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ANALYSIS OF ROADSIDE ACTIVITY IMPACTS ON URBAN ROAD LEVEL OF SERVICE: A CASE STUDY OF THE PASAR CIPANAS ROAD SEGMENT

Gde Ngurah Purnama Jaya [1*], Umar Mansyur[2], Ardiatno Yanuadi[3]

[1,3]Urban and Regional Planning, Faculty of Engineering, Pakuan University, Bogor, 16143, Indonesia
[2]Magister of Urban and Regional Planning, Graduate School, Pakuan University, Bogor, 16143, Indonesia
*Corresponding author: gde.purnamajawa@unpak.ac.id

ABSTRACT

This study investigates the impact of roadside activities on road performance along the Pasar Cipanas road segment, focusing on pedestrian movement, parking, and stopping of public and other vehicles, and vehicles entering and exiting adjacent properties. The research employs a quantitative approach, collecting primary data through field observations and traffic surveys to identify the frequency and characteristics of roadside activities. The results reveal that pedestrian activities are primarily caused by the occupation of sidewalks by street vendors, forcing pedestrians to use the roadway and increasing traffic conflicts. The lack of dedicated parking facilities leads to frequent parking and stopping of vehicles on the road, particularly in commercial areas, which significantly reduces road capacity and disrupts traffic flow. Additionally, the high intensity of vehicles entering and exiting adjacent commercial properties further contributes to congestion and safety risks. The study concludes that unmanaged roadside activities have a considerable negative impact on road performance and safety. These findings highlight the need for improved urban planning and the provision of supporting infrastructure, such as designated pedestrian paths and parking areas, to minimize roadside friction and enhance overall traffic efficiency and safety in the Pasar Cipanas area.

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1. INTRODUCTION

Transportation, in general, is the movement of goods and passengers from one place to another. Fundamentally, according to Hurst in Atmajaya (2011), transportation serves as a crucial benchmark for spatial interaction between regions, playing a vital role in the developmental process of an area. To maintain and preserve the condition and performance of roads from occurring issues, necessary actions must be taken, and these actions constitute road management. Article 8 of the Republic of Indonesia Law Number 22 of 2009 concerning Road Traffic and Transportation states that one aspect of road management is the inventory of road service levels and their associated problems.

Cianjur Regency has a functional interconnectedness in the balanced development between regions. This is based on Presidential Regulation of the Republic of Indonesia Number 60 of 2020 concerning the Spatial Plan for the Jakarta, Bogor, Depok, Tangerang, Bekasi, Puncak, and Cianjur Metropolitan Area. A portion of Cianjur Regency is included in the Jabodetabek-Punjur Metropolitan Area, which is a National Strategic Area from an economic perspective.

Based on Presidential Regulation of the Republic of Indonesia Number 60 of 2020 concerning the Spatial Plan for the Jakarta, Bogor, Depok, Tangerang, Bekasi, Puncak, and Cianjur Metropolitan Area, one of the transportation network systems, specifically the road network, functions to improve the service quality for the movement of people and goods, as well as to drive the economic growth of communities within the Jabodetabek-Punjur National Strategic Area. This includes the Cianjur-Puncak City Limits Road. This is also outlined in the Cianjur Regency Regional Spatial Plan for 2011-2031, where several road network systems are slated for improvement and development, one of which is the Cianjur-Puncak City Limits Road.

The rapid development of urban areas has led to increased activities along road segments, particularly on segments serving as centers of economic and social activities. Roadside activities such as pedestrian movement, stopping vehicles, vehicles entering and exiting from the roadside, and slow-moving vehicles can create side friction that significantly affects the capacity and performance of urban roads (Abbas, 2000). Such side friction often results in decreased vehicle speed, traffic congestion, and increased travel times, ultimately leading to a decline in road service levels (Bahar, 2000).

The level of service (LOS) is a qualitative measure that describes the operational quality of a road segment based on parameters such as speed, smoothness of flow, and drivers' freedom of maneuver (Bina Marga, 1997). In the context of urban roads, particularly in segments near activity centers such as traditional markets, roadside activities tend to reduce road capacity and cause a decline in road service levels to suboptimal conditions (Fatimah, 2019; Hariyani, 2021).

The Cipanas Market Road Segment is one of the urban road segments experiencing high roadside activity due to the presence of markets and surrounding commercial activities. Therefore, analyzing the impact of roadside activities on road conditions and service levels in this segment is crucial to support more effective and efficient transportation planning and management (Aziz & Asrul, 2018; Jaya, 2024).

