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DRY PORT LOCATION SELECTION: A CASE STUDY OF TANJUNG INTAN PORT

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Abstract
A dry port is established as an inland extension of a port. Tanjung Intan Port, which is located in Cilacap and within the range of tsunami risk zones, has no dry port to accommodate its customers. This research proposes a dry port location selection for Tanjung Intan Port with the following main criteria: adequate road and rail access, safer from tsunami risks, and achieve maximal demand coverage. By applying AHP (Analytical Hierarchy Process), the location candidates were ranked and further selected by using MCLP (Maximum Coverage Location Problem) to choose the best candidate. The study result selects Maos railway station as the most attractive dry port location. The feasibility study result shows that the location has: (1) a lower risk of tsunami impact, (2) potential for the port's market expansion, (3) less pollution potential, (4) adequate railway tracks, (5) large area, (6) good location away from densely populated areas and, (7) easy access for trucks.

Keywords:
Dry Port; AHP; MCLP; location-allocation; tsunami-risk

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1. Introduction

The Cilacap Regency is the largest district in Central Java and is situated on the boundary between the Sunda and Australian tectonic plates, making it vulnerable to earthquakes and tsunamis [1] [2]. With 823 natural disasters in 2019, Cilacap ranks first among the other regencies in Central Java for the frequency of natural disasters. The tsunami incident in Cilacap in 2006 resulted in 167 deaths, eight injuries, and thirty people being affected and displaced, in addition to the frequent occurrence of natural disasters, making Cilacap a location vulnerable to the perils of natural disasters, particularly tsunamis [3]. The only main port in Cilacap is Tanjung Intan Port, which is located in the southern part of the city and is extremely vulnerable to tsunamis [4]. Moreover, Tanjung Intan Port is adjacent to the oil fuel terminal of PT Pertamina. There is a probability that if a tsunami occurs, the port area will also be impacted by potential disasters caused by oil spills from the oil fuel terminal.

With a total weight of 1,628,977.66 kg in 2021, Tanjung Intan terminal is the second-largest loading terminal for exports from Central Java [5, 6], which makes this port a vital role in the economy of Central Java. It is also the only commercial port on Java Island's southern coast. The principal commodity of the port is dry bulk, which includes iron grit, clinkers, coal, and soybeans. However, based on initial observations and conversations with port management, it was determined that shippers and prospective shippers frequently complained about the port's difficult access and the great distances they had to travel to convey their goods. The primary reason for the complaint is the port's remote location from the primary transportation routes in northern Java. Consequently, many prospective shippers in Cilacap prefer to send their products through other ports in northern Java, such as Tanjung Emas Port in Semarang, Tanjung Priok Port in Jakarta, and Tanjung Perak Port in Surabaya, despite the fact that these ports are further away and have an average four-day dwell time. Moreover, prospective shippers did not select Tanjung Intan Port as their primary option because the quantity of goods conveyed is small and the port does not offer container handling services; consequently, it became customary to send non-bulk goods to the northern ports of Java. Despite this, the Tanjung Intan Port remains attractive for dry bulk shippers transporting large quantities of cargo because its dwell time is shorter than other major ports in northern Java. In addition, the port location's susceptibility to disaster risks such as tsunamis is one of the reasons why this is the only commercial port established on the south coast of Java. If natural disasters strike the port area, port operations will be disrupted or rendered inoperable. This may result in economic losses and supply chain disruption.

This study suggests establishing a dry port for Tanjung Intan Port in order to increase the port's appeal to shippers and reduce the risk of natural disasters affecting the port's operations. A dry port, or inland port, is a rail or barge terminal directly connected to a seaport with regular inland transport services [7]. It has the same functions as the seaport but is located far from the sea. It is equipped with high-capacity traffic modes such as rail. Shippers can leave and/or collect their goods at a dry port in intermodal loading units, as if directly to the seaport [8]. This concept eliminates the need for shippers to travel to the seaport, as their products will be transported from the dry port to the seaport by high-capacity modes of transportation such as trains. By simply delivering their products to the dry port, shippers can save time and avoid longer road congestions near seaports. With the existence of a dry port, not only can it facilitate improved logistics solutions for shippers by reducing the distance travelled by them, but it also becomes a way of shifting freight volumes from road to more energy-efficient traffic modes that are less harmful to the environment, and relieve seaport cities from congestion [9].

Currently, there is no dry port linked to Tanjung Intan port. Therefore, planning the location needs to consider various things to sustain the dry port. Site selection aims to select geographic locations for multiple elements in the supply chain [10]. Site selection is required when the organization opens a new facility. The dry port location should benefit the port's customers, such as shippers or cargo owners. Many previous studies have been conducted related to this topic. The research by [11] used Analytic Network Process (ANP) model to select the best location for a dry port in Niger. They analyzed the data based on fifteen respondents on a 22-question questionnaire. The result showed that Dosso, Gaya, and Niamey ranked first, second, and third, respectively. Based on the experts' judgments showed that demand is not the only important criteria to determine the best dry port location. Still, other factors such as cost and proximity are also critical criteria to be considered. Research by [12] applied Analytic Hierarchy Process (AHP) to determine the best location among five candidates for dry port in Turkey. The data were collected from 85 experts. The comparison judgements were made using two different scales: the Saaty's fundamental scale and the balanced scale. The results showed that based on two scales of judgments brought the same in alternatives ranking. But when doing sensitivity analysis, Saaty's fundamental scale is more sensitive than the balanced scale.

According to [7], a dry port location has to be an intermodal rail or barge terminal, is connected to a seaport through rail, barge or truck services, and is located near logistics activities and industrial zones. Hence, it is necessary to consider the distance between the dry port and the location of the cargo owners. Additionally, it is essential to establish a dry port that considers the tsunami risk zone to reduce the risk of the adverse impact of natural disasters on the port. In conclusion, this study focuses on selecting the dry port location that can cover the most demands, away from the tsunami risk zone, and ensuring the selected location is feasible for the dry port construction.

