Journal of Mechanical, Civil and Industrial Engineering
ISSN: 2710-1436
DOI: 10.32996/jmcie
Journal Homepage: www.al-kindipublisher.com/index.php/jmcie

JMCIE
AL-KINDI CENTER FOR RESEARCH AND DEVELOPMENT

| RESEARCH ARTICLE

Technical Feasibility Study of Trans Metro Dewata Bus Operation Plan for Corridor 5

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| ABSTRACT
The high mobility in the urban area of Sarbagita, Bali, has led to an increased need for transportation options. The BRT Trans Metro Dewata public transportation system has been operated since 2020, aiming to reduce private vehicle usage. The plan to implement corridor 5 (Kuta Central Parking- PNB Campus -Titi Banda) starting from May 2023 aims to expand service coverage and increase the load factor. A technical feasibility study was conducted involving passenger surveys, questionnaires, and interviews to analyze demand and supply. Passenger characteristics reveal a majority aged 16-30, with bachelor's and high school education levels, employed in the private sector, with incomes ranging from 4-8 million IDR per month. They include "Choice users" who could use private vehicles but choose public transportation. The potential demand averages 27,194 passengers per month, peaking at 29,060 passengers in June, with a load factor of 28.88%. The low passenger growth rate (1-2%) estimates around 29,438 passengers per month in five years. Optimal operation by the operator involves 16 bus fleets while maintaining minimal standards. Eliminating subsidies requires substantial growth, reaching 16,339 passengers daily.

| KEYWORDS

Corridor 5 Passengers, Load factor, Demand, Supply, VOC, Eligibility

| ARTICLE INFORMATION

ACCEPTED: 02 November 2023 **PUBLISHED:** 30 November 2023 **DOI:** 10.32996/jmcie.2023.4.4.6

1. Introduction

1.1 Research background

Developments in the region of urban Sarbagita in Bali after the pandemic in several sectors like economy and tourism resulted in the high mobility of community and tourists from one place to another. Height mobility impacts more and more, increasing the need for public mode transportation. Public transport cannot be separated from the system of city transportation. Public transport has a very important role in accommodating the dynamics of society. The existence of public transport is also required to enhance quality and progress development area urban [Upa, 2017]. Results of the study by the PNB Research Team on the availability and demand of infrastructure and public transportation facilities in Bali in 2019 recommended the development of mode transport based technology information like mode alternative train /LRT/ART/Bus BRT, given the huge potential *demand* of 66.5% (15.80 million) passengers [Hermawati et al. 2019]. Recommendation materialized on September 7, 2020; the Government Province of Bali, with support from the government center through the Directorate of Public Land Transportation, has realized the Procurement of Trans Metro Dewata (TMD) Buses, which are ground transportation /transport-based bulk roads. TMD buses are beginning to serve four corridors, and in 2022, there will be five corridors in the area Agglomeration Sarbagita, which includes Denpasar, Badung, Gianyar, and Tabanan [Bali Teman Bus n.d]. The number of Trans Metro Dewata bus fleets amounts to 105 units, with the provision of every bus operating days 95 units and 10 units to be reserved. Trans Metro Dewata, which is managed by PT. Satria Trans Jaya has 5 (five) routes/routes service [Bali Teman Bus n.d] as follows:

1. Corridor 1 (one), serving from Central Parking Kuta - Terminal Pesapan Tabanan pp, with stops at Ubung Terminal and Mengwi Terminal.

2. Corridor 2 (two), serving from Ubung Terminal - Ngurah Rai Sports Arena Denpasar - Ngurah Rai Tuban Airport, Badung, round-trip
3. Corridor 3 (three), serving from Ubung Terminal - Matahari Beach, round-trip with a Stop by Housing Dalung Beautiful.
4. Corridor 4 (four), serving from GOR Ngurah Rai - Monkey Forest Ubud, Gianyar, round-trip
5. Corridor 5 (five), serving from Central Parking Kuta - Bali State Polytechnic - Titi Banda, round-trip