According to the Decree of the Minister of Public Works and Public Housing Number 248/KPTS/M/2015 concerning the Stipulation of Road Sections within the Primary Road Network Based on Their Function as Arterial and Collector Roads – 1, the Cianjur-Puncak City Limits Road functions as a primary collector road with the status of a National Road.

Initial observations indicate that roadside activities along the Pasar Cipanas road segment have become a source of friction, negatively impacting traffic flow. This is evidenced by the consistently slow-moving traffic, often leading to congestion that backs up beyond the Cipanas Presidential Palace, particularly during peak hours on both weekdays and weekends. This situation is undesirable, considering the Pasar Cipanas road segment's role in realizing an effective and efficient spatial structure for the Jabodetabek-Punjur National Strategic Area to promote community economic growth. Furthermore, its proximity to the Cipanas Presidential Palace suggests a lack of supervision

and control over factors contributing to traffic problems, as indicated by the disorganized traffic flow. Based on the background described above, the research problems in this study are formulated as follows. First, how does roadside activity affect the condition of the road on the Pasar Cipanas Road Segment? Second, how does roadside activity influence the level of service of the Pasar Cipanas Road Segment? The theoretical framework serves to support the study to be conducted, guiding the selection of appropriate research methodology and enriching the breadth of understanding in the analysis. Therefore, the objectives of this study are to identify the impact of roadside activities on the condition of the Pasar Cipanas Road Segment and to identify the level of service of the Pasar Cipanas Road Segment as influenced by roadside activities.

2. RESEARCH METHODOLOGY

2.1 Scope of the Research

The research location is the Pasar Cipanas road segment, determined by observing the road characteristics along this segment. This study focuses on the Pasar Cipanas road segment, part of the Cianjur-Puncak City Limits Road.

A survey will be conducted at the research location to understand the impact of roadside activities on the level of service of the Pasar Cipanas road segment. This survey aims to identify the types, classes, passenger car equivalent factors, and the number of vehicles passing through to determine the traffic volume. Additionally, the analysis will examine the influence of roadside activities to determine the capacity of the Pasar Cipanas road segment. The level of service of the Pasar Cipanas road segment will be assessed based on the degree of saturation, which is the ratio between the traffic volume and the road capacity.

2.2 Data Collection Methods

The data collection for this research consists of two types: primary data and secondary data. Primary data are collected directly from the sources through methods such as field observations, interviews, and surveys, providing firsthand and current information related to the research topic. Secondary data, on the other hand, are obtained from existing sources such as books, scientific journals, previous research reports, and official documents, which are used to support and complement the primary data collected (Sugiyono, 2017).

2.2.1 Primary Data Collection Method

Field observations were conducted in the Cipanas District, Cianjur Regency, specifically on the road segment from the Cianjur City Border to Puncak, focusing on the Pasar Cipanas road segment. Several activities were carried out during the field observation/survey, including:

1) Observation of Road Characteristics/Existing Conditions
   This involved assessing the basic conditions that describe geometric characteristics such as road type, road widthcurbs, shoulders, and medians.
2) Observation of Roadside Activities/Roadside Friction
   The observation of roadside activities aimed to identify the types of roadside activities occurring, their frequency, and their impact on the basic conditions representing the geometric characteristics of the road.
3) Traffic Counting Survey
   The survey was conducted by counting traffic flow, specifically the types and number of vehicles passing through the road segment from the Cianjur City Border to Puncak.

2.2.2 Secondary Data Collection Method

1) Literature Study

The literature study was carried out by reviewing reference sources such as textbooks, documents, theses, laws, and regulations.

2) Agency Survey
The agency survey was conducted at the Public Works and Spatial Planning Office of Cianjur Regency and the Central Bureau of Statistics.