2. Literature Review

The dry port can be a solution to prevent the impact of natural disasters at a port by diverting storage, stacking and administration activities from what was previously in the port to the dry port. Dry port activities include cargo consolidation, warehousing or stacking, customs, and freight by train to port to be subsequently loaded onto ships [13]. Based on the dry port distance from the port, a dry port is divided into three categories, namely distant dry port (> 500 km), midrange dry port (50-500 km), and close dry port (<50 km) [14] [15]. With the establishment of a dry port, port activities can be minimized to loading-unloading processes and shipping activities only.

Abbasi and Pishvaee [16] used a two-stage optimization model based on Geographic Information System (GIS) to obtain optimal dry ports. The first stage is location selection using GIS and Analytical Hierarchy Process (AHP), and then the second stage uses a multi-objective integer model. The result is a dry port location that can reduce costs and pollution, increase customer satisfaction, and increase competitiveness. Burciu, et al. [17] used GIS and Mathematical Modelling of the Maximum Coverage Location Problem (MCLP), taking into account the capacity to determine the location of hubs connecting cereal producers with ports for export. Chanta and Sangsawang [18] proposed an optimization model for locating railway stations in Thailand. The research objective is to maximize the number of passengers fulfilled. Single allocation p-hub Maximum Covering Problem (p-hub MCP) and Simulated Annealing (SA) are used to solve the problem. The result is that SA gets the same optimal answer as Single allocation p-hub MCP with less time. Doerner, et al. [19] conducted a study on determining the public facilities' location in tsunami-prone areas. Minimum facility location criterion, MCLP, Genetic Algorithm (GA) is used to solve the problem.

This research used AHP and MCLP methods to solve location selection problems. AHP was used to select dry port candidates; furthermore, MLCP was used to select the location that could cover the most demands. The difference with previous studies is that this study considers tsunami-risk zone to locate a new dry port facility for the seaport. This research proposes "located in tsunami safe-zone" criteria to select dry port candidates on AHP process. Additionally, a post-disaster export supply chain network concept is proposed if the port is affected by the tsunami.

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3. Methodology

This research is a quantitative study using the AHP method and MCLP modelling to achieve the research objectives. The research is divided into four stages. The first stage is problem definition, the second stage is selecting dry port candidates using AHP, and the third stage is candidate selection using the MCLP model. The last stage is feasibility analysis. The selected dry port candidate is further analyzed from market and marketing, technical/operational, and environmental impact aspects. Experiments were conducted using Expert Choice 11 software and AMPL IDE Software Version: 3.1.0.201510231950 with Gurobi 8.0.0 solver.

The locations of dry port candidates are taken from several active stations in Cilacap. The reason for this selection is based on the establishment of Gedebage Container Terminal in West Java, which used to be the Halte Gedebage before it was converted into a dry port [20]. Thus, this study proposes 16 dry port candidate locations in total. Additionally, tsunami-risk area data were obtained from literature studies.

AHP method uses ranking to determine priority [21] [22]. Saaty introduced the AHP, which is very useful when the decision-maker cannot construct utility functions [22]. The stages in the AHP method in this study are the first making a hierarchical model; the second making pairwise comparisons; and the third, selecting candidates based on experimental results [21] [23]. In this research, data on the level of importance of the criteria is obtained from interviews with the technical manager, business manager, and technical supervisor of Tanjung Intan Port. The three samples were chosen because they are the decision-makers in determining the dry port location and knowing the character of the Tanjung Intan Port customers. Data on the level of importance of the candidates are obtained from secondary data. The data are the distance from the candidate to the provincial road or national road, the number of rail lines, the furthest candidate distance to demand, considerable and vacant land around the candidate, the proximity of the candidate's location to industrial areas, distance from candidate to the nearest residential area, distance from outside the yellow zone.

The Maximum Coverage Location Problem (MCLP) method or maximum demand covering problem is a mathematical model to solve location-allocation issues with the objective is to maximize the demand met [24]. MCLP modelling can be used to determine the optimal location with a maximum number of limited or predetermined facilities built [25]. Based on Francis et al. quoted by Farahani and Hekmatfar [24], MCLP is included in covering problems that can be used in selecting warehouse locations, selecting locations for emergency services, and so on. In this research, the demand location data is the primary data obtained from Tanjung Intan Port. The following are the models for the MCLP method and its explanation [24]:

i : Demand location index with $i = 1,2,3, \dots, I$

j : Facility candidate location index with $j = 1,2,3, \dots, J$

d_{ij} : Distance from demand $i \in I$ to facility $j \in J$

S : The facility distance limit can reach the demand

h_i : Demand at node $i \in I$

P : Number of facilities to be built

$a_{ij} = \begin{cases} 1 \\ 0 \end{cases}$ with 1, if candidate $j \in J$ covers demand $i \in I$, and 0, otherwise

$Z_i = \begin{cases} 1 \\ 0 \end{cases}$ with 1, if demand $i \in I$ covers demand $j \in J$, and 0, otherwise

$X_j = \begin{cases} 1 \\ 0 \end{cases}$ with 1, if candidate $j \in J$ is chosen and 0, otherwise