For nearly 3 years of operation, the existence of the TMD Bus has not been able to attract the public's interest in using public transportation. However, the level of occupancy of passengers (*load factor)* of 15.15 – 32.65% [Hermawati et al. 2022] does not meet public transport performance standards, which should be at least 70% [Suprayitno et al. 2016]. An ideal mass transportation system is urgently needed in the Sarbagita area of Bali, which has a high level of community mobility. The operation of the mass transportation system is expected to reduce the use of private vehicles by the public in supporting their various mobility. Since the end of 2022, the operator plans to rearrange the route by making changes to corridor 5 so that the destination goes to the UNUD and PNB campuses in Bukit Jimbaran. The corridor 5 route planned and realized since April 1 2023, is from Central Parking to the UNUD and PNB Campus in Bukit Jimbaran via the Ngurah Rai bypass road, then heading to Titi Banda round trip. Thus, passengers from Corridor 1 (*Pesiapan terminal*) and Corridor 2 (*GOR Ngurah Rai*) will be transported from Kuta Central Parking to go to the Bukit Jimbaran campus, Badung. To convince the government as the public transport regulator to issue a new Corridor Decree and avoid failure due to the low load factor in this new corridor, it is necessary to conduct a technical feasibility study for the planned operation of Corridor 5.

1.2 Research purposes

The specific goal of this research is to study the appropriateness technical of the planned operational public transport mass BRT Trans Metro Dewata corridor 5, as follows:

1. Knowing the characteristics of passengers, destinations, and travel distribution of bus passengers on the planned route in Corridor 5
2. Calculating the potential of existing demand using buses in corridor 5 at this time and predictions for the next five years
3. review the appropriateness of technical Bus operation in corridor 5 based on the balance number of the fleet *(supply)* and of passengers *(demand)*

2. Research Method

2.1 Research Design

In this study, we assessed the technical feasibility of the operational plan for Corridor 5 by analyzing the balance between passenger demand and the number of fleet vehicles that need to be provided on that corridor for the current period and its predictions for the next five years. Through this study, it will be possible to develop a new public transportation service route that meets the service standards set by the Ministry of Transportation, providing the community with safe, comfortable, highly reliable, and affordable public transportation. The operators managing the public transportation fleet will also benefit financially.

2.2 Research Instruments and Variables

The main instruments in this research are questionnaires and structured interview questionnaires. The research variables to be collected include personal characteristics (gender, age, occupation, income, vehicle ownership), the purpose and destination of travel, travel time, and feeder transportation required. Meanwhile, variables to be collected from household surveys include the number of household members, the number of vehicles owned, and travel data for each household member.

3. Results and Discussion

3.1 Routes and Operations Corridor 5

The corridor 5 route, which has been implemented since April 1 2023, is the 1st rerouting, starting from Central Parking Kuta - Bali State Polytechnic Campus - Titi Banda, round trip. The total length of the existing route is 61 km. The complete description of the route is as follows:

- Central Parking Kuta – Jl. Raya Kuta – Jl. Setia Budi – Jl. Sunset Road - Jl. By Pass Ngurah Rai – Jl. Unud Campus – Bali State Polytechnic
- Bali State Polytechnic – Jl. Unud Campus - Jl. By Pass Ngurah Rai – Jl. Ngurah Rai Airport - Jl. Raya Tuban – Jl. Raya Kuta – Jl. Mertanadi – Jl. Sunset Road - Jl. By Pass Ngurah Rai – Titi Banda – Jl. By Pass Ngurah Rai – Jl. Sunset Road-Jl. Mertanadi – Jl. Raya Kuta – Central Parking Kuta

The operational scheme in corridor 5 is to operate 21 fleet units per day and 2 reserves. Each unit, on average, under normal circumstances, takes 4 rites per day so that the total reaches 84 rites per day. The 1st rerouting was able to increase the load factor

by 1.16%. After 3 months of operation and this increase, the second volume of rerouting is planned only on the PNB – Titi Banda – Central Parking route with the following planned routes:

> Bali State Polytechnic – Jl. Unud Campus – Jl. By Pass Ngurah Rai – Jl. Sunset Road-Jl. Mertanadi – Jl. Raya Kuta – Jl. Setiabudi – Jl. Sunset Road – Jl. By Pass Ngurah Rai – Titi Banda – Jl. By Pass Ngurah Rai – Jl. Hang Tuah Timur - Jl. Sunset Road -Jl. Mertanadi – Jl. Raya Kuta – Central Parking Kuta

