Optimization of RoRo (Roll On-Roll Off) Ship Berthing Scheduling Using the Berth Allocation Problem (BAP) Model at Parit Rempak Port, Karimun Regency

Nisha Desfi Arianti[1*], Mey Krisselni Sitompul[2], Wulan Syahfina[3], Selvika Putri Rahmania[4], Ryryn Pransiska[5], Leonardo Zerrand[6]

[1,2,3,4,5]*Program Studi Manajemen Kepelabuhanan dan Pelayaran, Fakultas Sains dan Teknologi, Universitas Karimun, Kabupaten Karimun*

*Email: nishadesfiarianti@gmail.com[*1], meykrisselnisitompul@gmail.com[2], wsafina72@gmail.com[3], rahmaniaselvikaputri@gmail.com[4], ririnpransiska03@gmail.com[5], zerrandleonardo@gmail.com[6].*

**Corresponding author*

Received 9 July 2025; Revised 8 August 2025; Accepted 10 August 2025

Abstract - Parit Rempak RORO Port is one of the sea transportation hubs that serves inter-regional connectivity in Karimun Regency. The limitations of the dock infrastructure, such as a length of 100 meters and a width of 11 meters, pose challenges in managing ship berthing schedules, especially RORO type ships. This study aims to analyze the suitability of the dock capacity to the ship operational schedule using the Berth Allocation Problem (BAP) approach. The BAP model is compiled and simulated through the Python-based Google Colaboratory platform to avoid scheduling conflicts and minimize ship waiting time. The simulation results are displayed in the form of a Gantt Chart which shows that the four ships: KMP Teluk Singkil 1, KMP Teluk Singkil 2, KMP Tandemand, and KMP Kundur can be scheduled sequentially without overlapping berthing times. Spatial analysis of the length and width of the dock also shows that this port is ideal for serving one ship at a time. This study shows that digitalization of the scheduling system can be an efficient solution in optimizing dock operations.

Keywords - RORO Port, *Berth Allocation Problem*, ship scheduling, Google Colab, dock optimization

1. INTRODUCTION

Maritime transport is the foundation of global trade, with ports serving as key nodes in the international logistics network. The efficiency of port operations affects local economic stability and influences the resilience of regional and national supply chains. According to Law No. 17 of 2008 on Shipping, a port is defined as an area consisting of land and/or water with specific boundaries, used as a place for ships to dock, load and unload goods, embark and disembark passengers, and transfer between modes of transport. To support effective port operations, ports must have safety, security, and service facilities. One type of port that plays a strategic role in accelerating logistics flows and inter-regional mobility is the Roll On-Roll Off (RORO) port. RORO ports are specifically designed to serve ships that allow motor vehicles such as cars, trucks, and buses to board and disembark directly from the boat via ramps, without the need for conventional loading and unloading processes. This efficiency makes RORO ports crucial in supporting inter-island transportation, particularly in archipelagic regions like the Riau Islands, which heavily rely on maritime transport. Additionally, the RORO system facilitates integration with land-based modes of transport, creating a more connected and responsive logistics network to meet distribution needs.

Karimun Regency, which consists of large and small islands, heavily relies on maritime transport for community mobility and logistics distribution. One of the key ports in this region is Parit Rempak Port, located in Tanjung Balai Karimun. The port was established in 2004 and

e-ISSN : 2356-2579 | p-ISSN : 1412-2693, DOI : 10.62411/tc.v24i3.13575

officially began operations in 2009 under the management of the Transportation Department and the Port Management Unit (UPT Pelabuhan). Parit Rempak Port is a ferry port that operates Roll On-Roll Off (RORO) services, allowing vehicles and goods to board and disembark directly without manual loading and unloading processes. The routes include strategic connections to Telaga Punggur (Batam), Alai Insit, Dompak, Mengkapan, and Selat Beliah on the mainland of Sumatra. The port faces several challenges, including limited dock infrastructure, inadequate supporting facilities, and poor integration of various transportation modes. Research [1] has shown that developing RORO (Roll-On/Roll-Off) ports can help reduce regional disparities and enhance the efficiency of goods distribution. Consequently, there is an increasing urgency to develop Parit Rempak Port, focusing on physical improvements such as adding cargo terminals and upgrades to existing facilities and better operational management. One of the main challenges in port management is the efficient scheduling of ship berths. The Berth Allocation Problem (BAP) is a crucial issue in this context. BAP is an optimisation problem in placing ships at the dock, considering arrival times, space availability, and service order, aiming to minimize waiting times and avoid scheduling conflicts. Efficiency in berthing allocation is crucial, especially in small ports like Parit Rempak, which only has one active dockside measuring 100 metres in length and 11 metres in width.

