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ANALYTICAL HIERARCHY PROCESS (AHP) ANALYSIS ON PIONEER VESSELS UTILISATION

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Abstract

The government has implemented a policy to provide pioneer vessel transportation facilities to improve community accessibility and stimulate economic growth in remote areas. Many studies have highlighted the role of pioneer vessel transportation in economic development, but none have specifically examined the use of pioneer vessels built by the Directorate of Traffic and Sea Transportation. This study aims to evaluate the utilization and service conditions of these pioneer vessels. To do this, we gathered data on 34 pioneer ships across 10 locations through site surveys and secondary sources. Secondary data included a list of unhanded pioneer ships, ship samples, service condition analyses, ship assessments, analytical hierarchy process (AHP) evaluations, route compatibility, and optimal ship assignment methods. The analysis will provide results on ship evaluation, suggestions for route placement, overall costs, and potential cost savings. The study produces an inventory of how these pioneer vessels are utilized and offers recommendations for their deployment within the Directorate of Traffic and Sea Transportation.

Keywords: Analytical hierarchy process, Pioneer vessel, Ship assessment.

1. Introduction

The area of the Unitary State of the Republic of Indonesia is predominantly comprised of several islands extending from Sabang to Merauke. Sea transportation serves as a crucial conduit for sustaining connectivity across regions. The distance created by bodies of water significantly increases the discrepancy rate between locations. To mitigate this imbalance, the government has initiated an innovative maritime transportation initiative. The primary aim of the program is to enhance connectivity among regions of Indonesia, particularly in economically underdeveloped areas. This approach will facilitate a more efficient allocation of logistics and community movements, thereby reducing the disparity rate.

The Directorate of Traffic and Sea Transportation, a unit within the Directorate General of Sea Transportation at the Ministry of Transportation, is responsible for coordinating innovative sea transportation initiatives to serve all Indonesian citizens in islands not accessed by national merchant vessels, as well as in underdeveloped, remote, border, and outermost areas.

To date, the Directorate of Traffic and Sea Transportation has constructed 116 pioneering passenger sea transport vessels with the following specifications: The Directorate of Traffic and Sea Transportation has constructed 29 units of GT (Gross Tonnage) 2000 pioneer vessels, 33 units of GT 1200 type pioneer vessels, 26 units of 750 DWT (deadweight tonnage) type pioneer vessels, 16 units of 500 DWT type pioneer vessels, 6 units of 350 DWT type pioneer vessels, and 6 units of 200 DWT type pioneer vessels.

The sea transportation industry is crucial for facilitating economic activity by linking islands [1, 2]. Maritime transportation facilitates communication across Indonesia [3-5]. From this viewpoint, the innovative maritime transportation mode facilitates developmental dynamics by enabling the movement of individuals, commodities, and services while also bolstering national distribution (logistics) frameworks [6, 7].

Pioneer ships are designated vessels tasked with linking isolated regions or islands lacking sufficient transportation infrastructure, as well as serving underdeveloped, remote, outermost, and border areas. These ships operate under state-owned maritime transport, facilitating subsidized passenger and cargo transport as per the Regulation of the Minister of Transportation of the Republic of Indonesia Number PM 6 of 2016. The legislation stipulates that pioneer sea transportation conveys persons or products in waterways along routes designated by the government. This innovative maritime transportation initiative is regulated by the government to promote regional development, enhance and equalize economic growth, and ensure national stability [8].

According to the Regulation of the Minister of Transportation of the Republic of Indonesia Number PM 6 of 2016, the objectives of implementing pioneer ships are as follows: to link underdeveloped and/or remote regions, as well as outermost borders, with developed areas; to connect regions lacking sufficient alternative transportation modes; and to facilitate access to areas that are not yet commercially viable for sea, river, lake, or ferry transportation providers.