This 2nd rerouting mileage becomes longer, 61.9 km. For planned operations, increase the operational fleet to 22 units, bringing the total to 88 repetitions per day. Predictable things become the problem with this 2nd rerouting that needs to be fixed attention Regional Government is:

1. Need attention of Denpasar City:
   - Lots of illegal parking at Titi Banda and filing House stop
   - Overcoming traffic jams on the Sunrise Beach route – Titi Banda Statue and vice versa.
2. Need attention Badung Regency:
   - Point congestion at Central Parking Kuta
   - Coordination with Siloam Hospital to add a stop in front of it

3.2 Predictions Amount Passenger and Load Factor

3.2.1 Amount Existing Passengers and Load Factors

The number of passengers and load factors can be known based on field surveys that record the number of passengers getting on and off so that the number of passengers per day and total passengers per month can be known. So, in the number of passengers on corridor 5, in the period January to April (before the first rerouting), there was a decrease in the number and fill rate of passengers. However, after rerouting in May 2023 and still being free, the number of passengers increased by 3,430 people, and the passenger fill rate increased by 11.95%. The average number of passengers per month is 27,194 people. Similarly, after the establishment of the general tariff, passengers had to pay Rp. 4,400 - there was still an increase in the number of passengers by 276 people, and the load factor also increased by 1.22%. This condition shows that the route diversion with the diversion destination for Bali State Polytechnic campus and Jimbaran area campus is quite effective in increasing the number of daily and monthly passengers. The number and level of passenger occupancy in corridor 5 can be seen in Table 1.

Table 1. Total Passengers and *Load Factor* in Corridor 5 Year 2023

No.	Moon, Year 2023`	Passenger		Change	
		Number (person)	*Load Factor* (%)	Number (person)	*Load Factor* (%)
1	January	27,956	19.40%	Before rerouting	
2	February	26,167	16.63%		
3	March	25,841	15.76%		
4	April	25,354	15.71%		
5	May	28,784	27.66%	3,430	11.95%
6	June	29,060	28.88%	276	1.22%

As a description of passengers and levels of stuffing in the corridors, others can be seen in Graph 1. According to the graph, it can be seen that Corridor 1 has the highest filling at 48%; meanwhile, Corridor 2, after rerouting, reaches a sizeable increase from 26.86 % to 40.94 %. Corridor 4 is in position third, and Corridor 5 is in position fourth in a matter of passengers and levels stuffing passengers (*load factor*). But in all corridors, it is still below the standard minimum service, which should be 70%.

Figure 1. Development of TMD Bus Load Factor in Corridors K1 – K5

3.2.1 Predictions Amount Passenger

The estimation of the number of passengers for 5 years' future is based on the number of passengers excited, considering the growth of passengers according to the existing data series as well as various expected conditions that affect it. According to previous data, the level of growth in passengers is by 1 – 2%. To predict the number of passengers in the first 2 years is 1%, with consideration still preparing the infrastructure, transportation feeders, information on bus stops/halted, and outreach to all groups. From the year 3rd to 5th, grade growth is estimated to have increased by 2% because it has already started known accessibility improvement and development routes as well as more fleets. Predictions of the number of passengers for up to 5 years in the future can be seen in Table 2.

Table 2. Predictions amount TMD Koidor 5 Bus Passengers 2023 - 2028

No	Year	Amount Passenger (person)	Amount Monthly average passengers (person)
1	2023	326,324	27,194
2	2024	329,587	27,466
3	2025	332,883	27,740
4	2026	339,541	28,295
5	2027	346,332	28,861
6	2028	353,258	29,438

3.3 Characteristics Individual Passenger

Individual characteristics of passengers were obtained by distributing questionnaires containing a list of questions to bus passengers in Corridor 5, either by interview or by filling out the questionnaire form directly. The distribution of questionnaires has been done with participants as well (onboard) on the bus. The respondents were 150 passengers on the Trans Metro Dewata bus Corridor 5, which is a complete condition of 16% of the number of passengers daily. Individual characteristics of passengers, including gender, age, education, and occupation, can be seen in Figure 2.

