Impact of Pulau Balang Bridge Operations on Kariangau – Penajam Ferry Service

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Abstract

Pulau Balang Bridge is access to connect Balikpapan-Penajam. There are several alternative transportations from Balikpapan to Penajam, one of it using a ferry, its take 1.5 hours. Passengers can use speedboat service, that take only 15 minutes whit substandard safety. The number of passengers is significant for Balikpapan-Penajam Ferry Service, after Pulau Balang bridge operate must have impact. This study aims to predict the demand for Kariangau-Penajam Ferry Service after Pulau Balang bridge operate and determine of ships demand for the Kariangau-Penajam Ferry service after the bridge operates. The method used in this study is forecasting with linear regression and descriptive or survey research. The result of this study shoes that from opportunity cost, all users will use bridge, from fuel cost all routes is better to use the bridge. The user of Kariangau-Penajam Ferry service is 23% would like to switch, 33% users would take alternately using ship and bridge, 20% would use ferry, and 24% hadn't choosen yet. Projections of passenger demand in 2026 and 2031 after the bridge operation to be optimistic that the demand will decrease to 48,5% with maximum 15 ships, minimum 7 ships needed and pessimistic possibly 20% with maximum 7 ships, minimum 2 ships needed, based on the difference between the cost of fuel oil and ship rates the required number of ships is 2 ships per day, currently 19 ships are operating.

Keywords: Ferry service, Kariangau Penajam area, Pulau Balang Bridge

1. Introduction

Pulau Balang Bridge is the access to the Indonesia's Capital City of IKN and connects Balikpapan and Penajam. Pulau Balang bridge construction is designed with a width of 22.4 meters consisting of 2 connecting bridges, namely the main bridge, which is a bridge that connects Balang Island with the City of Balikpapan. This long-span bridge has 4 vehicle lanes equipped with 804 meters of right and left sidewalks with concrete construction and cable-stayed as a bridge support. To arrive at the entrance to the long-span bridge 15 km access road will be built from the city of Balikpapan, which is currently still in the acquisition land stage. The second bridge is a bridge that connects to Penajam Paser Utara Regency, which currently only has 2 main lanes. Going to the Penajam Paser Utara district from the short-span bridge is also planned to build an access road more or less the same as in Balikpapan [1].

Weak connectivity can be seen by the concentration of economic activity in urban areas and industrial activities that do not extend to underdeveloped and isolated areas due to limited transportation infrastructure. Connectivity between regions can be improved by providing adequate and reliable transport facilities and infrastructure, as well

as efficient operation to improve industrial access from processing centers to commercialization areas. Strengthening connectivity will have an impact on economic growth, equity and sustainability to reduce growth disparities and welfare inequalities between regions [2].

Furthermore, to carry out certain activities, each individual must be in a certain place and at a certain time. Furthermore, this will direct the individual to be in a certain location. At the lowest level, decisions are made regarding where, when, and how the trip will be made [3].

River Lake and Ferry Transportation is one type of transportation mode in Indonesia. included in the scope of ground transportation. However, technically and operationally it is the same as sea transportation because it has the same characteristics as water transportation. Based on its function, ferry transportation is divided into three, namely ferry transportation that loads passengers (passenger), ferry transportation that loads vehicles (Ro-Ro), and ferry transportation that loads passengers and vehicles (Ro-Pax) [4].

Ferry transportation has criteria close to the characteristics of road transportation, namely, high-frequency shuttle services, services without long waiting times, scheduled services with a constant headway; Reliable service is usually expressed in the parameters of regularity and punctuality, safe and comfortable shipping,

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moderate fares and accessibility to ferry ports that are not too far from the center of traffic generation. The crossing mode of transportation has the characteristics of being able to transport passengers and vehicles in large numbers and at relatively low speeds with low levels of pollution [5].

