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Analysis of Operational Service Performance in Container Terminal (Case Study: Tenau-Kupang Port)

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Abstract— *Tenau Port is one of 24 ports in Indonesia that have been declared by President Jokowi to become the center of the world's maritime axis. The presence of the port become the most important means to supporting the mobility of goods and people in Kupang city, this is indicated by the increase in ship visits each year at Tenau port. This study aims to evaluate the performance of container operational services at the Port of Tenau-Kupang and find solutions in efforts to improve the quality of container terminal services at the Port of Tenau-Kupang based on the Decree of the Director General of Transportation of the Republic of Indonesia in 2011, and analyze the capacity requirements at the container terminal for the next 20 years using multiple linear regression methods. Based on the evaluation results it is known that; approach time (AT) factor, condition of loading and unloading equipment, and area of container yard need to be considered. Where, the value of AT is 1.45 hours exceeds the standardized one hour, loading and unloading containers using cranes that should have been 12 boxes / cranes / hour only realized 7.33 boxes / cranes / hour, and the existing Yard Occupancy Ratio (YOR) value is 70% beyond the standardized 60%. The capacity analysis results show that in 2028 the jetty needs to be extended and at the same time in 2028 the port also needs to consider adding the number of moorings. Whereas for the stacking field, the value of the existing Yard Occupancy Ratio (YOR) is 70% and the required area for 2019 is 23513 m^2 or 2.35 Ha.*

Keywords— *Container, performance, port, regression.*

I. Introduction

Tenau Port, which serves container ships, began operating in 2012, based on records from PT. Pelindo flow of ships and containers entering Tenau port has increased every year. The increase in ship and container flow is not accompanied by an increase in container terminal infrastructure, which has an impact on container terminal capacity where, during high season (October-December) there is a congestion in container yards so the loading and unloading process is delayed and must wait for container delivery so that space CY can be used again. If this condition continues, it will reduce the quality of container operational services.

In line with this problem, in a study conducted by Arief Witjaksono, 2016 at PT Jakarta International Container Terminal, that long-term deposition or stacking affects the Dwelling time and the level of density of the stacking yard or Yard Occupancy Ratio (YOR), if the value of YOR exceeds the capacity it creates congestion which results in a decrease in port operational performance. Furthermore, in research conducted at the Koja container terminal (TPK Koja) at Tanjung Priok port, it is known that the length of time the container settles in the stacking field contributes to the high dwelling time and the main determinant factor related to dwelling time at the container terminal is the stacking field. This explanation gives an understanding that if the container in the stacking field exceeds the existing capacity, it will have a broad impact and be detrimental both economically and socially. Therefore it is necessary to evaluate the performance of container loading and unloading services and the capacity of existing container terminals based on standards from the Director General of Sea Transportation, as well as analysis of forecasting and container terminal capacity requirements for the next 20 years (long term port planning) so that PT. Pelindo can anticipate the surge in container flow and support loading and unloading activities to accelerate the pace of economic growth in Kupang city and surrounding areas.

In this study the analysis of container terminal performance refers to the service standards set by the Decree of the Directorate General of Sea Transportation Number UM.002/38/18/DJPL-11 of 2011 concerning Port Operational Service Performance Standards and the Director General of Sea Transportation Regulation Number: HK. 103/2/2/DJPL-17 concerning Guidelines for Calculation of Port Operational Service Performance. As for the calculation of container terminal capacity using the multiple linear regression method to determine the predicted flow of ships and containers, and the capacity is calculated using the formula recommended by the International Maritime Organization (IMO).

II. Literature Review

A. *Ship Service Performance Based on Decree of Director General of Sea Transportation*

Analysis of container terminal operational service performance is conducted in accordance with Port Operational Service Performance Standards according to Decree of the Director General of Sea Transportation No. UM.002 / 38/18 / DJPL-11 of 2011 and using the equation recommended in Regulation of the Director General of Sea Transportation Number: HK. 103/2/2/DJPL-17 concerning Guidelines for Calculation of Port Operational Service Performance. The performance indicator of the used ship service can be seen in the illustration in Fig. 1 below.