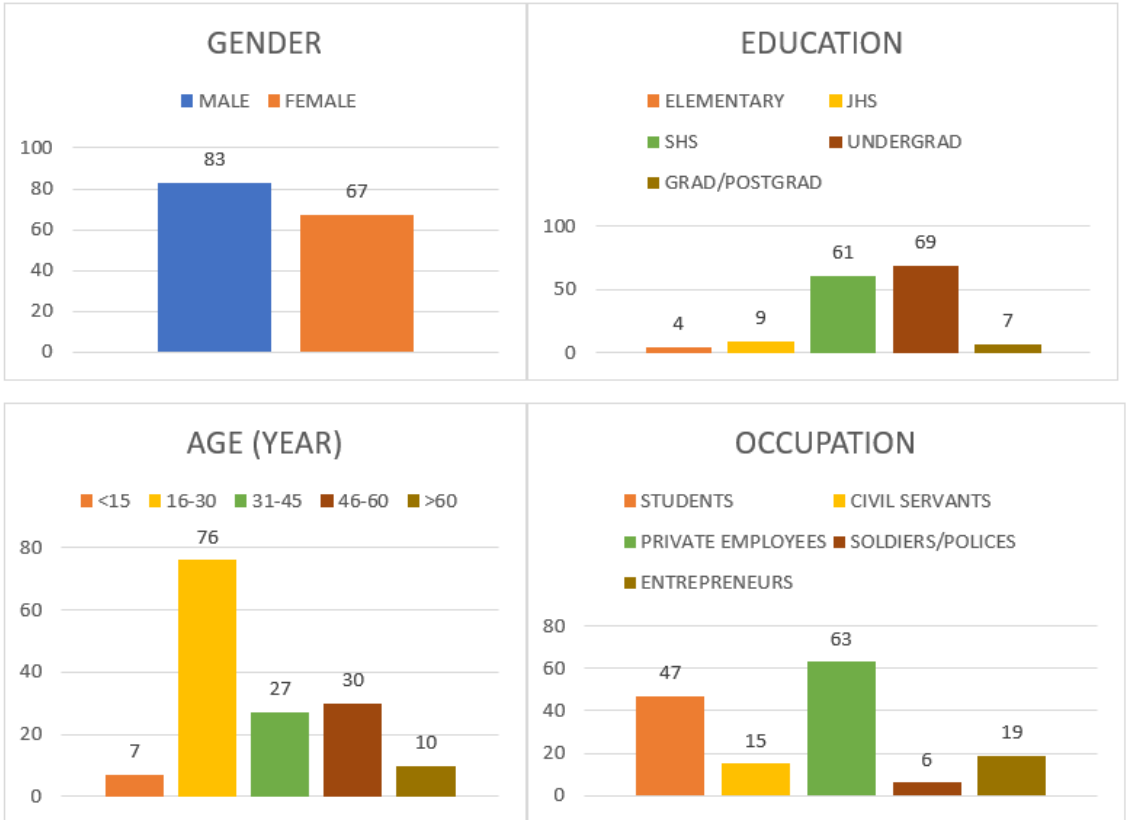

Figure 2. Individual Characteristics of Corridor 5 TMD Bus Passengers

Characteristics of bus passengers in corridor 5 can be seen in Figure 2, showing the composition of male passengers is more than female. The group's dominant age ranges from 16-60 years, and most are 16 – 30 years old. Furthermore, the level of majority education is bachelor's and high school, with predominant work as private sector employees and students. Based on family income (Figure 5.3), 50% have income less than Rp. 4 million, and 37% own revenue of 4-8 million, with a family of 4-5 people, which means they are from small families who have income with small to medium amount of income.