Several studies have investigated berth allocation and scheduling models to improve port operational efficiency. Nazri et al. (2024)[2] proposed an optimisation model for container terminals using Pyomo and Google Colaboratory, demonstrating how computational tools can support berth allocation decisions. Aslam et al. (2023, 2022) [3], [4] further developed metaheuristic approaches, such as the Cuckoo Search Algorithm, to handle berth allocation with multiple quays. Similarly, Korekane and Nishi, (2021) [5] applied a neural network-assisted branch-and-bound method for dynamic berth allocation, which can respond to real-time changes in port operations. Specific to Ro-Ro terminals, Di et al. (2022) [6] explored berth scheduling optimisation tailored to automotive Ro-Ro ports, highlighting the importance of synchronising berth availability with vehicle flow and ramp constraints. However, these studies were mainly conducted in large-scale or container-focused ports, leaving small and medium-sized Ro-Ro ports underexplored. Digitalisation has also become a focal point in port operations. Chen et al. (2023) [7] and Sumrit & Jaidee (2023) [8] emphasised the role of digital systems in improving decision-making and logistics performance in RoRo and RoPax ports. Despite its potential, the implementation of digital tools remains challenging, particularly in small or remote ports where infrastructure and digital awareness are limited (Chen et al., 2023) [7]. The application of Gantt Charts in port scheduling has been adopted in various settings to improve transparency and operational clarity [9], [10]. When combined with modelling and simulation (M&S), Gantt Charts can serve as effective visual aids for berth scheduling analysis [11].

While these studies have significantly contributed to the development of berth allocation models and digitalisation in port operations, there is limited literature addressing the optimisation of berth schedules at small-scale Ro-Ro ports using simple yet effective tools like Python-based Gantt visualisations. This research addresses that gap by applying the Berth Allocation Problem (BAP) model to a limited-infrastructure RoRo port and simulating the ship scheduling using Google Colaboratory. Considering these challenges and potential, this study aims to: Analyse the role of Parit Rempak Port in the maritime transport system of the Riau Islands; Assess the existing port infrastructure conditions; Apply the *Berth Allocation Problem* (BAP) model to develop an optimal ship loading and unloading scheduling system; Generate schedule visualisations using Gantt charts as a tool to aid operational decision-making. The *Berth Allocation Problem* (BAP) model will be simulated using Python on the Google Colaboratory platform. This simulation aims to optimize ship arrival schedules and improve berthing capacity. By adopting this approach, we expect to find adaptive solutions that address the dynamics of small-scale ports. Ultimately, this will contribute to modernizing data-driven and technology-based port management.

e-ISSN : 2356-2579 | p-ISSN : 1412-2693, DOI : 10.62411/tc.v24i3.13575

2. RESEARCH METHOD

2.1. Location, Time, and Research Approach

The study was conducted at Parit Rempak Port in Tanjung Balai Karimun, Karimun Regency, Riau Islands, in May 2025. This location was chosen because it is one of the leading maritime transport hubs in the border region, serving Roll On-Roll Off (RORO) ships with limited dock facilities.

The approach used in this study in descriptive qualitative, which aims to gain an in depth understanding of social and operational phenomena at small scale RoRo ports. Qualitative research is a methodological approach that explores experiences, perspectives, and backgrounds of individuals through non statistical data obtained from direct interactions, such as interviews, focus group discussions, and observations [12], [13], [14]. This approach aims to answer the questions 'why' and 'how' regarding social processes that cannot be explained solely through numeric data [15].

This study used a qualitative approach to gain a contextual understanding of the operational dynamics of minor ports in border areas, which face specific infrastructure and management challenges. Researchers conducted direct observations and structured interviews with port officials, vessel operators, and service users to describe the operational realities on the ground. Findings from this approach were then used as the basis for developing a vessel scheduling optimisation model using the Berth Allocation Problem (BAP) approach, thereby integrating empirical data with a simulation model.