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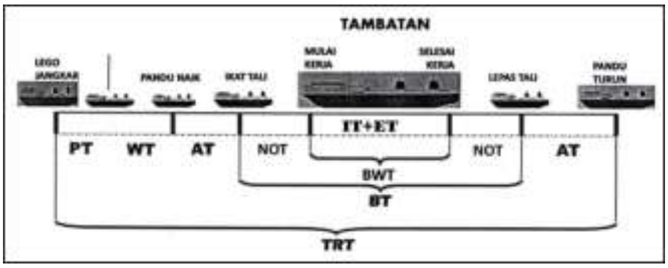

Fig. 1. Illustration of Vessel Service Time

B. Analysis of Container Terminal Capacity

In this study, the calculation of container terminal capacity uses the equation formula recommended by the International Maritime Organization (IMO) as follows:

1) Pier length

Calculation of pier length is divided into 2 types of piers namely; single berth and berth group as follows:

- Single berth

$$L = 10\%\ Loa\ + Loa\ + 10\%\ Loa$$

Where;
L = required pier length
Loa = average ship length that served

- Berth group

$$L = n(10\%\ Loa + Loa) + 10\% Loa$$

Where;
L = required pier length
n = number of pier
Loa = average ship length that served

2) Number of moorings

The number of moorings needed for a port is calculated using the equation formula from the International Maritime Organization (IMO) as follows:

$$n = \frac{ship\ flow \times service\ time}{365 \times BOR}$$

Where, service time is the operating time of a port (for Tenau port it is used 24 hours = 1 day).

3) Container yard

The area needed by the container yard depends on the way the container is handled. There are several methods in handling containers that are often used, including; chassis system, straddle system, gantry crane and transtainer system (Triatmodjo, 1996), at Tenau Port container terminal, a handling system uses a Rubber Tyred Gantry Crane. Table 1 below shows the required area per TEU according to the container handling system.

Table 1 below is used to see the selection of equipment operational methods with the land availability and soil conditions required for the container terminal. The required stack area is calculated using the following equation:

$$A = \frac{T \times D \times A_{TEU}}{365(1 - Bs)}$$

Where;
A = required stacking area (m2)
T = container flow per year (boxes, TEUs), 1 TEUs = 29 m3, 1 box = 1.7 TEUs
D = The average number of days container is stored in the stacking field. Tenau port uses 10 days.
ATEU = the area required for one TEU, depending on the container handling system and the number of container piles in the stacking yard.
Bs = broken stowage is the area lost due to the road or distance between containers in the container yard.
The value is around 25% - 50%.

TABLE 1. Area Required per TEUs

Peralatan dan Metode Penanganan	Tinggi/Jlh Peti Kemas	Luasan Diperlukan Per TEU A_{TEU}(m²)	
		PK 20 ft	PK 40 ft
Trailer	1	60	45
Truck Forklift	1	60	80
	2	30	40
	3	20	27
Straddler Carrier	1	30	
	2	15	
	3	10	
Rubber Tyred Gantry Crane/Transtainer	2	15	
	3	10	
	4	7,5	

III. METHODOLOGY

In this research, prediction or forecasting of ship and container visit flow is needed, predictions made using multiple linear regression methods for ship and container visit flow for the results will be used to estimate the capacity requirements of container terminals in order to meet the demand of service users. The regression equation model for the prediction of ship and container traffic at Kupang-Tenau Port is as follows:

$$Y' = a + b1X1 + b2X2 + b3X3 + \ldots\ldots + bnXn$$

Where;
Y ' = Dependent variable
X1 ..., Xn = Independent variable
a, b1, ..., bn = parameters of the regression equation

IV. RESULT AND DISCUSSION

The existing operational performance of Tenau Port container terminal in Kupang is calculated using the regulation of the Director General of Sea Transportation Number: HK. 103/2/2 / DJPL-17 of 2017 and based on a ship and container services survey conducted for a period of 1 month at the research site. The overall calculation results for the performance of ship services, containers and utility facilities at the Tenau container terminal are shown in Table 2 below.

