Maritime industry - ports and supporting activities: literature review

Juvinal Lucas Monteiro¹, Lukmandono², Pramudya Imawan Santoso³ and Rony Prabowo⁴

¹Postgraduate Student, Master of Industrial Engineering Department, Institut Teknologi Adhi Tama Surabaya, Indonesia
²,³,⁴Lecturer, Master of Industrial Engineering Department, Institut Teknologi Adhi Tama Surabaya, Indonesia
lukmandono@itats.ac.id

Abstracts- Queues are waiting for lines from customers to get service. The queue is caused by the needs of consumers to be served beyond the ability of service facilities, so consumers who come cannot immediately get service. Queue problems at ports often occur every day. Ship loading and unloading services is a queuing phenomenon in daily life. This queue can be caused by damage to the equipment that supports loading and unloading, labor, availability of warehouses, and the limited capacity of berths at berths and others. In maintaining optimal port services, it is necessary to avoid long waiting times and low queuing system utilities. Queues at the mooring service system occur due to mismatch between planning and realization. Waiting time for vessels inside and outside the port area is calculated using the simulation method in queuing theory so that it becomes a queuing model. Until finally, it produces the optimum berthing service system. Based on the simulation results obtained value, and which is much shorter than the conditions on realization. The potential causes of these conditions are divided into three factors, namely, internal factors, external factors, and weather factors.

1. Introduction

As an archipelagic nation, Indonesia holds great potential, especially its strategic location because it is located at a crossing of international trade routes. Shipping has become an important sector in supporting social, economic, government, defense, security, cultural and other life to unite separate islands and the vast ocean. Seeing the development of port infrastructure and facilities in Indonesia, it is not impossible that the port will become a sector capable of boosting national competitiveness and economy. As stated in the 2018 Global Competitiveness Report, if Indonesia maintains and improves performance and competitiveness it will be able to increase higher and sustainable income in the future.

The central pillar of the logistics system is to guarantee effectively and efficiently, which is reflected in low logistics costs, and responsive and satisfying service. Efficient and effective logistics management will help businesses to be more competitive in the competition through the creation of higher added value. Harbor is a part of its waters protected from storms, safe and well or suitable for accommodation for ships shelter, refueling, inventory, repair and loading, and unloading of goods[1]. Port is a protected harbor with marine terminal facilities consisting of mooring or dock for loading and
unloading of goods from ships, warehouses, transit, and other accumulation to store products in the short term or term-long[2].

Ports can also be interpreted as terminals and areas where ships loading or unloading at the dock, at the landing site, in the buoy-bui or the like and include waters were waiting for their turn to get service[3]. Based on the notions stated above, then the port can be interpreted as a place for ships anchored, maneuvering, and berthing to do activities securely raising and or lowering passengers and goods and safe. There are six assessment indicators for maritime logistics success: customs, infrastructure, ease of managing international shipping, competence logistics from local operators and service providers, domestic logistics costs, and delivery times[1, 9]. How many things need to be considered in analyzing the ship queue time include the average waiting time of the ship at the port, the characteristics of the queue of the ship seen from the level of arrival and level of service, factors that influence the waiting time of the ship.

1.1. Literature Review

1.1.1. Role of the Port. The port as a sub-system of shipping, and considering that the sail itself is a flag bearer following the trade pattern (ship follows the trade), then the port becomes one of the determining elements of trading activities. An efficiently managed business will encourage trade progress; even industries in the back regions will advance with itself[4]. If observed in the historical development of several metropolitan cities, moreover, in an archipelagic country such as Indonesia, the port will help to enlarge the city. The port triggers the growth of the road network, rail network railroad, and warehousing for distribution or consolidation of commodity goods[5]. The land transportation facility and infrastructure network become a port as an intramode node of land transportation and land-sea intermodal. Service costs at the port managed efficiently and professionally will be become low, so business in other sectors is overgrowing. Port acts as a focal point for the economy and trade and becomes a collection of business entities such as shipping and agency, warehousing, freight forwarding, and transportation of goods. Port has several functions, among others[6]:

1. Gateway. Derived from the word port or port that comes from the Latin word porta has meaning as a gateway or gateway[3, 12]. The port functions as the door that people and goods pass into and out of the harbor concerned. Referred to as the door because the port is an official road or area for trade in goods traffic. Entry and exit of goods must meet customs procedures and quarantine, outside the official way is not justified.

