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# Developments, Challenges, and Opportunities of Ro-Ro Ships in Maritime Transportation in Indonesia

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***Abstract***. *This study aims to analyze the development, challenges, and opportunities of Ro-Ro ships in the maritime transportation system in Indonesia. As an archipelagic country, Indonesia needs an efficient mode of sea transportation to connect areas between islands. The method used is a mixed approach, with quantitative analysis of shipping statistics and vehicle volume, as well as qualitative analysis through in-depth interviews with stakeholders. Data were analyzed using descriptive statistics and thematic analysis. The results of the study show that Ro-Ro ships have advantages in loading and unloading efficiency and travel time, especially on congested routes such as Merak-Bakauheni and Ketapang-Gilimanuk. However, there are major challenges in the aspects of port infrastructure, licensing regulations, and digitization of public services. This study recommends investment in port infrastructure, bureaucratic simplification, and the development of strategic routes and digital information systems to support the optimization of Ro-Ro ships as an efficient and sustainable mode of maritime transportation in Indonesia.*

***Keywords***: *Ro-Ro ships, maritime transportation, logistics, ports, transportation policy*

## 1. INTRODUCTION

Indonesia as the world's largest archipelagic country, with more than 17,000 islands spread from Sabang to Merauke, faces major challenges in building connectivity between regions. Complex geographical conditions make sea transportation the main backbone in the national logistics system, especially in reaching remote areas that are not served by land and air transportation modes (Puriningsih, 2019). In the midst of the government's efforts to strengthen the national maritime axis, Ro-Ro (Roll-on/Roll-off) ships are present as an efficient solution in supporting the smooth distribution of goods and human movement between islands quickly and flexibly (Noor, 2017). These vessels allow motorized vehicles to board and disembark without complex loading and unloading processes, thereby speeding up docking times and significantly lowering operational costs.

However, the use of Ro-Ro ships in Indonesia still faces various structural and technical obstacles. One of the main challenges is the uneven limitation of port infrastructure, especially in the eastern region of Indonesia, where there are still many ports that are not equipped with adequate facilities such as Ro-Ro special piers, modern loading and unloading equipment, and adequate supporting road access (Budisiswanto, 2023; Hadi, 2020). On the other hand, institutional and regulatory aspects also affect the operational effectiveness of Ro-Ro ships. The complexity of licensing bureaucracy and overlapping authority between agencies often cause uncertainty in the management of shipping routes and schedules (Buchari & Victoria, 2021; Silambi et al., 2022).

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The presence of Ro-Ro ships should be able to leverage local economic growth through logistics cost efficiency and market expansion of regional products. However, until now, the implementation of the concept has not been fully optimal, especially on non-commercial routes that require subsidies or government policy intervention. At the same time, the sea toll program and national logistics policy still tend to focus on major ports and containerization, so the Ro-Ro mode has not received commensurate attention in the grand map of national sea transportation development (Kusuma & Tseng, 2019; Berawi et al., 2019).

This study aims to comprehensively analyze the development of Ro-Ro ships in Indonesian marine transportation with a focus on infrastructure, institutional, and socio-economic potential. Through a descriptive approach and empirical analysis, this research also aims to identify the challenges faced as well as strategic opportunities that can be utilized in the development of an integrated and sustainable Ro-Ro transportation system.

Previous studies on sea transportation in Indonesia have emphasized more on major ports and containerization (Ridwan & Sunaryo, 2019; Saputra & Rijanto, 2021), while research that specifically discusses the development of Ro-Ro ships is still limited and generally descriptive. The lack of comparative studies between routes, the lack of operational cost-benefit analysis, and the lack of systematic mapping of institutional barriers make this theme have significant research gaps. In addition, there has been no study that directly links Ro-Ro ships to the optimization of the local tourism and agricultural sectors, even though both have a high dependence on efficient ocean logistics accessibility (Kambu & Bisay, 2023; Sulistyowati et al., 2021).