TABLE 2. Existing Operational Service Performance of Tenau Port Container Terminal in Kupang

No.	Ship Service	Unit	Realization
1	Waiting Time (WT)	Jam	0,43
2	Postpone Time (PT)	Jam	1,00
3	Approach Time (AT)	Jam	1,45
4	Berthing Time (BT)	Jam	44,96
5	Berth Working Time (BWT)	Jam	39,39
	- Iddle Time (IT)	Jam	1,34
	- Effective Time (ET)	Jam	38,05
6	Not Operation Time (NOT)	Jam	5,57
7	ET:BT	%	78,35
8	Turn Round Time (TRT)	Jam	47,84
No.	**Container Service**	**Unit**	**Realization**
1	Box/Crane/Jam	B/C/H	7,33
2	Box/Ship/Jam	B/S/H	6,09
No.	**Utility Fasilities**	**Unit**	**Realization**
1	Berth Occupancy Ratio (BOR)	%	58
2	Berth Throughput (BTP)	T/m	30,55
3	Yard Occupancy Ratio (YOR)	%	70
4	Yard Throughput (YTP)	T/Gsl	9,25

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Referring to the Decree of the Director General of Sea Transportation Number UM.002/38/18/DJPL-11 of 2011, the performance achievement of the Tenau port container terminal can be seen in Table 3 below.

TABLE 3. Performance Service Operational Achievements in the Tenau Container Terminal

No.	Service	Unit	Standard Value	Existing Value	Performance Achievement
A	**Ship Service**				
1	Waiting Time (WT)	Jam	1	0,43	Good
2	Approach Time (AT)	Jam	1	1,45	**Poor**
3	ET:BT	%	70	78,35	Good
B	**Container Service**				
1	Box/Crane/Jam	B/C/H	12	7,33	**Poor**
C	**Utility Fasilities**				
1	Berth Occupancy Ratio (BOR)	%	70	58	Good
2	Yard Occupancy Ratio (YOR)	%	60	70	**Poor**

Based on Table 3 above, it can be seen that some components of operational service performance have exceeded those standardized by the Decree of the Director General of Transportation, or need to be improved, namely;

1. Ship service performance needs to be improved, especially approach time (AT) which has exceeded the standard of 1 hour while the existing one reaches 1.45 hours.
2. Container service performance for loading and unloading with container cranes, has been standardized 12 Box / Crane / Hour but the existing condition is still 7.33 Box / Crane / Hour.
3. The stacking capacity has exceeded the standardized 60% but the existing capacity has reached 70%.

The second analysis is forecasting of ship visit flow and container flow at the Tenau Port container terminal in Kupang using Multiple Linear Regression method with the help of Statistical Package Service Solution (SPSS) application based on East Nusa Tenggara province economic data adjusted to the type of cargo entering the port, to see the effect of economic growth on the flow of ship visits and container flows at Tenau Port. East Nusa Tenggara provincial economic data is shown in Table 4 as follows.

TABLE 4. East Nusa Tenggara Economic Data (Million Rupiah)

No.	Description	Year				
		2014	2015	2016	2017	2018
1	Agriculture, Forestry, and Fisheries	Rp 20.456.314	Rp22.752.446	Rp 24.309.283	Rp26.168.120	Rp 28.145.406
2	Mining and digging	Rp 986.038	Rp 1.073.475	Rp 1.164.179	Rp 1.181.370	Rp 1.207.241
3	Processing industry	Rp 843.708	Rp 940.862	Rp 1.034.289	Rp 1.147.211	Rp 1.252.963
4	Electricity and Gas Procurement	Rp 33.612	Rp 43.569	Rp 59.409	Rp 66.389	Rp 75.073
5	Construction	Rp 7.095.979	Rp 7.845.054	Rp 8.957.210	Rp 9.719.303	Rp 10.744.878
6	Large trade and retail	Rp 7.296.703	Rp 8.272.331	Rp 9.212.312	Rp 9.940.201	Rp 11.054.067
7	Transportation and Warehousing	Rp 3.566.950	Rp 3.996.753	Rp 4.524.930	Rp 4.938.940	Rp 5.458.619
8	Real estate	Rp 1.860.878	Rp 2.054.341	Rp 2.179.209	Rp 2.315.519	Rp 2.475.130
10	Exports	Rp 1.009.833	Rp 1.330.767	Rp 1.256.663	Rp 1.566.743	Rp 1.274.343
11	Imports	Rp 418.543	Rp 188.368	Rp 199.500	Rp 827.907	Rp 691.079
12	Investation	Rp 22.195.978	Rp24.832.317	Rp 28.741.681	Rp32.479.914	Rp 33.345.400

Based on the SPSS analysis results, the best model for the flow of ship visits is as follows;
Flow of ship visits (Y)
$Y = 269{,}735 + 1{,}627 \times 10^{-7} X_{14}$
Where, Y is the flow of ship visits (Units) and X_{14} is the Import Value (Million Rupiah).