Ferry transportation is transportation that connects between areas separated by rivers. Ferry transport as a link to land transportation networks within the framework of a national transportation system that functions to unify the archipelago which consists of thousands of islands as one unit [6]. There are basically 2 (two) types of utility (use) that can be created by transportation or transportation, especially for goods being transported, namely, place utility, namely the increase or addition of the economic value or use value of a commodity that is created by transporting it from a place/area where the goods have greater use. Time utility, namely transportation will lead to the creation of the ability of goods to meet human needs by providing the goods concerned, namely not only where they are needed, but also when they are needed [7].

Currently, there are several alternative transportations to connect from the Balikpapan area to Penajam and vice versa, one of which is by ferry, alternative travel time is 1.5 hours plus time to queue. Another alternative is to use a speed boat, which takes about 15 minutes. Speed boats are only for passenger purposes and substandard safety.

Public complaints about the performance of the Kariangau - Penajam ferry service stated that passengers had to queue for a long time at the port or wait a long time on the ship waiting for loading and unloading [8]. The service attributes that occupy the top priority for improvement are the cleanliness of the bathroom/WC on the ship, the punctuality of arrival at the destination port, the punctuality of the cruise time, the air temperature on board and the presence of notifications/demonstration of safety equipment on board [9].

The supply of transportation services to meet people's needs is related to the demand for transportation services as a whole. Each transportation model has different characteristics and technical aspects, which will affect the transportation services offered by transportation. From the supply side, transportation services can be distinguished from several aspects as follows, the equipment used, available capacity, the technical condition of the transportation equipment used, the production of services that can be delivered by the transportation company, the financing system in the operation of the transportation equipment [9]. Passengers are people who use crossing transportation services including vehicle crew. Pedestrian passengers are passengers who will use crossing transportation services without using a vehicle. Passengers on vehicles are passengers who will use crossing transportation services by using a vehicle. Vehicle is a means of transportation on the road consisting of Motorized Vehicles and Non-Motorized Vehicles [9].

There are 19 units of ships at the Kariangau – Penajam ferry service, with 12 ships operating and 7 ships on standby. However, when conditions are crowded, the ships that are mooring are seconded to operate. The construction of the Pulau Balang bridge will have an impact that can weaken the development of the shipping ferry service industry in the Balikpapan - Penajam area. The number of requests for ferry services and currently existing ships is threatened to decrease after the Pulau Balang bridge is operated. Therefore, it is necessary to study the impact of operating the Pulau Balang bridge on the Kariangau – Penajam ferry service as well as the number of ships needed at the Kariangau ferry service after the Pulau Balang bridge operates.

2. Research Method

There are two data used for this research method. The primary method is descriptive or survey research with interviewing use a questionnaire to passenger of the Kariangau - Penajam ferry service, and secondary data has been processed by the port and shipping operators (shipping companies) operating on the Kariangau - Penajam shipping route, such as ship data, ship productivity for the last 5 years, operating patterns and specifications of ships in operation shown in Fig. 1.

2.1. Research sample

The sample is part of the population to be studied. The purpose of determining the sample is to obtain information about the object of research by observing only a portion of the population, a reduction in the number of objects of research. The research sample includes a number of elements (respondents) that are greater than the minimum requirements [10].

Data adequacy test was carried out to determine whether the measured data with a certain confidence level and accuracy were met. In this final project, the Slovin calculation can calculate a population's sample size with the desired accuracy level. The Slovin calculation in question is as follows [11]:

$$n = \frac{N}{(1+Ne)^2} \qquad (1)$$

where:
n = Number of samples
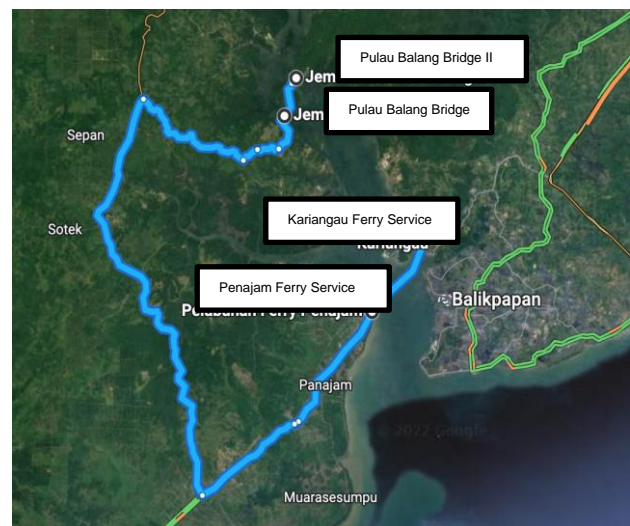N = Total population
e = error tolerance

Figure 1. The Kariangau – Penajam route ferry and bridge

In the Slovin calculation application, it is necessary to determine the desired error tolerance. The following are several classifications of error tolerance values:

a. 99% ≈ 0.01, small error rate with a very high level of confidence
b. 95% ≈ 0.05, medium error rate and a moderate level of confidence
c. 90% ≈ 0.1, the error rate is moderate, the error rate known to exceed the value of 10% or less than 90% cannot proceed to further data processing [12].

2.2. Opportunity cost

Opportunity costs are costs incurred by someone when choosing an activity; in other words, it is losses or gains from making a decision. In this case, analyzing the fees charged by transportation users if they prefer to use sea or land modes based on the time difference. Opportunity cost calculation can be seen below [13].

$$Opportunity\ Cost(Rp) = Goods\ Value \times Time\ Diff. \quad (2)$$

where:
Goods Value = UMR/hour
Time Difference = Land Time – Sea Time (Hours)

2.3. Forecasting

Forecasting passengers at Kariangau - Penajam ports with assumption before the Pulau Balang bridge operates, this forecast is calculated until 10 years afterward against the hinterland GRDP (Gross Regional Domestic Product) of these two ports. In this analysis, 4 types of vehicles representing each class are calculated, namely motorcycles, cars, buses, and trucks, using SUP (Satuan Unit Produksi) [14].

Forecasting predicts future events using analytical calculation techniques with qualitative and quantitative approaches using past reference data. The trend is a long-term movement in a period that can sometimes be described with a straight line. It is assumed that the trend can be represented by some simple function, such as a straight line through the period for the observed time series. If the data depicted on the scatter diagram is close to a straight line, then a time series like this is included in a linear trend [15]. The equation formula is:

$$Yt = a + bt \quad (3)$$

where:
Yt = Time series data to be estimated
t = Time variable
ab = Constants, and coefficients

2.4. Determining the number of vessels

Optimization is a mathematics discipline that focuses on systematically getting a minimum or maximum value from a function, opportunity, or another value search in various cases. Optimization can be used in various fields to achieve the effectiveness and efficiency of the desired target. The purpose of optimization is to determine the minimum total cost, so the goal in the mathematical model is minimization [16].

The formula below is used to determine the number of ships in operation.

$$N = \frac{KP}{KT} \times Load\ Factor \quad (3)$$

where :
N : Number of Vessels
KP : Capacity Used (Number of Passengers Per Day)
KT : Available Capacity (Available Ship Capacity)

3. Results and Discussion

3.1. Research sample results

In this study, the data adequacy test was carried out using a 90% error tolerance. Then the number of samples obtained is a minimum of 67 passengers as a sample according to the population of users of the Kariangau - Penajam Paser Utara ferry service on average - an average of 200 people per day. The number of samples taken was 140 passengers. There were 22 female respondents and 48 male respondents in this questionnaire. The age range of the respondents is from 17 to over 50 years old.

3.2. Probability of switching from the ferry to the bridge

On the Kariangau – Penajam ferry service, the areas of origin that depart from the Kariangau ferry service include the origin areas from the Kariangau Port, namely, Balikpapan (64%), Samarinda (20%), Kutai Kartanegara (13%) and Pontianak (3%), while the destination areas are the Penajam are Penajam Paser Utara (44%), Paser (29%) and Banjarmasin (27%).