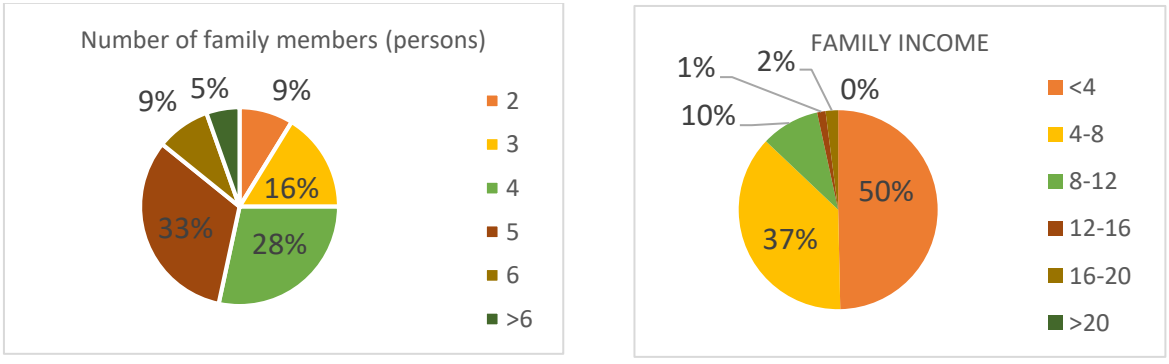

Figure 3. Characteristics of Families of Corridor 5 TMD Bus Passengers

3.4 Characteristics Journey Passenger

The purpose of the trip is 44% for work and 24% for education, so the frequency of trips every day one way is 35%, and everyday commuting is 23%. Furthermore, the average family ownership of 1 motorcycle is 48%, even those who own 2 motorbikes are 34%, and those who own 3 motorbikes are 14%, which means that the number of motorbikes in a family is almost the same as the number of family members. Likewise, with car ownership, as much as 86% have 1 car in the family, and there are even 12% who have 2 cars. This shows that passengers choose public transportation for transportation efficiency to work, school and campus even though they have motorbikes and cars, so it can be said that these passengers are in the "*Choice user* " category, namely

users who have convenience or access to private vehicles in such a way that can choose to use public transport. So passengers in corridor 5 are not " *captive users* ". This is a group of users who are forced to use public transportation due to the lack of private vehicles.