This research is expected to contribute in three main aspects. First, theoretically, this study enriches the treasure of maritime transportation science by highlighting the Ro-Ro mode as an important element in Indonesia's inclusive and adaptive marine logistics system. Second, practically, the results of this research can be a reference for the government in designing efficient infrastructure development policies and Ro-Ro transportation governance, especially in simplifying regulations and distribution of infrastructure investment. Third, socio-economically, this study can show how the use of Ro-Ro ships can encourage inter-regional connectivity, reduce distribution costs, and improve the welfare of the archipelago community equally (Ndraha et al., 2024; Gitasari & Handayeni, 2021).

Through a deeper understanding of the operational dynamics of Ro-Ro vessels and the challenges faced in the field, this research can also serve as a basis for the development of implementing strategies in areas that are not currently integrated into the Ro-Ro shipping

network. In addition, the results of this study can help the business world in making investment decisions in the shipping and marine logistics sector, as well as provide recommendations in order to improve the quality of public services for sea transportation as a whole (Ningsih & Utami, 2022; Asnawi & Handayeni, 2021).

Finally, this study seeks to fill the gap between the concept of ideal marine transportation planning and the reality of implementation in the field, especially related to the management and operation of Ro-Ro ships. By prioritizing an integrative and data-driven thematic approach, this research contributes to building a strong scientific and policy foundation to encourage a resilient and competitive national sea transportation system (Lesmana & Widiyarta, 2022; Tentowi, 2019).

## 2. LITERATURE REVIEW

Maritime transportation has a vital role in economic development and regional equity, especially for archipelagic countries such as Indonesia. According to transportation system theory, sea transportation modes are an important component in connecting logistics nodes and supporting supply chain efficiency (Berawi et al., 2019). In this context, Ro-Ro (Roll-on/Roll-off) ships are positioned as a strategic mode that is able to bridge the need for simultaneous mobility of vehicles and goods between islands. This concept refers to the efficiency of loading and unloading time and the flexibility of the cargo carried by the ship, thus providing a comparative advantage over conventional cargo ships (Noor, 2017).

In general, Ro-Ro ships belong to a special category of ships that are equipped with ramps or dock doors to facilitate vehicles entering and exiting without additional means of transport. This is in accordance with the basic principle of intermodal in the logistics system, namely the ability to integrate between modes of transportation to accelerate distribution and reduce logistics costs (Kusuma & Tseng, 2019). The existence of Ro-Ro ships is part of the transformation of the national marine transportation system towards a more responsive, flexible, and integrated model with the hinterland region. In this perspective, ports serve not only as transport nodes, but also as regional distribution centers.

In terms of regulation, the development of sea transportation – including Ro-Ro ships – cannot be separated from the aspects of public policy and the national legal framework. Transportation policy theory emphasizes the importance of cross-sector coordination and simplification of regulations so that transportation modes can develop optimally (Buchari & Victoria, 2021). In the Indonesian context, there are still obstacles in the form of overlapping authority, long bureaucracy, and differences in service standards between ports,

which have an impact on the operational efficiency of Ro-Ro ships on various routes (Silambi et al., 2022). This shows that institutional and governance improvements are important prerequisites in supporting the development of this mode.

Several previous studies have highlighted the port infrastructure aspect as a key factor in the effectiveness of Ro-Ro transportation. Hadi (2020) stated that secondary ports in Indonesia are still not ready in terms of physical facilities, ranging from the depth of the pool, the length of the pier, to the loading and unloading equipment that supports Ro-Ro ships. This is strengthened by the findings of Budisiswanto (2023), which shows that the port of Tanjung Priok still faces challenges in the integration of multimodal modes, so it requires a more adaptive and data-based approach to logistics planning.