2. Link. From the limits of understanding that have been explained before, the existence of a port essentially facilitates the movement of content goods between land transportation mode and sea transportation mode channeling incoming goods and exit customs areas as quickly and efficiently as possible[2, 15]. In this link function there are at least three important elements namely: (a) channel or move cargo on board to the truck[2, 6, 11]; (b) the transfer operation is rapidit means minimum delay [5, 10] and (c) efficient in the sense of cost[4, 16].

3. Interface. Freight transported via maritime transport is at least across the port area twice, once at the loading port, and once at the port unloading[6, 10]. At the loading port and likewise at the loading port, it is moved from or to transportation facilities by using various facilities and mechanical equipment and non-mechanical. Equipment for moving cargo bridging ships by truck to train or by ship. At the activity, the port function is the interface[9, 11]. At every item moving operation, which consists of ship operations, dock transfer operations, a warehouse used field operations, and handover of goods for conveyance & loading (lifting & transfer) goods-sequence necessary. In the service of bulk commodities, the interface functions very real physical. Loader and unloader equipment connects ships with trains or trucks on land. The reliability (reliability) of tools and work methodology systemic is the determining factor of the level of speed, smoothness, and efficiency port activity.

4. Industrial Entity. A well-organized port will grow and will fertilize other business fields so that the port area becomes a related industrial zone with port[11, 12, 16].
1.1.2. **Port Performance.** Port performance can be used to determine the level of service port to port users (ships and goods) depending on ship service time while in port. High port performance shows that the port can provide excellent service [7]. Based on the Decree of the Director-General of Sea Transportation Number UM.002 / 38/18 / DJP-11 dated 15 December 2011 concerning Performance Standards Port Operational Services, operational service performance is the result of work measurable achieved at the port in carrying out the service of ships, goods, utility facilities and equipment within a specified period and unit.

Performance indicator Services related to port services consist of[1, 5, 11]:

1. **Dwelling Time:** the amount of time since the submission of the mooring application after the ship arrives at the landing location until the ship is driven towards the mooring [3, 10].
2. **Approach Time (AT):** the amount of time used for ships moving from the anchored location to the rope tied inmooring or vice versa[4, 15].
3. **Effective Time (Effective Time - ET):** the number of hours for a ship is used for loading and unloading while the ship is on moorings[7, 12].
4. **Berth Time (BT):** the amount of time ready for mooring operation serving ships[4].
5. **Berth Working Time (BWT):** the time for loading and unloading for the ship is at the dock[3, 14].
6. **Receiving and Delivery of containers:** the speed of servicesubmission acceptance at the container terminal, which is calculated from the time the conveyor arrives at the entrance or exit.
7. **Level of Berth Occupancy Ratio (BOR):** a comparison between the time of use of the dock with the time of day available (docks ready for operation) within a specified period expressed as a percentage[1, 7].
8. **Shed Occupancy Ratio (SOR):** a comparison between the number of users of stacking space and space; the available stacking is calculated in units of tons or days M³ day unit[8, 10].
9. **Level of Use of Stacking Field (Yard Occupancy Ratio - YOR):** a comparison between the amount of space usageStacking with available stacking space (ready for operation) calculated in units of tons of days or M³ days[5].
10. **Equipment operation readiness:** a comparison between quantities of equipment that is ready to operate with the amount of equipment that is available in a certain period of time[9].

1.2. **Loading and Unloading**

Measures of tonnage, speed, and time of loading and unloading operations (time and motion measurements) is an important indicator for measuring level efficiency of operating activities[8]. For international ports used four common types of loading and unloading operation indicators, namely[3, 7, 12]: (1) **Flow of Goods (Output);** (2) **Boat service time (Service Time);** (3) **Ratio of use of berth facilities (Berth Occupancy);** (4) **Cost of loading and unloading goods (Cost per Ton Handled).** The four indicators are closely related to each other, mutually influence, and form a system in which one indicator is not stand alone in the following picture.

![Port Performance Diagram](image)

**Figure 1.** Port Service Indicator [2, 6]
1.2.1. Definition of Loading and Unloading. Dismantling is translated as: "Dismantling means lifting, bringing out all the contents of something, removing all. Meanwhile, according to the PBMAssociation Terminal Operator Communication Forum Jakarta (2002) Unloading is the activity of unloading cargo from a ship.

