Journal of Applied Sciences in Travel and Hospitality
Volume 8 Issue 2 Year 2025 Pages 177-198

DOI: http://dx.doi.org/10.31940/jasth.v8i2.177-198
URL: http://ojs2.pnb.ac.id/index.php/JASTH

The impact of traffic congestion on freight transport efficiency in a tourism corridor: A case study of the Denpasar–Gilimanuk road

Ahmad Soimun [1]*, Putu Diva Ariesthana Sadri [2], Dynes Rizky Navianti [3], Siti Nurlita Fitri [4,5]

[1,2,3] *Logistics Management, Bali Land Transportation Polytechnic, Indonesia*
[4] *Civil Engineering Department, Sebelas Maret University, Indonesia*
[5] *Graduate School of Engineering, Gifu University, Japan*

*Corresponding Author: soimun@poltradabali.ac.id

Abstract: Traffic congestion has a significant impact on the efficiency of freight transportation in tourism-intensive areas such as Bali. This study analyzes the impact of congestion on the Denpasar-Gilimanuk corridor by measuring travel delays, vehicle operating costs, and increased costs due to congestion. The mixed methodology combines quantitative analysis based on the Indonesian Road Capacity Guidelines (PKJI), Vehicle Operating Cost calculation with PCI, with qualitative interviews with 25 logistics stakeholders over 6 days, in conjunction with traffic surveys. The results show that during peak hours, the volume to capacity (V/C) ratio exceeds 1.02 with freight vehicle speeds dropping below 15 km/h. The regression analysis revealed a strong inverse relationship between traffic volume and vehicle speed, resulting in increasing operating costs. Congestion costs reached IDR 2,699/km for pick-ups and IDR 30,879/km for large trucks, a 60% increase over smooth traffic conditions. Interviews confirmed that delivery delays negatively impact supply chain reliability, particularly affecting the fulfillment of tourism needs. The research quantified the tourism logistics conflict in Bali, revealing that the overlap of peak tourist hours with delivery schedules increased waiting times by 56%. Recommendations include infrastructure improvements, dedicated freight lanes, implementation of smart traffic management, and scheduling of off-peak deliveries. The findings contribute to strategic transportation planning for multifunctional corridors serving both tourism and logistics sectors. Limitations of the study include the focus on national roads only and the short duration of data collection, which may not fully capture seasonal traffic variations. Future research should extend the observation period and include secondary road networks to better understand regional freight transportation dynamics.

Keywords: Bali, freight transport, tourism logistics conflict, traffic congestion, transport efficiency

History Article: Submitted 31 May 2025 | Revised 19 June 2025 | Accepted 1 September 2025

How to Cite: Soimun, A., Sadri, P. D. A., Navianti, D. R., & Fitri, S. N. (2025). The impact of traffic congestion on freight transport efficiency in a tourism corridor: A case study of the Denpasar–Gilimanuk road. *Journal of Applied Sciences in Travel and Hospitality, 8*(2), 177-198.

Introduction

Indonesia, especially the island of Bali, faces significant challenges in its transportation system, which is influenced by its role as an international tourism destination as well as a growing economic center. Bali's economy recorded growth of 6.96% in the second quarter of 2023, driven by the recovery of various sectors post-pandemic (BPS Provinsi Bali, 2023). This growth increases the need for mobility and distribution of goods. While tourism makes a positive contribution to the transportation sector, pressure on infrastructure due to the logistical needs and mobility of tourists creates complex challenges (Lim et al., 2019).

One of the strategic transportation routes in Bali is the Denpasar-Gilimanuk Road, which connects Gilimanuk Port with major tourist destinations such as Tabanan, Tanah Lot, Kintamani, and Ubud. This route is not only a vital access for tourists, but also plays an important role in the distribution of goods from the port to various regions in Bali. However, a significant increase in traffic volume makes this route prone to congestion, thus hampering logistics and tourism operations.

Traffic congestion is a global problem with serious economic impacts, especially on urban transport management and logistics (Kemei et al., 2024). In developing countries like Indonesia, this problem is exacerbated by rapid urbanization and inadequate infrastructure development (Aluko, 2019; Peñalosa et al., 2010). Indonesia, as a developing country as the largest economy in Southeast Asia, faces similar challenges, especially in strategic areas such as the island of Bali, which has unique characteristics as an international tourism destination (Khan et al., 2020). Bali's unique characteristics as an international tourism destination magnify this challenge, where the integration of technology and the concept of smart tourism is very important (Pribadi et al., 2021).

The Denpasar-Gilimanuk corridor represents the complexity of the modern transportation system, where the needs of tourism and commercial logistics must be balanced with limited infrastructure. Research shows that regions with such dual functions often face unique challenges in transportation management (Karuppanagounder, 2018). The significance of this corridor is increasing, given its role in the regional supply chain (Pan et al., 2012). Inefficiencies in strategic routes can reduce the productivity of the overall transportation network, with a ripple effect on the region's economy (Alvarez et al., 2018; Zhang et al., 2024).

In Bali, this challenge is exacerbated by the growth in the number of domestic and international tourists, as well as a surge in tourism activity during the holiday season. This increases the need for logistics to meet the demand of tourists. (Triyasa Cipta Transport, 2023). Geographical limitations, especially in mountainous areas, are the main obstacle in the development of transportation infrastructure (She et al., 2018). The location of tourism destinations correlates with the state of infrastructure and tourism development (Mandic et al., 2018; Samková & Navrátil, 2023). The unique characteristics of this corridor, which doubles as a tourist and logistical route, require an integrated approach (Ivasyshyna, 2024). Significant seasonal fluctuations are associated with the peak season of tourism (Martínez et al., 2020).

Recent studies by Aćimović et al., (2022) show that areas with characteristics such as the Denpasar-Gilimanuk corridor require an integrated transportation management approach. Reliance on changing routes often leads to uncertainty in delivery times and can increase overall logistics costs. In the context of the national logistics network, this corridor has a central role in supporting the distribution of goods in the central part of Indonesia (Roberts et al., 2020).

In addition to the challenges of conventional transportation, a significant increase in the volume of e-commerce trade makes it necessary to improve the quality of adequate infrastructure, so as not to add to the complexity of the existing challenges (Nopiah et al., 2024; Orbeta & C., 2000). In addition, the increase in e-commerce trade volume also puts additional pressure on transportation infrastructure. Regions with tourism based economies such as Bali face unique challenges in integrating e-commerce logistics needs with existing infrastructure, where delivery delays can negatively impact customer satisfaction and the image of tourist destinations (Gomes et al., 2023).

Bali is a global tourist destination that faces significant challenges in the transportation system due to the high flow of vehicles and limited infrastructure. Traffic congestion not only affects the daily lives of local people but also logistics operations, especially in the delivery of goods to other regions. Although there are many studies on the impact of congestion on urban transportation, there has not been much to highlight its impact on logistics efficiency in tourism-affected regions.

In the Denpasar-Gilimanuk corridor, this conflict is becoming increasingly real with the increasing number of tourists reaching 481,464 visits in 2023, along with significant growth in cargo volumes (BPS Provinsi Bali, 2023). Therefore, a comprehensive study of the impact of congestion on the efficiency of freight transportation in this corridor is of great importance. This study will not only provide a better understanding of transportation dynamics in strategic regions but will also contribute to the growing literature on transportation management in tourist destinations that also serve as regional logistics hubs.

This research presents a significant scientific novelty in transportation studies, particularly in the context of tourism areas that also function as major logistics corridors. The main focus of this research is the Denpasar-Gilimanuk corridor in Bali, which plays a dual role as a logistics distribution route and a major tourist destination. So far, most studies on congestion in Bali have emphasized its impact on tourist mobility, while the efficiency aspect of goods transportation has rarely received serious attention. Therefore, this study fills the empirical gap regarding the direct effect of traffic congestion on logistics performance in a region with multiple mobility pressures.

The concept of conflict between the phenomenon of tourism logistics conflict examined in this study emphasizes the tension in the utilization of road capacity in corridors with dense functions. Unlike previous studies that typically focus on tourism congestion or logistics costs separately, this research integrates both aspects into a single analytical framework. As a result, this study not only adds a new empirical dimension but also expands theoretical understanding of the trade-off between tourist mobility and goods distribution in tourist destinations.

This research aims to fill the gap by analyzing how congestion affects freight transportation in Bali, including economic and operational implications. This research also calculates the level of traffic volume based on PKJI. Furthermore, it calculates the congestion costs of freight vehicles based on vehicle operating costs using PCI. furthermore, it also conducts validation in the form of interviews to freight transportation companies. The study also provides practical recommendations to support integration between the logistics and tourism sectors to create a more efficient transportation system.

Methodology

This study uses a sequential mixed methods approach with the study of the Denpasar-Gilimanuk road section, especially at the location of the Adipura Monument in Tabanan, to Megati Market. This route was chosen based on data on the level of congestion on the road, and the location is quite high. This approach is carried out in two stages: the first stage is the collection and analysis of quantitative data to identify congestion patterns and their impact on the efficiency of goods transportation. The second stage is in the form of qualitative data collection through in-depth interviews, aiming to deepen the understanding of the causes and consequences of operational congestion (Creswell, 2018).

This research departs from the fact that Bali, as one of the main tourism destinations in Indonesia, relies heavily on the smooth logistics supply chain to support tourism activities. Congestion on the Denpasar-Gilimanuk road not only affects local logistics distribution but also has an impact on the sustainability of the tourism sector, such as delays in the delivery of foodstuffs, basic necessities, and other supporting goods for tourism activities.

This research was carried out on the Denpasar-Gilimanuk road, especially at the location of the Adipura Monument in Tabanan to Megati Market. Data were collected by survey for six days, from June 1 to 6, 2024, at three strategic observation points. This location was chosen because there is often severe congestion that results in delays in logistics activities in Bali. This road section is also the main route for the distribution of goods from ports and logistics centers to tourist areas such as the cities of Denpasar, Kuta, Seminyak, and Ubud.