2.2. Data Sources and Collection Techniques

This study used primary and secondary data to support the analysis and modelling process. Primary data refers to information collected directly from sources for specific research objectives. In port research, primary data can be collected through interviews, surveys [16], and direct field observations [17], [18]. In this study, primary data were collected through structured interviews and discussions with port authorities, ship operators, and service users, along with on-site observations of the dock's physical condition and patterns of ship movement.

Meanwhile, secondary data refers to existing information originally collected for different purposes but relevant to the current study. This includes official documents, government reports, journal publications [19], [20], and company records [17], [21]. In this research, secondary data encompassed RORO ship schedules, port operational reports for 2023–2025, documents from the local transportation department, and academic references related to the Berth Allocation Problem (BAP) and RoRo port development strategies.

2.3. Research Stages

The stages of the research activities are detailed as follows (Figure 1):

a) Problem Identification and Preliminary Study: Examine the actual conditions of the port and the challenges faced in managing the RORO ship berthing schedule.

b) Data Collection: Conduct observations and interviews, and collect secondary data from documents and reports.

c) Gantt Chart Modelling Analysis Techniques in the Context of Berth Allocation Problems (BAP) : Developing a mathematical model based on ship arrival time parameters, berthing duration, and berth availability, considering the following constraints:
Start time: $Si \geq Ai$
Non-overlapping constraint (no overlap between two ships): $Si + Di \leq Sj$ or $Sj + Dj \leq Si$ fr each pair of ships i and j.
Finish time: $Ei = Si + Di$ (1)

e-ISSN : 2356-2579 | p-ISSN : 1412-2693, DOI : 10.62411/tc.v24i3.13575

Ai : Arrival time
Si : berthing start time
Di : berthing duration; and
Ei : time to complete berthing

d) Schedule Simulation and Visualisation: The BAP model developed is simulated using Python on Google Colaboratory. The simulation results are displayed in a Gantt Chart format, where each row represents a ship and the bar's length indicates the berthing duration.. This visualisation helps intuitively identify the efficiency of time and space allocation while supporting data-driven operational decision making.
e) Efficiency Analysis and Evaluation: The Gantt Chart visualisation evaluates berthing patterns, identifies potential idle time, and designs alternative scheduling or vessel additions. This analysis considers the conditions of the Parit Rempak wharf, which has only one active side, and the need for service optimisation within a single operational day.
f) Formulation of Operational Recommendations: Data-based recommendations were provided for improving berthing management and small port development strategies.\

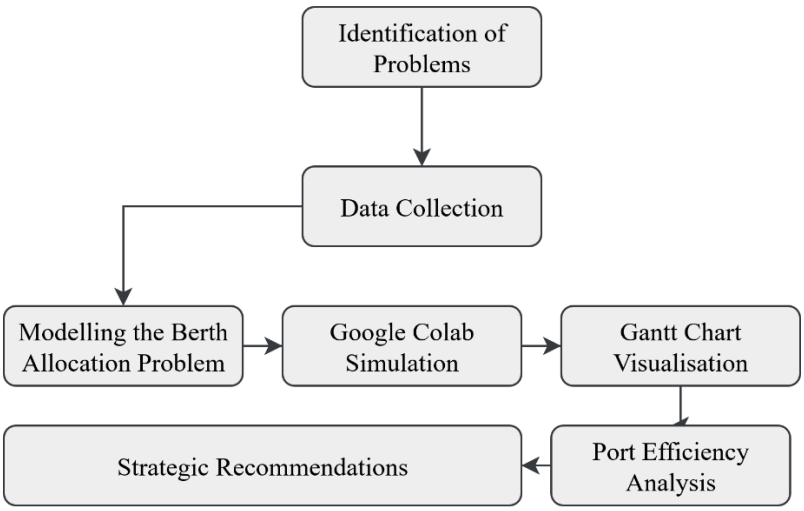

Figure 1. Systematic research steps

3. RESULTS AND DISCUSSION

3.1. Results of RORO Ship Schedule Modelling

Berth allocation (Berth Allocation Problem/BAP) was originally a critical optimisation problem in container terminal operations, aiming to minimise ship turnaround time and total service costs, including waiting time, handling, and penalties for late departures [4], [5], [22]. However, this study applies to RoRo ships. Combining the berth allocation model with a Gantt Chart allows berth operation management and planning to be improved by visually displaying task dependencies and scheduling.