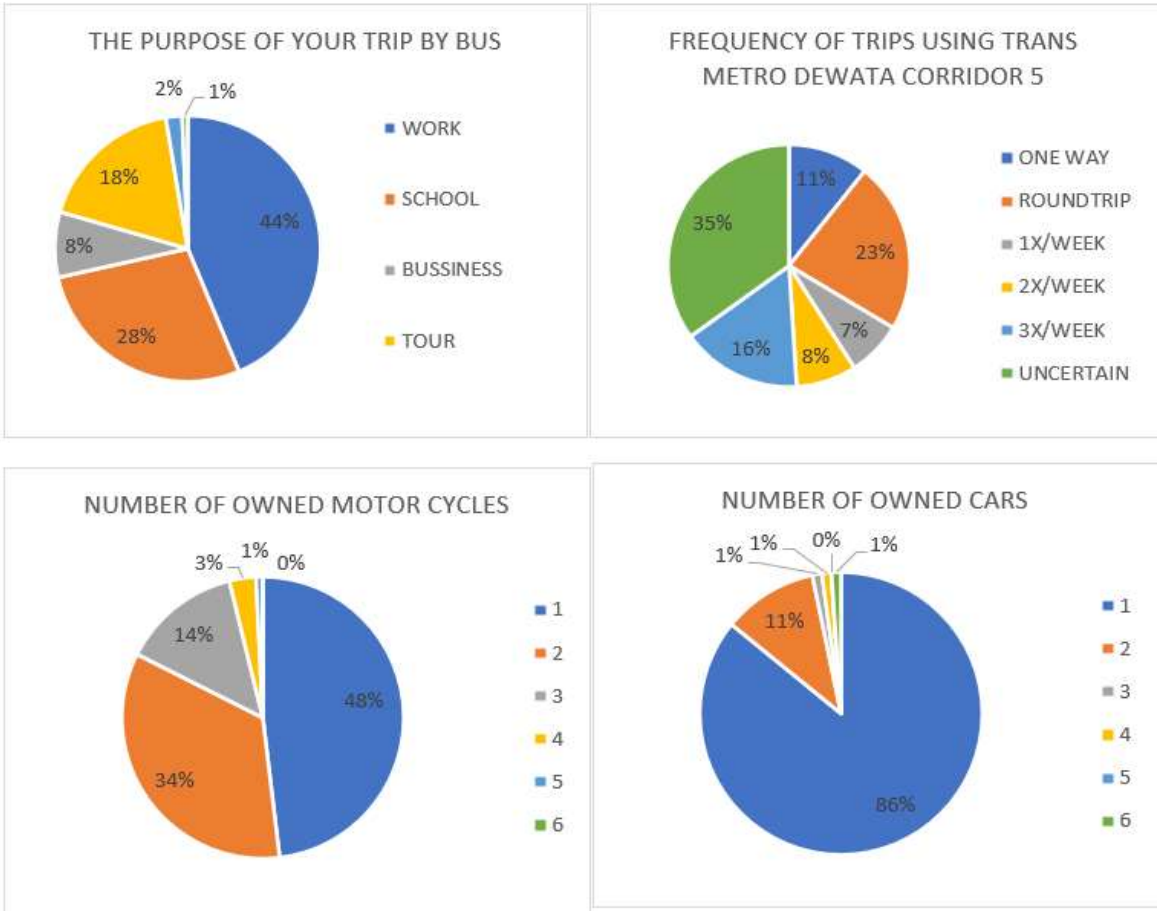

Figure 4. Travel Characteristics of Corridor 5 TMD Bus Passengers

3.5 Vehicle Operational Cost

Vehicle Operational Cost (VOC) is the total cost required to operate public transportation under certain traffic conditions for a particular type of vehicle per kilometer of distance traveled. VOC units are rupiah per kilometer. VOC is closely related to the cost of production. The calculation of basic costs based on the principle of cost per unit is the cost per passenger kilometer obtained from the total cost of public bus operations divided by total production, assuming a load factor of 70%. The total cost of operation is counted based on cost full (*full cost*) according to the system operational of the planned vehicle.

VOC analysis in this study used secondary data from the study before [4] because the price of existing units is still the same and applied until today. The standard calculation structure for bus production costs per kilometer by category of medium buses is described in Table 3.

Table 3. Standards Cost Moderate Bus Production per KM in Bali

No	Component	Bus Production Cost/km (Rp.)
I	Characteristics Vehicle	
1	Type	Medium buses
2	Service Type	Agglomeration urban
3	Capacity transport	40
II	Production per bus	
1	KM traveled per trip	65km
2	Frequency	6 races
3	KM traveled per day	390 km
4	Operating Days per Month	26 days
5	Operating Days per Year	312 days
6	KM traveled per month	10,140 km
7	KM traveled per year	121,680 km
8	Seat KM per route	Rp. 5,495
9	KM seats per day	Rp. 32,970
10	KM seats per month	Rp. 857220
11	Seat miles per year	Rp. 10,286,640

Standard operational data and costs are used in the calculation of basic cost notice level of accuracy, reasonableness, and cost efficiency, as well as an insured answer. Bus vehicle operational cost analysis is shown in Table 4.

Table 4. Analysis of Vehicle Operating Costs (VOC)

No	Recapitulation Component	VOC per KM (Rp.)
I	Cost Direct	
1	Cost shrinkage	160,000,000.00
2	Capital Interest Cost	45,000,000.00
3	Bus Crew Fees	130,187,500.00
4	fuel costs	456,000,000.00
5	Tire Fee	14,250,000.00
6	Cost Maintenance Vehicle	26,305,000.00
7	Terminal Fee	6,250,000.00
8	fee (STNK)	3,750,000.00
9	Bus fare	300,000.00
10	Cost Insurance	19,500,000.00
11	Cost Insurance Passenger	-
	Amount	861,542,500.00
II	Indirect Costs	38,450,000.00
III	Total Cost	899,992,500.00
IV	Tax	89,999,250.00
V	Total Amount	989,991,750.00
VII	10% profit	98,999,175.00
	Grand Totals	1,088,990,925.00
	Grand Total IDR / Km	8950.00

The cost of medium bus production per kilometer in Bali is Rp. 5,495/ trip or Rp. 32,970/ day. The cost of the operational vehicle (VOC) based on analysis costs directly and indirectly obtained the price of the VOC unit for medium bus operations in Bali is Rp. 8,950/km.