The six-day observation period was chosen considering the limited research resources available, as well as to obtain an overview of traffic conditions during a normal period without extreme seasonal disturbances. However, this limitation is recognized as a factor affecting the generalization of the results, so the interpretation of the findings must be viewed in the context of this limitation.

Data Collection

1. Traffic Volume Survey: The survey was conducted for 12 hours/day (06.00–18.00) with a recording interval of every 15 minutes, using a standardized survey form that includes vehicle classification based on the Indonesian Road Capacity Guidelines (PKJI, 2023).

2. Vehicle Speed Survey: Using the spot speed survey method to record the vehicle's travel time at a distance of 100 meters, then calculate the average speed. This data is used to analyze vehicle speed patterns.
3. Interviews and questionnaires: A total of 25 logistics actors were interviewed to gain qualitative insights into operational challenges due to congestion. It was carried out by 18 drivers, three leaders of logistics companies, three vehicle crews, and one broker. This interview is designed to explore their perceptions and experiences related to operational challenges on the research road. The questionnaire was distributed to collect additional information about delivery delays and drivers' perceptions of congestion conditions. The method of sampling was purposive, based on direct involvement in goods distribution activities in the research route, as well as ease of access (convenience) at the observation location. Justification for the number of respondents was based on the principle of data saturation. No significant new information was found after the last few interviews, so it was considered sufficient to gain an in-depth understanding.
4. This study was approved by the ethics committee. All respondents gave informed consent, and the data collected were kept confidential and only used for academic and scientific purposes.

Data Analysis Methods

1. Road Capacity Analysis:
   This analysis was carried out to evaluate the ability of the Denpasar-Gilimanuk road section to accommodate the volume of vehicles based on survey data. This method helps to understand the extent to which road capacity supports the smooth flow of traffic, which is crucial for the logistics distribution of the tourism sector.
2. Linear Regression Analysis:
   It is used to evaluate the relationship between the level of congestion between the volume of vehicles and the speed of the vehicle. Used to evaluate the relationship between congestion levels (independent variables, such as traffic volume and vehicle speed). The model will also identify indirect impacts on the tourism sector through delays in logistics distribution.
3. Operational Impact Analysis:
   Data from interviews and questionnaires are used to assess the impact of congestion on freight transportation operations. Indicators such as delivery delays, excess fuel consumption, and additional costs are analyzed to identify the economic consequences of congestion. These findings will be linked to the need for the tourism sector to highlight its impact on the distribution of food, beverages, and other consumer goods. A special focus is given on the relationship between logistics efficiency and tourism needs.
4. Integration with Tourism Data:
   The findings from quantitative and qualitative data will be analyzed in the context of Bali as a tourism area. The relationship between congestion, logistics efficiency, and its impact on the supply chain of goods for tourism needs will be the main focus of the integrative analysis.

Results and Discussions

Results

The cause of congestion that occurs on the Denpasar-Gilimanuk Road.

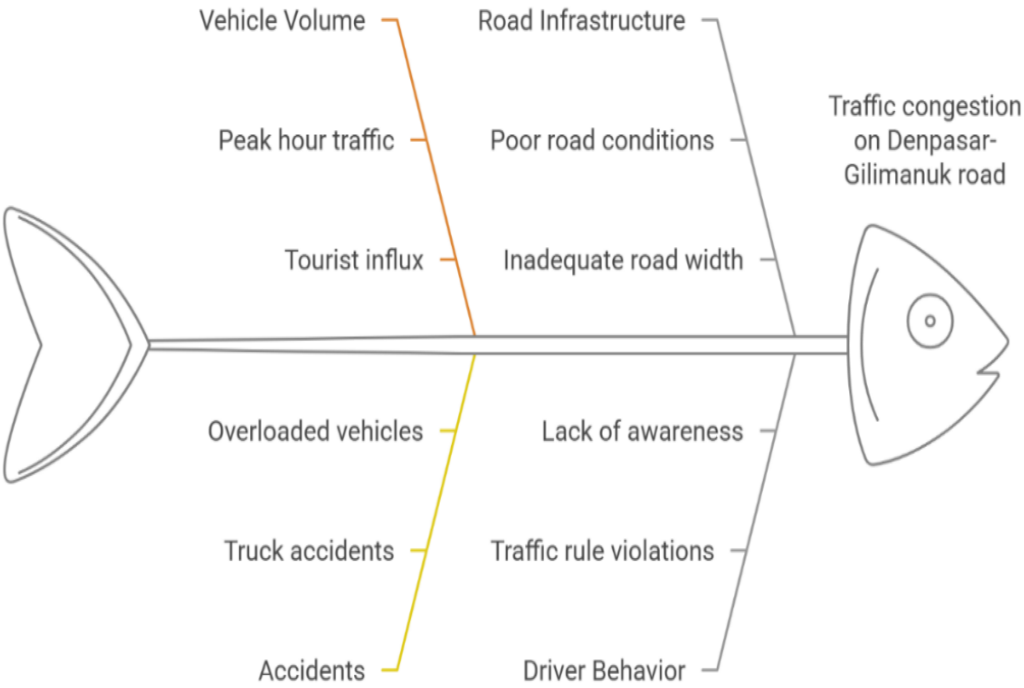
From the results of field observations, the congestion that occurs on the Denpasar-Gilimanuk road, especially at the location of Tugu Adipura Tabanan to Megati Market, is caused by several main factors that cause congestion:

1. Vehicle density is one of the main causes of congestion, which is the high volume of vehicles, especially during peak hours, such as when returning from work. This causes the accumulation of vehicles at several points, such as Simpang Cepaka, which is the main lane for vehicles from various directions. The density of vehicles on this road has increased

significantly, especially on weekends and holidays. Many tourists who go to tourist areas in Bali, use this route (Gede & Yoga, 2023). In addition, the growing number of private vehicles and motorcycles in Bali continues to contribute to congestion. Data from the Bali Provincial Transportation Office shows that the number of motor vehicles has doubled since the covid-19 pandemic. The influence of this traffic density increases road capacity so it is necessary to calculate the current road capacity. The Road Capacity Analysis aims to measure whether the volume of vehicles on the Denpasar-Gilimanuk road exceeds the available capacity. The result is a V/C ratio value that reflects the level of road service. The Degree of Saturation (DJ) is calculated to determine how congested the traffic conditions are. If the DJ value exceeds 1, it indicates a congestion condition (Hidayat et al., 2021).

2. Accidents and truck problems contribute significantly to congestion. Traffic accidents are frequent on these routes, especially involving heavy vehicles such as freight trucks. For example, in January 2024, three trucks experienced problems on this line, resulting in traffic flow stalling and long queues. Accidents not only result in vehicle buildup but can also trigger uncertainty in traffic flow. For example, in March 2024, an accident involving two large trucks caused the temporary closure of this lane for several hours. Accidents often occur as a result of trucks overloading their capacity, especially in areas with steep ramps and corners. This shows the need to improve driving safety and supervision of heavy vehicles.
3. The condition of road infrastructure is also an important factor in congestion. Some sections of the road are still in a damaged or poorly maintained condition, which slows down the flow of traffic. In addition, the insufficient width of the road to accommodate the high volume of vehicles is also a problem. The presence of obstacles on the road can slow down the flow of traffic significantly. For example, some points around Tugu Adipura and Pasar Megati have narrow lanes and lack of dedicated lanes for public vehicles or motorcycles.
4. Lack of traffic regulation. Many motorists report that the lack of traffic regulation at certain points, such as at Simpang Cepaka, causes confusion and queues of vehicles. Motorists suggest the need for traffic lights or officers to regulate the flow of vehicles to make it smoother. The placement of unclear traffic signs can also confuse motorists, slowing down the flow of vehicles.
5. Environmental and Weather Factors. Weather factors also play an important role in traffic conditions. Heavy rain can cause standing water and reduce visibility, so riders must reduce their speed. According to the Meteorology, Climatology and Geophysics Agency (BMKG), rainfall in Bali increases during the rainy season, which can worsen congestion. In addition, natural events such as landslides or fallen trees can also disrupt traffic flow. Fallen trees on the Denpasar-Gilimanuk route once caused severe congestion along 6.5 kilometers.
6. Rider behavior also contributes to congestion. Many motorists do not obey traffic rules, such as breaking through red lights or not using the lane according to its function. Awareness of driving safety still needs to be increased through educational campaigns. According to data from the Bali Provincial Transportation Office, the increase in the number of motorized vehicles without being balanced with awareness of traffic rules causes worsening congestion, especially in tourist areas (BPS Provinsi Bali, 2023).

From the results of field observations, the following are the causes of congestion that occurred on the Denpasar-Gilimanuk road, especially at the location of the Tabanan Adipura Monument to Megati Market as shown in Figure 1.



(Source: Processed Data, 2025)

Figure 1. Causes of traffic congestion on the Denpasar-Gilimanuk road section

Daily Traffic Volume

Determining the results of *counting* the highest vehicle volume in one hour is needed to find out the cause of the congestion that occurs. Based on the results of traffic *counting* on the Denpasar-Gilimanuk Road section from East to West at 3 *peak hours,* namely in the morning at 06.00-08.00, in the afternoon at 11.00-13.00, and in the afternoon at 16.00-18.00, the volume of vehicles converted into (PCU/Hour) units / hours based on (PKJI, 2023).

Based on the results of traffic counting data, it is known from the three peak hours that the highest volume of vehicles in a period of 1 hour is in the time range of 16.45 to 17.45 with a total of 7,450 vehicles. It is known that the highest volume of vehicles is in the *afternoon peak hour* precisely at 16.45-17.45 with the volume of vehicles based on PKJI of 3993.7 (PCU/Hour) respectively. The details of the vehicles are based on PKJI in (PCU/Hour) units as shown in Table 1.