Table 1. Roll-on/Roll-off (RoRo) Ship Berthing Schedule

No	Name of ship	Berthing time (Western Indonesian Time (UTC+7))	Duration
1	KMP TELUK SINGKIL 1	10.00-12.00	2
2	KMP TELUK SINGKIL 2	12.00-13.00	1
3	KMP TANDEMAND	13.00-15.00	2
4	KMP KUNDUR	21.00-00.00	3

Source: Documentation data at Parit Rempak Port, 2025.

e-ISSN : 2356-2579 | p-ISSN : 1412-2693, DOI : 10.62411/tc.v24i3.13575

Based on the schedule in Table 1, there is no overlap in time, allowing for the alternating use of the single sided dock. This also considers the condition of the dock facilities and the movable bridge (locally known as *jembatan bergerak*, abbreviated as BG) (Figure 1) owned by the Port of Parit Rempak. The ship schedule simulation was conducted using the Google Colaboratory platform with the Python programming language and visualised as a Gantt Chart. The Gantt Chart illustrates the scheduling of four RORO ships docking in one operational day (Figure 2).

Figure 1. Roll-on/Roll-off (RoRo) Ship Pier at Parit Rempak Port
Source: Lendoot.com

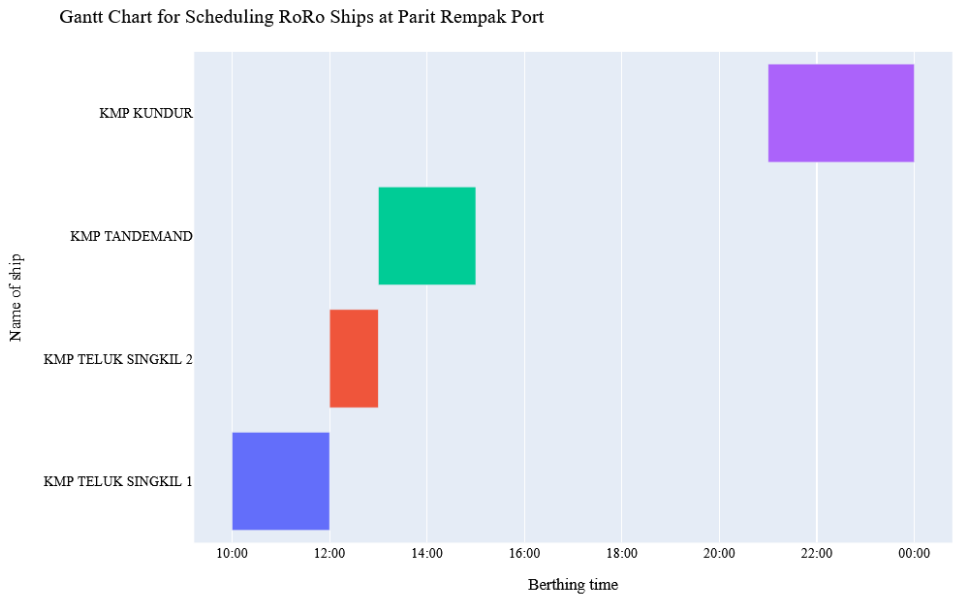

Figure 2. Gantt Chart for Scheduling RORO Ship Berthing at Parit Rempak Port

The Gantt Chart visualisation in Figure 2 shows that four ships are scheduled to arrive, with the first at 10:00 a.m. and the last at 9:00 p.m. There is no overlap between ship arrival times, indicating efficient scheduling from the perspective of a single dock. A significant gap between 15:00 and 21:00 WIB (approximately 6 hours) indicates potential underutilization. This idle time is logistically inefficient, especially when port demand is high.

Some efforts that can be made to improve port efficiency include:

e-ISSN : 2356-2579 | p-ISSN : 1412-2693, DOI : 10.62411/tc.v24i3.13575

1. Adding ships, the empty schedule between 15:00 and 21:00 WIB can be filled by additional ships (either from new regular routes or inter-island ships)
2. Rescheduling ships, if a fixed schedule does not bind the KMP Kundur ship, its schedule can be moved forward to shorten the empty time.