Dismantling is a transfer of goods from one place to another and can also be said unloading of products from the ship to the dock, from the dock to the warehouse or otherwise from the warehouse to warehouse or from the warehouse to new dock transported to ship[9].

Definition of Load contains, fits, fits, enters therein, can contain, load, fill, into, place. The load is the activity of loading cargo on board[10]. Loading and Unloading Activities is the activity of moving goods from the land conveyance, and to carry out the transfer of such activities required the availability of adequate facilities or equipment in a manner or service procedures[11]. Unloading is removal cargo from and above the ship to be piled in or directly transported to the place of the owner of the goods through the harbor dock by using loading and unloading apparatus, both those located at the dock and those located at the ship itself[12]. Loading and unloading is a series of terminal company activities to carry out loading or unloading from and onboard. Work to unload goods from the deck or hold and place it on the dock (kade) or into a barge or the opposite, loading from the dock or in a barge and placing it to the deck or into the hold using a boat crane[13].

2. Method
According to KM No. 25 of 2002 Article 1 concerning Basic Guidelines for Calculation Unloading and Shipping Rates for Shipping to and from ships at the port:

a. Stevedoring. The work of unloading goods from ships to dock and barge or truck or load goods from dock and barge or truck to ships until arranged in the hatch by using ship crane or land crane.

b. Cargodoring. The work of releasing goods from the rope nets (ex-tackle) on the dock and transport from the dock to the warehouse and stockyard then arrange in the warehouse field or vice versa.

c. I was receiving and delivery. The work of moving goods from the heap and place Stacking in the warehouse field stacking and handing up arranged on top of a vehicle at the door of the warehouse to a yard or stacking otherwise.

The definition of loading and unloading is[4]: (a) Load the Wharf Namely the work of loading goods from above or from the warehouse by using a derrick conveyor to be placed in the hold ship; (b) Unloading the hold Namely the work of unloading on decks or hatches with ships use a derrick/conveyor and put it to the dock or in a warehouse; (c) Load loading Namely service activities load or unload a load from the dock using a derrick or crane or with other loading and unloading tools. While the load data is required for the implementation of loading and unloading are (1) Type and amount of charge; (2) Form of delivery transportation; (3) List of goods or heavy loads, special loads or cargo dangerous.

2.1. Compaction principles
These are a. Protect the ship It was an effort to keep the ship safe during the activities loading and unloading or shipping, for example maintaining stability ships, do not load more than the capacity of the deck, pay attention to SWL (Safe Loading Ability) of an equipment loading and unloading, etc.

(1) Distribution of upright loads is an effort that must be done on a charge when loading so as not to damage the shipbuilding construction or can sink the ship.

(2) Load distribution horizontally Is an effort made on the current load loading each hatch from the front to the back must be balanced, so that the ship always has a little trim to the back, neither hogging nor sagging.

a. Trim Is the difference between the first draft and the backdraft on the ship. The selection is the distance between the ship's keel with water level limits.

b. Hogging Is a condition caused by placement cargo that is concentrated at the ends of the ship; as a result, the ship will break easily if it gets big waves. c) Sagging Is a condition caused by
5
placement; the cargo is concentrated in the middle of the ship; as a result, the ship will break easily if it gets the waves big.
c. Protect ship crews and laborers from cargo hazards
   Ensure that loading is carried out regularly and systematically to avoid long hatches, over stowage, over the carriage, and broken stowage [12, 17]
   (1) Long hatch is the distribution of load on each hold for each unloading port are uneven or centered on one hold, resulting in the ship taking too long at the loading port.
   (2) Over stowage is a condition where the cargo should be unloaded first at a port closed by another cargo that will be unloaded at the next port.
   (3) Over carriage is a condition where the cargo should be unloaded first in a port because of something brought to the port next.
   (4) Broken stowage is the percentage of hatch space that cannot be filled by load caused by the charge itself. A bulk carrier, bulk carrier, or bulker is a ship specifically designed to transport bulk cargo, such as grains, coal, iron ore, and cement in a cargo hold or hold.

2.2. Characteristics of Ship Queues
The existing condition of the port is generally divided into several terminals. The queue analysis flow at the port consists of the pre-analysis stage, the probability distribution test suitability stage, and the analysis stage [5, 17].