2.3 Data Analysis Methods

Analysis is the process of processing, grouping, identifying relationships, and interpreting data and information, following the objectives to be achieved. The analyses conducted in this study include:

a. Analysis of Types of Roadside Activities
The analysis of roadside activities in the Pasar Cipanas segment is conducted by directly observing various roadside activities (such as pedestrian crossings, parked vehicles, and vehicles entering or exiting adjacent areas), recording their frequency, multiplying each frequency by its impact weight according to the MKJI 1997 guidelines, summing these weighted values to obtain a total roadside activity score, and comparing this score against classification criteria to determine the level of obstruction (low, medium, or high) and its effect on road performance.

b. Analysis of the Classification of Roadside Activities
The frequency of each type of roadside activity occurring during peak traffic hours is multiplied by the weighting factor assigned to each type of roadside activity. The detailed calculation method for determining the class of roadside activities is as follows:

- Stage 1
  The frequency of each type of roadside activity is multiplied by the weighting factor assigned to each type of activity.
- Stage 2
  The results from Stage 1 are summed to obtain the weighted value of roadside activity occurrences.
- Stage 3
  The weighted values of roadside activities from both sides of the road are summed to obtain the total weighted value, which represents the class of roadside activities.

3. GENERAL OVERVIEW OF STUDY AREA

3.1 Geographical Conditions and Administrative Boundaries of Cianjur Regency

Cianjur Regency is one of the regencies located in West Java Province. Astronomically, Cianjur Regency is situated between 6°21’–7°25’ South Latitude and 106°42’–107°25’ East Longitude, with elevations ranging from 7 meters to 2,962 meters above sea level, covering a total area of 3,614.35 km². Administratively, Cianjur Regency is bordered by:

- North : Bogor Regency and Purwakarta Regency
- East : Bandung Regency, West Bandung Regency, and Garut Regency
- South : The Indian Ocean
- West : Sukabumi Regency and Bogor Regency

Cianjur Regency consists of 32 districts, 360 villages, and 6 urban villages, with Cianjur town as the administrative center. Its diverse topography—ranging from southern coasts to central lowlands and northern mountains like Mount Gede—shapes the region's socio-economic activities, from agriculture to tourism. This geographical and administrative structure supports regional planning and development (Badan Pusat Statistik Kabupaten Cianjur, 2022).

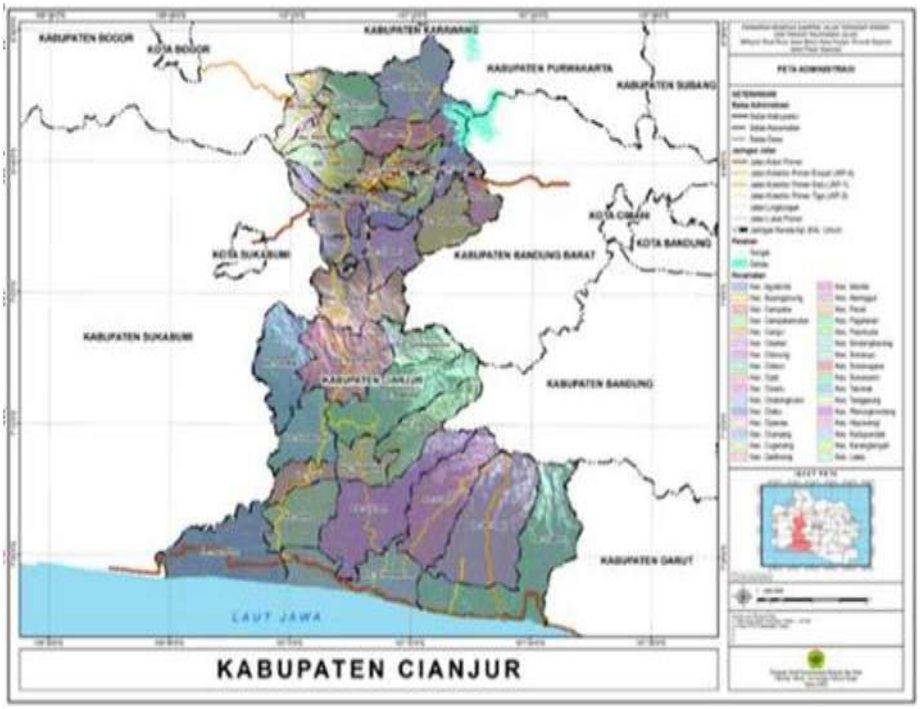


Figure 1. Administrative Map of Cianjur Regency

3.1.1 Basic Physical Conditions of Cianjur Regency

1) Topography
   Cianjur Regency features varying elevations, ranging from a minimum altitude of 7 meters to a maximum altitude of 2,962 meters above sea level.
2) Slope Gradient
   The slope gradient in Cianjur Regency ranges from flatlands with a slope of 0–8% to hilly areas with slopes greater than 40%.
3) Land Use
   Land use in Cianjur Regency is predominantly forested areas, covering 94,138 hectares, followed by plantations with an area of 76,723 hectares, mixed gardens covering 60,891 hectares, and residential areas occupying 25,330 hectares.