This aligns with the findings of [6], which state that operational efficiency improvements at Ro-Ro terminals can be achieved through optimising berthing schedules, adjusting vessel arrival times, or increasing vessel allocations during idle dock periods.

Compared to the study by Aslam et al., (2022) at a large-scale container port, the efficiency of the single dock at Parit Rempak demonstrates higher operational flexibility due to lower traffic loads, despite limited infrastructure.

3.2. Relevance to Port Development Strategy

Gantt Charts provide a clear visual representation of dock usage schedules, helping port operators manage ship arrivals and departures efficiently[9], [10]. By integrating the Gantt Chart with an optimisation model, port operators can better understand and manage task dependencies, reducing turnaround times and improving port performance [4], [22]. However, this Gantt Chart will be ineffective or chaotic if too many tasks are assigned.

Digitalisation is a key strategy in the development of RoRo ports. Studies show digitalisation can improve operational efficiency and assist strategic port planning [7], [8]. However, the implementation of digitalisation is currently inefficient, especially on small islands in border areas, as technology providers do not yet fully understand the port business ecosystem and the business impact of digitalisation [7]. Modelling and simulation (M&S) techniques can be used as decision-making tools for RoRo port system managers, helping to address various operational and strategic issues [11].

The development of an effective RoRo port requires the implementation of a comprehensive strategy that includes digitalisation to improve operational efficiency and support strategic planning, cost reduction through transport system integration and enhanced logistics efficiency, investment in technology and the application of international standards to ensure sustainable development, and operational planning that takes into account uncertainty and probability in the transport process. By integrating these strategies, RoRo ports can develop efficiently and sustainably, and significantly contribute to improving trade and logistics performance.

In addition to digitisation and scheduling optimisation, the technical aspects of RORO ship operations and the conditions of small-scale ports also need to be considered as part of port development strategies. A study by Apriani and Achmadita (2025) [23]shows that RORO ships have operational advantages in fast loading and unloading processes without cranes, simply by utilising ramps as direct access for vehicles to the ship's deck. However, this system requires ample horizontal space and high operational discipline, as the distance between vehicles must be maintained to ensure safety and evacuation. Meanwhile, a study by Sunarti (2018) [18] highlights the main challenges small ports face in island regions, such as limited wharves, inadequate supporting infrastructure, and dependence on weather conditions. In this context, implementing the RORO system at small ports like Parit Rempak must consider these limitations to avoid creating new risks. Schedule optimisation, digitalisation, and improvements in physical capacity and operational competence are crucial for small-scale ports to efficiently and safely serve RORO ships.

4. CONCLUSION

This study shows that applying the Berth Allocation Problem (BAP) model through the Google Colaboratory platform can produce an efficient RORO ship scheduling system that is in line with the physical capacity of the Parit Rempak Port. Although the dock can only serve one ship at a time, the technology-based scheduling approach allows operations to run smoothly without

e-ISSN : 2356-2579 | p-ISSN : 1412-2693, DOI : 10.62411/tc.v24i3.13575

significant obstacles. This simulation underscores the importance of integrating operational planning with port digitalisation, particularly at small ports with limited infrastructure but high logistics mobility. Based on these findings, this study recommends that port authorities adopt a digital scheduling system as an operational standard. With an adaptive, transparent, and data-driven system, Parit Rempak RORO Port has the potential to enhance service efficiency and strengthen inter-regional logistics competitiveness.

REFERENCES

[1] S. K. Syafril KA and S. Sujarwanto, "Pengembangan Pelayaran Perintis pada Perintis Pulau-Pulau Terisolir di Kepulauan Riau," *J. Penelit. Transp. Laut*, vol. 17, no. 2, pp. 43–53, 2020 [in Bahasa], doi: 10.25104/transla.v17i2.1411.

[2] S. N. Nazri, K. Mokhtar, A. Abu Bakar, B. C. Mclellan, and S. M. Mhd Ruslan, "Optimization berth allocation in container terminals: A Pyomo and Google Colab approach," *Ocean Coast. Manag.*, vol. 258, 2024, doi: 10.1016/j.ocecoaman.2024.107359.