Using the model produced above, it can be predicted the flow of ship visits (Units) in the future (20 years) as shown in Table 5 below.

TABLE 5. Results of Forecasting Ship Flow in Units

Year	Forecasting of Vessel Flow (Unit)	Year	Forecasting of Vessel Flow (Unit)
2019	403	2029	596
2020	422	2030	615
2021	442	2031	634
2022	461	2032	654
2023	480	2033	673
2024	500	2034	692
2025	519	2035	712
2026	538	2036	731
2027	557	2037	750
2028	577	2038	769

Next, a container flow model is made using the same data and the 4 best models for container flow are obtained as follows:

1. Container Flow ($Y_{2,1}$)
   $Y_{2,1} = -258676{,}157 + 0{,}070X_1 - 1562{,}103X_3$
   Where, $Y_{2,1}$ is the container flow; X_1 is the population (life) and; X_3 is the inflation value (%).
2. Container Flow ($Y_{2,2}$)
   $Y_{2,2} = 48538{,}574 - 1758{,}551X_3 + 0{,}055X_7$
   Where, $Y_{2,2}$ is the container flow; X_3 is the value of inflation (%) and; X_7 is the PDRB industrial sector (million rupiah).
3. Container Flow ($Y_{2,3}$)
   $Y_{2,3} = 21423{,}226 + 0{,}008X_{11}$
   Where, $Y_{2,3}$ is the container flow and; X_{11} is the PDRB of the large trade and retail sector (million rupiah)
4. Container Flow ($Y_{2,4}$)
   $Y_{2,4} = 12561{,}025 + 0{,}088X_{15}$
   Where, $Y_{2,4}$ is the container flow and; X_{15} is the flow of ship visits (GT).

Using the 4 variations of the model above, we can predict the flow of containers in the next 20 years, as shown in Table 6 below.

TABLE 6. Results of 20 Year Container Flow Forecasting (TEUs)

Year	*Forecasting* Model 1	*Forecasting* Model 2	*Forecasting* Model 3	*Forecasting* Model 4
2019	122.604	122.232	116.702	119.713
2020	130.381	130.032	124.049	126.865
2021	138.158	137.832	131.395	134.017
2022	145.934	145.631	138.741	141.170
2023	153.711	153.431	146.087	148.322
2024	161.488	161.231	153.433	155.474
2025	169.265	169.031	160.779	162.627
2026	177.041	176.830	168.125	169.779
2027	184.818	184.630	175.471	176.931
2028	192.595	192.430	182.817	184.084
2029	200.372	200.230	190.163	191.236
2030	208.149	208.029	197.509	198.388
2031	215.925	215.829	204.855	205.541
2032	223.702	223.629	212.201	212.693
2033	231.479	231.429	219.548	219.845
2034	239.256	239.228	226.894	226.998
2035	247.033	247.028	234.240	234.150
2036	254.809	254.828	241.586	241.302
2037	262.586	262.628	248.932	248.455
2038	270.363	270.427	256.278	255.607
Total	**3.929.669**	**3.926.595**	**3.729.804**	**3.753.195**

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The prediction result of ship and container flows in Table 4 and Table 6 above are then used to analyze the capacity and capacity requirements of the pier in 2019 - 2038, including the number of berths and length of the pier, using the formula recommended by the International Maritime Organization (IMO), the results obtained as shown in Table 7 below.

