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DEVELOPING AN INTEGRATED INTER-ISLAND MARITIME TRANSPORTATION MODEL FOR LOCAL ECONOMIC ADVANCEMENT: EVIDENCE FROM HUAMUAL BELAKANG DISTRICT, MALUKU PROVINCE

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Abstract

This study aims to analyze existing conditions, identify key constraints, and formulate an optimal and sustainable inter-island maritime transportation development model in Huamual Belakang District, West Seram Regency, Maluku Province. This study utilized a qualitative case study approach and the data was collected through field observations, in-depth interviews, and document analysis. The analysis is supported by SWOT analysis and Internal Factor Evaluation (IFE) and External Factor Evaluation (EFE) matrices to assess internal and external conditions. The findings indicate that the current maritime transportation system is not yet optimal, as reflected in disparities in port infrastructure capacity, an imbalanced vessel-to-population ratio (1:1,916), high operational costs, and fragmented institutional arrangements. Despite these limitations, the region demonstrates substantial local economic potential and promising opportunities for digital technology convergence. Based on the analysis, the proposed development model emphasizes an integrated approach that combines a hub-and-spoke system with Hatu Port as the primary hub, integration of supply chains for leading commodities, particularly fisheries and cloves, supported by cold storage facilities, cross-subsidy mechanisms through a Public Service Obligation (PSO) scheme, and the adoption of a digital platform, "E-Sampan," to improve efficiency and accessibility. Strategic recommendations focus on institutional consolidation through the establishment of an integrated management authority, capacity enhancement of feeder port infrastructure, the addition of seaworthy vessels, and strengthening human resources through training and certification programs. The implementation of this model is expected to serve as a catalyst for improved connectivity, reduced logistics costs, and accelerated inclusive and sustainable local economic growth.

Keywords: ***Inter-Island Maritime Transportation; Hub-and-Spoke Model; Archipelagic Connectivity; Development of Disadvantaged Regions; Sustainable Logistics***

INTRODUCTION

Archipelagic states such as Indonesia face distinctive challenges in maintaining territorial connectivity and safeguarding sovereignty. Under the United Nations Convention on the Law of the Sea (UNCLOS) 1982, archipelagic states are recognized as entities in which islands and the waters between them constitute an integral part of national territory. This legal framework implies that border and peripheral areas must be managed through a holistic approach that encompasses land, sea, and air dimensions (Sujarwanto, 2019; Purwanto & Mangku, 2016). These regions function not only as defensive frontiers, but also as vital trade corridors and centers for natural resource management. Consequently, their governance requires an integrated perspective that combines legal, security, economic, and infrastructural considerations to strengthen sovereignty while promoting public welfare.

Within Indonesia's geographical context which comprises 17,001 islands, maritime transportation serves as an irreplaceable connective backbone. The vast expanse of national waters, covering approximately 1,892,410.09 km², underscores the extent to which population mobility, goods distribution, and national economic integration depend on the effectiveness of maritime transport systems (BPS, 2024). In the absence of reliable maritime transportation, remote islands risk isolation, limited access to basic services, widening regional disparities, and delayed regional development (Turukay, 2023; Sundari et al., 2020). This challenge is particularly pronounced in dispersed archipelagic regions such as Maluku, where the sea is not a barrier, but the primary medium through which

socio-economic life is sustained. Huamual Belakang District in West Seram Regency exemplifies many of the transportation challenges faced by Indonesia's archipelagic regions. Consisting of 7 villages and 27 hamlets, the district is characterized by a predominantly maritime landscape with numerous small, dispersed islands. The local population relies largely on agriculture and fisheries for their livelihoods. However, the distribution of these commodities is frequently constrained by an inadequate, irregular, and costly maritime transportation system (Turukay, 2023). Such conditions limit market access, reduce the economic added value of local products, and perpetuate cycles of poverty.

Recent studies indicate that limitations in port infrastructure and vessel availability represent systemic issues across many Indonesian archipelagic areas. A study by Kakerisa et al. (2023) in Maluku highlighted that insufficient port facilities and mismatches between vessel capacity and community needs lead to operational inefficiencies and restricted mobility. Similarly, Mariyanto et al. (2021) demonstrated that disproportionate vessel-to-population ratios directly affect sailing frequency and service affordability. In Huamual Belakang District, these challenges are exacerbated by the concentration of port facilities in Waesala Village, while access to smaller islands, such as Kelang Island and Buano Island, depends heavily on motorboats or speedboats that are both expensive and unscheduled. Technological advancement and sustainability have also emerged as critical considerations in contemporary maritime transport development. The application of digital technologies, including the Internet of Things (IoT) and artificial intelligence (AI), offers opportunities to enhance safety, optimize routing, and enable preventive vessel maintenance (Mosyofa & Muammar, 2024). Nevertheless, the adoption of such technologies remains limited in underdeveloped archipelagic regions. At the same time, environmental concerns necessitate the promotion of greener maritime transport through low-emission vessels and responsible waste management, as discussed by Safitri et al. (2024) in their study on hybrid electric vessels as a pathway toward net zero emissions.

Studies on the development of inter-island maritime transportation models have attracted increasing scholarly attention. Researches by Kakerisa et al. (2023) and Putri et al. (2020) shows that existing maritime transport models in Indonesia remain largely concentrated on main ports or inter-provincial shipping corridors. Such a macro-oriented focus, however, tends to overlook the operational complexity and connectivity challenges at the local level, where conditions are often highly specific and cannot be fully captured by large-scale analyses. In contrast, studies by Sujarwanto (2019) and Mariyanto et al. (2021) generally emphasized single aspects, such as port infrastructure, fleet performance, or economic impacts, which were examined separately. Although several policy-oriented studies have proposed integrated approaches, including the hub-and-spoke model (Ministry of Transportation, 2022), these models are frequently presented in a generic form and have not been sufficiently tailored to specific geographic characteristics, seasonal demand patterns, local commodity potentials, or regional fiscal capacity. As a result, there is a gap between the theoretical models proposed in the literature and their practical feasibility, particularly with regard to financing mechanisms, governance arrangements, and long-term sustainability. The potential application of advanced technologies, such as the IoT, AI, and digital platforms, has also been widely discussed, but predominantly in the context of large international ports (Wang et al., 2022). More recent studies emphasize that community involvement in planning processes can generate solutions that are more context-sensitive and sustainable (Lestari, 2022). Conversely, institutional fragmentation among government agencies, operators, and the private sector is frequently identified as a major barrier to effective coordination and policy implementation (Suryawan, 2021).