In addition to ensuring connectivity throughout Indonesia, marine transportation offers two additional benefits [8]. First, sea transportation as a catalyst for trade implies that islands lacking a trade sector are bypassed by pioneering shipping routes, perhaps enhancing the local economy, while secondly, the role of maritime transportation as a facilitator of commerce suggests that it fulfils the need for freight transit between islands. In other words, maritime transportation serves as a facilitator of the advancing economic sector.

Transportation serves as a public service sector with the objective of fostering balanced national economic development and acting as a stimulus for economic growth [9]. This pioneering vessel serves to sustain connectivity across islands and to bolster the economies of the adjacent island populations [7]. The establishment of this pioneering maritime route can enhance trade, tourism, and the local economy, as transportation access is exclusively reliant on seaways [10]. Establishing a new road or maritime access to the islands facilitates not only the delivery of commodities but also the dissemination of information regarding the island's potential for enhancement [3].

Sea transportation is crucial not only as a facilitator of interregional trade but also due to the necessity of routes arising from the demand for commodities between islands [11-14]. In locations with tradable commodities, a connection link between islands is necessary for their distribution. The conveyance of pioneer ship fleets facilitates economic operations that link different regions [6, 15, 16].

The Regulation of the Minister of Transportation of the Republic of Indonesia Number PM 48 of 2018 regarding the Implementation of Pioneer Ship Public Service Activities delineates the mechanism for executing these activities, the involved parties, their respective rights and obligations, and the procedures for budget disbursement for the implementation of pioneer ship public services. The process for implementing pioneer ship public service initiatives is outlined below: The task is executed by PT. Pelayaran Nasional Indonesia using state-owned pioneer vessels. National shipping corporations coordinated the selection of alternative service providers in accordance with the stipulations of laws and rules governing public procurement of products and services.

The description indicates that enhancing the performance of the existing ships in pioneering passenger sea transportation necessitates an assessment of the optimal utilization of the pioneer fleet. This study aims to examine the use of pioneer ships constructed within the jurisdiction of the Directorate of Traffic and Navy. The examination of pioneer ship use includes assessing the status of seven ships that have not yet been delivered, as well as examining a sample of vessels located at the survey site.

We evaluate the ship's condition by analysing the current conditions from the location survey or observation, using data from the ship's specification and/or inventory, and categorizing it into very bad, bad, moderate, good, and very good. The forthcoming analysis is a cost-benefit analysis of the deployment of pioneer ships within each GT class, based on the vessel's condition and age. We conduct a risk analysis of ship utilization in each GT class, considering the vessel's condition and age as a determining factor for pioneer ship operations.

While policy frameworks and infrastructure investment have been widely studied, there is **limited empirical research** evaluating the operational performance and deployment strategies of these government-commissioned vessels. Existing studies tend to focus on macro-level indicators (e.g., logistics cost, regional connectivity) or regulatory analysis, leaving a gap in data-driven evaluations at the vessel level. Moreover, decisions regarding which vessels are best suited for specific routes are often made without a transparent and systematic evaluation process.

This study provides an inventory of the utilization of seven pioneer ship fleets that have been constructed but not yet transferred to the Directorate of Sea Traffic and Transportation. Outcomes of Supply and Demand Analysis of Pioneer Vessel Utilization; Outcomes of Optimization in Identifying Pioneer Ship Categories; We are seeking suggestions and insights for the deployment of pioneer ship fleets, especially those that have not yet been transferred or are not yet operational. The policy should be developed to propose a pioneering shipping route network. We are formulating a policy to set standards for prospective operators.

2. Methods

This study utilizes quantitative and qualitative methodology, conducting a survey and document analysis across ten locations from a total of 39 base ports, including Aceh, Padang, Pontianak, Semarang, Kupang, Ternate, Kendari, Ambon, Sorong, and Jayapura. Geographic distribution of survey activities as shown in Fig. 1.

Fig. 1. Geographic distribution of survey activities.