The objective function of MCLP modelling is to maximize the demand that can be met,

$$\text{Maximise} \quad \sum_{i \in I} h_i Z_i \tag{1}$$

Demand that can be reached by more than one facility,

$$Z_i \le \sum_{j \in J} a_{ij} X_j \qquad \forall i \in I \tag{2}$$

where a_{ij} = 1 if $d_{ij} < S$, and 0 if $d_{ij} \ge S$

The number of facilities selected does not exceed P limit,

$$\sum_{j \in J} X_j = P \tag{3}$$

The variables X_j and Z_i are binary numbers,

$$X_j \in \{0,1\} \qquad \forall j \in J \tag{4}$$

$$Z_i \in \{0,1\} \qquad \forall i \in I \tag{5}$$

4. Result and Discussion

The determination of used criteria in this study is based on the academic literature and adjusted with the characteristics of the Tanjung Intan Port. More than 50% of Tanjung Intan Port customers are located in Cilacap; therefore, this research focuses on establishing a "close dry port" type, as it will be an added value for the customers if the dry port is built near the customers' locations [26]. Combining criteria based on the literature study from Abbasi and Pishvaee [16] and Frost [26], it is concluded that six criteria will be used to assess the dry port location in Cilacap. One of our contributions is considering a new criterion for this research: "located in the tsunami-safe zone" to score each dry port candidate's sites based on the safety from the tsunami risks. In addition, the distance between each candidate and the port has not deemed a criterion because, according to the dry port category, only candidates less than 50 kilometers away from the port are considered. Therefore, regardless of how near the distance is, it is assumed that it has no effect on the attractiveness of the dry port, as it is still less than 50 kilometers away.

Truck-friendly road access is a common consideration for dry port locations. The delivery of goods from the dry port to the port will also be conducted by railway; therefore, the site must have rail access. Furthermore, a dry port typically requires a large area for storing goods and containers, warehouses, buildings, cranes, vehicle activities, etc.; therefore, a large vacant land for the location of the dry port candidates is an asset. Additionally, environmental and social factors are required to ensure the dry port's viability. The location of the dry port in an industrial area, as opposed to a densely populated area, is also an advantage, as the activity of trucks and heavy equipment, such as cranes, as well as the pollution caused by dry port activities, can be disruptive to adjacent residents. Dry port locations should also be avoided in tsunami-risk zones in order to reduce the likelihood of infrastructure damage caused by natural disasters. Even though the Tanjung Intan Port is in close proximity to PT Pertamina's oil terminal, the risk of explosion hazard is not included in the criteria because the scope of this study is limited to natural disasters, specifically tsunamis. The criteria are summarized in Table 1.

Table 1. Dry port location selection criteria

Criteria	Symbol
Easy access to trucking roads	C1
Connected to the railroad	C2
Proximity to customers	C3
Massive land	C4
Proximity to the industrial area	C5
Far from densely populated areas	C6
Located in a tsunami-safe zone	C7

As previously mentioned in the methodology, the locations of dry port candidates are taken from 16 active railway stations in Cilacap. A list of dry port candidates and candidates' location points can be seen in Table 2 and Fig. 1.

Table 2. Location of dry port candidates

Station Candidates	Symbol	Station Candidates	Symbol
Kroya	A1	Randegan	A9
Sikampuh	A2	Meluwung	A10
Maos	A3	Cipari	A11
Kasugihan	A4	Sidareja	A12
Karangkandri	A5	Gandrungmangun	A13
Gumilir	A6	Kawungaten	A14
Cilacap	A7	Jeruklegi	A15
Karangtalun	A8	Lebeng	A16

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Figure 1. Map location of dry port candidates

A. Selecting Dry Port Candidates using AHP Method

The stages in the AHP method in this study are divided into three, the first is the hierarchy model, the second is a pairwise comparison of criteria, and the last is dry port candidates' selection.

- Hierarchy Model

The research hierarchy is depicted in Fig. 2. The hierarchy is based on Ka [27] with a hierarchical order from top to bottom, namely goals, criteria, and alternatives. The top hierarchy shows the goals to be achieved. The goal to be achieved is the dry port location. The second level hierarchy shows the seven criteria in Table 1, and the lowest hierarchy shows the dry port candidates in Table 2.

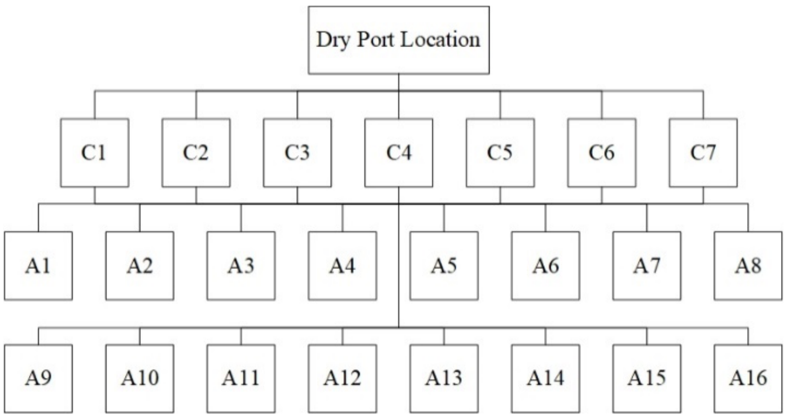

Figure 2. Dry port location hierarchy model

- Pairwise Comparison of Criteria

The pairwise comparison matrix is used to obtain the weight of the comparison of the importance of the criteria with one another. Interviews with stakeholders at Tanjung Intan Port were conducted to get the results of the comparison matrix. The respondents are the Technical Manager, Business Manager and Technical Supervisor. Those respondents were chosen because they are experts who have a role in determining the location of the dry port and are familiar with the character of the Tanjung Intan Port customers. The respondents also played a direct role in the planning and selection of dry port locations. However, insufficient circumstances and data made it

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impossible to conduct interviews with consumers of Tanjung Intan Port. Based on three expert sources who played a role in making dry port development decisions, a comparison matrix is obtained in Table 3 and Fig. 3.

Table 3. Pairwise comparison matrix of criteria.