These studies illustrate the diverse dynamics shaping maritime transportation development models. Nevertheless, in-depth researches on maritime transportation systems at the district level, particularly in areas characterized by small and micro-island configurations, such as Huamual Belakang District, remain limited. In addition, studies integrating technical infrastructure analysis, fleet operations, cost economics, institutional coordination, and social participation within a single, holistic analytical framework, especially for disadvantaged regions, are even more limited. Moreover, modern logistics systems and their application to community-based maritime transportation in Frontier, Outermost, and Underdeveloped (Terdepan, Terluar, Tertinggal, 3T) regions, like Huamual Belakang District have received little scholarly attention. Based on the above explanation, it becomes evident that the development of an inter-island maritime transportation model in Huamual Belakang District is not merely a technical issue, but also encompasses economic, social, environmental, and governance dimensions. Accordingly, this study proposes the following research questions: (1) What are the existing conditions of infrastructure, facilities, and operational aspects of inter-island maritime transportation in Huamual Belakang District and what factors constitute the main constraints to its effectiveness?; (2) Which internal factors (strengths and weaknesses) and external factors (opportunities and threats) significantly influence the development of a sustainable maritime transportation system in Huamual Belakang District?; and (3) How can an optimal inter-island maritime

transportation model be formulated to meet community mobility needs, support the distribution of local commodities, and stimulate economic growth in Huamual Belakang District? Based on these considerations, this study aims to analyze existing conditions, identify the key determinants of effectiveness, and formulate an optimal maritime transportation development model that aligns with local needs and sustainability principles. This study seeks to contribute strategic recommendations for improving connectivity and accelerating economic development in disadvantaged archipelagic regions

LITERATURE REVIEW

Maritime Transportation Model Development Concept

Transportation model development is the process of designing a transportation system aimed at improving efficiency, affordability, and sustainability. In the context of inter-island maritime transportation, transportation model development includes analysis of technical, economic, social, and environmental aspects. One key approach is the gravity model, which predicts transportation flows based on population factors, the economic attractiveness of a region, and the distance between regions. In addition to the gravity model, optimization-based approaches such as linear programming are used to determine optimal shipping schedules, minimize operational costs, and meet logistics needs. Maritime transportation model development also involves the integration of information technology, such as satellite-based navigation systems and digital logistics data management. The use of this technology aims to increase transparency, accuracy, and efficiency in maritime transportation management.

A maritime transport model is a conceptual or mathematical representation used to analyze, plan, and optimize maritime transport systems. This model aims to systematically describe how the travel and distribution of goods or people occurs through waterways. A transport model encompasses four main stages: trip generation, trip distribution, mode selection, and network loading (Sulala et al., 2023). The first stage, trip generation, determines the number of trips made based on community needs and economic activity. Factors such as population, income level, and type of economic activity influence the number of trips generated in a region. The second stage, trip distribution, analyzes movement patterns between origin and destination regions. In maritime transportation, this distribution can be influenced by distance between ports, travel time, and transportation costs.

The third stage, mode selection, determines the type of transportation mode to be used for a particular trip. In the context of maritime transportation, mode choice can involve fast boats for passengers, ferries, or cargo ships for goods. The fourth stage, network assignment, allocates trips across available transportation routes. Technologies such as Geographic Information Systems (GIS) can be used to map shipping routes, analyze trip distribution, and optimize transportation networks.

Archipelagic Sea Transportation

As an archipelagic nation, Indonesia faces significant challenges in managing maritime transportation. This region, comprised of thousands of islands, requires an efficient and integrated maritime transportation system to support population mobility and the distribution of goods. These challenges include a lack of port infrastructure in remote areas, a limited shipping fleet, and often unpredictable natural conditions. Developing maritime transportation in archipelagic regions requires an integrated approach. The government, private sector, and local communities need to collaborate to create effective solutions. The development of small ports in remote areas is one solution to improve accessibility and connectivity between islands. Furthermore, procuring a fleet of ships appropriate to the region's geographic characteristics is also crucial to support population mobility and the distribution of goods (Kakerisa et al., 2023). Sustainability is also a key concern in managing maritime transportation in archipelagic regions. Efforts to reduce negative environmental impacts need to be implemented through the use of environmentally friendly technologies, such as low-emission fuel vessels, and the responsible management of shipping waste.

Factors Influencing Inter-Island Maritime Transportation

Inter-island maritime transportation is influenced by various interrelated factors, namely:

1. Geographic Factors
   Distance between islands, water conditions, and seabed topography are the main factors in planning shipping routes and the type of vessel used. Islands with limited or shallow water access require smaller vessels, while areas with greater distances between islands require vessels with larger capacities and greater cruising range.
2. Economic Factors

Demand for transportation services, operational costs, and public purchasing power influence the sustainability of maritime transportation operations. For example, maritime transportation in areas with high economic activity tends to be more developed than in remote areas with lower purchasing power.

3. Technological Factors
   The use of modern technology, such as advanced navigation systems, energy-efficient vessels, and digital-based applications for shipping management, can improve the efficiency and safety of maritime transportation.
4. Regulatory Factors
   Supportive government policies, such as fuel subsidies, shipping safety regulations, and environmental protection, play a crucial role in creating a sustainable maritime transportation system.
5. Social Factors
   Public perceptions of the safety, comfort, and reliability of maritime transportation modes also influence their usage levels.

METHOD

This study utilized a qualitative research design using a case study approach. This approach was considered appropriate for gaining an in-depth understanding of the dynamics involved in the development of an inter-island maritime transportation model in Huamual Belakang District, West Seram Regency. The data was collected through interviews, field observations, and document analysis. The research was conducted over a three-month period, from March to May 2025, beginning with preliminary observations and concluding with data analysis and reporting. The study area covered Huamual Belakang District, comprising of 7 villages and 27 hamlets. This location was selected due to its considerable maritime transportation potential in supporting inter-island community mobility.

Further, this study utilized both qualitative and quantitative data. The qualitative data were obtained from interviews, observations, and document reviews related to the condition of maritime transportation in the study area. The quantitative data, meanwhile, consisted of numerical information used to support the analysis, including the number of vessels, passenger volumes, and maritime transportation costs. The primary data were collected directly through interviews with relevant stakeholders, such as local government officials, maritime transport operators, and community members who used maritime transportation services. Secondary data were derived from official documents, previous studies, government reports, and other relevant references.