TABLE 7. Calculation Results of Length Capacity Needs and Number of Wharfs

Year	Container Flow (TEUs)	Vessel Flow (Unit)	BOR (%)	BTP (TEUs/M)	n (Unit)	Wharf Length (m)
2019	122.604	403	70	516,34	2,00	218,50
2020	130.381	422	70	549,09	2,00	218,50
2021	138.158	442	70	581,84	2,00	218,50
2022	145.934	461	70	614,59	2,00	218,50
2023	153.711	480	70	647,34	2,00	218,50
2024	161.488	500	70	680,09	2,00	218,50
2025	169.265	519	70	712,84	2,03	221,71
2026	177.041	538	70	745,59	2,11	229,59
2027	184.818	557	70	778,35	2,18	237,48
2028	192.595	577	70	811,10	2,26	245,36
2029	200.372	596	70	843,85	2,33	253,24
2030	208.149	615	70	876,60	2,41	261,13
2031	215.925	634	70	909,35	2,48	269,01
2032	223.702	654	70	942,10	2,56	276,89
2033	231.479	673	70	974,85	2,63	284,77
2034	239.256	692	70	1.007,60	2,71	292,66
2035	247.033	712	70	1.040,36	2,79	300,54
2036	254.809	731	70	1.073,11	2,86	308,42
2037	262.586	750	70	1.105,86	2,94	316,30
2038	270.363	769	70	1.138,61	3,01	324,19

Based on the calculation results in Table 7 above, the length of the existing pier that is 237.48 meters with 2 moorings not separated is able to serve the flow of ships until 2027 while maintaining a 70% BOR value.

Stacking field area (container yard) requirements as shown in Table 8 as follows:

TABLE 8. Calculation Results of Stacking Field Capacity Needs

Year	Container Flow	Dt (hari)	Sf (m³)	Sth	Bs	A (m^2)	A (ha)
2013	74.074	10	29	4	0,25	20294,25	2,0
2014	81.408	10	29	4	0,25	22303,56	2,2
2015	90.271	10	29	4	0,25	24731,78	2,5
2016	101.310	10	29	4	0,25	27756,16	2,8
2017	107.533	10	29	4	0,25	29461,10	2,9
2018	111.592	10	29	4	0,25	30573,15	3,1
2019	122.604	10	29	4	0,25	33590,14	3,4
2020	130.381	10	29	4	0,25	35720,77	3,6
2021	138.158	10	29	4	0,25	37851,39	3,8
2022	145.934	10	29	4	0,25	39982,02	4,0
2023	153.711	10	29	4	0,25	42112,64	4,2
2024	161.488	10	29	4	0,25	44243,27	4,4
2025	169.265	10	29	4	0,25	46373,89	4,6
2026	177.041	10	29	4	0,25	48504,52	4,9
2027	184.818	10	29	4	0,25	50635,14	5,1
2028	192.595	10	29	4	0,25	52765,77	5,3
2029	200.372	10	29	4	0,25	54896,39	5,5
2030	208.149	10	29	4	0,25	57027,02	5,7
2031	215.925	10	29	4	0,25	59157,64	5,9
2032	223.702	10	29	4	0,25	61288,27	6,1
2033	231.479	10	29	4	0,25	63418,89	6,3
2034	239.256	10	29	4	0,25	65549,52	6,6
2035	247.033	10	29	4	0,25	67680,14	6,8
2036	254.809	10	29	4	0,25	69810,77	7,0
2037	262.586	10	29	4	0,25	71941,40	7,2
2038	270.363	10	29	4	0,25	74072,02	7,4

Based on the calculation results in Table 8 above, it can be seen the needs of the container stacking field in Tenau Port Container Terminal for the next 20 years, where the existing container stacking area is 2.6 hectares based on the above calculation has been fulfilled until 2015 and the required field area in 2019 there will be 3.4 hectares. The existing YOR is worth 70%, so that 70% of 33,590 m^2 (2019 needs) is 23,513 square meters or 2.35 Ha.

V. CONCLUSION

Based on the results of the data analysis and discussion described in section 4, and referring to the purpose of this research, the following conclusions can be concluded:

1. The analysis results of the existing performance operational services referring to the Decree of the Director General of Sea Transportation in 2011 show that the value of Approach time (AT), container loading and unloading performance using container cranes, and Yard Occupancy Ratio (YOR) or the level of use of stacking fields, have a poor level of performance and needs to be considered and improved the quality of service.
2. Based on the capacity calculation results, in 2028 the pier needs to be extended and it must also be considered to increase the number of moorings so that the port is able to serve all the flow of ships and containers that enter the Tenau port. In addition, the Tenau-Kupang container terminal stacking yard needs to be considered for expansion because the current capacity of 2.6 hectares has almost been fulfilled in 2019 and the YOR value has exceeded the standard.

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