	C1	C2	C3	C4	C5	C6	C7
C1	1	0.71	1.63	2.43	2.59	4.41	1.73
C2	1.40	1	3.46	3.80	5.85	6.85	2.82
C3	0.61	0.29	1	1.53	2.81	5.92	1.73
C4	0.41	0.26	0.65	1	1.04	3.98	1.01
C5	0.39	0.17	035	0.96	1	3.35	0.67
C6	0.23	0.14	0.17	0.25	0.30	1	0.63
C7	0.58	0.35	0.58	0.99	1.50	1.58	1

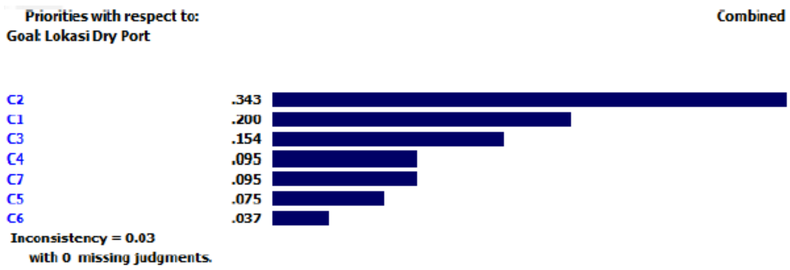

Figure 3. Criteria Priorities

Using Expert Choice 11 software, the inconsistency level is 0.03. The results of the comparison of criteria can be said to be consistent if the level of inconsistency is below 0.1; therefore, the results of the level of importance can be said to be consistent.

- Dry Port Candidates Selection

The selection of dry port candidates is based on the data that has been obtained. The data consist of all data supporting the criterion for each dry port candidate. The data shown in Table 4 was collected for each criterion. These data are further needed for data processing using the AHP method.

Table **4.** Data collection for each criterion

Criteria	Data Collection
C1	• Provincial roads and national roads around the candidate location • Overview access roads to the candidate location
C2	Number of rail tracks on each station (candidate location)
C3	The furthest distance from the customer location point to each candidate location point
C4	Size of empty land around the candidate location
C5	Distance from the candidate location to the nearest industrial area
C6	Distance from the candidate location to the nearest populated area
C7	• Tsunami hazard zones • Distance from the candidate location to the outer line of the Tsunami hazard zone

Each criterion has a criterion objective to be achieved. The details and objectives of each criterion are summarized in Table 5.

Table 5. Details and goals of each criterion

Criteria		Detail	Unit	Objectives
C1	Easy access to trucking roads	Distance from the candidate to the provincial road or national road	Kilometer	Minimize
C2	Connected to the railroad	Number of railroad track	Number	Maximize
C3	Proximity to customers	The furthest candidate distance to demand	Kilometer	Minimize
C4	Massive land	Large vacant land around the candidate	Hectare	Maximize
C5	Proximity to the industrial area	Proximity of the candidate's location to industrial areas	Kilometer	Minimize
C6	Far from densely populated areas	Distance from candidate to the nearest residential area	Meter	Maximize
C7	Located in a tsunami-safe zone	Distance from outside the yellow zone	Kilometer	Maximize

The first criterion (C1), the “easy access to trucking roads”, is assessed by analyzing whether the roads around the candidate’s location are passable by trucks. The distance from the candidate’s location to the nearest provincial or national road is also measured. If trucks can pass, the smaller the distance from the station to the provincial or national roads, the better. This criterion ranks as the second most important criterion. The result shows that 6 candidates are not accessible for trucks because there are not enough wide roads surrounding them. Those candidates are A2, A4, A5, A9, A11 and A14. On the other hand, there are 5 candidates who are located next to provincial or national roads: A12, A13, A15, and A16. Other candidates are located near provincial or national roads and still accessible for trucks, where A3 and A6 are the nearest. The second criterion (C2), “connected to the railroad”, is assessed by the number of available railroad tracks at the station. A dry port must have at least 3-4 railroad tracks, of which 1-2 tracks are for dry ports and 2 are straight railroad tracks [26]. The pairwise comparison ranks this criterion first as the most important. The result shows that A1 has the most railroad tracks of 9, followed by A3 and A8 with 7 tracks each. A7 has 5 tracks, and other candidates have below 5 tracks.

“Proximity to customers” as the third criterion (C3) ranks third most important. The closer the distance from the candidate to the furthest demand, the better. A15 has the closest distance to the furthest demand with 30,02 kilometers, followed by A8 with 34,81 kilometers. Other candidates rank from the less distance to the most distant, respectively: A16, A6, A7, A5, A4, A3, A14, A2, A9, A13, A10, A1, A12, and A11. The fourth criterion (C4) of “massive land” ranks the fourth most important. The wider the available land, the better it is to accommodate the volume demand and truck activity in the dry port. There are 10 candidates with no empty land around them, namely candidates A1, A4, A5, A6, A7, A11, A12, A13, A14, and A15. For example, candidate A1 (Kroya Station) is located in the middle of a densely populated area, making building a dry port quite challenging. On the contrary, there are 6 candidates around which there is vacant land, namely candidates A3, A2, A9, A8, A16, and A10. Candidate A3 (Maos Station) has the most vacant land around it, approximately 187 ha.

“Proximity to the industrial area” (C5) ranks the sixth most important. The criterion’s score is better if the candidate’s location is closer to the nearest industrial zone. Candidate A7 (Cilacap Station) is located closest to Tanjung Intan Port Industrial Zone, A8 (Karangtalun Station) is closest to Cilacap Industrial Zone, A5 (Karangkandri Station) is closest to Karangkandri Industrial Zone, and A3 (Maos Station) is closest to Bunton Industrial Zone. C6 criterion of being “far from a densely populated area” ranks the least important. The further the candidate is located from a densely populated area, the more suitable it is as a dry port location. A3 (Maos Station) has the furthest location from a populated area, while A1, A4, A5, A6, A7, A11, A12, A13, A14, and A15 are located the nearest.