To ensure the accuracy and comprehensiveness of the data, several data collection techniques were employed, namely field observation, in-depth interviews, and questionnaires. Field observations were conducted to directly examine maritime transportation conditions, including port infrastructure, types of vessels in operation, transportation movement patterns, and the constraints faced by both operators and service users. In-depth interviews were carried out with representatives from the transportation agency, vessel operators, port managers, fishermen, and community members to capture perspectives on existing policies, operational challenges, and expectations for the future development of maritime transportation.

In addition, a structured questionnaire was designed using a Likert scale to obtain quantitative data on community perceptions of maritime transportation services. The questionnaire assessed key service attributes, including fare affordability, comfort, punctuality, and safety. To reduce response ambiguity, the original five-point Likert scale was modified into four response categories: strongly agree (4), agree (3), somewhat disagree (2), and disagree (1). After the relevant factors were identified, the data were analyzed using Internal Factor Analysis Summary (IFAS) and External Factor Analysis Summary (EFAS) matrices to support the Strength, Weakness, Opportunity, and Threat (SWOT) analysis.

RESULTS AND DISCUSSION

Maritime Transportation Infrastructure and Facilities in Huamual Belakang District

In an archipelagic setting, such as Huamual Belakang District, maritime transportation infrastructure is not merely a supporting facility but constitutes the backbone of community life, economic activity, and local governance. The relationship between island-based transport systems and infrastructure conditions is both symbiotic and determinative. A reliable maritime transportation system cannot exist without adequate infrastructure, while well-built infrastructure can only be sustained through orderly management and effective operational practices. Given the geographical characteristics of archipelagic regions, maritime transportation functions as the sole vital connective artery. Unlike mainland areas, which offer multiple transportation alternatives, island communities depend entirely on the condition of docks, vessel availability, and supporting facilities for their daily survival. Logistics distribution, access to emergency healthcare, and educational mobility are all closely linked to the performance of maritime

infrastructure. Empirical findings from the field reveal that damage to a single dock, such as that observed in Luhu, does not merely disrupt a single access point, but can sever supply chains and communication networks serving multiple islands. In extreme cases, such disruptions risk isolating entire communities and paralyzing local economic activity. Poor infrastructure conditions directly shape connectivity levels and logistics costs within the maritime transportation system. Damaged or undersized docks that cannot accommodate larger vessels compel operators to rely on smaller boats, which typically incur higher operating costs per unit of cargo. Moreover, the frequent occurrence of manual transshipment due to vessels being unable to berth properly increases waiting times and labor costs. The cumulative effect is the emergence of an inefficient, high-cost, and risk-prone transportation system that ultimately contributes to higher prices of basic goods in remote island communities. At the regency level, West Seram Regency is reported to have at least ten ports and docks distributed across various locations. Within Huamual Belakang District, which encompasses coastal areas and small islands, the ports most relevant to inter-island mobility include Manipa Port (Negeri Luhu Tubang), Waesala Ferry Port, and the Huamual Public Port (Negeri Luhu). This spatial distribution reflects an effort to support inter-island movement, although its capacity in reaching all villages within Huamual Belakang District requires further assessment.

From a technical perspective, all recorded docks are constructed of concrete and are officially classified as being in "good" condition. Nevertheless, their capacities vary considerably. For example, Hatu Port has a dock length of 123.8 meters and a total area of 16,443 m², indicating its potential role as a collector or hub port. In contrast, the Huamual Public Port serves a more localized function, with a dock length of only 42 meters and a total area of 950 m², which significantly limits loading and unloading capacity as well as the types of vessels that can be accommodated. Meanwhile, the availability of supporting facilities as an essential component of an effective maritime transportation system also shows uneven development. Several ports, including Hatu Port, Manipa Port, and Waipirit Port, are equipped with basic facilities, such as administrative offices, waiting areas, warehouses, sanitation facilities, and parking areas. Additional features, such as transmission towers at Hatu Port and Waesala Port and a prayer room at Waipirit Port, further enhance service quality. However, the privately managed Waisarisa Special Port is recorded as having no supporting facilities at all, which may pose practical constraints for service users and reduce overall system performance.

Factors Influencing the Effectiveness of Inter-Island Maritime Transportation in Huamual Belakang District

The effectiveness of inter-island maritime transportation in archipelagic areas, such as Huamual Belakang District, is strongly shaped by the condition of basic infrastructure and operational factors. The data indicate that limitations in dock length and port capacity significantly constrain loading and unloading volumes. Small-scale ports with dock lengths of less than 50 meters are typically able to serve only one to two vessels at a time (Ministry of Transportation, 2022). Further, a study by Mariyanto et al. (2021) confirmed that an imbalanced vessel-to-population ratio of approximately 1:1,916 results in suboptimal sailing frequency. The frequent breakdown of aging vessels, occurring three to four times per month, directly reduces effective carrying capacity by an estimated 30-40% (Maluku Transportation Agency, 2023).

Geographical and economic conditions also exert a determinant influence on system performance. Putri et al. (2020) reported that high-wave seasons lasting up to four months each year lead to the cancellation of as many as 60% of scheduled sailings. At the household level, affordability emerges as a critical constraint, as transportation costs account for 15–25% of monthly income (BPS, 2023). Lestari (2022) found that fluctuations in fuel prices translate directly into fare increases of around 8-12%, thereby further limiting population mobility. Moreover, fragmented management involving multiple stakeholders without integrated coordination has been shown to create service inefficiencies (Suryawan, 2021). These findings highlight the need for an integrated approach to improve the overall effectiveness of inter-island maritime transportation. Empirical evidence from the field suggests that several interrelated factors influence the effectiveness of inter-island maritime transportation in Huamual Belakang District, as discussed below:

1. Availability and Condition of Basic Infrastructure

The primary determinant is the physical condition and availability of docks and ports. The data shows that of the ten ports recorded at the regency level, only one is located directly in the district capital, namely the Huamual Public Port. This port has limited dimensions, with a dock length of 42 meters and a total area of 950 m², which is considerably smaller than Hatu Port, whose dock extends 123.8 meters with a total area of 16,443 m². Such capacity constraints directly affect both the volume and frequency of loading and unloading activities. Small ports are generally able to accommodate only one to two vessels simultaneously, whereas larger ports can serve three to four vessels at the same time. Similar limitations are evident in the availability of ports and small boat mooring facilities.