Figure 2 shows the passenger of ferry service choice if Pulau Balang bridge is operating. 23% of the passenger Kariangau Penajam ferry service will switch to the bridge, another 33% will take turns using the ship, and the bridge, 20% of passengers will continue to use the ferry, and 24% The other still not choosing yet what mode they will use.

3.3. Analysis characteristics of passenger and vehicle loads on the Kariangau – Penajam ferry track

Some of the document study results were the names and capacities of the vessels operating at the Kariangau – Penajam ferry service. There is also data for the last 5 years on the Kariangau and Penajam Ports.
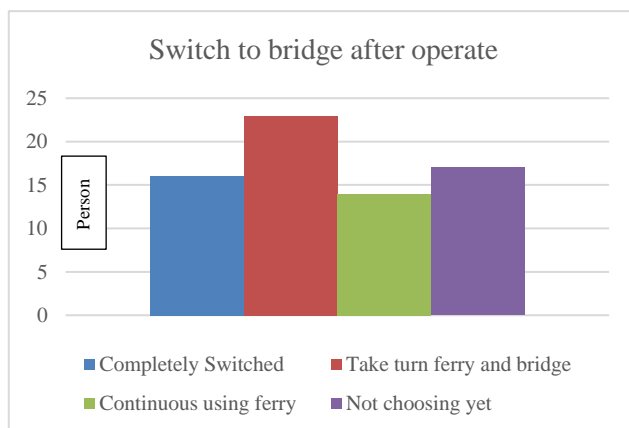

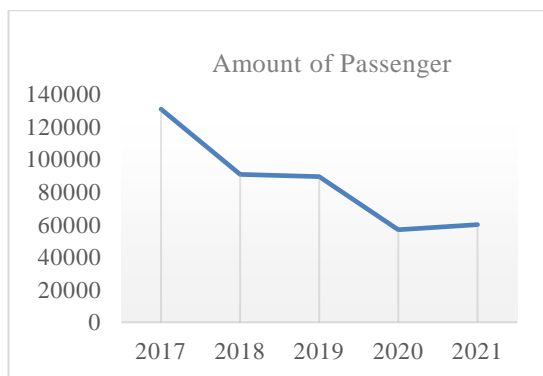Figure 2. Passengers switch to Pulau Balang bridge if already operating

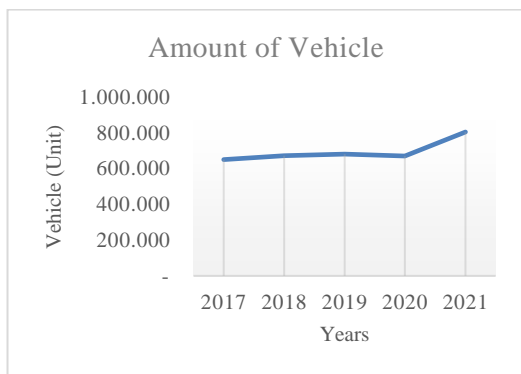Figure 3. Kariangau – Penajam ferry service passenger production

Figure 4. Kariangau – Penajam ferry service vehicles production

Figure 3 presents the total service production for all passengers, both adults and children, from 2017 to 2021. From 2017 to 2018, it rose 1.3%, then in 2019 it increased again by 1.1%, then decreased in 2020 by 11 % and in 2021 there will be an increase of 18%. The number of passengers during 2017-2021 is classified as fluctuating. The decline in passengers in 2020 was caused by the Covid-19 virus pandemic and then began to revive in 2021 when the rules regarding travel and Covid-19 have improved.

Figure 4 presents the total service production for all vehicles from class I - IX from 2017 to 2021. From 2017 to 2018, it rose 3.2%. In 2019 it increased by 1.4%, then decreased in 2020 by 1.5%. In 2021 there will be an increase of 2%. The number of vehicles during 2017-2021 is classified as fluctuating. The decline in the number of vehicles in 2020 was caused by the covid-19 virus pandemic and then began to revive in 2021 when the rules regarding travel and covid-19 have improved.