3.1.2 Demographics

1) Population Size and Growth in Cianjur Regency
   The population of Cianjur Regency from 2017 to 2021 shows an increasing trend (Table 1).

Table 1 Population Growth in Cianjur Regency from 2017 to 2021

Year	Gender (people)		Total Population
	Male	Female	(People)
2017	1.160.520	1.096.069	2.256.589
2018	1.161.997	1.098.623	2.260.620
2019	1.180.362	1.105.609	2.285.971
2020	1.271.458	1.206.102	2.447.560
2021	1.285.980	1.220.702	2.506.682

Source: Cianjur Regency in Numbers, 2018-2022

2) Population of Cianjur Regency by Age Group
Based on age group data, it is evident that Cianjur Regency has a larger proportion of residents in the productive age group. In 2021, the majority of the population was dominated by individuals aged 20–24 years.

3) Road Network Conditions in Cianjur Regency
The total road length in Cianjur Regency in 2020 was recorded at 1,301.7 kilometers. Based on the surface type, 1,114.90 kilometers were paved roads, 186.80 kilometers were gravel roads, and another 186.80 kilometers were classified as earth or unpaved roads. The condition of the roads in Cianjur Regency varies, ranging from roads in good condition to those that are severely damaged.

3.2 General Overview of the Pasar Cipanas Road Segment

1) Function and Status of the Pasar Cipanas Road Segment
The Pasar Cipanas road segment is an integral part of the National Road network, designated as a Primary Collector Road (JKP-1) according to the classification set by the Ministry of Public Works and Housing (Menteri Pekerjaan Umum dan Perumahan Rakyat, 2015). This segment stretches approximately 405 meters and serves as a vital corridor facilitating the movement of traffic within the urban area. Its strategic function supports the distribution of traffic from local roads to arterial roads, thereby playing a key role in maintaining the connectivity and accessibility of the surrounding urban zones. The physical condition of the road includes the road function classification, road type, lane width, curb width, shoulder width, and median width (Table 2).

Table 2 Physical Condition of the Pasar Cipanas Road Segment

Geometric Description	Pasar Cipanas Road Segment
Road Function	Primary Collector (JKP-1)
Road Type	4/2 D
Segment Length	0,405 km
Lane Width	7 meters
Width Per Lane	3,5 meters
Median Width	0,30 meters
Curb Width	0,20 meters

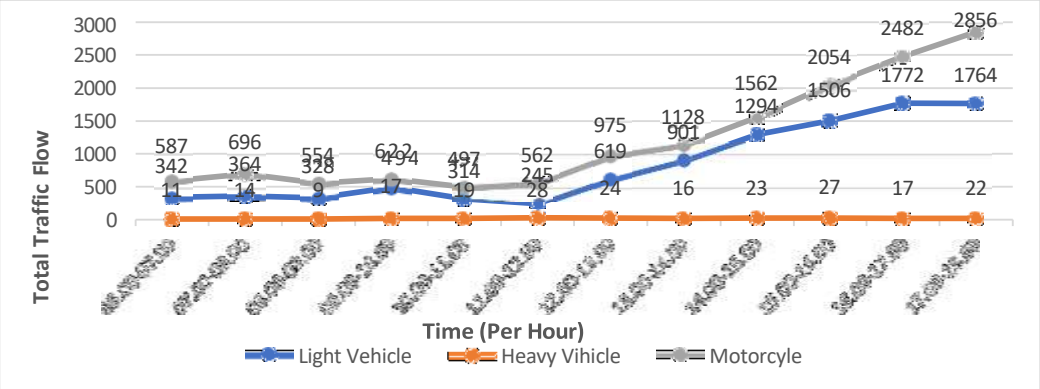
Source: Cianjur Regency Public Works and Spatial Planning Office (PUPR), 2022

2) Land Use and Building Functions Along the Pasar Cipanas Road Segment
Land use refers to the utilization of land by communities for various purposes such as agriculture, plantations, settlements, or other activities. The term "land use" is often associated with land allocation, which reflects human activities over a specific area (Baja, 2012).
Land use around traditional markets in Cianjur Regency shows competition between agricultural areas and residential or commercial zones. Population growth and economic demands have accelerated the conversion of agricultural land, threatening food supply sources (Cianjur Agriculture Office, 2013, in the second source). Additionally, minimarkets near public markets, particularly in Ciranjang District, violate local regulations on minimum distance, creating unhealthy competition that harms traditional market traders (Agustin, 2016).
The Pasar Cipanas road segment is part of the city boundary Cianjur–Puncak road section, where the land use along the sides of the road is predominantly for commercial and service purposes. The building functions vary, including the Cipanas Market, retail shops, restaurants, and other commercial facilities.