In Huamual Belakang District, facilities such as the Buano-Waesala Ferry Port and the North Buano -Masika Jaya small boat mooring play a vital role in sustaining inter-island connectivity. The travel distances involved, approximately 12.75 km and 10.72 km respectively, indicate that these maritime infrastructures serve medium-distance routes linking island communities with local economic centers. From a regional development perspective, the availability of port infrastructure constitutes a fundamental prerequisite for facilitating the movement of goods and services as well as population mobility (Maryaningsih et al., 2014). Adequate infrastructure of this kind directly supports local economic activities, particularly fisheries and inter-island trade, by reducing logistics costs and travel time (Hutasoit et al., 2024). However, the mere presence of infrastructure is insufficient without adequate quality and supporting conditions. Existing data largely report distance and location, while critical aspects such as the physical condition of facilities, harbor basin depth, dock availability, loading and unloading equipment, and road access to ports are not clearly documented. This lack of detailed information suggests potential quality-related challenges that may affect both operational efficiency and navigational safety within the inter-island maritime transportation system.

Table 1. Distance between Existing Ports in Huamual Belakang District

No.	Port / Boat Mooring Name	Distance (Km)	Distance (Mile)
1.	Buano Sea Port – Waisala Ferry Port	12.75	7.92
2.	North Buano Boat Mooring – Masik Jaya Boat Mooring	10.72	6.66

Source: Transportation Agency, 2025

2. Adequacy and Suitability of Transportation Fleet

According to data from the local Transportation Agency, the vessel-to-population ratio in Huamual Belakang District is highly imbalanced. Only 15 regular vessels serve a population of 28,742 residents (BPS, 2023), resulting in a ratio of approximately 1:1,916. In practical terms, a single vessel is required to serve nearly 2,000 residents. Moreover, around 60% of the operating fleet is over 15 years old, with breakdown frequencies reaching three to four incidents per vessel per month. This condition leads to frequent schedule disruptions, with an average of 8-12 sailing cancellations each month.

3. Geographical and Oceanographic Factors

Data from the Meteorology, Climatology, and Geophysics Agency (Badan MeteorologI, Klimatologi, dan Geofisika, BMKG) indicate that the area experiences a transportation low season lasting approximately four months, from December to March. During this period, average wave heights range between 2.5 and 4 meters, resulting in sailing cancellation rates of 40-60% compared to normal schedules. In addition, of the 17 villages in the district, only six villages (35%) are equipped with basic docks. The remaining 11 villages (65%) still rely on natural landing sites that can only be used under favorable tidal conditions, further constraining accessibility and operational reliability.

4. Availaibility of Supporting Facilities

In terms of supporting facilities, only about 30% of ports in the area are equipped with electronic scheduling information systems. The Huamual Belakang Public Port itself has only one waiting room with a capacity of 50 passengers, which is clearly inadequate given that daily passenger volumes can reach 150–200 people on peak days. Safety infrastructure is also limited, as only two of the six main ports are equipped with complete first-aid facilities. These shortcomings reduce service quality and increase operational and safety risks for passengers.

5. Economic and Affordability Factors

Field survey results show that maritime transportation costs account for approximately 15-25% of households' monthly income, with average inter-island fares ranging from IDR 75,000 to IDR 150,000 per trip. This relatively high cost of travel has behavioral implications, as 35% of respondents reported that they usually only take one to two non-emergency trips per period. In addition, fluctuations in fuel prices have a direct impact on fare levels. Each IDR 1,000 increase in fuel prices is associated with an 8-12% rise in passenger fares, further constraining mobility and access to services.

6. Regulatory and Institutional Factors

From an institutional perspective, the management of maritime transportation in Huamual Belakang District is fragmented among four different managing bodies, including the Kairatu Port Authority Unit (Unit Penyelenggara Pelabuhan, UPP), local government, and River, Lake, and Crossing Transportation (Angkutan Sungai, Danau, dan Penyeberangan, ASDP). This fragmentation contributes to service inefficiencies, particularly in scheduling and operational coordination. Weak inter-agency coordination is reflected in the lack of integrated timetables between ports, resulting in average waiting time discrepancies of two to three hours between arrivals and departures at connecting ports. Furthermore, only 8.5% of the Regional Budget, equivalent to approximately IDR 1.5 billion, is allocated to the maintenance of maritime transportation infrastructure within the total transportation budget of West Seram Regency.

7. Availability of Human Resources

Data from the Transportation Agency indicate that of the 45 crew members operating in the area, only about 60% hold official competency certificates. Crew turnover rates reach approximately 25% per year, largely due to low financial incentives, with average monthly wages ranging between IDR 1.8 and 2.5 million. This situation has direct implications for service quality, operational consistency, and overall safety standards.

8. Demand Factors and Mobility Patterns

Data from Statistics Indonesia (BPS) show that 75% of inter-island travel is driven by economic activities, particularly market-related purposes, while 15% is associated with education and healthcare needs, and the remaining 10% with social activities. Clear seasonal patterns are evident, with peak mobility occurring between June and August during the clove harvest season. During this period, passenger volumes increase by up to 45% compared to average months. However, the mismatch between transportation capacity and fluctuating demand results in overload levels of up to 30% during peak periods, highlighting structural inefficiencies in capacity planning and service provision.

A Maritime Transportation Model Supporting Local Economic Development in Huamual Belakang District

The development of an integrated maritime transportation model represents a fundamental prerequisite for accelerating local economic development in Huamual Belakang District. As an archipelagic region, the effectiveness of goods distribution and human mobility is highly dependent on the performance of the maritime sector. Mariyanto et al. (2021) demonstrated that an appropriately designed transportation model can increase the volume of goods handled at ports by up to 35%, thereby directly reducing logistics costs. Accordingly, any proposed model must be grounded in local geographic characteristics, economic potential, and existing infrastructure constraints in order to create a transportation system that is both reliable and affordable for communities and economic actors.