Currently, 19 vessels are operating On the Kariangau and Penajam Ports with passenger capacity around 71 – 400 person and vechicle capacity around 13 – 30 vechicle. This ship is under few shipping company, PT. ASDP Indonesia, PT. Dharma Lautan Utama, PT. Sadena Mitra Bahari, PT. Pascadana Sundari, PT. Jembatan Nusantara, PT. Bahtera Samudera and PT. Tranship Indonesia.

3.4. Opportunity cost result

In this calculation, the distance and time between using the ferry crossing and the bridge are calculated, then it is reviewed which is more effective between land and sea distances. At this stage the analysis determines the point of origin and destination. The starting point of the destination is the origin area of Balikpapan and the destination point is the Penajam area. Then analyze the time and distance in each area of origin and destination.

Comparison of the distance between modes, the mode of using a ferry is a travel scheme that uses land transportation first to port A then crosses to port B and then uses land transportation again to reach the desired point. In the mode of crossing the bridge, from the point of origin to the point of destination, it will be directly served from and to the destination of transportation. Meanwhile, using the bridge mode only uses land vehicles, and from the point of origin to the destination it is connected by a bridge. The distance to the starting point of each ferry route and bridge is presented in table

The time comparison between modes is calculated after knowing the distance between modes, the distance between modes of the ferry from the starting point to the destination point that will be taken by transportation users. It is known that the sea distance between Kariangau (Balikpapan) - Penajam is 7 km and an average speed of 5 knots will get a travel time of 90 minutes. While the distance between the point of origin to the point of destination will be known the travel time that will be taken by land transportation users. It is known that the length of the Balang Island Bridge is 1.9 km which will be taken assuming the average speed while driving is 40 km/hour.

Table 2 is the total time required for each route from the origin of the ferry and bridge mode points. With the difference in time calculated in absolute terms, the results of the time sacrificed for each selected mode will be assessed as the same as the UMR (Regional Minimum Wage) per hour in each district/city. In this analysis, 4 types of vehicles representing each class are calculated: motorcycles, passenger cars, buses, and goods trucks using SUP units (Production Units) [5]. The following is an example of the results of opportunity cost analysis on the Kariangau Penajam ferry service as presented in Table 3.

Table 1. Comparison of distance between bridge and ferry (KM)

| Origin | Destination | | | | | |
| | Penajam Paser Utara | | Paser | | Banjarmasin | |
	Bridge	Ferry	Bridge	Ferry	Bridge	Ferry
Balikpapan	74	19	220	165	523	468
Samarinda	172	125	318	271	621	574
Kutai Kartanegara	187	140	333	286	636	589
Pontianak	1,689	1,642	1,835	1,788	2,138	2,091

Table 2. Comparison of time between bridge and ferry (Hours)

| Origin | Destination | | | | | |
| | Penajam Paser Utara | | Paser | | Banjarmasin | |
	Bridge	Ferry	Bridge	Ferry	Bridge	Ferry
Balikpapan	1.23	1.82	3.67	4.25	8.72	9.30
Samarinda	2.87	3.58	5.30	6.02	10.35	11.07
Kutai Kartanegara	3.12	3.83	5.55	6.27	10.60	11.32
Pontianak	28.15	28.87	30.58	31.30	35.63	36.35

Table 3. Opportunity cost for passengers (Rp)

Origin	Destination		
	Penajam Paser Utara	Paser	Banjarmasin
Balikpapan	2,453	2,453	2,453
Samarinda	3,080	3,080	3,080
Kutai Kartanegara	3,141	3,141	3,141
Pontianak	2,532	2,532	2,532

Following Table 1 the results of the intermodal distance analysis show that the 12 existing routes will all be closer if you use the Kariangau – Penajam ferry crossing. However, in Table 2 the results of the intermodal time analysis show that the 12 existing routes will all be faster using the Balang Island Bridge. In Table 3 opportunity cost for passengers, the biggest cost for passengers is from Kutai Kartanegara, which is Rp. 3,141

Figure 5 shows that for the purpose of the Penajam Paser Utara from each area of origin faster if using the Balang Island bridge. Figure 6 shows that for the purpose of the Paser from each area of origin faster if using the Balang Island bridge. Figure 7 shows that for the purpose of the Banjarmasin from each area of origin faster if using the Balang Island bridge.