3.6 Supply-Demand Feasibility

Requests will be counted based on the percentage group age passengers according to Figure 5.2, then the percentage of general passengers will be known and the percentage of passengers specifically (children, the elderly, students, and Bachelor/D4/D3

students) because there are different rates between category general passenger with category passenger specifically, you need to know how much amount passengers from average passengers per day, which is general passenger as well as special passenger. The number of passengers based on category is counted with the percentage of the second category with supporting data, which is the number of average passengers over 6 months in 2023. The total average number of passengers per month in 2023 is 27,194 people, and the average number of passengers per day is as big as 907 people. A complete demand analysis can be seen in Table 5.

Table 5. Potential TMD Bus Corridor 5 Daily *Demand*

Group age	Passenger		Percentage Passenger	
	Amount	Percentage	Special rates	General Rates
< 15 years	7	4.67%	26.53%	73.47%
16 - 30 years	76	50.67%		
31 - 45 years	27	18.00%		
45 - 60 years	30	20.00%		
> 60 years	10	6.67%		
	150	100.00%	100.00%	
Total Passengers/day			907 people	
Total Passengers/day according to the tariff			241 people	666 people

3.7 Feasibility of Supply – Demand from Bus Operators

In the analysis of appropriateness *Supply -Demand,* then the VOC plays a role as supply, ie cost, which must issued by the inner bus operator that operates 21 buses in corridor 5; following is the VOC of the Trans Metro Dewata bus Corridors 5 per day.

Expenditures for VOC per day = IDR 8,950 /km x (21 buses x 4 trips x 61 km)

= Rp. 8,950,- /km x 5,124

= IDR 45,859,800

Operator revenue-based *Requests* passengers and income cost *Buy The Service (BTS).* The BTS rate is used in the highest range of Rp. 12,000 per km.

BTS revenue per day = Rp. 12,000/km x 5,124

= Rp. 61,488,000

Based on the revenue from buy the service, VOC and the existing load factor, optimization of the number of fleets in operation is carried out, as shown in Table 5.6. The results of the analysis show that with the existing load factor, 16 bus fleets per day can be operated financially in corridor 5. Optimizing the number of operating fleets must, of course, meet the minimum service standards in Minister of Transportation Regulation No. PM 15 year 2019 and Decree of the Directorate Public of Land Transportation No. SK.687/AJ.206/DRJD/2002 concerning "Technical Guidelines for Organizing Public Passenger Transportation in Urban Areas on Fixed and Regular Routes", with standard indicators set such as headway, travel time, and return time taking into account traffic conditions cross.

Table 6. Analysis Optimal Fleet Amount

No.	Optimal Fleet Parameters	Fare (VOC Rp. 8.950,- /km BTS Rp. 12.000,- /km)
1	BOOK per day	45,859,800
2	Income per day	61,488,000
3	Revenue – VOC per day	15,628,200
4	Existing Load Factor 28%	28%
5	LF (BEP) = (VOC/ Revenue) x 80% existing LF	21%
6	The existing fleet of 21 units	21 Units
7	Optimal Fleet = (existing LF / LFBEP) X Existing Fleet	16 Units

3.7.1 Feasibility of Supply – Demand from the Owner's Side Services (Government)

In the analysis of appropriateness *Supply -Demand* from the Owner side (Government), payment *buys the service* role as *supply* or supply, i.e. cost which must be issued by the Owner to the bus operator in corridor 5. In this case, it is the same as income received by Trans Metro Dewata buses Corridor 5 per day, i.e., Rp. 61,488,000,-

Income received by the owner service (Owner) based *Requests* passengers and income from rates charged to the passengers is Rp. 4,400, - for general passengers and Rp. 2.000,-

Owner's income from tariff per day = (Rp. 2,000 x 241) + (Rp. 4,400 x 666)
= Rp. 3,412,400