The tsunami-prone zone is divided into two: the Tsunami Hazard Zone I or the red zone, indicating the zone is dangerous for an estimated tsunami wave height above 3 meters. Tsunami Danger Zone II, or the yellow zone, indicates that the zone is dangerous for estimated tsunami wave heights below 3 meters. The last criterion of C7, “located in the tsunami-safe zone”, is measured from the station distance from the outer line of Tsunami Hazard Zone II. One candidate is located in the Tsunami Hazard Zone I, A7 (Cilacap Station). The furthest location considered the safest is A10 (Meluwung Station), followed by A11, A12, and A13. Other candidates are located at least 11 kilometers and less from the outer line of the yellow zone.

All these data then being processed using Expert Choice 11 software to obtain dry port candidate ratings. Based on the seven criteria objectives in Table 5 above, the type of each criterion was adjusted on the Formula Grid toolbar. The increment formula type is used for maximization criteria objectives, while the decrement formula is used for the minimization. Each criterion is also measured for the lowest and highest values to serve as the lower and upper limits. Criteria data is then entered on the Data Grid toolbar. The candidate ranking results are shown in Fig. 4. Maos Station (A3), Kroya Station (A1), Karangtalun Station (A8), Cilacap Station (A7), and Jeruklegi Station (A15) are the top five dry port candidates. It was found that Maos Station resulted first on AHP because it has high scores on several important criteria. Maos Station has 7 rail tracks, which is the most important criterion for dry port location selection. The station also has easy access to trucking roads and is located quite near to the furthest customer. Although the station is located only 1,03 kilometers from the outer line of tsunami hazard zone II (yellow line), so are most other candidates, and it is still in the safe zone. Most importantly, the station wins in having massive empty land to be utilized for dry port construction and is located far away from the populated area.

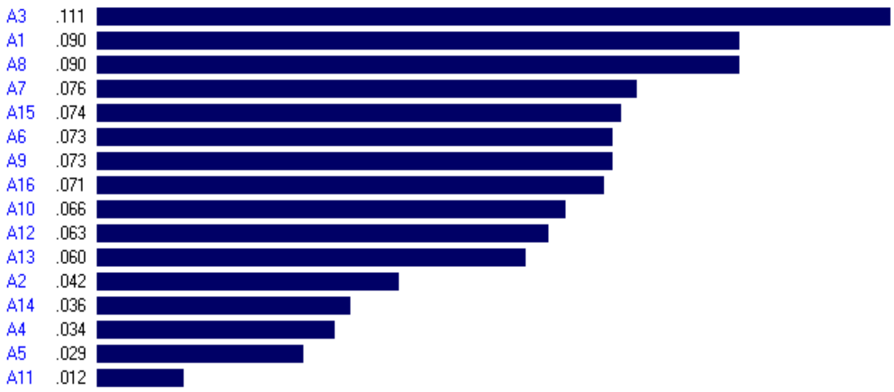

Figure 4. AHP result

B. Selecting The Best Dry Port Location using MCLP

To determine the best location, we combine the AHP and MCLP as optimization model. It is also our contribution to the paper. Combining those methods is justified to accommodate the bias when evaluating multi-criteria. The top five candidates derived from AHP are further selected by using MCLP to get the best candidate who can cover the most optimal demand. As the study focuses on the close dry port category, the distance limit $S = 50$ km of which a candidate can reach the dry port location is determined based on demand changes in modes of transport trucks to trains at a distance of 50 km [28]. It is also determined based on the characteristics of goods owners who use container services are dominated by 50% at a distance of 0-50 km [29].

When the number facility built is limited to $P = 1$, the result shows that Maos Station (A3) is the chosen candidate with 100% of demands that can be reached by dry port from a total of 93 existing demands. The result shows that Maos Station is the selected candidate with an AHP score of 0.11 and an MCLP result of 100% demands are covered.

C. Feasibility Analysis

The analysis of selected dry port candidates is reviewed based on the business feasibility. A business feasibility study is an in-depth study of a business to be carried out to determine whether the business is feasible or not [30]. The business feasibility is divided into seven aspects: legal aspect, market and marketing aspect, financial aspect, technical/operational aspect, management and organization aspect, economic and social aspect, and environmental impact aspect. Based on the research of Black, et al. [31], Crainic, et al. [15] and Dadvar, et al. [32], the business feasibility analysis discussed in this study only focuses on market and marketing aspects, technical/operational aspects, and environmental impact aspects.

a. The Market and Marketing Aspect

This aspect discusses the real market, potential, and marketing strategies [30]. The actual market is a collection of customers with interest, income, and access to certain products or services, which means that these customers are sure to make transactions. Market potential is new customers who desire to buy or use certain products or services.

Using the assumption that all Tanjung Intan Port customers are the dry port's actual market, the dry port's existing market is industries. Although in the MCLP the location of Maos Station can cover all demand, if seen from the distribution strategy based on the closest distance, Maos Station will more effectively accommodate 60% of demand, and the port can accommodate 40%. Fig. 5 shows the export supply chain strategy of Tanjung Intan Port using dry port and can also be used for other seaports in general.

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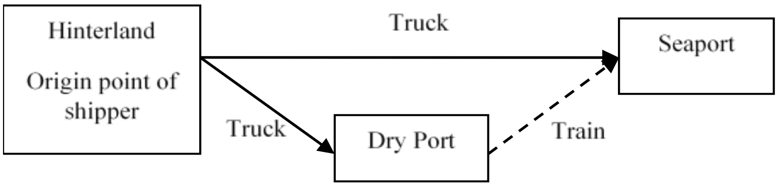

Figure 5. Export Supply Chain Strategy

The general benefit of dry ports associated with this aspect is opening new markets [14]. If seen from the benefits of a dry port and the purpose of this research, the location of Maos Station is suitable for the establishment of a close dry port because, as illustrated in Fig. 6, with an assumed dry port and port range of 50 km, the location of Maos Station has new market potential outside Cilacap, such as Purwokerto while still be able to reach all existing demand. Based on the actual market and existing market potential, the marketing strategy is focused on bringing ports closer to customers and opening up new markets outside the Cilacap Regency.