3.3 General Overview of the Pasar Cipanas Road Segment

3.3.1 Traffic Flow of Vehicles on Segment 1 of the Pasar Cipanas Road Segment

a. Point 1 of the Pasar Cipanas Road Segment on Sunday, April 17, 2022
Based on traffic observations at Segment 1 of the Pasar Cipanas Road Segment in the direction of Cianjur–Puncak (northbound), the total vehicle traffic flow recorded over 12 hours was 4,642 vehicles/hour. For a clearer illustration, please refer to Figure 2 below.

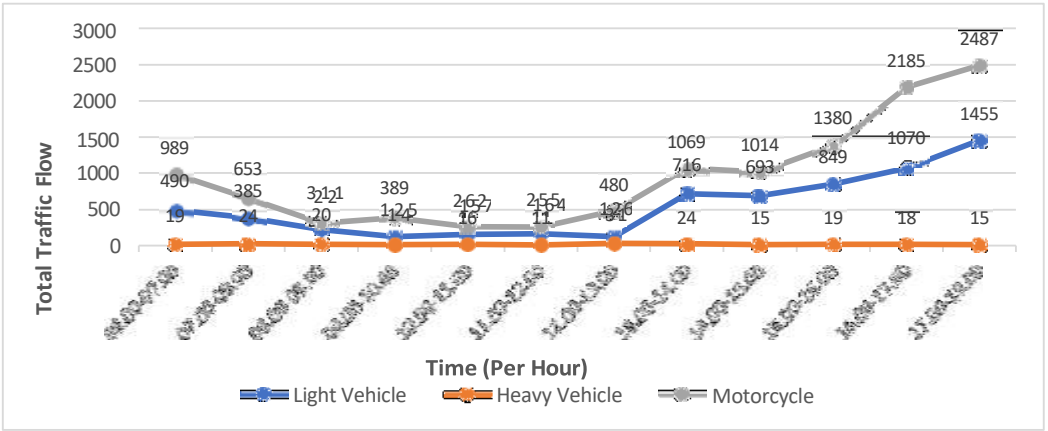


Source: Field Observation, 2022

Figure 2. Graph of Total Traffic Flow in Segment 1, Direction Cianjur–Puncak, Sunday, April 17, 2022 (Vehicles/Hour)

The traffic flow at Point 1 of the Pasar Cipanas Road Segment (Direction: Cianjur–Puncak) gradually increases from 06:00 to 18:00, dominated by light vehicles, followed by motorcycles, with minimal heavy vehicle presence. Traffic peaks between 17:00 and 18:00 at 2,856 vehicles, with a notable afternoon surge in motorcycle volume.

b. Point 1 of the Pasar Cipanas Road Segment on Monday, April 18, 2022
Based on the traffic observation in the direction of Cianjur–Puncak (northbound), the total vehicle traffic flow recorded over 12 hours was 3,957 vehicles/hour. For a clearer illustration, please refer to Figure 3 below.



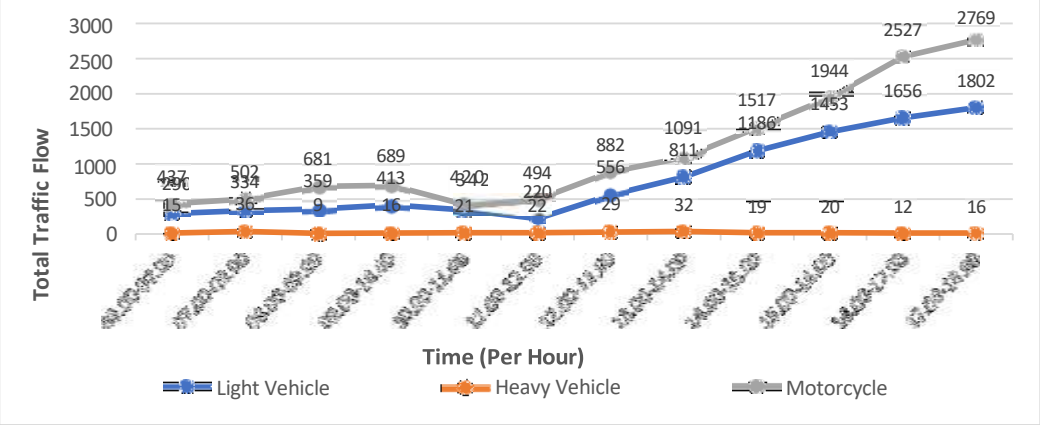
Source: Field Observation, 2022

Figure 3. Graph of Total Traffic Flow in Segment 1, Direction Cianjur–Puncak, Monday, April 18, 2022 (Vehicles/Hour)