Table 1. Vehicle Volume by PKJI

Time	Private Transportation		Public Transportation	Freight Transportation				Unmotor cycle	Volume (PCU/H)
	Motorbike	Private Car	Big Bus	Pick Up	Small Truck	Medium Truck	Big Truck		
16.45-17.45	647	1740	23.4	478	213	351	538.2	3	3993.6

Source: Processed Data, 2025

This volume indicates the heavy load on the road capacity at peak times, which contributes to congestion. High vehicle volumes at certain hours indicate the need to reset traffic management or use alternative lanes to ease congestion. In this study, it is focused on the analysis of the frustration of two types of freight transport vehicles with the highest volume, namely pick-up truck and large trucks.

Road Capacity Calculation

The calculation of road capacity is needed to find out the cause of traffic congestion on the Denpasar-Gilimanuk Road section from East to West which has a correlation with the highest volume of vehicles in one hour. Based on the results of observations on the Denpasar-Gilimanuk Road section in the direction of East to West, the components of the calculation of city Road Capacity based on the Indonesian Road Capacity Guidelines (PKJI) that have been successfully identified can be seen in Table 2.

Table 2. Components of road capacity calculation based on PKJI

No.	Component	Description	Value
1	C_0 Road segment for type 2/2-TT	Two undivided lanes	3850 (C_0 PCU/Hour 2/2- TT)
2	Capacity correction factor due to lane width difference	Two undivided lanes	FC_L = 1.21
3	Capacity correction factor due to PA on undivided road types	Flow direction separation (Road Type 2/2-TT size 50-50)	FC_{PA} = 1.00
4	Capacity correction factor due to KHS on the road	High (Rural, road through village area, residential activities) (Kereb road to nearest barrier 1.5m away)	FC_{HS} = 0.84

Source: Processed Data, 2025

Based on the components, it can be continued to the process of calculating the City Road Capacity based on PKJI with the formula C = Co x FCLJ x FCPA x FCHS. The road capacity is calculated based on PKJI with the appropriate formula. The calculation results show that the capacity of the Denpasar-Gilimanuk road from East to West is 3913.14 PCU/Hour based on PKJI.

The identified capacity is not able to accommodate the volume of existing vehicles, especially during peak hours. This contributes to the occurrence of congestion which has an impact on the efficiency of logistics and the tourism sector.

Calculation of Road Saturation Degree

The calculation of the Degree of Saturation aims to obtain the level of congestion on the Denpasar Gilimanuk Road Section from East to West, with the formula DJ=Total Volume (PCU/HOUR)/Capacity, which can be seen in Table 3**.**

Table 3. Results of the calculation of the saturation degree based on PKJI

No	Segment Name	Road Function	Road Status	Road Type	Directional Separator	Total Volume (PCU/H)	Capacity	DJ
1	Denpasar-Gilimanuk Road (East of Simpang Gerogak)	National Road	Out-of-town streets	2/2 TT	50-50	3,993.7	3913.14	1.02

Source: Processed Data, 2025

The results of the calculation of the V/C ratio in Table 3 above have shown that the Degree of Saturation of the Denpasar-Gilimanuk Road Section based on PKJI is 1.02, respectively. Meanwhile, based on the results of calculations with PKJI, it has been known that the value of the degree of road saturation is above 1 which indicates the occurrence of congestion on the road section. In addition, to strengthen the analysis, an analysis of the results of the calculation of the degree of saturation was carried out on the Minister of Transportation Regulation Number: KM 14 of 2006 concerning Traffic Management and Engineering on the Road. The analysis aims to determine whether the results of the calculation of the degree of saturation are in accordance with the speed conditions of the vehicle in real conditions. Based on this, a spot speed survey was carried out related to the speed of the two freight transport vehicles with the highest volume, namely pick-ups and large trucks**.**

The following is data related to the speed of pick-up vehicles at each peak hour obtained through the spot speed survey. It is known that the speed of pick-up vehicles on the Denpasar-Gilimanuk Road section from East to West is at 12 km/h to 39 km/h. In addition, the following is data related to the speed of large truck vehicles at each peak hour obtained through the spot speed survey. It can be known that the speed of large trucks on the Denpasar-Gilimanuk Road section from East to West is at 9 km/h to 35 km/h.

The results of the calculation above showed that the Degree of Saturation for the Denpasar-Gilimanuk Road Section based on MKJI and PKJI was 1.23 and 1.02, respectively. Based on the Minister of Transportation Regulation Number: KM 14 of 2006 in the category of secondary arterial roads with service level F states that if the Degree of Saturation exceeds 1, it can be categorized as a restrained flow with traffic jams and an average travel speed of < 15 km/h. In the results of the spot speed survey, it is known that the speed of pick-up vehicles and large trucks at the highest peak hour volume is 12 km/h and 9 km/h, respectively. This has a correlation with the Minister of Transportation Regulation Number: KM 14 of 2006, which states that the speed of vehicles with a Saturation Degree of 1.06 is < 15 km/h. Therefore, the cause of congestion on the Denpasar-Gilimanuk Road East to West section is the high volume of vehicles with insufficient road capacity. It can be said that the road does not function optimally. The decrease in speed that occurs due to the increase in vehicle volume can affect travel time and logistics efficiency. Therefore, it is necessary to implement traffic management or traffic management technology that can reduce the impact of congestion (Tamin, 2008).

Congestion Cost

Analysis of the relationship between vehicle volume and speed

The process of analyzing the relationship between speed and vehicle volume aims to determine how the effect of increasing or decreasing vehicle volume on changes in vehicle speed on the Denpasar-Gilimanuk road section. Based on this, it requires data on the volume of vehicles and the speed generated by vehicles at each peak hour.

1. The relationship between vehicle volume and pickup vehicle speed

The following is vehicle volume data, pickup truck, and large truck vehicle speed at each peak hour, as seen in Table 4.

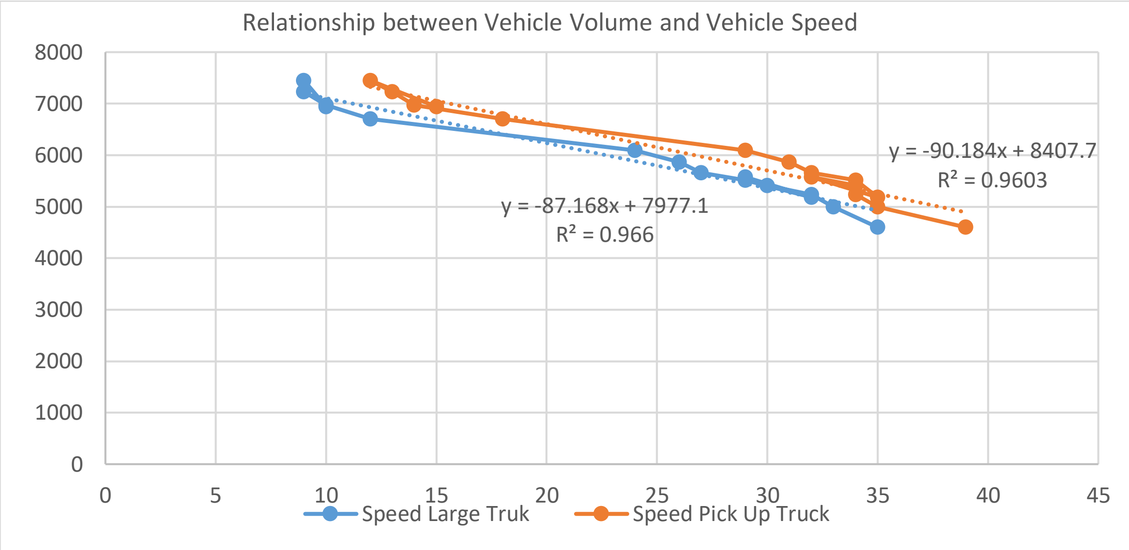
Table 4. Vehicle volume and speed at each peak hour

Time	Speed Pick Up Truck (km/h)	Speed Large Truck (km/h)	Volume (PCU/H)
06.00-07.00	39	35	4598
06.15-07.15	35	33	4999
06.30-07.30	34	32	5236
06.45-07.45	34	30	5410
07.00-08.00	32	29	5577
10.00-11.00	35	32	5179
10.15-11.15	34	29	5511
10.30-11.30	32	27	5655
10.45-11.45	31	26	5868
11.00-12.00	29	24	6087
16.00-17.00	18	12	6700
16.15-17.15	14	10	6972
16.30-17.30	13	9	7229
16.45-17.45	12	9	7450

17.00-18.00	15	10	6939

Source: Processed Data, 2025

It can be seen that an increase or decrease in the number of vehicle volumes at each peak hour has an influence on changes in the speed of pick-up vehicles and large trucks on the Denpasar-Gilimanuk road section in the east-to-west direction. The analysis process is supported by identifying the variable relationship model using simple linear regression which can be seen through the graph in Figure 2.



(Source: Processed Data, 2025)

Figure 2. Relationship between vehicle volume and vehicle speed

Based on Figure 2, it can be seen that large truck vehicles with a linear regression equation generated through the relationship between volume and speed is Y =-87.168X + 7977.1 with an R-Squared value of 0.966. For pick-up vehicles, a linear regression equation generated through the relationship between volume and speed is Y = -90.184X + 8407.7 with an R-Squared value of 0.9603. The R-squared value of the relationship between volume and speed is above 0.75, which is included in the strong category, so the regression model is said to be good (Kumaat, 2023). This identifies that the independent variable has the ability to provide all the information needed to predict the dependent variable (Ghozali, 2016). Based on this, an increase or decrease in vehicle volume affects changes in the speed of large trucks and pickup trucks on the Denpasar-Gilimanuk Road from east to west.

Calculation of Vehicle Operating Costs

Determination of the cost of pick-up vehicle congestion can be obtained through the calculation of Vehicle Operating Costs (BOK) with the PCI method at the average vehicle speed and out-of-town vehicle speed. On the Denpasar-Gilimanuk road section, it is known that the average speed of vehicles is in units of km/hour at each peak hour. The following are the cost components needed to calculate the BOK PCI method can be seen in Table 5.