The first model proposed is the development of a hub-and-spoke port system. In this framework, Hatu Port in Piru Village functions as the primary hub, connected to feeder ports such as Manipa Port and Huamual Public Port in Luhu Village. From a technical perspective, Hatu Port has a total area of 16,443 m² and a dock length of 123.8 meters, enabling it to accommodate larger vessels from outside the region. Manipa Port, with an area of 3,759 m², can be optimized as a collection point for agricultural and fisheries commodities from surrounding villages. Cargo consolidation at the main hub is expected to improve operational efficiency and reduce distribution costs by up to 25% (Ministry of Transportation, 2022). The second model proposed involves integrating maritime transportation with the supply chains of key local commodities. Huamual Belakang District has substantial production potential, including capture fisheries estimated at 4,500 tons per year and clove production of approximately 1,200 tons per year (Statistics Indonesia of West Seram Regency, 2023). However, disruptions along the supply chain mean that only around 40% of this output is currently marketed beyond the local area. This model requires vessel scheduling that aligns with harvest seasons, supported by the provision of cold storage facilities at feeder ports. A research by Putri et al. (2020) showed that cold-chain logistics integration can reduce post-harvest losses in fisheries from 30% to below 10%, while simultaneously increasing added values for local fishermen.

Affordability and cross-subsidy mechanisms constitute the third pillar of a sustainable maritime transport model. The data by Statistics Indonesia (2023) confirm that transportation costs still absorb between 15-25% of household income in the district. To address this issue, a cross-subsidy scheme in which commercially viable routes (such as Hatu-Ambon) subsidize socially essential routes to remote islands can help ensure equitable access. Suryawan (2021) recommended the application of a Public Service Obligation (PSO) mechanism financed through the Regional Budget, which has proven effective in stabilizing fares and increasing sailing frequency by up to 50%

on non-commercial routes in 3T regions. Institutional strengthening is a determinant factor in ensuring the sustainability of this integrated model. The current fragmentation of management among entities such as UPP Kairatu and the local government has resulted in operational inefficiencies. The establishment of a Huamual Belakang Maritime Transportation Management Authority, responsible for integrated planning, fare setting, and scheduling, is expected to address these coordination challenges. Evidence from Lestari (2022) who conducted her study in the context of the island regions of East Nusa Tenggara indicated that similar integrated institutional arrangements were able to reduce intermodal waiting times from three hours to one hour and increase user satisfaction by 40%.

The economic impacts of implementing this integrated transportation model are projected to be substantial. Simulation studies suggest that a 20% reduction in logistics costs could increase profit margins for fisheries products by approximately 15% and stimulate the emergence of 8-10 new micro and small enterprises annually (Bappenas, 2023). Improved connectivity would also open access to marine tourism destinations on small islands such as Buano, which possess significant potential but have long been constrained by limited transportation access. According to the West Seram Tourism Agency (2023), every additional 1,000 tourist visits can generate around 25 new jobs and stimulate economic activity in coastal villages. In this context, it can be argued that a maritime transportation model capable of supporting local economic development in Huamual Belakang District must be multidimensional, encompassing infrastructure development, supply chain integration, affordability mechanisms, and institutional capacity. The combined implementation of a hub-and-spoke system, integrated commodity logistics, and cross-subsidy schemes, supported by strong institutions and appropriate technology, offers a viable response to connectivity challenges while acting as a catalyst for sustainable local economic growth. Sustained commitment from local governments, along with collaboration involving the private sector and local communities, will be essential to ensure the successful transformation of the maritime transport system and the long-term prosperity of this archipelagic region.

SWOT Analysis of the Development of an Inter-Island Maritime Transportation Model in Huamual Belakang District, West Seram Regency

A SWOT analysis was employed to systematically examine the internal and external factors influencing the development of an inter-island maritime transportation model in Huamual Belakang District. This analysis provides a structured basis for formulating strategies that are responsive to local conditions while remaining aligned with broader policy and environmental contexts.

A. Strength

- Availability of Basic Port Infrastructure

Several ports in the area are technically classified as being in "good" condition, notably Hatu Port, with a dock length of 123.8 meters, and Manipa Port, both of which have the potential to serve as the backbone of the local maritime transportation system (Maluku Transportation Agency, 2023).

- Strategic Geographic Position

From a spatial perspective, Huamual Belakang District occupies a strategic geographic position in the heart of the Maluku Islands. This location provides inherent advantages for its development as a regional logistics node capable of linking surrounding islands and facilitating inter-island trade flows.

- Strong Local Economic Potential

Huamual Belakang District is supported with significant local economic potential. Capture fisheries production is estimated at 4,500 tons per year, while clove production reaches approximately 1,200 tons per year. These commodities require a reliable and efficient distribution system to maximize their economic value (Statistics Indonesia of West Seram Regency, 2023).

- Presence of A Multi-Stakeholder Institutional Framework

Institutionally, the presence of multiple stakeholders, including UPP, local government, and ASDP, indicates that maritime transportation has received attention from various levels of governance. Although currently fragmented, this institutional diversity provides a foundation that can be consolidated into a more integrated management framework.

B. Weakness

- Disparity in Infrastructure Capacity among Feeder Ports

A significant disparity exists between the capacity of the main hub port and that of feeder ports. For example, while Hatu Port functions as a major hub, the Huamual Public Port has an area of only 950 m², limiting its role in the supply chain and reducing overall system efficiency (Maluku Transportation Agency, 2023).

- Limited Fleet Availability and Sailing Frequency

The vessel-to-population ratio stands at approximately 1:1,916, and around 60% of the fleet consists of aging vessels. These conditions contribute to low sailing frequency and unreliable schedules (Maluku Transportation Agency, 2023).

- Inadequate Supporting Facilities

Supporting facilities at feeder ports are insufficient, particularly with respect to cold storage, passenger waiting areas, and electronic scheduling information systems.

- High Transportation Operating Costs

Transportation costs account for 15-25% of household income, placing a substantial burden on the local economy and limiting mobility (Statistics Indonesia, 2023).

- Fragmented Management Across Institutions

Weak coordination among multiple managing entities, such as UPP, local government, and private operators, creates inefficiencies and results in policies that are neither synchronized nor mutually reinforcing (Suryawan, 2021).

C. Opportunity

- National Policy Support

At the national level, policy support is available through programs such as PSO schemes and Village Funds, which can be allocated for fare subsidies and infrastructure maintenance (Lestari, 2022).

- Increased Commodity Added Values

Integrating maritime transportation with supply chains and cold storage facilities can reduce post-harvest losses and increase the selling price of local products by up to 15% (Putri et al., 2020).

- Marine Tourism Development Potential

Improved connectivity further opens opportunities for the development of marine and island-based tourism. Enhanced access to small islands can generate new employment opportunities and stimulate local economies (West Seram Tourism Agency, 2023).

- Innovative Partnership Models

Public-Private-Community Partnership (Kemitraan Pemerintah-Swasta-Masyarakat, KPSM) could be developed to improve the professional management of ports and fleets.