In terms of logistics efficiency, Saputra and Rijanto (2021) introduced the concept of automatic guided vehicles (AGV) for container terminals, which can actually also be applied in Ro-Ro terminals to reduce loading and unloading process time. These findings open up opportunities for the integration of automation technology in the Ro-Ro ship system, thereby strengthening the competitiveness of Indonesian ports in the face of global competition and increasing domestic logistics demand. The implementation of this system must also be supported by competent human resources and qualified digital infrastructure.

On the other hand, some studies highlight the importance of the relationship between marine transportation and the development of other sectors, such as fisheries and tourism. Kambu and Bisay (2023) show that the efficiency of the marine product logistics chain is highly dependent on fast and affordable modes of sea transportation. Ro-Ro vessels have great potential in the distribution of fishery products from coastal areas to consumption centers, thereby shortening delivery times and reducing damage to goods. In the tourism sector, Sulistyowati et al. (2021) found that the comfort, punctuality, and quality of ship services have a direct effect on tourists' interest in using sea modes, especially for archipelago destinations such as Karimunjawa.

The study of demand dynamics and community mobility patterns is also the basis for Ro-Ro route planning. Asnawi and Handayeni (2021) noted the importance of planning transportation facilities that support intermodal movement, such as parks and rides in urban areas. Meanwhile, Gitasari and Handayeni (2021) show that the implementation of congestion pricing-based tariff policies can influence users' decisions to switch modes, which indirectly opens up opportunities for increased demand for marine modes such as Ro-Ro ships on congested cross-island routes.

Meanwhile, in terms of payments and public services, Lesmana and Widiyarta (2022) revealed that technology such as QRIS can improve transaction efficiency in public transportation. The application of similar technology in the Ro-Ro ship ticket reservation and payment system will help drive the digitalization of the national shipping sector. This is in line with the digital transformation echoed in the marine transportation bureaucratic reform.

As for the institutional perspective, Ndraha et al. (2024) emphasized the importance of transparency and public participation in the management of public services, including the transportation sector. With increasing public awareness of the rights of service users, Ro-Ro ship operators need to prioritize accountable and needs-based services. This includes not only safety and convenience factors, but also open access to information, predictable schedules, and professional complaint management.

Based on the theoretical description and previous studies, it can be concluded that the development of Ro-Ro ships in Indonesia is not only a technical problem of shipping, but involves structural, policy, social, and technological dimensions simultaneously. Therefore, a holistic approach is needed in reviewing and designing the national Ro-Ro transportation system, which bridges economic interests, logistics efficiency, and equitable access between islands in a sustainable manner.

## 3. RESEARCH METHODS

This study uses a mixed methods approach that combines quantitative and qualitative methods to provide a comprehensive understanding of the development, challenges, and opportunities of Ro-Ro ships in the maritime transportation system in Indonesia. Quantitative methods were used to analyze secondary statistical data regarding the number of Ro-Ro ships, shipping frequency, transport capacity, and volume of goods and vehicles transported on several main routes, such as Surabaya-Lombok, Merak-Bakauheni, and Ketapang-Gilimanuk. Data is collected from official sources such as the Ministry of Transportation, the Central Statistics Agency (BPS), and shipping companies' operational reports. The analysis techniques used include descriptive statistics and simple correlations to see trends and relationships between variables. This approach is used to explain the role of Ro-Ro ships in accelerating logistics flows, lowering distribution costs, and supporting regional connectivity (Saputra & Rijanto, 2021; Budisiswanto, 2023).

Meanwhile, the qualitative method is applied through in-depth interviews with various stakeholders such as port operators, shipping entrepreneurs, service users, regional

transportation officials, and logistics practitioners. Informants were selected using purposive sampling techniques, taking into account position, experience, and direct involvement in the operation of the Ro-Ro vessel. The purpose of this approach is to explore perceptions, field constraints, and expectations for the development of Ro-Ro ships that are not captured by quantitative data. Qualitative data were analyzed using thematic methods to identify key patterns, such as bureaucratic barriers, infrastructure limitations, and market dynamics of shipping services. This approach is also supported by policy documentation studies and evaluations of public service practices of sea transportation (Silambi et al., 2022; Ndraha et al., 2024). With the combination of these two methods, the research is expected to be able to produce contextual, data-based, and applicative policy recommendations to support the development of efficient and sustainable marine transportation.