Table 5. The cost components of the calculation of BOK for pickup truck vehicles and large trucks

No.	Component Cost	Pick-up truck	Truck Large	Unit
1	Vehicle Price	Rp 196,500,000	Rp 1,320,000,000	/Unit
2	Fuel Price (Solar)	Rp 6,800	Rp 6,800	/Liter
3	Tire Price	Rp 690,000	Rp 3,850,000	/Unit
4	Price of Lubricating Oil	Rp 483,000	Rp 549,000	/Liter
5	Price of Mechanic Wages	Rp 18,924	Rp 24,000	/Hour

6	Price of Driver Wages	Rp 15,369	Rp 20,821	/Hour
7	Price of Henchman Wages		Rp 2,862,946	/Hour

Source: Processed Data, 2025

Based on the data in Table 5, the BOK calculation will be carried out to find non-fixed costs and fixed costs. Non-fixed costs consist of fuel costs, lubricant costs, tire wear costs, maintenance costs, and overhead costs. Fixed costs consist of insurance costs, capital interest costs, depreciation costs, and time value costs.

Calculation of total vehicle operating costs

The calculation process of total vehicle operating costs (BOK) is obtained through the sum of all components included in fixed costs and non-fixed costs at a distance of 1000 km and 1 km which can be seen in Table 6.

Table 6. Calculation of the total operating costs of pick-up vehicles

V (Km/h)	Vehicle Operating Cost (Rp/1000 Km)	Vehicle Operating Cost (Rp/Km)
12	Rp 2,699,040.19	Rp 2,699.04
13	Rp 2,514,128.32	Rp 2,514.13
14	Rp 2,348,026.76	Rp 2,348.03
18	Rp 1,814,336.02	Rp 1,814.34
29	Rp 898,136.33	Rp 898.14
31	Rp 780,877.34	Rp 780.88
32	Rp 726,336.31	Rp 726.34
34	Rp 624,806.60	Rp 624.81
35	Rp 577,608.78	Rp 577.61
39	Rp 410,631.40	Rp 410.63
60	Rp 2,485,439.35	Rp 2,485.44

Source: Processed Data, 2025

The calculation of BOK for large truck vehicles (Trintin) which are included in Class II B vehicles results in details of vehicle operating costs which are fuel, engine oil, tires, parts cost, labor cost, vehicle depreciation, interest rate, insurance, driver wages, and overhead cost.

The calculation process of total vehicle operating costs (BOK) is obtained through the sum of all components included in fixed costs and non-fixed costs at a distance of 1000 km and 1 km which can be seen in Table 7.

Table 7. Calculation of total vehicle operating costs of trintin truck vehicles

V (Km/h)	Vehicle Operating Cost (Rp/1000 Km)	Vehicle Operating Cost (Rp/Km)
9	Rp 30,878,636.54	Rp 30,878.64
10	Rp 29,428,119.67	Rp 29,428.12
12	Rp 27,157,225.75	Rp 27,157.23
24	Rp 20,513,805.96	Rp 20,513.81
26	Rp 19,911,233.90	Rp 19,911.23
27	Rp 19,639,290.17	Rp 19,639.29
29	Rp 19,147,165.18	Rp 19,147.17
30	Rp 18,924,758.25	Rp 18,924.76
31	Rp 18,716,872.02	Rp 18,716.87
32	Rp 18,522,712.17	Rp 18,522.71
33	Rp 18,341,578.12	Rp 18,341.58
35	Rp 18,015,974.46	Rp 18,015.97
60	Rp 17,067,440.45	Rp 17,067.44
70	Rp 17,981,208.14	Rp 17,981.21
80	Rp 19,535,371.97	Rp 19,535.37
90	Rp 21,702,205.48	Rp 21,702.21

Source: Processed Data, 2025

Calculation of congestion costs

The process of calculating congestion costs is obtained through the results of the reduction between the total BOK of vehicles at each speed of Pick Up vehicles and trintin trucks at peak hour with the total BOK of vehicles at the speed of 60 km/h out-of-town vehicles which can be seen through tables and Table 8 and 9.

Table 8. Congestion cost based on the effect of speed, based on pickup truck vehicle operating costs

V (Km/h)	Vehicle Operating Cost (Rp/Km)	V (Km/h)	Vehicle Operating Cost (Rp/Km)	Congestion Cost Difference based on Vehicle Operating Cost
12	Rp 5,184.48	60	Rp 2,485.44	Rp 2,699.04
13	Rp 4,999.57	60	Rp 2,485.44	Rp 2,514.13
14	Rp 4,833.47	60	Rp 2,485.44	Rp 2,348.03
18	Rp 4,299.78	60	Rp 2,485.44	Rp 1,814.34
29	Rp 3,383.58	60	Rp 2,485.44	Rp 898.14
31	Rp 3,266.32	60	Rp 2,485.44	Rp 780.88
32	Rp 3,211.78	60	Rp 2,485.44	Rp 726.34
34	Rp 3,110.25	60	Rp 2,485.44	Rp 624.81
35	Rp 3,063.05	60	Rp 2,485.44	Rp 577.61
39	Rp 2,896.07	60	Rp 2,485.44	Rp 410.63

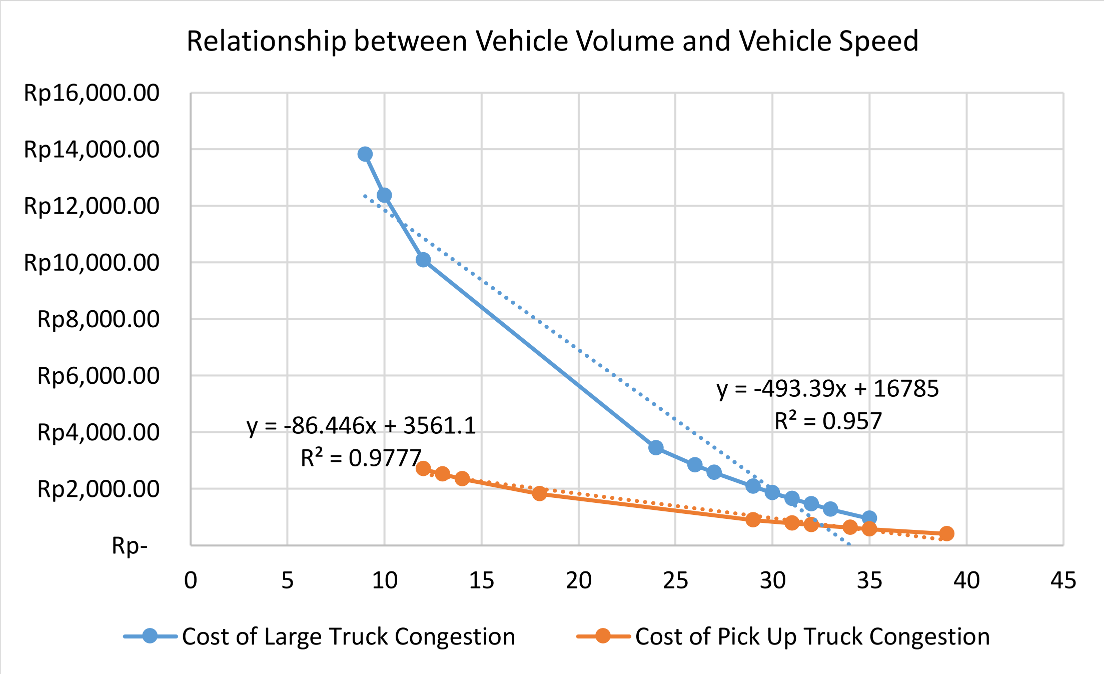
Source: Processed Data, 2025

Table 9. Congestion cost based on the effect of speed on vehicle operating costs for large trucks

V (Km/h)	Vehicle Operating Cost (Rp/Km)	V (Km/h)	Vehicle Operating Cost (Rp/Km)	Congestion Cost Difference based on Vehicle Operating Cost
9	Rp 30,878.64	60	Rp 17,067.44	Rp 13,811.20
10	Rp 29,428.12	60	Rp 17,067.44	Rp 12,360.68
12	Rp 27,157.23	60	Rp 17,067.44	Rp 10,089.79
24	Rp 20,513.81	60	Rp 17,067.44	Rp 3,446.37
26	Rp 19,911.23	60	Rp 17,067.44	Rp 2,843.79
27	Rp 19,639.29	60	Rp 17,067.44	Rp 2,571.85
29	Rp 19,147.17	60	Rp 17,067.44	Rp 2,079.72
30	Rp 18,924.76	60	Rp 17,067.44	Rp 1,857.32
31	Rp 18,716.87	60	Rp 17,067.44	Rp 1,649.43
32	Rp 18,522.71	60	Rp 17,067.44	Rp 1,455.27
33	Rp 18,341.58	60	Rp 17,067.44	Rp 1,274.14
35	Rp 18,015.97	60	Rp 17,067.44	Rp 948.53

Source: Processed Data, 2025

Based on Figure 3, it can be seen that the linear regression equation generated through the relationship between speed and congestion costs for pick up truck vehicles is Y = -86.446X + 3561.1 with an R - Squared value of 0.977. while the linear regression equation generated through the relationship between speed and congestion costs for large truck vehicles is Y = -493.39X + 16785 with an R - Squared value of 0.957. The R-squared value of the relationship between speed and congestion costs is above 0.75 which is included in the strong category, so the regression model is said to be good (Kumaat, 2023). This identifies that the independent variables have the ability to provide all the information needed to predict the dependent variable (Ghozali, 2016). Based on this, the increase or decrease in speed affects the change in congestion costs of pickup vehicles and trintin truck vehicles on the Denpasar-Gilimanuk Road section in the East to West direction. This can be seen from when a vehicle speed decreases, the cost of vehicle congestion will increase (Lubis, 2016).



(Source: Processed Data, 2025)

Figure 3. Relationship between speed and vehicle operating cost

The impact of traffic congestion on Jalan Denpasar-Gilimanuk on the travel time of goods transport vehicles.