This study comprises three components. The first component is assessing the technical state of vessels, which includes the quantity and classification of the existing pioneer ship fleet while also considering the use aspect of this fleet. The second is determining the usage parameters of transportation services and networks, evaluating the performance of pioneering maritime transport services, and analysing the cost and revenue dimensions of such services; the third is employing the analytic hierarchy approach for vessel evaluation.

This research employed a multi-stage methodology involving document analysis, direct observation, and the application of the **Analytical Hierarchy Process (AHP)** to assess the operational suitability of government-procured pioneer vessels. The study focused on 34 ships-30 existing (active) vessels and 4 newly delivered ones-across 10 base port locations in Indonesia, selected to represent a wide range of geographic and logistical contexts. These ports were chosen based on route diversity, regional significance, and vessel availability, ensuring that the sample provided both **representativeness and relevance** to current deployment conditions.

3. Results and Discussions

Analytic hierarchy process ship assessment includes assessment of old and new ships. The hierarchical structure to be established is to evaluate passenger capacity, cargo capacity, current speed, age, and physical condition. The criteria will subsequently be assigned weight values according to the decision-maker's evaluations of the relative importance of each aspect in comparison to others. In the final stage, there are options comprising both old and new ships that will be allocated. The highest level (goal) of this AHP is the objective of evaluating the ship. The subsequent level includes criteria for evaluating existing alternatives, as seen in Fig. 2.

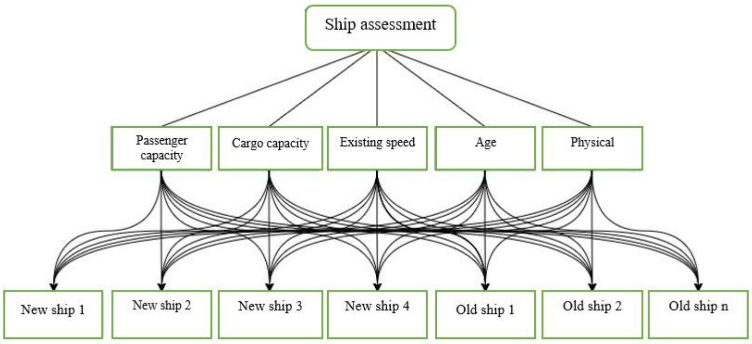

Fig. 2. Analytical hierarchy process.

This study focused on 34 pioneer vessels, comprising 30 operational older ships and 4 new ships. The evaluation of each vessel is predicated on five criteria that will serve as a benchmark. The physical criteria are derived from the ship assessment, which is based on two weights: the investment value and the risk priority number, each contributing 50% to the overall evaluation. The comprehensive value of all vessels is available in the Ship Assessment Results. Each criterion undergoes pairwise comparison, wherein criteria are evaluated against one another in pairs to ascertain the relative importance of each criterion. This value employs a grading scale ranging from 1 to 5. For instance, as illustrated in Table 1, the criteria for goods capacity hold greater significance than passenger capacity, with an importance rating of 1; existing speed is prioritized over passenger capacity, with a value of 4, and so forth.

Table 1. Level of significance criteria.

Criteria		More significance	Scale
1	**2**	**1 or 2**	**(1 - 5)**
Passenger capacity	**Cargo capacity**	2	1
Passenger capacity	**Existing speed**	2	4
Passenger capacity	**Age**	2	5
Passenger capacity	**Physical**	2	5
Cargo capacity	**Existing speed**	2	2
Cargo capacity	**Age**	2	4
Cargo capacity	**Physical**	2	4
Existing speed	**Age**	1	2
Existing speed	**Physical**	2	2
Age	**Physical**	2	3

3.1. New ship assessment

A pairwise comparison is conducted to ascertain the criteria value between new and old ships. All criteria are evaluated with a score of 0, except for the age criterion, which has a score of 1. This indicates that the number 0 possesses a directly proportional value while the number 1 has an inversely proportional value. The age criteria were inversely proportional; as the ship's age increases, its performance diminishes. The criterion values for various vessels are presented in Table 2.