3.5. Fuel cost result

From Table 3, a table of comparisons of distances between bridge and ferry is obtained, from this comparison, the difference between the two modes is obtained, according to Table 4.
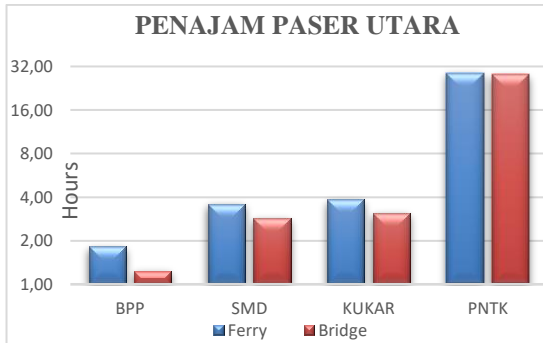

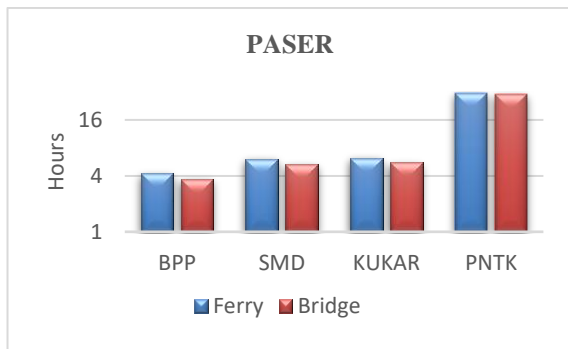Figure 5. Comparison of ferry service and bridge times at Penajam Paser Utara destination points

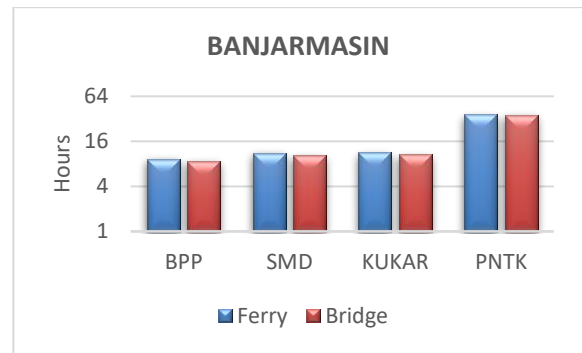Figure 6. Comparison of ferry service and bridge times at Paser destination points

Figure 7. Comparison of ferry service and bridge times at Banjarmasin destination points

Table 4. Difference distance between ferry and bridge (KM)

Origin	Destination		
	Penajam Paser Utara	Paser	Banjarmasin
Balikpapan	55	55	55
Samarinda	47	47	47
Kutai Kartanegara	47	47	47
Pontianak	47	47	47

From the difference in the distance between modes that pass through the bridge and the ferry, the difference in costs between using the Pulang Balang bridge and the Kariangau – Penajam crossing is obtained, for a distance difference of 55 km, on 2-wheeled, 4-wheeled and 6-wheeled vehicles according to the Table 5 and 6.