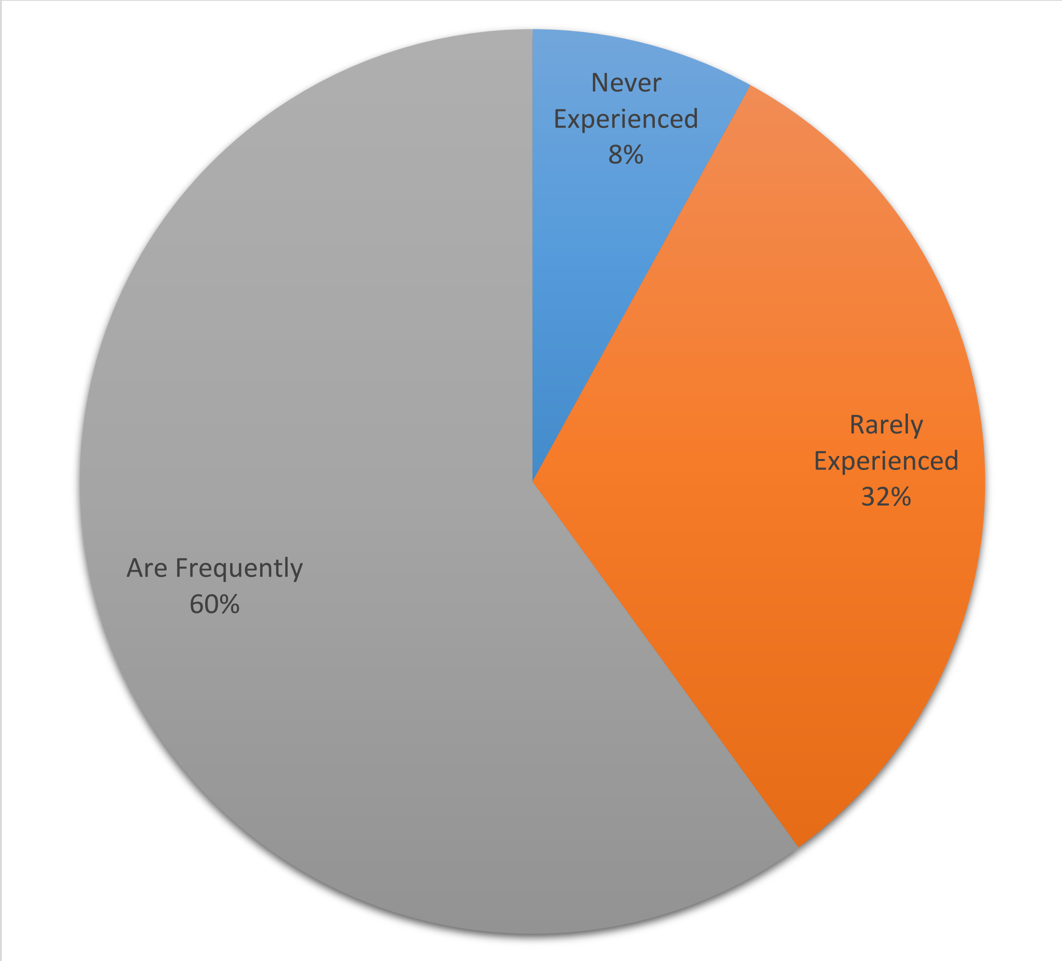
The results of the discussion related to the impact of traffic congestion on Jalan Denpasar-Gilimanuk on the travel time of freight vehicles, can be known through the results of interviews with 25 respondents who work in freight transportation companies, namely:

The intensity of freight transport companies experiencing congestion on the Denpasar-Gilimanuk road

Congestion is a problem experienced by freight transport companies when making deliveries through the Denpasar-Gilimanuk road. The determination of the intensity of freight transportation companies experiencing congestion can be known through the results of interviews with 25 respondents. The results of the interview related to the question about the intensity of freight transportation companies experiencing congestion on the Denpasar-Gilimanuk Road can be seen through the graph in Figure 4.

The congestion that occurs on the Denpasar-Gilimanuk Road is one of the big challenges in maintaining smooth mobility and transportation efficiency in Bali. Based on the results of the responses from the respondents, most revealed that congestion on this route often occurs, even outside of holiday hours. This condition usually peaks in the afternoon to night, especially during peak hours. Some respondents also noted that the average duration of congestion reached about 10 minutes, especially in the area around the ports of Ketapang and Gilimanuk. However, waiting times can become longer in certain periods, such as ahead of big days, including Eid al-Fitr, Galungan, and Nyepi, when the flow of tourist vehicles and goods increases significantly. A small percentage of respondents also mentioned that congestion is more often localized in certain areas, such as the Sam-sam ramp, at certain times.

The high volume of vehicles on this route cannot be separated from Bali's role as the main tourist destination. Private vehicles, tourism buses, and rental cars used by tourists are one of the main factors that increase traffic density. This condition has a direct impact on the distribution of goods, especially those related to the needs of the tourism sector, such as food delivery, beverages, and hotel supplies. Some respondents complained that the congestion caused delays in delivery as well as increased logistics costs, which ultimately impacted the efficiency of the supply chain to support the tourism industry.



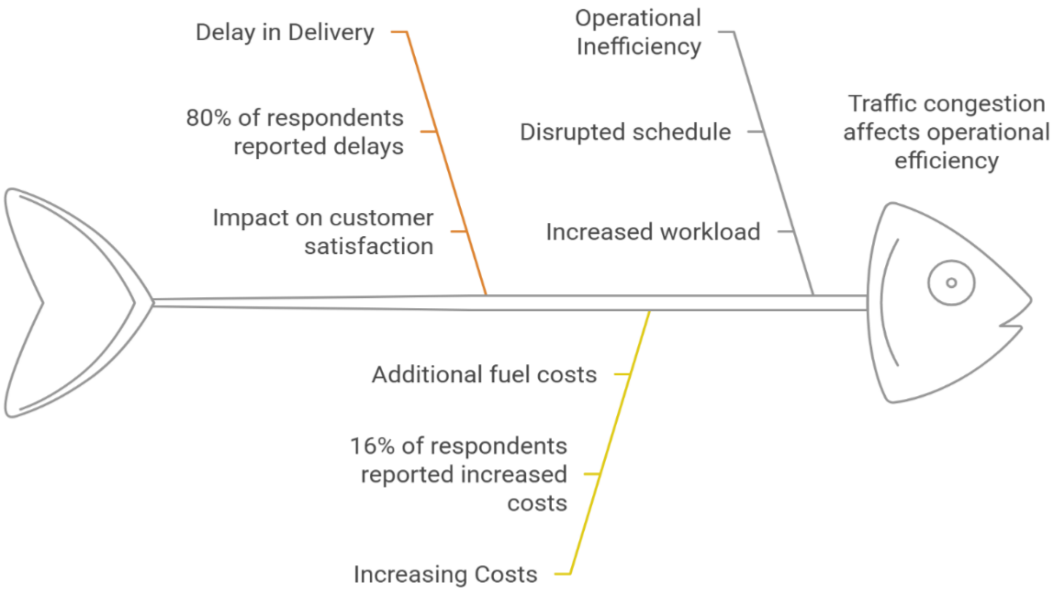
(Source: Processed Data, 2025)

Figure 4. Graph of the intensity of freight transport companies experiencing traffic jams

The effect of congestion on the operation of freight forwarding companies

The congestion experienced by freight transportation companies has several negative impacts, one of which is on the company's operational activities. Based on the results of interviews with 25 respondents related to questions about the influence of congestion on Jalan Denpasar-Gilimanuk on the company's operations, it can be seen through the graph in Figure 5.

The congestion that occurred on Jalan Denpasar-Gilimanuk had a significant impact on the company's operations, especially in the logistics aspect. Many respondents revealed that goods often do not arrive on time, even in severe congestion situations, rescheduling the departure of goods at ports such as Tanjung Perak becomes inevitable. This problem not only extends travel time but also increases the company's operating costs, such as additional fuel consumption and meal costs for drivers. This condition worsens delivery efficiency, hampers the distribution of goods, and delays the scheduling of the delivery of raw materials and products, including food items that are needed by the tourism sector in Bali.



(Source: Processed Data, 2025)

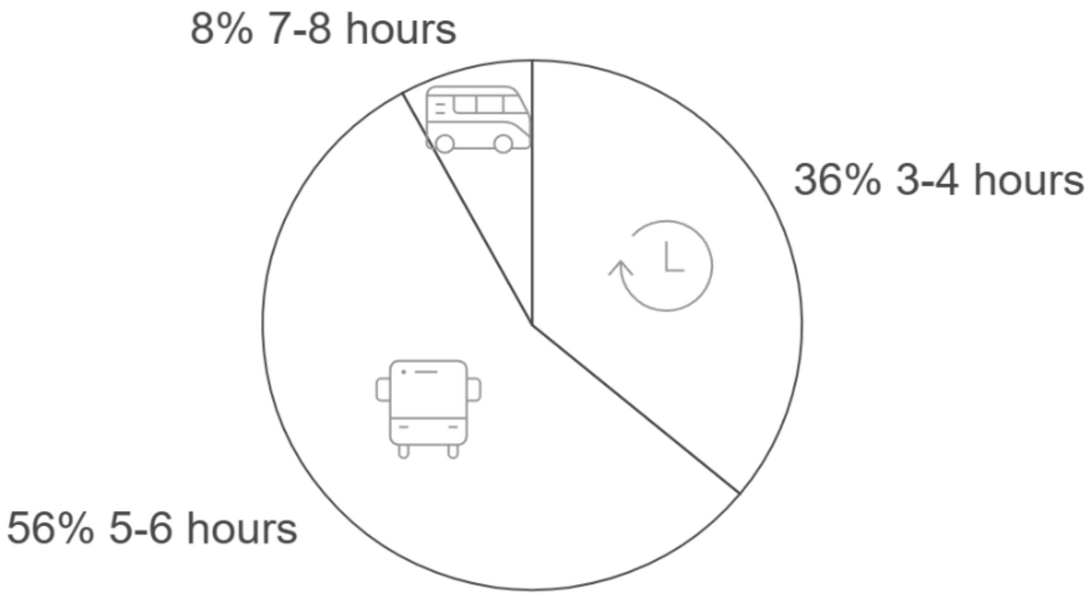
Figure 5. Graph of the effect of congestion on company operations

As one of the main tourist destinations, Bali relies heavily on an efficient supply chain to support its tourism industry. Supply needs such as food, beverages, and hotel or villa necessities are disrupted due to this congestion. In addition, the increasing volume of vehicles, both from tourists using private vehicles and logistics fleets, further worsens the traffic conditions on the route. This not only has an impact on logistics companies but also on the tourism sector which relies on timely delivery of goods to maintain the quality of their services.