1. Estimating Number of Servers (M)
   A number of servers are calculated assuming utilizing the length of the existing dock at the port and the average length of the ship with the equation:
   
   \[ M = \text{rounddown} \left( \frac{\text{docklength}}{\text{averagelengthofship}+\text{guard}} \right) \] (1)

2. Arrival Rate (\( \lambda \)) Arrival rate is the average of many ships coming (k) per day.

   \[ \lambda = \frac{\text{firstday}^{+\cdots+} \text{lastday}}{\text{manydays}} \] (2)

3. Service Rate (\( \mu \))
   Service Rate (\( \mu \)) is the average ship service per day. The length of service for each ship is obtained by the following formula:

   \[ \Omega = \frac{\sum_{k=1}^{n} \text{Timetoleave-LeaningTime}_k}{n} \] (3)

   Where:
   \( k \): ship serial number; \( n \): many ships get services during an observation

   After obtaining the Average Ship Service Time (\( \Omega \)), the Service Rate (\( \mu \)) can be found using the following formula:

   \[ \mu = \frac{1}{\Omega} \] (4)

4. Stages of Test Suitability of Poisson Distribution of Ship Arrival Probability
   To calculate the probability of ship arrival per day, the following equation is used:

   \[ P(x) = \frac{e^{-\lambda} \lambda^x}{x!}, \text{ untuk } x = 0, 1, 2, 3, 4, \] (5)

   where: \( P(x) \) = chance of arrival \( x \) ship/day; \( x \) = number of ship arrival/day;
   \( \lambda \) = average ship arrival/day \( e = 2.7183 \)
5. Ship Service Exponential Distribution Test Exponential test for service time is carried out using the following equation:

\[ P(t) = \lambda e^{-\lambda t}, \text{for } t \geq 0 \]  

where:  
\[ t = \text{opportunity service time more than } t \]  
\[ \lambda = \text{service time} \]  
\[ \mu = \text{average service time} \]  
\[ e = 2.7183 \]

6. Server Utilization (\( \rho \)) is the percentage of server usage using the equation:

\[ \rho = \frac{\lambda}{M\mu} \]  

Where:  
\[ M = \text{number of service channels}; \]  
\[ \mu = \text{channel average service level in each (channel)} \]  
\[ \lambda = \text{average arrival rate} \]

7. The chances are that not one ship in the system uses the equation:

\[ P_0 = \frac{1}{\sum_{n=0}^{M-1} \frac{1}{n!} \left( \frac{\lambda}{\mu} \right)^{n}} + \frac{1}{M! \left( \frac{\lambda}{\mu} \right)^{M}} \frac{M\mu}{M\mu - \lambda}, \text{for } M\mu > \lambda \]

8. The average number of ships in the system uses the equation:

\[ L_S = \frac{\lambda\mu (\lambda/\mu)^{M}}{M-1)(M\mu - \lambda)^2} P_0 + \frac{1}{\mu} \]  

9. Average waiting time and service using the equation:

\[ W_s = \frac{\lambda\mu (\lambda/\mu)^{M}}{M-1)(M\mu - \lambda)^2} P_0 + \frac{1}{\mu} \]

10. The average ship (unit) that waits for the equation used

\[ L_q = L_S - \frac{1}{\mu} \]

11. The average waiting time for the equation used:

\[ W_q = W_s - \frac{1}{\mu} \]

---

**Figure 2.** Terminal Queue Concept [3, 7, 15]
2.3. Berth Working Time Parameter

The ship's visit to a port is aimed at carrying out unloading activities load as fast and safely as possible. If you don't need a ship, it won't take long at the port, including times waiting for the availability of facilities, cargo, completion of documents, and local port work schedule[14]. Ship time at port (Ship Turnaround Time or Ship's Time in Port) counted since the ship made use of the anchorage waters where the ship anchored. It was recorded that it had arrived at the local port or when the Pand was on board until leaving the harbor when the guide releases the ship's departure concerned. Ship Turnaround Time or abbreviated as TRT decomposes to Ship time at the dock (Ship Berthing Time or Ship's Time at Berth) abbreviated as BT after deducting the waiting time for the opportunity to lean on a dock (Waiting Time) abbreviated as WT[2, 5, 17].

Ship Berthing Time breaks down into Timeworking boat at the berth (Berth Working Time) abbreviated as BWT after deduction Non-operational timetable abbreviated NOT[1, 6, 12]. Berth Working Time decomposes to Effective ship time (Effective Time) abbreviated ET after deducting the operation stop time (Idle Time) abbreviated as IT.