[3] S. Aslam, M. P. Michaelides, and H. Herodotou, "Enhanced Berth Allocation Using the Cuckoo Search Algorithm," *SN Comput. Sci.*, vol. 3, no. 4, 2022, doi: 10.1007/s42979-022-01211-z.

[4] S. Aslam, M. P. Michaelides, and H. Herodotou, "Berth Allocation Considering Multiple Quays: A Practical Approach Using Cuckoo Search Optimization," *J. Mar. Sci. Eng.*, vol. 11, no. 7, 2023, doi: 10.3390/jmse11071280.

[5] S. Korekane and T. Nishi, "Neural Network Assisted Branch-and-Bound Method for Dynamic Berth Allocation Problems," in *Conference Proceedings - IEEE International Conference on Systems, Man and Cybernetics*, Okayama University, Graduate School of Natural Science and Technology, Okayama City, Okayama, 700-8530, Japan: Institute of Electrical and Electronics Engineers Inc., 2021, pp. 208–213. doi: 10.1109/SMC52423.2021.9658903.

[6] Z. DI, M. Zi-qiao, C. Feng, and Z. Yi-fei, "Research of Berth Scheduling Optimization Model and Algorithm on Automotive RO-RO Terminals," *Operations Research and Management Science*, vol. 31, no. 3. pp. 9–16, 2022. [Online]. Available: http://www.jorms.net

[7] Y. Chen, A. Tsvetkova, K. Edelman, I. Wahlström, M. Heikkilä, and M. Hellström, "The Role Of Digitalisation In Changing The Business Models In Logistics: Case Of Ropax Ports," in *36th Bled eConference: Digital Economy and Society: The Balancing Act for Digital Innovation in Times of Instability, BLED 2023 - Proceedings*, P. A., B. M.K., B. R., B. R., O. G., H. M., and V. D., Eds., Åbo Akademi University, Laboratory of Industrial Management, Turku, Finland: University of Maribor Press, 2023, pp. 49–66. doi: 10.18690/um.fov.4.2023.4.

[8] D. Sumrit and R. Jaidee, "An integrated fuzzy multi-criteria decision-making approach for prioritising strategies to drive the sustainable roll-on/roll-off port development: a case study of Thailand," *Int. J. Appl. Decis. Sci.*, vol. 17, no. 1, pp. 1–35, 2023, doi: 10.1504/IJADS.2024.135193.

[9] A. Bednjanec and M. F. Tretinjak, "Application of Gantt charts in the educational process," in *2013 36th International Convention on Information and Communication Technology, Electronics and Microelectronics, MIPRO 2013 - Proceedings*, School of Electrical Engineering (Elektrotehnička Škola), Zagreb, Croatia, 2013, pp. 631–635. [Online]. Available: https://www.scopus.com/inward/record.uri?eid=2-s2.0-84886919135&partnerID=40&md5=f28103faba77398b63b36dd6a1dc4ed5

[10] D. Elam, "Keeping on schedule in 2009, part 1," *EM Air Waste Manag. Assoc. Mag. Environ. Manag.*, no. JAN, pp. 30–31, 2009, [Online]. Available:

e-ISSN : 2356-2579 | p-ISSN : 1412-2693, DOI : 10.62411/tc.v24i3.13575

https://www.scopus.com/inward/record.uri?eid=2-s2.0-77952020112&partnerID=40&md5=e63a8a93251bd20c8b886a0fa58f932c

[11] M. Balaban and T. Mastaglio, "RoPax/RoRo: Exploring the use of simulation as decision support system," in *OCEANS 2013 MTS/IEEE - San Diego: An Ocean in Common*, MYMIC LLC, Portsmouth, VA 23703, United States: IEEE Computer Society, 2013. [Online]. Available: https://www.scopus.com/inward/record.uri?eid=2-s2.0-84896361468&partnerID=40&md5=1788afd61a6617fa918b16a4f143a63e

[12] R. Whitley, "Social capital and public health: Qualitative and ethnographic approaches," in *Social Capital and Health*, Dartmouth Medical School, Dartmouth Psychiatric Research Center, Lebanon, NH, United States: Springer New York, 2008, pp. 95–115. doi: 10.1007/978-0-387-71311-3_6.

[13] U. Kemparaj and S. Chavan, "Qualitative research: A brief description," *Indian J. Med. Sci.*, vol. 67, no. 3, pp. 89–98, 2013, doi: 10.4103/0019-5359.121127.