Congestion also affects the productivity of drivers, who are often exhausted due to longer travel times. Delays in delivery can disrupt activity schedules, slow down production, and ultimately add to the company's operational costs. In the context of Bali as a crowded tourist destination, the impact of this congestion is increasingly felt because delays in the supply chain can affect the tourist experience, which ultimately harms the local economic sector. Thus, congestion on Jalan Denpasar-Gilimanuk is a serious challenge that must be addressed to maintain the smooth logistics and sustainability of the tourism industry in Bali.

Denpasar-Gilimanuk travel duration in normal times

Information on the duration of the delivery journey by freight forwarding companies to travel the Denpasar-Gilimanuk road at normal times is done by conducting interviews. Based on the results of interviews with 25 respondents related to questions about the duration of the Denpasar-Gilimanuk trip at normal time, it can be seen through the graph in Figure 6.



(Source: Processed Data, 2025)

Figure 6. Graph of Denpasar-Gilimanuk Travel Duration Normal Time

The travel time of logistics goods transportation vehicles on the Denpasar-Gilimanuk route under normal conditions varies based on respondents' responses. Most mention that the normal travel time ranges from 4 to 6 hours. However, there are also respondents who note that the trip can be completed within 3 to 4 hours if conditions are completely smooth. On the other hand, the travel time can be as high as 7 to 8 hours in some specific cases, especially when the volume of vehicles starts to increase or is approaching the holiday season.

For Bali tourism, the efficiency of travel time has a significant impact. The Denpasar-Gilimanuk route is one of the main distribution routes of goods that support the tourism sector, including the delivery of foodstuffs, beverages, as well as hotel and restaurant needs. Efficient travel time is essential to ensure that goods arrive on time and in good condition, so that they can support seamless tourism operations. Therefore, maintaining smooth traffic on this route is an important priority for the sustainability of Bali's tourism which depends on a reliable logistics supply chain.

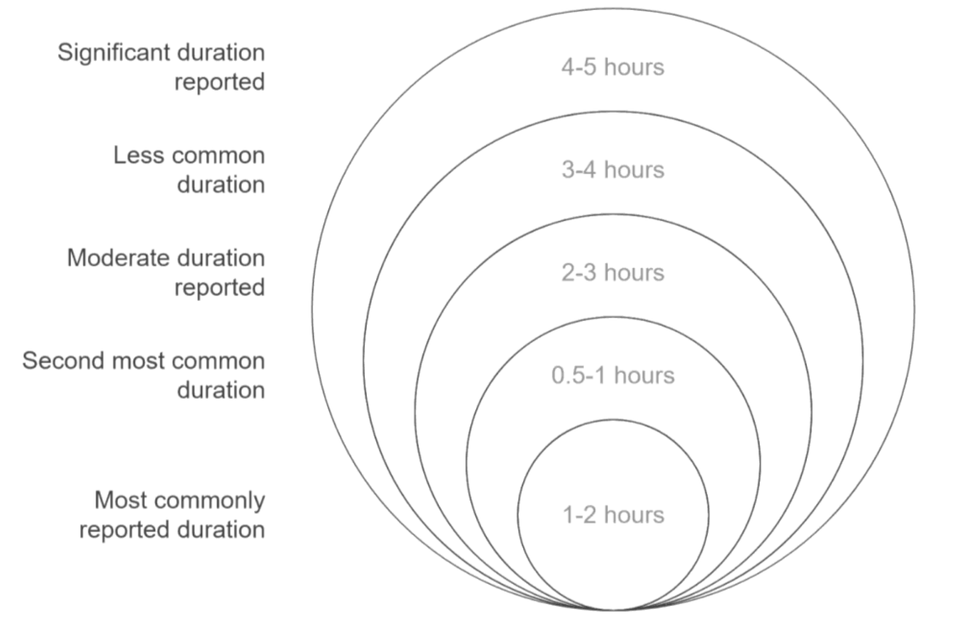
Duration of time wasted due to congestion

The congestion experienced by freight forwarding companies when delivering goods through Jalan Denpasar-Gilimanuk causes wasted delivery time. Based on the results of interviews with 25 respondents related to the question of the duration of time wasted due to the congestion that occurred, it can be seen through the graph in Figure 7.

The time wasted due to congestion for logistics goods transport vehicles on the Denpasar-Gilimanuk route varies depending on the severity of the congestion. In light congestion situations, the time wasted ranges from 1 to 2 hours. However, for moderate to severe congestion, the lost time can reach 30 minutes to 1 hour, and in extreme conditions even reach 4 to 5 hours. Some respondents mentioned that the average duration of severe traffic jams can cause travel time to be delayed up to more than 5 hours.

For Bali's tourism sector, this congestion has a significant impact because the logistics of goods, such as groceries, beverages, and operational needs of hotels or restaurants, become inefficient. Delays in delivery due to congestion can disrupt the operations of the tourism sector, which relies heavily on timely supply chains. In addition, wasted time also affects logistics costs, including fuel consumption and driver workload. Therefore, strategic solutions are needed to overcome congestion, such as optimizing logistics routes and developing transportation infrastructure, to support the sustainability of Bali's tourism.

To overcome this problem, strategic measures are needed that focus on better traffic management. The strategy in question is the application of smart technology for traffic management, optimization of logistics routes to avoid congestion points, and the development of alternative routes that are able to reduce the burden of vehicles on the Denpasar-Gilimanuk main route. With this solution, not only the efficiency of logistics transportation will increase, but also the smooth mobility of tourists, which is an important pillar for Bali's economy.



(Source: Processed Data, 2025)

Figure 7. Graph of the Duration of Time Wasted Due to Traffic Jams

Integration with Tourism

The findings from the quantitative and qualitative analysis show a close relationship between congestion, logistics efficiency, and their impact on the supply chain of goods for tourism needs. In the context of Bali as a tourism area, traffic congestion has a direct impact on logistics and tourism transportation activities in Bali. Delays caused by congestion can affect the availability of goods for the tourism sector, such as food and beverages for restaurants and goods for hotels. Previous research has shown that delivery delays can reduce customer satisfaction (Nazarenus Mwinuka, 2023).

The increase in travel time due to congestion contributes to an increase in operational costs for logistics companies (Fattah et al., 2022). The analysis shows that additional costs due to delays can reach 23-35%, well above the global average of 15% (Logistics Performance Index (LPI), 2023). Data analysis shows that congestion in the Denpasar-Gilimanuk corridor is not only a transportation problem, but also has broad implications for the tourism sector and the local economy. With the growth in the number of tourists reaching 12 million in 2023, the need to manage traffic flow has become even more urgent (BPS Provinsi Bali, 2023).

In addition, traffic congestion in metropolitan areas negatively impacts the efficiency of logistics distribution, affects vehicle rotation, delivery times, and increases operational and fuel costs (Trifena et al., 2024). Therefore, the development of integrated infrastructure, such as port expansion accompanied by investment in improving road and rail infrastructure that supports the movement of goods from ports to final destinations, will help overcome traffic congestion and improve logistics efficiency (Mutlisah, 2023).

Discussions

The Impact of Congestion on Transportation Efficiency

The results of this study corroborate previous findings about the impact of traffic congestion on the efficiency of goods transportation. For example, a study by Hidayat et al. (2021) shows that traffic congestion significantly reduces vehicle speed on roads with low service levels. This is in line with the results of the spot speed survey on Jalan Denpasar-Gilimanuk, where the average speed of pick-up vehicles and large trucks only reaches 12 km/h and 9 km/h respectively during peak hours, far below the speed standard for roads with a high degree of saturation.

This study is in line with findings that show that inadequate road capacity and increased vehicle volume can lead to a significant decrease in logistics efficiency (Wedagama et al., 2023). The obstacles posed by heavy vehicles (HVs) to other vehicles in mixed traffic flows are proven to affect overall road capacity and level of service (LoS), as found in the study. The analysis of road capacity in the Denpasar-Gilimanuk section shows that the V/C ratio values based on PKJI are 1.02, respectively, which indicates that the capacity is already saturated.

A study in Spain by Alvarez et al. (2018) found that considering real-time traffic congestion in route optimization can result in time savings of up to 11% in urban areas (Alvarez et al., 2018). However, the unavailability of alternative routes in Bali—unlike the flexibility of the road network in Spain—resulted in a more direct and uncompensated impact on distribution accuracy. By comparison, Chittagong, Bangladesh, shows that seasonal port congestion causes ships to wait more than a week before loading and unloading, due to limited capacity and a lack of alternative port options (Chowdhury, 2020). These conditions confirm that regions such as Bali, with linear corridors and no backup routes, are more vulnerable to logistical disruptions exacerbated by congestion.

This has implications for longer travel times and increased logistics costs, similar to those reported in the analysis of strategic transport corridors (Miltiadou et al., 2012). The location of the infrastructure in this case also affects the level of congestion in the process of shipping goods in the Bali region (Gautama et al., 2023; Soimun et al., 2024).