As for the activities of loading and unloading of cargo ships in the following order[3, 8, 16]: (a) **Ship operation.** The operation to lower cargo directly to the truck or to railroad cars and or barges, and through warehouses or fields build up; (b) **Quay transfer operation.** The operation of moving goods from the dock, especially to the warehouse or field; (c) **Storage or shed & yard operation.** Operation of arranging goods in a manner regularly in the warehouse field; (d) **Receiving & delivery operation.** Handover of goods that can be received takes place at the dock location (to the truck or to the barge), and on the landside warehouse or stacking yard.

3. Result and Discussion

Services in calculating terminal operational performance, there are several indicators, especially those relating to ship service at the dock, namely service time. This service time consists of[9, 12]: (1) Berthing time, i.e., the total time spent by the ship during moorings. Berthing time consists of berthing working time and not operation time; and (2) Berth working time is the planned time to carry out activities loading and unloading, which consists of effective time and idle time.

Berthing time (BT):

\[ BT = BWT + NOT \] (13)

Where: BT = number of hours one boat while in additional

Berth Working Time (BWT):

\[ BWT = ET + IT \] (14)

\[ BWT = BT - NOT \] (15)

Where:

- Berth Working Time, which is the number of hours a ship is planned for conduct container loading unloading activities while in mooring, not operation time, which is the planned time for not working (not carrying out loading and unloading activities), such as rest periods, namely 30 minutes each Shift[2, 9, 11]
- Effective time, which is the time used to carry out activities loading and unloading effectively[5, 17]
- Idle time, i.e., time that is not used to carry out activities unloading or idle time, such as time wasted when loading and unloading equipment is broken[3, 7, 8]

Service at the port or general cargo terminal is said to be quality if port managers or equivalent, carry out control functions by seeking waiting time, non-operational time, idle time, and berth. The lowest possible working time is close to zero[4, 15]. At the same time, function control is directed at the loading and unloading speed supported by the right choice for mechanical and non-mechanical devices and other resources. Here the author will focus more and discuss a lot in terms of working
berth the time of the many assessments in the waiting time of the ship. According to the author, berth working time has a significant influence inside the port[9]. The working time of ships at the dock, especially during the loading and unloading process, must take place effectively and efficiently to improve the performance of the port itself.

3.1. Port Revenue

Revenue is the amount of money received by a company from an activity that is done, and most of these activities are activities product sales and / or service sales to consumers[15, 17]. The word income in the business world is no stranger. For investors, income is not very important when compared to profits, which is the amount of money that will be received after deducting expenses. Revenues are inflows gross of economic benefits arising from the normal activities of an entity during a period, if the inflows result in an increase in equity that does not originate from investment contributions. Revenues are inflows or completion (or combination of both) of the delivery or production of goods, provide services, or perform other activities, which are the main activities or centra’s ongoing activities[16].

3.2. Port Revenue Sources

Facilities services are divided into two, namely necessary facilities and facilities ancillary services. The basic facilities are intended primarily for serviceships, goods, and passengers; Supporting facilities include public services includes leasing land and buildings/offices, water for ships, electricity, parking lot, and port fitting. Production of basic facilities for ships, including[10, 12]: (1) safety navigation services; (2) anchoring services; (3) guiding services; (4) delay services; (5) mooring or unmooring services; (6) mooring services.

Production of basic facilities for cargo, including[2, 13]: (1) dock services; (2) stevedoring services; (3) transfer services to the warehouse; (4) extra movement services; (5) receiving-delivery services; (6) warehouse services; (7) tool rental services.

While revenue from ship production can be obtained from[7, 11]: (1) Navigation safety services (port dues) are levied on the use of sailing facilities in the form of grooves, vessel traffic control, breakwaters, firefighters, sea pollution advocates, and maritime security; (2) Landing service (anchorage) is imposed on the utilization of anchor area when arrive, wait, or depart; (3) Pilotage services are levied on the use of the functions of sea-guided personnel and guide the city; (4) Towage services are imposed on the use of tugs when the ship mooring, shifting and unmooring; (5) Mooring / unmooring service is charged for the use of gang power mooring gang; and (6) Berthage services are levied on the use of berthing, berthing facilities, jetty.