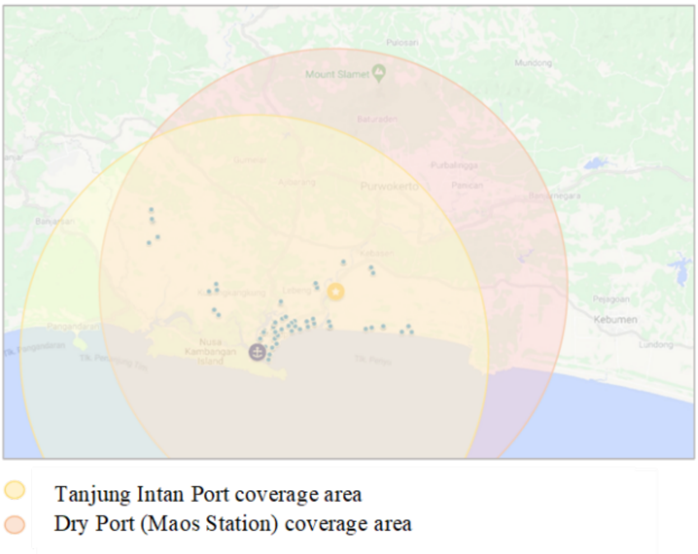

Figure 6. Port and Dry Port Market Coverage Areas

b. Technical/Operational Aspect

This aspect discusses determining the required facilities' location, layout design, and design [30]. The location determination assessment has been carried out using the AHP method. The layout design focuses on the flow of goods into the dry port until the goods arrive at the port. The design of the required facilities is seen from the dry port facilities in Indonesia and the facilities available at the port.

Based on the technical/operational aspects, the location is feasible to establish a dry port with the advantages of an adequate number of available lanes, extensive land, and being far from densely populated areas. Another advantage is the truck road access to the dry port because of its location next to the national highway.

The overview of the inbound and outbound in the layout of the dry port is created. The inbound and outbound dry port layouts can be seen in Fig. 7. The design of the dry port railway route to the port can be seen in Fig. 8.

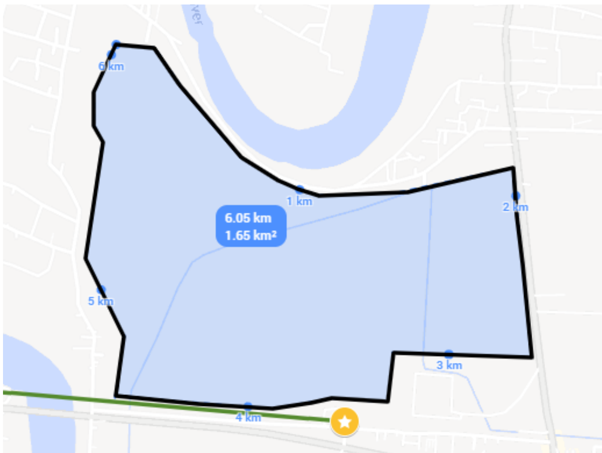

Figure 7. Overview of inbound and outbound dry port layout

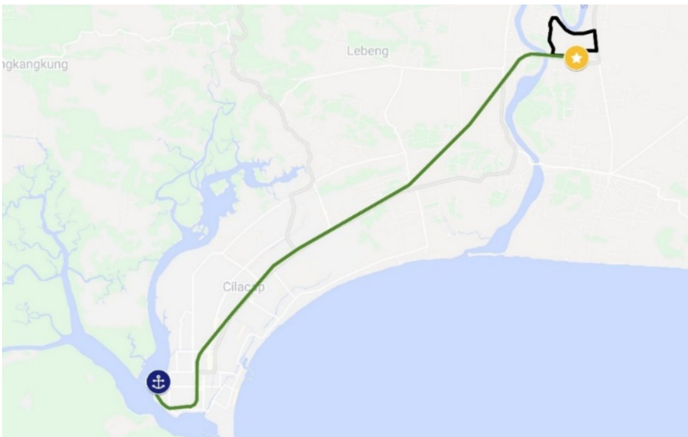

Figure 8. Design of distribution route by train from Maos dry port to Tanjung Intan port

In general, dry port facilities must be available: an intermodal terminal, a strategic location (situated inland), and a rail connection to the port with scheduled and reliable services. It also must provide services available at the freight terminal and port, such as container maintenance, container storage, forwarding, road haulage, and customs clearance [33]. Using the assumption that the area of storage and warehouse required by the dry port is the same as the port, and the construction of a dry port is at least 50 m from TBBM Pertamina Maos to prevent fire and explosion hazards [34]. The facilities that a dry port requires are as follows:

- Land facilities (the total land available = 165 ha)
  - A minimum of 8,7 ha of yard
  - Container yard
  - Empty container yard
  - A minimum of 7.100 m^2 of warehouse
- Area for truck activities (parking, road, et cetera)
  - Building facilities
  - Intermodal terminal
  - Integrated customs
  - Office

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- Equipment facilities (crane, forklift, etc.)

c. Environmental Impact Aspect

Environmental benefits of having a dry port for the port include reducing CO_2 emissions and congestion [14]. Despite the lack of research on the environmental impact of the dry port on the environment around the dry port, it is necessary to pay attention to the potential environmental impacts that may arise during pre-construction, during construction, post-construction, and during operation [30]. This aspect analyses the environmental impact around the dry port caused by the dry port, both positive and negative impacts, analysis of potential disasters at the location, and prevention of the impact of these potential disasters.

From the point of view of the potential for non-natural disasters, the potential problem in establishing a dry port at the Maos Station location is that it is located close to TBBM Pertamina Maos, which can create a risk of fire and explosion disasters [34]. The radius of fire exposure is in the range of 13-20.7 m. The radius of heat exposure is in the range of 5-50 m from outside the tank [34]. To prevent fire and explosion hazards, constructing a dry port is at least 50 m away from TBBM Pertamina Maos.