This study reveals the significant impact of traffic congestion on the efficiency of goods transportation in the Denpasar-Gilimanuk corridor. The results of the study show that congestion can increase travel time by up to 50%, especially during the tourist season and weekends, with delays ranging from 1-2 hours. These findings are in line with research that found that urban congestion can increase fuel consumption, travel time, and carbon dioxide emissions by up to 80% compared to no congestion (Faheem et al., 2024). Our research shows a 16% increase in operating costs, which is consistent with recent studies in similar tourism-logistics corridors.

The Phenomenon of Tourism Logistics Conflict

Based on the study, there was a decrease in road capacity between 14.37% to 26.60% and a decrease in speed between 13.79% and 76.19% in tourism areas, which caused significant problems on arterial roads (Wedagama et al., 2022). The critical finding of this study is the phenomenon of "tourist logistics conflict". The study expands on the concept by quantifying its impact in the context of Bali, where the overlap between peak hours of tourist activity and logistics delivery schedules resulted in an increase in waiting times by up to 56%. This finding is very significant considering Bali's dual role as a tourist destination and logistics center.

The tourism-logistics conflict identified in this study is in line with the findings of research in the Guilin tourist area, China, where tourist traffic congestion has been analyzed using a big data approach to understand the imbalance between tourism supply and demand (Qin & Li, 2021). However, conditions in Bali are far more critical due to its characteristics as a linear corridor with no alternative routes. In comparison, in Phuket also a major tourist destination studied by

Supradit & Suthiwartnarueput (2025) transportation connectivity and logistics systems were found to greatly affect tourist satisfaction (Supradit & Suthiwartnarueput, 2025).

Nevertheless, Phuket's road network still allows for route diversification despite significant congestion, as mentioned in the analysis of sustainable tourism management in the region (Puchongkawarin & Ransikarbum, 2021). Bali's uniqueness as a narrow corridor with no alternative route options exacerbates the impact of conflicts between tourist mobility and logistics operations. This underscores the important empirical contribution of this study to the literature, as it highlights real conditions that are structurally different from previous international studies.

Infrastructure and Capacity Constraints

This analysis supports the IMF's findings (2022) that port congestion is often caused by infrastructure limitations and increased volumes that exceed available capacity. Particularly noted this pattern in touristy dense areas, where road capacity constraints failed to accommodate the surge in vehicle volumes during peak tourist seasons (Komaromi et al., 2022) improving the quality of transportation infrastructure has a vital role in supporting the tourism sector (Raharjo et al., 2023). This mismatch between infrastructure and demand is particularly noticeable in our area of study.

Impact on Supply Chain Performance

The results of this study are consistent with the findings from Oteng et al. (2022) in Ghana, which show that traffic congestion significantly disrupts supply chain performance through delivery delays and increased operational costs. A new study by Zhao & Lee (2023) expands on these findings by showing that the implementation of connected and autonomous vehicles (CAVs) in distribution can improve supply chain performance, particularly by reducing the impact of congestion. Furthermore, research by Adu et al. (2023) emphasizes that adequate road infrastructure and compliance with driving safety greatly contribute to reducing delays and logistics costs. However, conditions in Bali are different: congestion is not only caused by infrastructure or the number of freight vehicles, but also by the overlap between tourist traffic and logistics distribution, exacerbated by seasonal demand variations. This confirms that tourist areas such as Bali face unique challenges that exacerbate logistics inefficiencies, a dimension that is still rarely highlighted in the literature.

Theoretical and Practical Implications

This research makes an important contribution to transportation management theory by expanding the concept of tourism-logistics conflict, especially in the context of developing economies. This study presents empirical evidence that shows the relationship between traffic congestion and the operations of freight transport companies, thus emphasizing the importance of transportation efficiency in supporting regional economic growth. In addition, the study develops a framework for analyzing multifunctional transportation corridors that serve tourism and logistics needs simultaneously, providing a theoretical basis for future research.

From a practical point of view, the findings of this study are relevant for various stakeholders. For policymakers in tourism based regions, the results of this study provide guidance for designing transportation policies that can reduce the conflict between the needs of tourists and logistics. Logistics operators operating in mixed-use corridors can use these insights to optimize delivery schedules and company operational strategies. In addition, urban planners responsible for the management of tourism-logistics infrastructure can leverage this framework to develop more effective solutions in overcoming infrastructure limitations and improving connectivity. Thus, this research not only enriches the academic literature but also has a direct impact on transportation management practices in the field.

Conclusions

This study provides empirical evidence that traffic congestion in the Denpasar-Gilimanuk corridor significantly impedes freight transport performance in regions dependent on tourism. The findings reveal that road saturation exceeding the recommended threshold (V/C ratio of 1.02) results in a substantial decrease in the speed of freight vehicles (9-12 km/h during peak hours), leading to a 60% increase in operational costs and compromising the supply chain efficiency of tourism-related industries.

Regression analysis shows a strong inverse relationship between traffic volume and vehicle speed, with direct implications for the escalation of congestion costs. Qualitative findings from structured interviews with 25 logistics operators reinforce these quantitative results, confirming that persistent congestion systematically undermines delivery reliability, increases fuel consumption, and degrades service quality in the logistics sector.

These findings contribute to transportation management theory by providing context-specific empirical evidence from dual-purpose transportation corridors that serve both tourism and freight functions. The study offers practical insights for policymakers and logistics stakeholders operating in similar environments, supporting the implementation of integrated solutions, including infrastructure expansion, dedicated freight lanes, intelligent transportation systems, and time-based access restrictions.

Although this study advances our understanding of the impact of congestion on freight logistics in tourism corridors, there are several methodological limitations that need to be acknowledged. The regression analysis in this study focuses on the relationship between traffic volume, speed, and operational costs, but does not include control variables for external factors such as weather conditions, traffic accidents, or road infrastructure work. The absence of these variables constitutes a limitation that may affect the estimation results. Additionally, limitations include temporal coverage and limited stakeholder representation.

Future research should integrate extended observation periods to capture seasonal variations, enrich the model by incorporating these external factors to produce more accurate conclusions, and expand the geographical scope to comparable tourism areas. Integrating diverse stakeholder perspectives will enhance policy relevant insights, tourism operator and infrastructure panners. Advanced traffic simulation modeling and analysis of transportation operators' compliance behavior toward regulatory interventions represent promising avenues for further investigation.

Acknowledgments

This research was supported by Bali Land Transportation Polytechnic. The authors would like to thank the logistics and freight forwarding companies that participated in this research.

References

Aćimović, S., Mijušković, V., & Fedajev, A. (2022). Comparative analysis of transport management preparedness: Evidence from CEE countries. *Industrija*, *50*(2), 21–35. https://doi.org/10.5937/INDUSTRIJA50-41713

Adu, J. P., Dorasamy, N., & Keelson, S. A. (2023). Road transport infrastructure and supply chain performance in the beverage manufacturing setting: Does road safety compliance matter? *Journal of law and sustainable development*, *11*(3). https://doi.org/10.55908/SDGS.V11I3.581

Aluko, O. (2019). Review of urbanisation and transport challenges in developing countries. *International Journal for Innovation Education and Research*, *7*(4), 315–323. https://doi.org/10.31686/IJIER.VOL7.ISS4.1410

Alvarez, P., Lerga, I., Serrano-Hernandez, A., & Faulin, J. (2018). The impact of traffic congestion when optimising delivery routes in real time. A case study in Spain. *International Journal of Logistics Research and Applications*, *21*(5), 529–541. https://doi.org/10.1080/13675567.2018.1457634

BPS Provinsi Bali. (2023, December). *Perkembangan Pariwisata Provinsi Bali Desember 2023 - Badan Pusat Statistik Provinsi Bali*.