[14] C. Gillan, C. Palmer, and A. Bolderston, "Qualitative methodologies and analysis," in *Research for the Radiation Therapist: From Question to Culture*, Princess Margaret Cancer Centre, Department of Radiation Oncology, University of Toronto, Toronto, Canada: Apple Academic Press, 2014, pp. 127–152. [Online]. Available: https://www.scopus.com/inward/record.uri?eid=2-s2.0-85054208035&partnerID=40&md5=adc14e465f46c26e67f99db85e02bd70

[15] Z. S. Feuer and D. V Makarov, "Qualitative and mixed methods in urology," in *Translational Urology: Handbook for Designing and Conducting Clinical and Translational Research*, Department of Urology, University of North Carolina, Chapel Hill, NC, United States: Elsevier, 2024, pp. 195–198. doi: 10.1016/B978-0-323-90186-4.00083-3.

[16] R. A. P. J. Sultra, R. M. C. Nabela, G. Wibisono, and D. P. Sirait, "Delivery Order (DO) Online Implementation in Accelerating Document Flow Service of Imported Goods in Payment Companies," in *Journal of Physics: Conference Series*, Institute of Transportation and Logistic Trisakti, Jakarta, Indonesia: IOP Publishing Ltd, 2020. doi: 10.1088/1742-6596/1573/1/012028.

[17] M. P. Hatta, R. Karamma, and H. Fazry, "The Study of Port Capacity Development Plan in Wosu," in *IOP Conference Series: Earth and Environmental Science*, Department of Civil Engineering, Faculty of Engineering, Universitas Hasanuddin, Gowa, Indonesia: IOP Publishing Ltd, 2021. doi: 10.1088/1755-1315/921/1/012082.

[18] S. Sunarti, "Transportation Limitation Access to the Small Islands (Case Study: Banggai Laut Regency)," in *IOP Conference Series: Earth and Environmental Science*, Urban and Regional Planning Department, Faculty of Engineering, Diponegoro University, Indonesia: Institute of Physics Publishing, 2018. doi: 10.1088/1755-1315/123/1/012018.

[19] E. Rabinovich and S. Cheon, "Expanding horizons and deepening understanding via the use of secondary data sources," *J. Bus. Logist.*, vol. 32, no. 4, pp. 303–316, 2011, doi: 10.1111/j.0000-0000.2011.01026.x.

[20] K. Choi and H. Kwag, "Comparing urban public service using super-efficiency model and statistical testing: Cases using secondary data," *Int. J. Appl. Eng. Res.*, vol. 9, no. 22, pp. 14795–14802, 2014, [Online]. Available: https://www.scopus.com/inward/record.uri?eid=2-s2.0-84925426493&partnerID=40&md5=e1933503991cac38b4e1fbe5c136101c

[21] I. Meidutė-Kavaliauskienė and R. Činčikaitė, "The Infrastructure of Seaports—The Guarantor of State Security," in *Lecture Notes in Intelligent Transportation and Infrastructure*, vol. Part F230, General Jonas Žemaitis Military Academy of Lithuania, Šilo St. 5A, Vilnius, Lithuania: Springer Nature, 2025, pp. 167–175. doi: 10.1007/978-3-031-85390-6_17.

[22] S. N. A. Nazri, K. Mokhtar, A. Abu Bakar, B. C. Mclellan, and S. M. Mhd Ruslan,

e-ISSN : 2356-2579 | p-ISSN : 1412-2693, DOI : 10.62411/tc.v24i3.13575

"Optimization berth allocation in container terminals: A Pyomo and Google Colab approach," *Ocean Coast. Manag.*, vol. 258, p. 107359, Nov. 2024, doi: 10.1016/J.OCECOAMAN.2024.107359.

[23] D. D. Apriani and A. Achmadita, "Study of the Vehicle Loading System on the Ro-Ro Route Bajoe - Kolaka Ferry," *IOP Conf. Ser. Earth Environ. Sci.*, vol. 1461, no. 1, 2025, doi: 10.1088/1755-1315/1461/1/012029.

e-ISSN : 2356-2579 | p-ISSN : 1412-2693, DOI : 10.62411/tc.v24i3.13575