Feasibility of the current supply-demand of the Owner side shows mark necessary subsidies issued to the Government are:

Subsidy Public Transportation Bus Corridor 5 = Rp. 61,488,000 – Rp. 3,412,400
= Rp. 58,075,600,- / day

Based on the predicted number of passengers in 2028, with the assumption that the contract buys the service and fixes the rates for passengers, the analysis of the necessary subsidies becomes Table 7. With amount passengers, 982 people/day, then Still needed a subsidy of Rp. 57,792,459 per day

Table 7. Recapitulation Subsidy with Growth Rate Passenger 1-2%

No.	Optimal Subsidy Parameters	Passenger fare (special Rp. 2,000, - general Rp. 4,400, -)
	Amount of Passengers per day Th. 2028	982
2	Amount of Special Passenger (26.53%)	261
3	Amount General Passengers (73.47%)	721
4	Income of passenger special	521,049
5	Income of general passenger	3,174,492
6	Total Revenue per day	3,695,541
7	fee per day	61,488,000
8	Subsidies to be prepared	57,792,459

Furthermore analyzed to negate subsidy government on transport public Bus TMD corridor 5, with assumption cost *Buy The Service* and rates passenger fixed, so is known amount must passenger use general transport. Based on recapitulation, the analysis shown in Table 8 can be seen that amount passengers must reach 16,339 people so that the government does not need to provide subsidies for general transportation. This requires efforts in promotion and outreach. The operator, as well as the government, as well as policy, must herd public switch from private transport to general transport.

Table 8. Recapitulation Need Amount Passengers for Zero Subsidies

No.	Optimal Subsidy Parameters	Rates (special Rp. 2,000, - general Rp. 4,400, -)
1	Amount of Passengers per day Th. 2028	16,339
2	Amount of Special Passenger (26.53%)	4,335
3	Amount of General Passengers (73.47%)	12.004
4	Income of special passenger	8,669,473
5	Income of general passenger	52,818,759
6	Total Revenue per day	61,488,000
7	fee per day	61,488,000
8	Subsidies to be prepared	(0)

4. Conclusion

The characteristics of individual passengers in Corridor 5 indicate that the majority of them fall within the age group of 16 to 30 years. Additionally, the majority of passengers have educational backgrounds ranging from Bachelor's degrees to High School. The dominant occupations among these passengers include private sector employees and students, and their monthly family income typically ranges from 4 to 8 million rupiahs. Interestingly, it's observed that at least 48% of families in this corridor own one or more motorcycles, while 86% have at least one car. This data suggests that passengers in Corridor 5 cannot be categorized as "captive users" or those who are forced to use public transport due to the absence of personal vehicles. Instead, they belong to the category of "User Choice," indicating that they have access to personal vehicles and can choose to use public transport.

The potential demand for travel in Corridor 5, particularly along the Central Parking route – PNB Campus – Titi Banda round-trip, has shown a noticeable increase since the rerouting in May 2023. On average, the corridor serves around 27,194 passengers per month, with the highest recorded at 29,060 passengers per month. The loading factor in June reached 28.88%, positioning Corridor 5 as the fourth busiest among all corridors. Although there has been a slight growth factor of 1-2%, it is estimated that the number of passengers in the next five years will reach approximately 29,438 people per month, equivalent to 982 people per day, and will be served by 21 fleet units covering a route length of 61 km. Considering the Variable Operating Cost (VOC) at Rp. 8,950 per kilometer, and the income from buying the service (BTS) at Rp. 12,000 per kilometer, along with the existing load factor, the operators in Corridor 5 are earning a daily surplus of Rp. 15,628. To optimize the supply and demand balance from the operator's perspective, it is recommended to operate 16 units of bus fleets while ensuring compliance with the minimum service standards set by the Ministry of Transportation. Furthermore, based on the BTS payment expenses and income rates, the government subsidy required for public transportation amounts to Rp. 58,000,000. To eliminate the need for subsidies, there must be a significant increase in the number of passengers, reaching 16,339 people per day, which would require a substantial growth rate in passenger numbers.

Funding: This research received no external funding.
Conflicts of Interest: The authors declare no conflict of interest.

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