D. Threat

- Natural Conditions and Climate Change

High-wave seasons lasting approximately four months (December-March) can lead to the cancellation of up to 60% of scheduled sailings, disrupting supply continuity (BMKG, 2023).

- Macroeconomic Pressures

Fluctuations in fuel prices directly translate into fare increases of 8-12%, further straining economic limitations (Lestari, 2022).

- Population Dynamics

Outmigration of productive-age populations to bigger cities, driven by isolation and limited employment opportunities, may gradually reduce the local human resource potential.

- Human Resource Competence and Regulatory Constraints

Only about 60% of vessel crews possess formal competency certification, and regulatory complexities may hinder efforts to improve service quality and safety standards (Maluku Transportation Agency, 2023).

- Dependence on Central Government Funding

The sustainability of development programs remains vulnerable to shifts in national budget priorities and policy directions, which may affect the consistency of State Budget allocations.

Analysis of SWOT-Based Strategies for the Development of an Inter-Island Maritime Transportation Model in Huamual Belakang District, West Seram Regency

Building on the SWOT analysis, this study formulates strategic directions that integrate internal capacities with external conditions. The resulting strategies are structured to support a resilient, inclusive, and economically supportive maritime transportation system for Huamual Belakang District.

- *S-O (Strength-Opportunity) Strategy*

The S-O strategy emphasizes the optimal use of existing strengths to capture available opportunities. In this context, relatively adequate port infrastructure and substantial local economic potential can be leveraged through the adoption

of supportive technologies and policies. One concrete approach is the development of Hatu Port as a digitally enabled smart hub, integrated with cold-chain facilities for fisheries products. This mechanism would allow the port to function not only as a transit point, but also as a value-adding logistics node by utilizing PSO funds.

- *W-O (Weakness-Opportunity) Strategy*

The W-O strategy focuses on addressing internal weaknesses by capitalizing on external opportunities. Institutional fragmentation, which currently limits system efficiency, can be mitigated through the establishment of an Integrated Maritime Transportation Management Authority. This body would consolidate institutional fragmentations and at the same time, opportunities for public–private partnerships can be harnessed to attract private investment for fleet expansion and the construction of cold storage facilities.

- *S-T (Strength-Threat) Strategy*

The S-T strategy seeks to use internal strengths to reduce exposure to external threats. Huamual Belakang District's strategic geographic position and existing infrastructure provide a foundation for designing shipping routes that are more resilient to adverse weather conditions. In parallel, systematic training and certification of local human resources are essential to enhance the overall resilience of the maritime transport system.

- *W-T (Weakness-Threat) Strategy*

The W-T strategy represents a defensive approach aimed at minimizing weaknesses while avoiding or reducing the impact of external threats. Preventive maintenance and gradual capacity upgrades at feeder ports are critical to reducing vulnerability to damage caused by extreme weather events. These technical measures should be complemented by the design of affordable maritime transport insurance schemes, which can protect fishermen and small traders from economic shocks arising from fuel price fluctuations. In relation to the preceding findings, the Internal Factor Evaluation (IFE) matrix can be delineated as follows:

Table 2. IFE Matrix for the Development of Inter-Island Maritime Transportation in Huamual Belakang District, West Seram Regency

No.	Internal Factor	Weight (0.0 - 1.0)	Rating (1-4)	Score (Weight x Rating)
A. STRENGTH				
1.	Availability of basic port infrastructure	0.15	4	0.60
2.	Strategic geographic position	0.12	3	0.36
3.	Strong local economic potential	0.13	4	0.52
4.	Presence of a multi-stakeholder institutional framework	0.08	2	0.16
B. WEAKNESS				
1.	Disparity in infrastructure capacity among feeder ports	0.14	1	0.14
2.	Limited fleet availability and sailing frequency	0.12	1	0.12
3.	Inadequate supporting facilities	0.10	2	0.20
4.	High transportation operating costs	0.11	1	0.11
5.	Fragmented management across institutions	0.05	2	0.10
	Total			**2.31**

Source: Research findings, 2025

The IFE results presented above yield a total score of 2.31, which is slightly above the average benchmark on the 1-4 scale, where 2.5 represents the midpoint. This score indicates that, overall, internal strengths currently outweigh internal weaknesses, although the margin remains modest and signals the need for substantial improvement. Among the identified strengths, the availability of basic port infrastructure (0.60) and strong local

economic potential (0.52) emerge as the most influential factors. These two elements should therefore serve as the primary foundation for formulating future development strategies. Conversely, the most critical internal weaknesses are reflected in the pronounced disparity in infrastructure capacity among feeder ports (0.14) and the limited fleet availability and sailing frequency (0.12). These weaknesses directly constrain system performance and reliability, and thus require priority intervention within the transportation development agenda. Based on these internal conditions, the analysis proceeds with the construction of the External Factor Evaluation (EFE) matrix, which is presented in the following section.

Table 3. EFE Matrix for the Development of Inter-Island Maritime Transportation in Huamual Belakang District, West Seram Regency

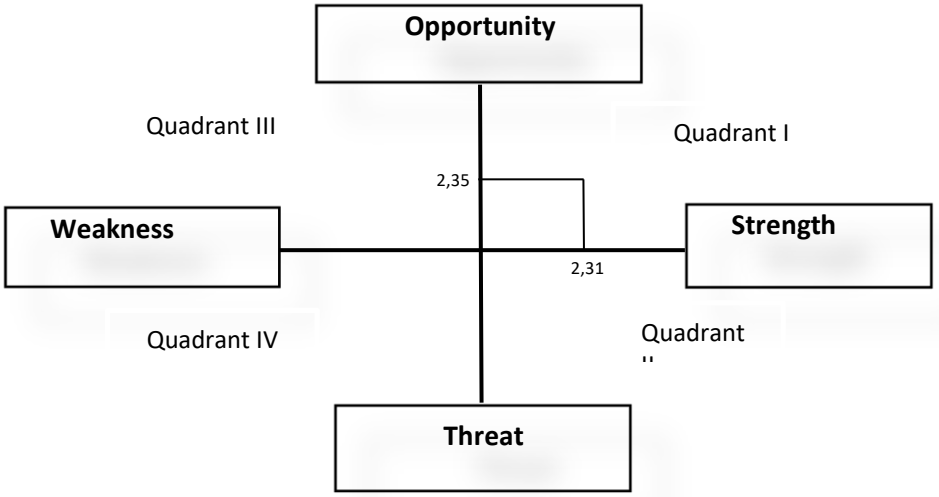
No.	External Factor	Weight (0.0 -1.0)	Rating (1-4)	Score (Weight x Rating)
C. OPPORTUNITY				
1.	National policy support	0.16	3	0.48
2.	Digital technology convergence	0.15	4	0.60
3.	Increased commodity added values	0.13	3	0.39
4.	Marine tourism development potential	0.09	2	0.18
5.	Innovative partnership models	0.07	2	0.14
D. THREAT				
1.	Natural conditions and climate change	0.14	1	0.14
2.	Macroeconomic pressures	0.11	2	0.22
3.	Population dynamics	0.06	1	0.06
4.	Human resource competence and regulatory constraints	0.05	2	0.10
5.	Dependence on central government funding	0.04	1	0.04
Total				**2.35**