Due to the dry port location is safer from potential tsunami impacts than the port location, the natural disaster prevention analysis is focused on the port by utilizing the dry port location. In this study, the authors propose a supply chain network concept to overcome the problems of the port export supply chain network due to the tsunami disaster. In the event of a tsunami disaster and the port is affected (Fig. 9 and Fig. 10), cargo owners who are not affected by the tsunami can send their exported goods to the dry port through other nearby ports, such as Tanjung Mas Port, until the recovery period Tanjung Intan Port is finished and the port can normally run again.

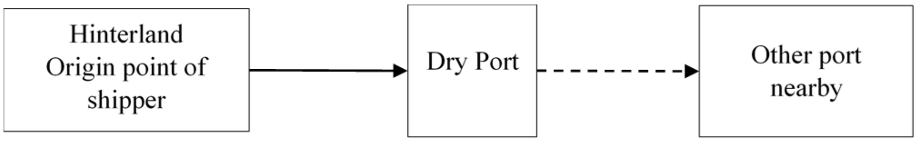

Figure 9. Export supply chain network after disaster

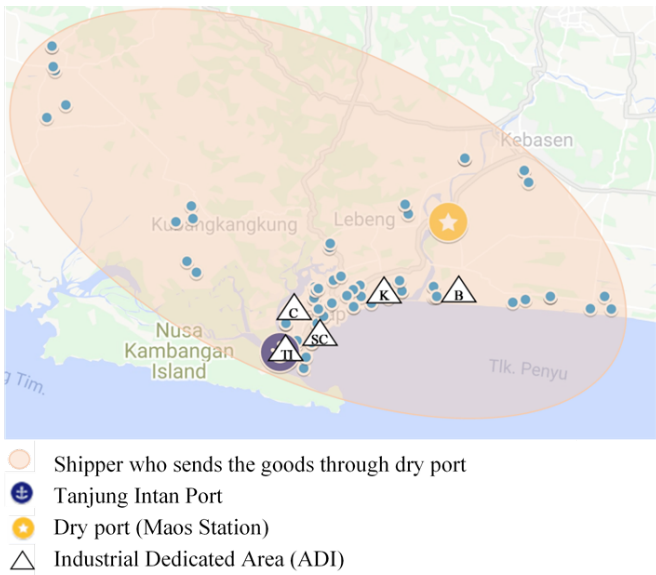

Figure 10. Dry port coverage area post-disaster

4. Conclusion

This study used the AHP method and MCLP modelling to select the most attractive location for the dry port of Tanjung Intan Port, which meets the criteria such as adequate road and rail access, being safer from potential tsunami impacts, and able to cover the demand points of cargo owners. Using AHP, seven criteria need to be considered in choosing the dry port location; (1) easy access to trucking roads (2) connection to the railroad, (3) proximity to customers, (4) massive land, (5) proximity to the industrial area, (6) far from densely populated areas, and (7) located in a tsunami-safe zone. MCLP modelling aims to choose the best dry port location that can cover as many demands as possible.

Maos Station is the best dry port location in terms of these seven criteria, and the location can cover all customer locations. Based on the market and marketing analysis results, the dry port marketing strategy at Maos Station is focused on bringing the port closer to customers and opening up new markets outside Cilacap regency because of its location, which can reach a broader market potential. Based on the technical/operational aspects, the location is feasible to establish a dry port with the advantages of an adequate number of available railway trucks, massive land, and being far from densely populated areas. Another advantage is the truck road access to the dry port because of its location next to the national highway. Based on the environmental impact aspect, dry ports generally provide the benefit of reducing total CO_2 emissions and reducing road loads. The selected dry port location is also safer from tsunami risk, and thus the dry port could be used as a buffer point if the seaport was affected by the disaster.

This study still has not considered a dry port investment and operating costs. Furthermore, it does not pay attention to dry port and train capacity and analysis from other business feasibility (legal, financial, management, organization, economic, and social). Further research is needed in terms of cost comparison between truck and train transportation to determine the level of competition for freight transport modes to improve marketing strategies in terms of price. Further research is also needed regarding the required dry port capacity and dry port layout so that the layout can be designed in more detail. It is hoped that in future research, these things can be considered.

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References

[1] Pemerintah Kabupaten Cilacap. (2020). *Profil: Kondisi Umum*. Available: https://cilacapkab.go.id/v3/kondisi-umum/
[2] I. G. Tejakusuma, "Analisis pasca bencana tsunami Ciamis-Cilacap," *Jurnal Sains dan Teknologi Indonesia,* vol. 10, no. 2, 2012.
[3] Badan Nasional Penanggulangan Bencana. (2020). *Data Informasi Bencana Indonesia*. Available: http://bnpb.cloud/dibi/laporan5a
[4] E. Hilmi *et al.*, "Analisis potensi bencana abrasi dan tsunami di pesisir Cilacap," *Jurnal Dialog dan Penanggulangan Bencana,* vol. 3, no. 1, pp. 35-42, 2012.
[5] Badan Pusat Statistik Provinsi Jawa Tengah. (2022). *Volume and Value of Export by Loading Port at Jawa Tengah Province, 2018-2021*. Available: https://jateng.bps.go.id/statictable/2021/04/15/2438/volume-dan-nilai-ekspor-dirinci-menurut-pelabuhan-muat-di-provinsi-jawa-tengah-2018-2021.html
[6] Pelindo. (23 April). *Profil Pelabuhan Tanjung Intan - Cilacap*. Available at: https://pelindo.co.id/port/pelabuhan-tanjung-intan-cilacap Accessed on: 23 April, 2023.
[7] T. Notteboom *et al.*, *Port Economics, Management and Policy*. Routledge, 2022. Available at: https://books.google.co.id/books?id=3xGQzgEACAAJ
[8] V. Roso *et al.*, "The dry port concept: connecting container seaports with the hinterland," *Journal of Transport Geography,* vol. 17, pp. 338-345, 09/01 2009. Available at: https://10.1016/j.jtrangeo.2008.10.008
[9] V. Roso, "Factors influencing implementation of a dry port," *International Journal of Physical Distribution & Logistics Management,* vol. 38, pp. 782-798, 11/07 2008. Available at: https://10.1108/09600030810926493
[10] D. Waters, *Logistics: An Introduction to Supply Chain Management*. Palgrave Macmillan, 2003. Available at: https://books.google.co.id/books?id=BoJ5QgAACAAJ
[11] H. Abdoulkarim *et al.*, "The Selection of Dry Port Location by Analytic Network Process Model: A Case Study of Dosso-Niger," *Journal of Transportation Technologies,* vol. 09, pp. 146-155, 01/01 2019. Available at: https://10.4236/jtts.2019.92009
[12] M. Saka and O. Cetin, "Comparing two judgment scales of AHP with a case study: reaching a decision on a dry port location," *WMU Journal of Maritime Affairs,* vol. 19, no. 4, pp. 427-461, 2020/12/01 2020. Available at: https://10.1007/s13437-020-00218-8