4. Conclusions

Ship loading and unloading queues can be reduce though maximizing the performance of loading and unloading workers and diverting ships to terminals that are still not busy and improving services and procedures for handling documents at the port to cope with the increase in the flow of goods, development of shipping lanes to revitalize shipping lanes and port ponds, apply regulations on port properly and maximize existing guide forces in anticipation of increased ship visits, increasing the length of the pier or by diverting first to lean on supporting ports and Encouraging and maximizing cruise line projects to deepen Shipping Lines and port ponds, and Increase the number of guide and tugboats to anticipate increased ship traffic, placing and using loading and unloading equipment in accordance with its purpose and adding information technology facilities at the port to anticipate an increase in the flow of goods at the port, maximizing the performance of Unloading Workers and placing ships at the dock as well as simplifying document service procedures at the port to reduce the level of dock usage. move existing installation facilities in the shipping lane and maximize pilotage to facilitate ship traffic.
5. References

[1] A. Bacchioni and J. Ramus. 2008. Best Practices in Port Management: An Assessment of Two Ports, no. 4 May.
[2] O. Baccelli, M. Percoco, and A. Tedeschi. 2008. Port Authorities as cluster managers: the case of the Ligurian ports, vol. 39, pp. 44–58.
[3] H. Meersman, E. Van de Voorde, and T. Vanselslander. 2012. Port Congestion and Implications to Maritime Logistics,” Marit. Logist., pp. 49–68.
[4] P. Gaur. 2005. Port Planning as a Strategic Tool: A Typology. No. April p. 89.
[5] E. William K. Ruto. 2015. Logistical Factors Influencing Port Performance a Case of Kenya Ports Authority (Kpa). Int. J.Curr. Res. Rev., vol. 7, no. 12, pp. 52–59.
[6] K. McGinley. 2014. Preparing port container terminals for the future: Making the most of intelligent transport systems (ITS). WIT Trans. Built Environ., vol. 138, pp. 419–427.
[7] W. C. Huang, T. C. Kuo, C. T. Wu, and C. C. Kuo. 2012. Port management improvement strategies based on the simulation model. J. Mar. Sci. Technol., vol. 20, no. 5, pp. 492–507.
[8] H. Aprilianty and H. Evander. 2018. Information Technology in Port Container Terminal: Automation Tally System Implemented in Port of Tanjung Priok, vol. 147, no. Grost, pp. 758–766.
[9] M. Dooms, C. Macharis, and A. Verbeke. 2004. Proactive stakeholder management in the port planning process: empirical evidence from the port of Brussels. 44th Eur. Congr. Eur. Reg. Sci. Assoc., p. 34.
[10] E. T. Lawer, J. Herbeck, and M. Flitner. 2019. Selective adoption: How to port authorities in Europe and West Africa engage with the globalizing ‘green port’ idea. Sustain., vol. 11, no. 18.
[11] E. Van De Voorde and H. Meersman. 2014. Discussion paper Port Pricing: Principles, Structure, and Models. Norges Handel., no. April 2014.
[12] D. Ozer Caylan and Ç. Emiroglu. 2014. the Importance of Strategic Leadership for Port Management: a Delphi Research on Top Managers of Turkish Private Ports. J. Glob. Strategy. Manag., vol. 2, no. 8, pp. 5–5.
[13] B. B. Khiem. 2017. Port Authority Models and Application Possible in Vietnam. J. Econ. Bus. Manag., vol. 5, no. 3, pp. 154–159.
[14] R. Prabowo, M. L. Singgih, P. D. Karningsih, and E. Widodo. 2020. New product development from inactive problem perspective in indonesian SMEs to open innovation.J. Open Innov. Technol. Mark. Complex., vol. 6, no. 1.
[15] B. A. Priyambodho. 2016. Container Port Development Projects on The Java Sea, Indonesia, vol. 5, no. 1.
[16] J. Hollebrands. 2011. Performance-Based Contracting: A New Tool 1 Introduction.
[17] Basuki M, Lukmandono L, ZauBeu MM. 2020. Ballast Water Management at Inaport 4th Makasar Based Environmental Risk Assessment. Available at SSRN 3512750.

Acknowledgment

The author would like to thank the financial support given from The Ministry of Research and Technology / National Agency for Research and Innovation of Indonesia under the Magister Thesis Research scheme 2020 (Contract No. 046/SP2H/LT/MULTI/L7/2019 and 046/SP2H/AMD/LT/MULTI/ L7/2020)