## 4. RESULTS AND DISCUSSION

### Development of Ro-Ro Ships in Indonesia

Statistical data shows that the number of Ro-Ro ships operating in Indonesia has increased in the last decade. Based on data from the Ministry of Transportation, there will be more than 150 units of Ro-Ro ships serving inter-island crossing routes in 2023, an increase from only about 90 units in 2013. This increase is driven by the sea toll program and the push for national connectivity policies, especially in integrating the eastern regions of Indonesia that have been logistically isolated (Kusuma & Tseng, 2019). Main routes such as Merak-Bakauheni, Ketapang-Gilimanuk, and Surabaya-Lombok are congested routes that show the vitality of this mode in transporting vehicles and passengers efficiently. Based on operational data from several major ports, it can be seen that the Ro-Ro ship route has different characteristics in terms of frequency, travel time, and vehicle volume. These details can be seen in the following Table 1:

**Table 1.** Ro-Ro Ship Operational Data on Several Routes in Indonesia

| Route Ro-Ro | Frequency (trip/day) | Travel Time (hours) | Vehicle Volume (units/day) |
|---|---|---|---|
| Merak–Bakauheni | 120 | 2 | 8000 |
| Ketapang–Gilimanuk | 95 | 1 | 6500 |
| Surabaya–Lombok | 5 | 18 | 700 |
| Tanjung Perak–Tenau | 3 | 30 | 250 |
| Semarang–Karimunjawa | 2 | 6 | 180 |

*Source: Author's processed data (2025)*

As shown in Table 1, the Merak-Bakauheni route has the highest frequency in Ro-Ro ship operations with 120 trips per day and the volume of vehicles reaches 8,000 units per

day. This shows that short routes with congested land connectivity in two main regions (Java and Sumatra) result in a very high demand for Ro-Ro services. Followed by the Ketapang-Gilimanuk route with 95 trips and a vehicle volume of 6,500 units/day, which indicates similar characteristics, namely short distances, high commuter rates, and very intensive crossing frequencies.

Meanwhile, routes such as Surabaya–Lombok, Tanjung Perak–Tenau, and Semarang–Karimunjawa have a much lower frequency (only 2–5 trips/day), longer travel time (6–30 hours), and a smaller volume of vehicles. This reflects geographical challenges and dependence on open sea conditions, as well as the limitations of port infrastructure in eastern Indonesia. This condition is also one of the factors why the development of Ro-Ro ships in the eastern part of Indonesia is not as optimal as the western region.

**Operational Efficiency and Logistics Excellence**

The results of the quantitative analysis show that Ro-Ro ships are able to reduce dwelling time by up to 30-40% compared to conventional freight ship modes. This is mainly due to the faster loading and unloading process as the vehicle can directly enter and exit the ship without additional aids. This advantage has a significant impact on total logistics costs, especially for commodities with high turnover such as agricultural products and fast-circulation consumer goods (Saputra & Rijanto, 2021). The reliability of the Ro-Ro ship schedule also provides better certainty of travel time, especially on short routes.

**Limitations of Port Infrastructure**

Despite the increasing operational trend, the main obstacle faced is the limitation of port infrastructure, especially in the eastern part of Indonesia. Based on interviews with operators at the ports of Tenau (Kupang) and Namlea (Maluku), it was found that the piers that do not meet the standards of Ro-Ro ships, the shallow depth of the port pool, and the lack of modern loading and unloading equipment are the main obstacles. Hadi (2020) said that most secondary ports in Indonesia have not met the technical criteria for Ro-Ro docking, which causes ships to have to wait for sea tide or use inefficient alternative loading and unloading methods.