Table 2. Analytical hierarchy process assessment matrix for new ship.

No.	Ship name	Code	Type	Passenger capacity	Cargo capacity	Designed speed	Age	Physical	Aggregate	Rank
1	MV Sabuk Nusantara 74	KB1	2000 GT	0.25	0.25	0.25	0.25	0.21	0.24	3
2	MV Sabuk Nusantara 76	KB2	2000 GT	0.25	0.25	0.25	0.25	0.35	0.29	1
3	MV Sabuk Nusantara 89	KB3	2000 GT	0.25	0.25	0.25	0.25	0.19	0.23	4
4	MV Sabuk Nusantara 73	KB4	2000 GT	0.25	0.25	0.25	0.25	0.24	0.25	2
	Total			**1.00**	**1.00**	**1.00**	**1.00**	**1.00**		

The total value of each ship is derived from the multiplication of the ship's value matrix by the weight of the criteria, as presented in Table 1. This figure will decide the ranking of the ship, which is derived from the AHP assessment of new vessels. Table 2 shows that the vessel KM. Sabuk Nusantara 76 has the highest aggregate value, with a score of 0.292. The second vessel is KM Nusantara 73, valued at 0.245; the third is KM Sabuk Nusantara 74, valued at 0.236; and the last vessel is KM Sabuk Nusantara 89, valued at 0.227.

3.2. Old ship assessment

The identification of criteria values was conducted by pairwise comparison with the previous ship alternative. All criteria were evaluated with a score of 0, except for the age criterion, which received a score of 1. This indicates that the number 0 possesses a directly proportional value while the number 1 has an inversely proportional value. The age criteria were inversely proportional; as the ship's age increases, its performance diminishes. The KL code in the table denotes the Old Ship. The criterion values for various vessels are presented in Table 3.

The aggregate value of 30 ships, as presented in Table 3, indicates that the highest value is attributed to MV Sabuk Nusantara 75 at 0.0477, while the lowest value is assigned to MV Papua Empat at 0.0106. A higher aggregate value signifies that the ship is favoured over those with lower values. The results of the AHP analysis reveal significant variation in the suitability of pioneer vessels for deployment across Indonesia’s maritime routes. Vessels with younger age profiles, moderate-to-high speeds, and good physical condition consistently scored higher in the overall ranking. Notably, certain ships that met only one or two criteria-such as high capacity, but poor condition-ranked significantly lower, underscoring the importance of evaluating performance holistically rather than based on isolated attributes.

Table 3. Analytical hierarchy process assessment matrix of old ships.