Source: Research findings, 2025

The resulting EFE score of 2.35 is very close to the midpoint of the scale (2.5), indicating that external opportunities slightly outweigh existing threats, although the region's overall response to these external factors remains marginally below the average level. Further, among the identified opportunities, digital technology convergence emerges as the most influential factor (0.60). This result reflects a substantial potential for technological leapfrogging in the delivery of inter-island maritime transportation services. Furthermore, national policy support constitutes the second most significant opportunity (0.48). These policy frameworks offer strategic leverage for securing financial resources and stabilizing tariffs.

Despite these favorable prospects, several external threats remain pronounced. Natural conditions and climate change represent the most critical threat (0.14), as they directly disrupt sailing operations and service continuity. In addition, macroeconomic pressurespose a high-impact threat (0.22) by increasing operational costs and further constraining service affordability.

Figure 1. SWOT Analysis of the Development of Inter-Island Maritime Transportation Model in Huamual Belakang District, West Seram Regency



Source: Research findings, 2025

Based on the results of the IFE and EFE analyses, the development of inter-island maritime transportation in Huamual Belakang District, West Seram Regency, can be advanced through the following strategic directions:

Table 4. Inter-Island Maritime Transportation Development Strategies

Development Strategy	Description
Strategic positions within the concentrated growth quadrant	The total IFE score of 2.31 and EFE score of 2.35 place Huamual Belakang District in the growth and stability quadrant. This position indicates that the area possesses a relatively solid internal foundation amid promising external opportunities, although overall performance has not yet reached an optimal level. An IFE score of 2.31 reflects that existing internal strengths, particularly the availability of core port infrastructure and local economic potential, are sufficient to offset key weaknesses, such as infrastructure disparities and limited fleet capacity. Meanwhile, the EFE score of 2.35 suggests that the region's ability to respond to external conditions remains at an average level, where opportunities related to digitalization and policy support have been recognized but not yet fully leveraged.
Dominance of internal factors supported by local economic potentials	The internal factor analysis highlights that the strongest elements lie in the availability of basic infrastructure, with a score of 0.60, and local economic potential, with a score of 0.52. These findings indicate that Hatu Port and Manipa Port function as strategic assets capable of serving as the backbone of the transportation system. Capture fisheries production of approximately 4,500 tons per year and clove production of about 1,200 tons per year constitute the main economic drivers linking transportation demand to tangible economic activities. Nevertheless, the low score for infrastructure capacity disparities (0.14) signals uneven development between primary ports and feeder ports, which constrains overall system efficiency.
Digitalization opportunities as a game changer for the transportation system	External factor analysis identifies digitalization as the most prominent opportunity, with the highest score of 0.60, indicating that technological convergence is widely perceived as a transformative solution for improving connectivity. The development of E-Sampan platform has the potential not only to enhance transparency and operational efficiency, but also to foster an integrated digital ecosystem linked to the marketing of local products. National policy support, reflected in a score of 0.48, further reinforces this opportunity, suggesting that instruments such as PSO schemes and Village

	Funds can act as catalysts for accelerated development if implemented in a targeted and sustainable manner.
Operational threats requiring comprehensive mitigation strategies	The most significant threat arises from natural conditions and climate change, which received a score of 0.14 and represent the vulnerability of maritime transportation operations during periods of high waves. This immutable geographic characteristic necessitates adaptive strategies, including vessel design modification, route reconfiguration, and the establishment of early warning systems. Macroeconomic pressures, with a score of 0.22, further compound these challenges, as fuel price fluctuations that translate into 8–12% increases in operating costs impose a structural burden that undermines service affordability for local communities.
Priority strategies based on quantitative analysis	Based on strategic mapping, the S-O strategy, with a score range of 0.75–0.80, emerges as the top priority, as it capitalizes on the optimal combination of existing strengths and external opportunities. Initiatives, such as digitalizing hub ports and integrating cold-chain logistics, are strategic actions capable of generating multiple benefits, both in terms of transportation efficiency and increased economic value of local commodities. The W-O strategy, with scores ranging from 0.25–0.75, ranks as the second priority, serving as a corrective approach to address structural weaknesses through institutional consolidation and fleet expansion.
Resource-based implementation and a realistic timeline	A phased implementation plan structured into three stages reflects a realistic and measurable approach. Prioritizing digitalization and institutional consolidation in the first year establishes a critical foundation before progressing to vessel modification and energy diversification in subsequent years. Budget allocations of IDR 3.5 billion for digitalization and IDR 2.1 billion for institutional consolidation demonstrate an appropriate balance, positioning technological investment as a priority while acknowledging the central role of institutional reform as a key enabling factor.
Performance targets and indicators of success	Defined performance targets, such as a 25% increase in vessel occupancy rates, a 20% reduction in post-harvest losses, and a 40% decrease in waiting times, are specific, measurable, and directly aligned with existing challenges. The projected achievement period of 1–2 years reflects an awareness of the urgency for improvement without compromising technical feasibility. Furthermore, projections to raise the IFE score to 2.8 and the EFE score to 2.9 within three years indicate a grounded optimism rooted in well-planned strategic interventions.
Sustainability and long-term impacts	This analysis extends beyond immediate outcomes to emphasize long-term sustainability through defensive and sustainable W-T strategies. Preventive maintenance programs and human resource development are framed as long-term investments that ensure the durability of the transportation system. Such a comprehensive approach is expected not only to address transportation constraints, but also to serve as a catalyst for inclusive and sustainable local economic development in Huamual Belakang District.