The same calculation is carried out for wheels 4 and 6. In terms of distance, all routes are closer if you pass the Kariangau – Penajam ferry crossing. It's just that in comparison to the price of fuel consumption with boat fares it is much cheaper if it passes through the Balang

Table 5. Difference of 55 KM for ship rate and fuel cost for group II

MOTORCYCLE (GROUP II)			
Operational			
Distance	=	55.0	Km
Ship Rate	=	Rp 34,000	
Fuel Oil			
Fuel Conversion			
1 Liter	=	20	km
1 Liter	=	Rp 10,000	
Fuel type	=	Pertalite	
Margin	=	10%	
Fuel needs	=	Rp 27,500	/trip
Amount Cost	=	Rp 30,250	/SUP/trip

Table 6. Difference of 47 KM in ship rate and fuel cost for group II

MOTORCYCLE (GROUP II)			
Operational			
Distance	=	47.0	Km
Ship Rate	=	Rp 34,000	
Fuel Oil			
Fuel Conversion			
1 Liter	=	20	km
1 Liter	=	Rp 10,000	
Fuel type		Pertalite	
Margin	=	10%	
Fuel needs	=	Rp 23,500	/trip
Amount Cost	=	Rp 25,850	/trip

Island bridge, especially for 4, 6 and more wheeled vehicles. For Class II vehicles, the difference between the boat fare and fuel costs is Rp. 3,750 and Rp. 8,150, Group IV, the difference is Rp. 206,408 and Rp. 216,822, for Group VI the difference between the ship fare and fuel costs is Rp. 465,795 and Rp. 499,075. If viewed from a comparison of fuel prices for ferry fares, it is possible for 4 and 6 wheeled vehicles to switch to using the Balang Island bridge.

3.6. Forecasting results

Figure 8 is the forecast for passengers at Kariangau and Penajam ports with the assumption that before the Pulau Balang bridge operates for the next 10 years, the GRDP of these two ports will be hinterland. Projections of passengers at the Kariangau port without a bridge, according to Figure 3.1 projected demand for the Kariangau ferry service without a bridge on Balang Island from 2022 – 2031.

From the projections that have been carried out using the linear regression method, according to the Ministry of Blood Transportation, the demand for crossings for passengers has decreased in existing data because in 2020 there was a Covid-19 virus pandemic and then began to revive in 2021 when the rules regarding travel and Covid-19 have started to improve. In 2021 the number of requests for crossings for passengers is 2,362,828 people and in 2031 it is estimated that the demand for crossings for passengers will be 2,597,818 people. This is illustrated in Figure 8. The projected demand for the Kariangau ferry crossing without the Balang Island bridge is not yet operational. In accordance with the data from interviews using a questionnaire, most of the users of the Kariangau – Penajam ferry crossing aim to work, so it can be said that many of these passengers repeatedly use the ferry.

Figure 9 is the demand for crossings for vehicles has increased, especially in 2021 the number of requests for crossings for vehicles is 802,631 units and in 2031 it is estimated that there will be an increase in the demand for crossings for passengers amounting to 1,077,480 units.
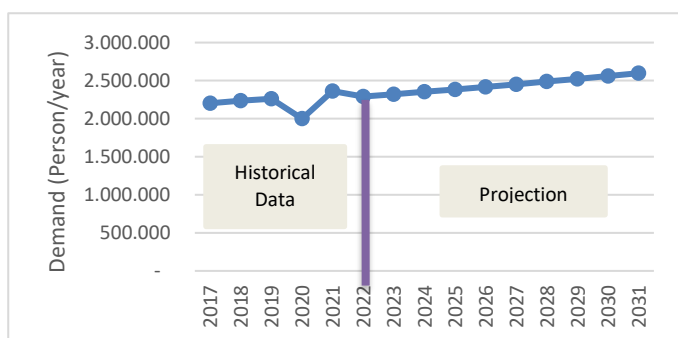

Figure 8. Projection of passenger demand for Kariangau Penajam ferry service without Balang Island bridge
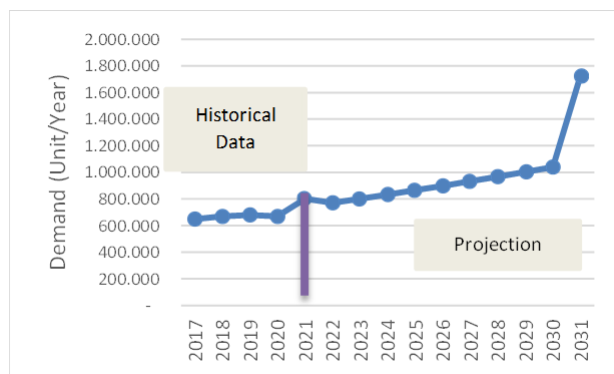

