and its vicinity. To effectively manage the risks posed by the pandemic on marine operations at Northport, Port Klang, several key recommendations can be proposed. Firstly, stringent health and safety protocols must be implemented to mitigate the risk of infection among port workers and visitors. This includes enforcing measures such as mandatory mask-wearing, maintaining social distancing, regular sanitation of facilities and equipment, and conducting temperature checks. These protocols are essential for safeguarding the health and well-being of individuals within the port environment and minimizing the risk of viral transmission.

Secondly, it is imperative to prioritize the most severe zones, such as the Vehicle's Terminal and Passenger's Terminal areas, in risk management strategies and protocols. This entails allocating additional resources and support to these zones and implementing targeted measures to mitigate the specific risks associated with the pandemic. By focusing efforts on high-risk areas, port authorities can effectively address vulnerabilities and minimize the potential impact of pandemic-related disruptions on marine operations.

Furthermore, regular risk assessments should be conducted to monitor the evolving risks associated with the pandemic at Northport, Port Klang. These assessments enable port authorities to stay abreast of changing circumstances and adapt risk management strategies and protocols accordingly. By continuously evaluating and updating risk mitigation measures, port authorities can enhance the resilience of marine operations and ensure their continued functionality in the face of evolving challenges posed by the pandemic.

Lastly, fostering collaboration and communication among port stakeholders is essential in managing pandemic-related risks effectively. Port authorities, shipping companies, and other relevant parties must work together to share information, coordinate response efforts, and implement cohesive strategies for risk management. Regular communication channels and information-sharing platforms facilitate mutual understanding of risks and ensure that all stakeholders are aligned in their efforts to mitigate the impact of the pandemic on marine operations. By fostering a collaborative approach, port stakeholders can enhance their collective capacity to respond to challenges and safeguard the resilience of Northport, Port Klang, amidst the uncertainties posed by the pandemic.

5. Conclusion

The marine pandemic risk assessment for different zones at Port Klang was conducted, where each activity was assigned, a score representing the "Level of Severity". The severity scores were calculated by multiplying the mean severity score with the mean likelihood score of each zone. The study revealed that the highest severity score is 17.72 at the vehicle's terminal, falling under the "Very High" severity level which is an indication of an extremely significant risk in terms of pandemic transmission and requiring urgent attention or action. The zone with the lowest severity score is the container zone, with a score of 13.39, falling under the "High" severity level. The ancillary service zone (with severity score of 13.65) is also categorized as "High" severity area, indicating some degree of significance but not a major concern in terms of pandemic transmission. The study concluded that the vehicle termina has the highest pandemic risk at Northport, Port Klang, therefore, by adhering to the recommendations outlined above, the detrimental impact of the COVID-19 pandemic on marine operations at Northport, Port Klang, can be mitigated, thereby ensuring the uninterrupted flow of trade and economic activities at the port. The successful implementation of these recommendations is crucial for maintaining the operational continuity and resilience of Northport amidst the challenges posed by the ongoing pandemic.

The study's findings underscore the importance of adopting a proactive approach to risk management and mitigation in response to the COVID-19 pandemic. By implementing strict health and safety protocols, such as mask-wearing, social distancing, and regular sanitation, port authorities can minimize the risk of viral transmission among port workers and visitors, thereby safeguarding public health and ensuring the uninterrupted functioning of marine operations.

Furthermore, prioritizing high-risk zones, such as the Vehicle's Terminal and Passenger's Terminal areas, in risk management strategies is essential for effectively addressing vulnerabilities and minimizing the potential impact of pandemic-related disruptions on port activities. Through targeted measures and increased support for these zones, port authorities can mitigate risks more effectively and ensure the continued functionality of critical port operations.

Regular risk assessments play a vital role in monitoring the evolving risks associated with the pandemic and enabling port authorities to adapt their risk management strategies accordingly. By conducting frequent assessments and updating risk mitigation measures as necessary, port stakeholders can enhance their resilience to pandemic-related challenges and maintain operational continuity at Northport, Port Klang.

Lastly, fostering collaboration and communication among port stakeholders is essential for promoting a coordinated and cohesive response to the pandemic. By working together to share information, coordinate response efforts, and implement joint strategies for risk management, port stakeholders can enhance their collective capacity to respond to challenges and ensure the continued functionality of Northport amidst the uncertainties posed by the pandemic.

In conclusion, this study provides valuable insights into the risks associated with the COVID-19 pandemic on marine operations at Northport, Port Klang, and offers practical recommendations to help manage and mitigate these risks effectively. By implementing these recommendations, port authorities can enhance the resilience of Northport, minimize the impact of the pandemic on port activities, and ensure the continued flow of trade and economic activities at the port.

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Conflict of Interest

The authors have no conflict of interest to declare that are relevant to this article.

Author Contribution

The authors confirm contribution to the paper as follows: Ayati Parmen; ***Author of this article, collect the primary data and analyzed them****. Regarding to this research have been achieved gold medal and best of the best award for International Research and Innovative Symposium 2022 (RISE 2022). She is also active in publication of journal: Nazirah Mohamad Abdullah;* ***Corresponding author and supervisor of this research****. She is senior lecturer of Tun Hussien Onn Malaysia University. Active in this project and publication: Badrul Hisham Ismail;* ***The author is staff of Port Klang Authority (PKA) as person in charge for this research at PKA.*** *PKA is main stakeholder provide secondary data for this reseach. PKA supervise, monitoring and validate this research. All authors reviewed the results and approved the final version of the manuscript.*

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