p-ISSN: 2963-8577
e-ISSN: 2964-3511

[13] J. Woxenius *et al.*, "The dry port concept–connecting seaports with their hinterland by rail," in *ICLSP Conference Proceedings*, 2004, pp. 305-319: Citeseer.
[14] V. Roso *et al.*, "The dry port concept: connecting container seaports with the hinterland," *Journal of Transport Geography,* vol. 17, no. 5, pp. 338-345, 2009.
[15] T. G. Crainic *et al.*, "Modeling dry-port-based freight distribution planning," *Transportation Research Part C: Emerging Technologies,* vol. 55, pp. 518-534, 2015.
[16] M. Abbasi and M. S. Pishvaee, "A two-stage GIS-based optimization model for the dry port location problem: A case study of Iran," *Journal of Industrial Systems Engineering,* vol. 11, no. 1, pp. 50-73, 2018.
[17] Ş. Burciu *et al.*, "Location of an intermediate hub for port activities," in *IOP conference series: materials science and engineering*, 2015, vol. 95, no. 1, p. 012064: IOP Publishing.
[18] S. Chanta and O. Sangsawang, "A single allocation P-Hub maximal covering model for optimizing railway station location," in *International Conference on Intelligent Computing & Optimization*, 2018, pp. 522-530: Springer.
[19] K. F. Doerner *et al.*, "Multi-criteria location planning for public facilities in tsunami-prone coastal areas," *Journal OR spectrum,* vol. 31, no. 3, pp. 651-678, 2009.
[20] Direktorat Jenderal Perkeretaapian Kementrian Perhubungan Republik Indonesia. (2014). *Buku Informasi Perkeretaapian*.
[21] G.-H. Tzeng and J.-J. Huang, *Multiple attribute decision making: methods and applications*. CRC press, 2011.
[22] A. Ishizaka and P. Nemery, *Multi-criteria decision analysis: methods and software*. John Wiley & Sons, 2013.
[23] F. A. Tanti, "Sistem Pendukung Keputusan Prioritas Lokasi Perbaikan Jalan Menggunakan Metode AHP (Analytical Hierarchy Process) dan SAW (Simple Additive Weighting) Studi Kasus Kabupaten Pasuruan," Universitas Muhammadiyah Malang, 2020
[24] R. Z. Farahani and M. Hekmatfar, *Facility location: concepts, models, algorithms and case studies*. Springer Science & Business Media, 2009.
[25] A. A. N. P. Redi *et al.*, "Maximum covering location problem to select facility location for operation timbang in the City of Iloilo, Philippines," *Jurnal Sistem dan Manajemen Industri,* vol. 6, no. 2, pp. 135-142, 2022.
[26] J. D. Frost, "The Close Dry Port Concept and the Canadian Context," *Journal of Maritime Economics Logistics,* vol. 10, no. 2, pp. 108-129, 2010.
[27] B. Ka, "Application of fuzzy AHP and ELECTRE to China dry port location selection," *The Asian Journal of Shipping Logistics,* vol. 27, no. 2, pp. 331-353, 2011.
[28] R. Fitriah *et al.*, "Analisis Perbandingan Biaya Pengangkutan Peti Kemas Menggunakan Moda Truk, Kereta Api dan Kapal Provinsi Sulawesi Selatan," *Jurnal Penelitian Enjiniring,* vol. 22, no. 1, pp. 70-75, 2018.
[29] Kemenhub, "“Dry Ports Potential in Indonesia had not been Optimally Benefitted"," Badan Penelitian dan Pengembangan Kementerian Perhubungan Republik Indonesia2010, Available at: http://dephub.go.id/post/read/potensi-dry-port-di-indonesia-belum-dikembangkan-secara-optimal-2275, Accessed on: 3 March 2020.
[30] S. Kasmir, *Studi Kelayakan Bisnis: Edisi Revisi*. Prenada Media, 2015.
[31] J. Black *et al.*, "Issues in dry port location and implementation in metropolitan areas: The case of Sydney, Australia," *Journal Transactions on Maritime Science,* vol. 7, no. 01, pp. 41-50, 2018.
[32] E. Dadvar *et al.*, "Feasibility of establishment of “Dry Ports” in the developing countries—the case of Iran," *Journal of Transportation Security,* vol. 4, no. 1, pp. 19-33, 2011.
[33] D.-W. Song and P. Panayides, *Maritime logistics: A guide to contemporary shipping and port management*. Kogan Page Publishers, 2015.
[34] A. J. Sukma and R. B. Cahyono, "Potential Risk Analysis of Fire Hazard and Explosion and Its Impact on Workers and Community in PT. Pertamina-terminal BBM Rewulu," *Berita Kedokteran Masyarakat,* vol. 33, no. 11, pp. 1087-1098, 2017.

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