**Institutions and Regulations**

On the institutional side, the licensing process for Ro-Ro ship routes and routes is still hampered by long and non-uniform bureaucracy between regions. Some operators state that the process of opening new routes can take more than six months, which creates investment uncertainty. According to Buchari and Victoria (2021), weak coordination between ministries and the absence of an integrated digital system cause the efficiency of the

shipping sector to be hampered. In this context, the research of Silambi et al. (2022) emphasizes the need for deregulation and inter-agency data integration as the first step to improving maritime transportation governance. To illustrate more clearly the difference in vehicle volume on each route, the following Graph 1 is presented:

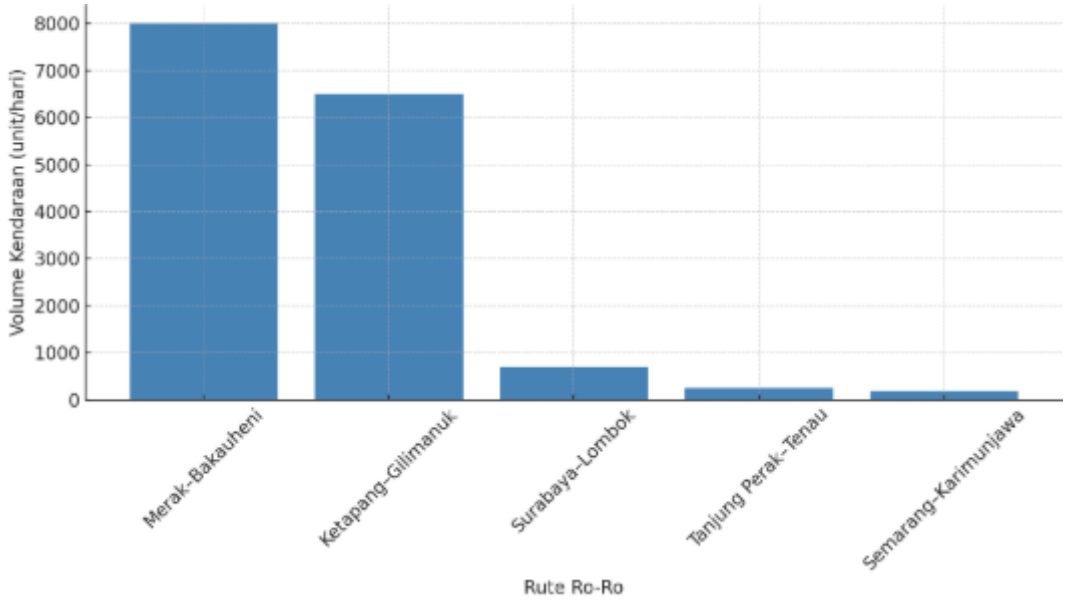


**Figure 1.** Daily Vehicle Volume on Ro-Ro Ship Routes
*Source: Author's processed data (2025)*

Graph 1 clarifies the disparity in demand between routes. Routes with short travel times and strategic locations show a significant spike in vehicle volume, while long routes show limited utilization. This shows that although Ro-Ro ships are technically capable of reaching various islands, their success depends heavily on port infrastructure support, cruise frequency and market conditions. These findings are in line with research by Budisiswanto (2023) which emphasizes the importance of synchronization between port capacity and logistics demand in the development of efficient modes of sea transportation.

**Case Study of Surabaya–Lombok Route**

On the Surabaya-Lombok route, which is the focus of a field case study, it was found that Ro-Ro ships have a significant impact in encouraging local economic growth. This route not only serves private vehicles, but also logistics trucks from East Java that bring basic materials, building materials, and industrial products to NTB. The Tanjung Perak port operator said that the efficiency of 18 hours of travel time is better than ordinary freight ship modes which can take up to two days. This study is in line with the findings of Kambu and Bisay (2023) who emphasize that Ro-Ro ships are very effective in supporting food and seafood logistics quickly and cost-effectively.