Figure 9. Projection of class I - III demand for Kariangau Penajam ferry service without Pulau Balang bridge

Table 7. Prediction of the number of users of the Kariangau - Penajam ferry service after the Pulau Balang bridge operates

Kariangau – Penajam Ferry Service (SUP)			
Years	Amount of Passanger	Optimistic	Pessimistic
2026	2,418,067.54	1,172,763	483,614
2031	2,597,817.54	1,259,941	519,564
2026	898,522.88	435,784	179,705
2031	1,723,967.61	836,124	344,793

3.7. Results of the number of ferry users after the bridge is in operation

From the total percentage of users of the Kariangau – Penajam ferry service who do not switch and continue to use the ferry multiplied by the demand for waiter services which was previously calculated by forecasting. The questionnaire was divided into 4 categories of respondents, namely people who still use ships (20%), passengers who will completely switch to the bridge (23%), passengers who will take turns using ships and bridges (33%), and passengers who do not know what mode would they use (24%).

The optimistic possibility is obtained from 20% of people who will continue to use the ship and half of the 57% of people who will take turns and do not know what mode to use. So the possibility of optimism is 20% plus 29%, which is 49% of passengers. Meanwhile, on the pessimistic possibility, it is only counted by people who will definitely continue to use the ship, namely 20%.

Regarding the number of passengers after the Balang Island bridge operates. Passenger forecasting data taken according to forecasting projections before the Pulau Balang bridge operates then taken the 5th (2026) and 10th (2031) years, so the data obtained is in accordance with what is presented in Table 7 prediction of the number of users of the Kariangau ferry crossing service - Penajam after the Balang Island bridge operates.

3.8. Results of determining the number of vessels after the bridge is in operation

Currently there are 19 ships with a 12-7 operating pattern. Determination of the number of ships is done by calculating the number of people per day after the Balang Island bridge is operational divided by the capacity of the

ships per day and multiplied by the load factor which is 76%, then an optimistic possibility is obtained or 48.5% of the number of requests for crossing services in 2026 for ships with a capacity 200 people needed 12 ships, a capacity of 200 - 300 people needed 9 ships, a capacity of more than 300 people needed 7 ships per day and 2031 for ships with a passenger capacity of 200 people needed 15 ships, a capacity of 200 - 300 people needed 13 ships, a capacity of more than 300 people are needed by 11 ships per day. While the possibility is pessimistic or 20% of the number of requests for ferry services in 2026 for ships with a passenger capacity of 200 people, 5 ships are needed, 2 ships with a capacity of 200 - 300 people are needed, 3 ships are needed for a capacity of more than 300 people, 2 ships per day and 2031 for ships with a passenger capacity of 200 people needed 7 ships, a capacity of 200 - 300 people needed 4 ships, a capacity of more than 300 people needed 3 ships per day.

Based from the selection of passengers based on the difference in the cost of fuel oil and ship rates, it is likely that the required number of ships is 2 ships per day.

4. Conclusion

Based on the data and discussion carried out, it is predicted that the growth in the number of ferry users after the bridge operates is proportional to the increase in the total number of crossings. In terms of the distance, all crossing routes are closer if they use the Kariangau – Penajam ferry line. In terms of time, all crossing routes are closer if they pass the Balang Island bridge. Based on the comparison of the use of fuel oil and ferry fares, all routes are cheaper if they pass through the Balang Island bridge. Currently there are 19 ships with an operating pattern of 12 - 7 at the Kariangau - Penajam Ferry Crossing. Based on the results of interviews and forecasting, the possibility is optimistic that in 2026 12 ships will be needed for ships with a passenger capacity of 200 people.

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