No.	Ship Name	Code	Type	Passenger Capacity	Cargo Capacity	Existing Speed	Age	Physical	Aggregate	Rank
1	MV Sabuk Nusantara 75	KL1	2000 GT	0.025	0.104	0.039	0.063	0.037	0.048	1
2	MV Sabuk Nusantara 90	KL2	2000 GT	0.042	0.026	0.031	0.063	0.037	0.041	4
3	MV Sabuk Nusantara 82	KL3	2000 GT	0.042	0.026	0.031	0.063	0.037	0.040	5
4	MV Sabuk Nusantara 103	KL4	1200 GT	0.037	0.013	0.031	0.063	0.036	0.039	7
5	MV Sabuk Nusantara 77	KL5	2000 GT	0.042	0.026	0.039	0.063	0.037	0.042	3
6	MV Sabuk Nusantara 105	KL6	1200 GT	0.037	0.013	0.047	0.063	0.036	0.043	2
7	MV Sabuk Nusantara 68	KL7	2000 GT	0.042	0.026	0.039	0.042	0.037	0.038	8
8	MV Sabuk Nusantara 108	KL8	1200 GT	0.037	0.013	0.039	0.042	0.036	0.036	15
9	MV Sabuk Nusantara 67	KL9	2000 GT	0.042	0.026	0.035	0.042	0.037	0.037	13
10	MV Sabuk Nusantara 86	KL10	2000 GT	0.042	0.026	0.047	0.042	0.037	0.040	6
11	MV Sabuk Nusantara 78	KL11	2000 GT	0.042	0.026	0.035	0.042	0.035	0.037	14
12	MV Sabuk Nusantara 106	KL12	1200 GT	0.037	0.013	0.035	0.042	0.037	0.036	16
13	MV Sabuk Nusantara 107	KL13	1200 GT	0.037	0.013	0.047	0.042	0.033	0.037	12
14	MV Sabuk Nusantara 71	KL14	2000 GT	0.042	0.026	0.039	0.042	0.037	0.038	10
15	MV Sabuk Nusantara 87	KL15	2000 GT	0.042	0.026	0.039	0.042	0.037	0.038	9
16	MV Sabuk Nusantara 100	KL16	1200 GT	0.037	0.013	0.039	0.042	0.033	0.035	17
17	MV Sabuk Nusantara 56	KL17	750 DWT	0.025	0.104	0.035	0.021	0.035	0.037	11
18	MV Sabuk Nusantara 44	KL18	750 DWT	0.042	0.026	0.033	0.018	0.037	0.031	18
19	MV Sabuk Nusantara 42	KL19	1200 GT	0.011	0.029	0.031	0.018	0.034	0.028	23
20	MV Sabuk Nusantara 45	KL20	200 DWT	0.011	0.029	0.035	0.018	0.037	0.030	21
21	KM. Sabuk Nusantara 34	KL21	1200 GT	0.037	0.013	0.029	0.018	0.034	0.028	24
22	MV Sabuk Nusantara 30	KL22	1200 GT	0.037	0.013	0.031	0.016	0.036	0.029	22
23	MV Sabuk Nusantara 32	KL23	750 DWT	0.042	0.026	0.033	0.016	0.035	0.030	20
24	MV Sabuk Nusantara 29	KL24	500 DWT	0.023	0.063	0.039	0.014	0.030	0.031	19
25	MV Papua Empat	KL25	200 DWT	0.011	0.029	-	0.011	0.013	0.011	30
26	MV Papua Enam	KL26	350 DWT	0.022	0.037	0.031	0.010	0.031	0.027	27
27	MV Wetar	KL27	750 DWT	0.042	0.026	0.027	0.010	0.034	0.027	26
28	MV Kasuari Pasifik II	KL28	500 DWT	0.023	0.063	-	0.010	0.019	0.017	29
29	KIE RAHA II	KL29	500 DWT	0.023	0.063	0.027	0.010	0.031	0.028	25
30	MV Manusela	KL30	500 DWT	0.023	0.063	0.029	0.010	0.016	0.022	28
	Total			1,00	1,00	1,00	1,00	1,00		

4. Conclusion

Based on the results of the weighing study of the ship assessment criteria using the AHP (Analytical Hierarchy Process) methodology, the following weights have been assigned to each criterion. First, the weight assigned to passenger capacity is 0.06. Then, the weight assigned to cargo capacity is 0.08. The ship's age is 0.21. My physical condition is 0.40. The ship currently travels at a speed of 0.24. The ship evaluation yielded the weight values for each vessel. The analysis yielded the following results. The new vessel, MV Sabuk Nusantara 76, has the highest aggregate value of 0.292. The second order pertains to the vessel KM Nusantara 73, which possesses an aggregate value of 0.245. MV Sabuk Nusantara 74 ranks third with a value of 0.236, while MV Sabuk Nusantara 89 occupies the last position with a rating of 0.227. And the maximum value recorded on the old ship is MV Sabuk Nusantara 75 at 0.0477, while the minimum value is MV Papua Empat at 0.0106.

The results suggest that future shipbuilding efforts should prioritize modular, adaptable designs that optimize fuel efficiency, speed, and resilience in challenging maritime conditions. Additionally, a shift toward data-driven deployment strategies-where vessel characteristics are matched to route profiles-could significantly enhance the impact of government-funded maritime programs.

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