https://bali.bps.go.id/id/pressrelease/2024/02/01/717890/perkembangan-pariwisata-provinsi-bali-desember-2023.html?utm_source=chatgpt.com
Chowdhury, S. H. (2020). *Port congestion at Chittagong: Seasonal demand, capacity constraints, and logistic delays. In Resilient Maritime Logistics (Case Study 22).* UNCTAD. https://resilientmaritimelogistics.unctad.org/guidebook/case-study-22-port-chittagong-bangladesh?utm_source=chatgpt.com
Creswell, J. W. , & C. J. D. (2018). Research design: Qualitative, quantitative, and mixed methods approaches. *Sage Publications.*
Direktorat Jenderal Bina Marga. (2023). *Pedoman Kapasitas Jalan Indonesia (PKJI)* (Issue 021). Direktorat Jenderal Bina Marga dan Departemen Pekerjaan Umum.
Faheem, H. B., Shorbagy, A. M. El, & Gabr, M. E. (2024). Impact of traffic congestion on transportation system: challenges and remediations - A review. *Mansoura Engineering Journal*, *49*(2). https://doi.org/10.58491/2735-4202.3191
Fattah, M. A., Morshed, S. R., & Kafy, A. Al. (2022). Insights into the socio-economic impacts of traffic congestion in the port and industrial areas of Chittagong city, Bangladesh. *Transportation Engineering*, *9*, 100122. https://doi.org/10.1016/J.TRENG.2022.100122
Gautama, N. W., Soimun, A., & Gilang, A. P. (2023). Analisis lokasi gudang pusat distribusi logistik di Provinsi Bali. *Jurnal Teknologi Transportasi Dan Logistik*, *4*(1), 49–56. https://doi.org/10.52920/JTTL.V4I1.126
Gede, W., & Yoga, D. (2023). Analisis kinerja ruas jalan Denpasar Gilimanuk Segmen Kecamatan Mengwi. *Reinforcement Review in Civil Engineering Studies and Management*, *2*(1), 1–7. https://doi.org/10.38043/REINFORCEMENT.V2I1.4280
Ghozali, I. (2016). *Aplikasi analisis multivariete dengan program IBM SPSS 23 (Edisi 8).* Badan Penerbit Universitas Diponegoro.
Gomes, A. C., De Lima Junior, F. B., Soliani, R. D., Oliveira, P. R. de S., De Oliveira, D. A., Siqueira, R. M., Nora, L. A. R. da S., & De Macêdo, J. J. S. (2023). Logistics management in e-commerce: challenges and opportunities. *Revista de Gestão e Secretariado (Management and Administrative Professional Review)*, *14*(5), 7252–7272. https://doi.org/10.7769/GESEC.V14I5.2119
Hidayat, D.W., Mardikawati, B., Oktopianto, Y., & Shofiah, S. (2021). Analisis lalu lintas ruas jalan Denpasar-Gilimanuk Tabanan Bali Masa Pendemi Covid 19. *Jurnal Keselamatan Transportasi Jalan (Indonesian Journal of Road Safety)*, *8*(2), 137–144. https://doi.org/10.46447/KTJ.V8I2.406
Ivasyshyna, N. (2024). Development of transport logistics in tourism. *E3S Web of Conferences*, *508*. https://doi.org/10.1051/E3SCONF/202450808010
Karuppanagounder, K. (2018). *Economic impact of traffic congestion-estimation and challenges*. https://www.researchgate.net/publication/326235494
Kemei, N., Kapkiyai, C., & Uyoga, D. (2024). Urban logistics and supply chain performance: Does logistics management systems moderate? *International Journal of Academic Research in Business and Social Sciences*, *14*(9). https://doi.org/10.6007/IJARBSS/V14-I9/22820
Khan, A., Bibi, S., Lorenzo, A., Lyu, J., & Babar, Z. U. (2020). Tourism and development in developing economies: A policy implication perspective. *Sustainability (Switzerland)*, *12*(4). https://doi.org/10.3390/SU12041618
Komaromi, A., Cerdeiro, Mr. D. A., & Liu, Y. (2022). Supply chains and port congestion around the world. *IMF Working Papers*. https://ideas.repec.org/p/imf/imfwpa/2022-059.html
Kumaat, M. (2023). Analisis karakteristik dan tingkat pelayanan arus pejalan kaki (Studi kasus: Jl. Suprapto – Jl. Lembong). *Tekno*, 21(84).
Lim, C., Zhu, L., & Koo, T. T. R. (2019). Urban redevelopment and tourism growth: Relationship between tourism infrastructure and international visitor flows. *International Journal of Tourism Research*, *21*(2), 187–196. https://doi.org/10.1002/JTR.2253
Logistics Performance Index (LPI). (2023). Retrieved January 5, 2025, from https://lpi.worldbank.org/international/global
Lubis, Y. A. (2016). Analisis Biaya Kemacetan Kendaraan di Jalan Setiabudi (Studi Kasus Depan Sekolah Yayasan Pendidikan Shafiyyatul Amaliyyah) (YPSA). *Jurnal Warta* , 48, 1829–7463.

Mandic, A., Mrnjavac, Ž., & Kordic, L. (2018). Tourism infrastructure, recreational facilities and tourism development. *Tourism and Hospitality Management*, *24*(1), 41–62. https://doi.org/10.20867/THM.24.1.12

Martínez, J. M. G., Martín, J. M. M., & Rey, M. del S. O. (2020). An analysis of the changes in the seasonal patterns of tourist behavior during a process of economic recovery. *Technological Forecasting and Social Change*, *161*, 120280. https://doi.org/10.1016/J.TECHFORE.2020.120280

Miltiadou, M., Taxiltaris, C., Mintsis, G., & Basbas, S. (2012). *Pan-European corridor x development: Case of literal implementation of the European transport strategy itself or of change of the general environment in the region?* https://doi.org/10.1016/j.sbspro.2012.06.1207

Mutlisah, S. (2023). Pembangunan infrastruktur maritim dan dampak bagi sdm konektivitas regional: Studi kasus Pelabuhan Patimban. *Triwikrama: Jurnal Ilmu Sosial*, *1*(4), 150–160. https://doi.org/10.6578/TJIS.V1I4.202

Nazarenus Mwinuka, N. (2023). *The Impact Of Waiting Lines On Customer Satisfaction In Tourism Companies*. https://e-conf.usd.ac.id/index.php/icebmr/

Nopiah, R., Ekaputri, R. A., Barika, B., & Febriani, R. E. (2024). Impact of e-commerce on indonesia economic growth: Intermediation models with financial technology constraint. *Jurnal REP (Riset Ekonomi Pembangunan)*, *9*(1), 1–23. https://doi.org/10.31002/REP.V9I1.1216

Orbeta, & C., A. Jr. (2000). E-commerce in Southeast Asia: A review of developments, challenges and issues. *Discussion Papers*. https://ideas.repec.org/p/phd/dpaper/dp_2000-38.html

Oteng, M., Opoku, O. A., & Gyamfi, E. (2022). The effect of road traffic on supply chain performance of Kwasi Oppong Company Limited in Ghana. *Journal of Production, Operations Management and Economics*, *21*, 27–36. https://doi.org/10.55529/JPOME.21.27.36

Pan, J., Khan, M. A., Popa, I. S., Zeitouni, K., & Borcea, C. (2012). Proactive vehicle re-routing strategies for congestion avoidance. *Proceedings - IEEE International Conference on Distributed Computing in Sensor Systems, DCOSS 2012*, 265–272. https://doi.org/10.1109/DCOSS.2012.29

Peñalosa, E., Wright, L., Friedrich, A., Litman, T., Institute, W., Shah, J., Iyer, N. V, Fjellstrom, K., Hook, W., Silcock, D., & Lacroix, J. (2010). *Challenges of urban transport in developing countries-a summary Challenges of urban transport in developing countries-a summary Based on the GTZ Sourcebook on Sustainable Urban Transport for Policymakers in Developing Cities*. www.sutp.org-www.sutp.cn

Pribadi, T. I., Tahir, R., & Yuliawati, A. K. (2021). The challenges in developing smart tourism: a literature review. *InfoTekJar : Jurnal Nasional Informatika Dan Teknologi Jaringan*, *5*(2), 254–258. https://doi.org/10.30743/INFOTEKJAR.V5I2.3462

Puchongkawarin, C., & Ransikarbum, K. (2021). An integrative decision support system for improving tourism logistics and public transportation in thailand. *Tourism Planning and Development*, *18*(6), 614–629. https://doi.org/10.1080/21568316.2020.1837229

Qin, J., & Li, S. (2021). Supply and demand congestion of tourism based on the big data method-take Guilin as example. *Advances in Intelligent Systems and Computing*, *1303*, 821–829. https://doi.org/10.1007/978-981-33-4572-0_118

Raharjo, E. P., Surya, K., Adidana, P., Candrarahayu, A. M., & Fitasari, Y. (2023). Pengaruh pembangunan infrastruktur transportasi dalam mendukung kunjungan wisatawan mancanegara di Provinsi Bali. *Jurnal Teknologi Transportasi Dan Logistik*, *4*(1), 1–10. https://doi.org/10.52920/JTTL.V4I1.103

Roberts, M., Melecky, M., Bougna, T., & Xu, Y. (2020). Transport corridors and their wider economic benefits: A quantitative review of the literature. *Journal of Regional Science*, *60*(2), 207–248. https://doi.org/10.1111/JORS.12467

Samková, L., & Navrátil, J. (2023). Significance of the public transport for tourism development in destinations. *Journal Of Regional Development And Tourism*, *15*, 2023.

She, Y., Shen, L., Jiao, L., Zuo, J., Tam, V. W. Y., & Yan, H. (2018). Constraints to achieve infrastructure sustainability for mountainous townships in China. *Habitat International*, *73*, 65–78. https://doi.org/10.1016/J.HABITATINT.2018.01.009

Soimun, A., Widiangga, N., & Surya, A. A. B. O. K. (2024). Optimizing freight terminal location in sarbagita region: a decision analysis approach using analytic hierarchy process (AHP). *JRSI (Jurnal Rekayasa Sistem Dan Industri)*, *11*(1), 33–41. https://doi.org/10.25124/JRSI.V11I01.735

Supradit, A., & Suthiwartnarueput, K. (2025). Tourism logistics factors affecting wellness tourism in Phuket. In *Journal of Thai Hospitality and Tourism* (Vol. 20, Issue 1, pp. 30–40). https://so04.tci-thaijo.org/index.php/tourismtaat/article/view/265861

Tamin, Ofyar Z. (2008). *Perencanaan, pemodelan, dan rekayasa transportasi: Teori contoh soal, dan aplikasi*. ITB.

Trifena, O., Piyd, L., Shatara Nugraha, A., Romadhon, M. A., Triningsih, N., & Widodo, M. S. (2024). *Analisis dampak kemacetan lalu lintas terhadap efisiensi distribusi logistik di kawasan metropolitan*.

Triyasa Cipta Transport (2023). *Peran Logistik dalam Memajukan Infrastruktur Pariwisata | Artikel | PT. Triyasa Cipta Transport*. https://www.pt-tct.com/Artikel/Peran-Logistik-dalam-Memajukan-Infrastruktur-Pariwisata.html

Wedagama, D. M. P., Suweda, I. W., & Astariyani, N. L. G. (2022). The influence of side friction on speed-mixed flow behavior on arterial roads in tourism area in Bali. *Civil Engineering and Architecture*, *10*(1), 27–44. https://doi.org/10.13189/CEA.2022.100103

Wedagama, D. M. P., Dissanayake, D., & Ali, F. B. (2023). The impact of changing flow of freight transport on stochastic capacity of road links. *Jurnal Teknologi Transportasi Dan Logistik*, *4*(2), 131–140. https://doi.org/10.52920/JTTL.V4I2.178

Zhang, W., Chen, Y., Zhang, K., & Chen, B. (2024). Effects of route guidance strategies on traffic emissions in urban traffic networks. *Https://Doi.Org/10.1142/S0129183124501833*. https://doi.org/10.1142/S0129183124501833

Zhao, J., & Lee, J. Y. (2023). Effect of connected and autonomous vehicles on supply chain performance. *Transportation Research Record*, *2677*(3), 402–424. https://doi.org/10.1177/03611981221115425