**Comparison with Previous Research**

When compared to the findings of Ridwan and Sunaryo (2019) which highlight the importance of shipping safety and navigation efficiency in large ports such as Tanjung Priok, Ro-Ro ships present unique problems, especially related to integration with land transportation. Most Ro-Ro ports do not have wide and strong road access to accommodate heavy vehicles simultaneously. This is exacerbated by the absence of buffer facilities such as parking areas, loading depots, and goods consolidation services. Budisiswanto (2023) said that to optimize multimodal services, ports must be designed as integrated logistics nodes, not just ship stopovers.

**Potential of Digitalization and Public Services**

In terms of public services, the results of observations show that most Ro-Ro ship operators still rely on manual systems in ticket booking and departure scheduling. This often leads to long queues, uncertainty, and potential fraud. Lesmana and Widiyarta (2022) emphasized the importance of digitizing payment systems and integrating reservation platforms as part of public service reform. The implementation of QRIS or application-based e-ticketing system is a strategic first step to increase transparency and user convenience.

**Social Impact and Tourism**

Ro-Ro ships also bring significant social impacts, especially in strengthening connectivity between regions and encouraging the mobility of middle-class people. In the context of tourism, Sulistyowati et al. (2021) found that the presence of Ro-Ro ships on the Semarang-Karimunjawa route increased the number of tourist visits by up to 40% during the holiday season. This shows that Ro-Ro ships are not only a means of logistics, but also a catalyst for the development of island-based tourist destinations that require high accessibility and regular travel frequency.

**Community Participation and Supervision**

Public participation in the supervision of Ro-Ro services is also an important aspect that emerges from the results of the interviews. Some service users complained about the lack of route and schedule information, as well as the inaccuracy of departure times. Ndraha et al. (2024) emphasized the importance of feedback mechanisms and information disclosure in increasing public trust in sea transportation services. Therefore, an integrated information system is needed that allows users to track schedules, ship status, and fares online and submit complaints effectively.

**Implications and Development Direction**

Overall, these results and discussions indicate that the development of Ro-Ro ships in Indonesia still faces major challenges in terms of infrastructure, institutional, and digitalization. Nevertheless, this mode holds extraordinary potential in driving the region's economy, reducing logistics disparities, and improving the welfare of maritime communities. With reference to previous research and the results of field analysis, the future development direction should focus on port modernization, public service system integration, and incentives for operators to open new routes to disadvantaged areas. This approach not only supports transportation efficiency, but also makes Ro-Ro ships a pillar of sustainable national maritime connectivity.

## 5. CONCLUSIONS AND SUGGESTIONS

This study shows that Ro-Ro ships have a strategic role in supporting maritime connectivity and logistics efficiency in Indonesia, especially in bridging the mobility of vehicles and goods between islands. This mode has proven to be effective in reducing loading and unloading times, reducing transportation costs, and increasing the speed of goods distribution, especially on short routes such as Merak-Bakauheni and Ketapang-Gilimanuk. However, the development of Ro-Ro ships still faces structural challenges such as limited port infrastructure, regulatory constraints, and low digitalization of service systems. The operational success of Ro-Ro ships is greatly influenced by the readiness of port facilities, institutional coordination, and the overall integration of land and sea transportation modes.

To optimize the role of Ro-Ro ships in the national transportation system, it is recommended that the government increase investment in port development and modernization, especially in the eastern region of Indonesia. In addition, it is necessary to simplify route licensing regulations and strengthen platform-based digital information systems for ticketing, schedule, and shipping monitoring services. Support for digitalization and responsive public service management will increase public trust and operational efficiency. Strategic routes that have high economic, tourism, and local production potential must be a priority in future Ro-Ro development planning. With an integrated approach that combines technical, institutional, and social aspects, Ro-Ro ships have the potential to become the backbone of inclusive and sustainable maritime transportation in Indonesia.

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