Source: Research findings, 2025

Analysis of the Development of an Inter-Island Maritime Transportation Model in Huamual Belakang District, West Seram Regency

The development of an effective maritime transportation system in archipelagic regions is a fundamental prerequisite for economic growth and the improvement of community welfare. In Huamual Belakang District, efforts to develop an inter-island maritime transportation model face multifaceted challenges that require an integrated approach. Drawing on port technical data and the area's geographical characteristics, this study analyzes the development of a comprehensive transportation model by considering infrastructure, operational, institutional, and economic dimensions. Mariyanto et al. (2021) emphasized that a well-designed transportation model can improve supply chain efficiency by up to 35% in 3T regions, underscoring the strategic importance of appropriate system design. The existing condition of maritime transportation infrastructure reveals a pronounced disparity between main ports and feeder ports. Technical data indicate that Hatu Port, functioning as the primary hub, is equipped with a 123.8-meter dock and a total area of 16,443 m², whereas Huamual Public Port has a dock length of only 42 meters and an area of 950 m² (Maluku Transportation Agency, 2023). This imbalance constrains loading and unloading

capacity and limits the ability to accommodate larger vessels. Suryawan (2021) demonstrated that such infrastructure disparities can increase logistics costs by 25-30% due to inefficient transshipment processes, thereby weakening overall system performance. From a connectivity perspective, the implementation of an integrated hub-and-spoke model is both feasible and appropriate, with Hatu Port serving as the central hub linked to feeder ports in Manipa, Waesala, and local community ports. This model enables cargo consolidation and route optimization, aligning transportation supply with actual demand patterns. Data from Statistics Indonesia (2023) show that approximately 75% of inter-island travel converges toward the regency capital, indicating that the hub-and-spoke approach is consistent with prevailing mobility trends. Similar applications in the Riau Islands, implemented by the Ministry of Transportation (2022), resulted in a 50% increase in sailing frequency on non-commercial routes, further supporting the relevance of this model.

Integrating maritime transportation with the supply chains of leading local commodities constitutes a critical component of the proposed development model. Huamual Belakang District records capture fisheries production of approximately 4,500 tons per year and clove production of around 1,200 tons per year (Statistics Indonesia of West Seram Regency, 2023). However, disruptions in the supply chain mean that only about 40% of this output is distributed optimally. The proposed model, therefore, requires synchronization between vessel schedules and harvest seasons, supported by the provision of cold storage facilities at feeder ports. Empirical evidence from Putri et al. (2020) showed that cold-chain logistics integration can reduce post-harvest losses in fisheries from 30% to below 10%. Further, affordability remains a central concern, given that transportation costs still account for 15-25% of household income (Statistics Indonesia, 2023). To address this issue, cross-subsidy mechanisms through PSO schemes are necessary to maintain affordable tariffs on non-commercial routes. Experience from East Nusa Tenggara documented by Lestari (2022) indicated that allocating 5-7% of the Regional Budget to PSO programs can stabilize fares and increase sailing frequency on remote routes by up to 40%.

Furthermore, institutional challenges, particularly the fragmentation of management among UPP Waisarisa, local government, and private operators, further complicate system performance. Institutional restructuring through the establishment of a Huamual Belakang Maritime Transportation Management Authority, responsible for integrated planning, tariff setting, and scheduling, is proposed as a solution to coordination gaps. Suryawan (2021) provided empirical support for this approach, showing that integrated institutional models can reduce intermodal waiting times from three hours to one hour and increase user satisfaction by 40%. The utilization of digital technology through the development of E-Sampan platform, integrating ticket booking, vessel tracking, and logistics services, offers a transformative opportunity to enhance accessibility and efficiency. Similar systems implemented in Southeast Maluku by the Ministry of Transportation (2022) increased vessel occupancy rates from 65% to 85% within six months. Beyond transportation services, E-Sampan can be linked to local product marketing, fostering a comprehensive digital ecosystem that supports the growth of micro, small, and medium enterprises (MSMEs).

The projected economic impacts of implementing an integrated transportation model are substantial. Simulation studies suggest that a 20% reduction in logistics costs could increase profit margins for fisheries products by approximately 15% and stimulate the creation of 8-10 new MSMEs annually (Bappenas, 2023). Improved connectivity would also facilitate the development of marine tourism in small islands, such as Buano Island. According to the West Seram Tourism Office (2023), every additional 1,000 tourist visits has the potential to generate 25 new jobs, thereby contributing to local economic diversification. Based on this comprehensive analysis, the development of an inter-island maritime transportation model in Huamual Belakang District requires an integrated approach encompassing infrastructure upgrading, route optimization, supply chain integration, affordability assurance, institutional restructuring, and technological innovation. The implementation of an integrated hub-and-spoke model, supported by PSO policies and digital platforms, is projected to address connectivity challenges while simultaneously acting as a catalyst for local economic growth. Sustained commitment from local government, combined with multi-stakeholder collaboration, will be critical to the successful transformation of the maritime transportation system in this archipelagic region.

CONCLUSION

Based on the findings of this study, the maritime transportation in Huamual Belakang District faces multidimensional challenges that contribute to territorial isolation and constrain local economic activity. These challenges are reflected in pronounced disparities in port capacity between the main hub and smaller feeder ports, an imbalanced vessel-to-population ratio, high operational costs, and fragmented institutional arrangements among key stakeholders. At the same time, Huamual Belakang District possesses considerable local economic potential, particularly in the fisheries and clove sectors, alongside favorable external opportunities in the form of national

policy support and the convergence of digital technologies. The SWOT analysis positions Huamual Belakang District within a growth-oriented quadrant, indicating that existing strengths and opportunities can serve as a foundation for systemic transformation, although external risks such as prolonged high-wave seasons and fuel price volatility must be carefully anticipated. Therefore, the recommended development strategy emphasizes an integrated approach. This includes institutional consolidation through the establishment of a unified management body, the implementation of a hub-and-spoke model with Hatu Port serving as the primary node, and the integration of leading commodity supply chains supported by cold storage facilities. Cross-subsidy mechanisms and the application of PSO schemes are essential to ensure tariff affordability, particularly on non-commercial routes. In addition, strengthening human resource capacity, promoting the adoption of environmentally friendly vessels, and fostering partnerships among government, the private sector, and local communities are identified as key supporting factors. With holistic and sustained implementation, a reliable and affordable maritime transportation system is expected to become the backbone of connectivity and a catalyst for inclusive and sustainable economic development in this archipelagic region.

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