Based on the table above, the highest traffic flow occurs between 17:00–18:00 with a total of 2,487 vehicles, which is slightly lower than the peak traffic volume recorded on Sunday (2,856 vehicles). Compared to Sunday, Monday's traffic build-up starts later in the day and the overall traffic flow throughout the morning and early afternoon is significantly lower.

3.3.2 Traffic Flow of Vehicles on Segment 2 of the Pasar Cipanas Road Segment

a. Point 2 of Pasar Cipanas Road Segment, Direction Puncak–Cianjur (Sunday, April 17, 2022)
Based on the traffic observation results, the total vehicle flow over 12 hours was recorded at 4,587 vehicles per hour. For more details, refer to Figure 4 below.

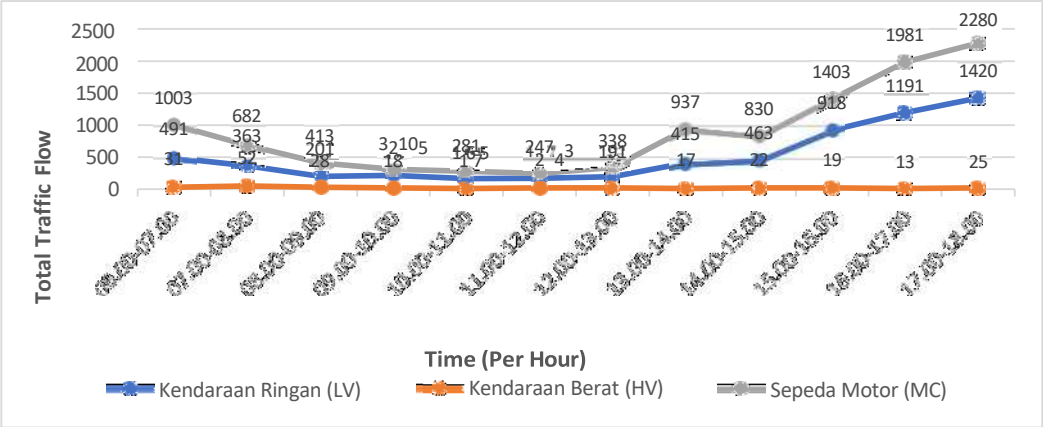


Source: Field Observation, 2022

Figure 4. Graph of Total Traffic Flow in Segment 2, Direction Cianjur–Puncak, Sunday, April 17, 2022 (Vehicles/Hour)

During the peak hour (17:00–18:00) on Sunday, April 17, 2022, at Segment 2 (Direction: Cianjur–Puncak), light vehicles recorded 1,802 vehicles per hour, motorcycles 2,769 vehicles per hour, and heavy vehicles only 16 vehicles per hour. Traffic congestion was mainly caused by the high volume of private cars and motorcycles, with heavy vehicles having minimal impact.

b. Point 2 of Pasar Cipanas Road Segment, Direction Puncak–Cianjur (Monday, April 18, 2022)
Based on the traffic observation results at Segment 2 of Pasar Cipanas Road, in the Puncak-Cianjur (southbound) direction, the total traffic flow was recorded at 3,725 vehicles per hour. At the peak hour between 17.00 and 18.00, the traffic flow on the Pasar Cipanas road segment was dominated by motorcycles (MC), reaching 2,280 vehicles per hour. Light vehicles (LV) also recorded a high volume of 1,420 vehicles per hour, showing a significant contribution to the overall traffic.
Meanwhile, heavy vehicles (HV) had a relatively minor presence, with only 25 vehicles per hour. This pattern indicates that motorcycles were the predominant type of vehicle during this peak period, followed by light vehicles, with heavy vehicles contributing minimally to the total traffic flow. For more details, refer to Figure 5 below.



Source: Field Observation, 2022

Figure 5. Graph of Total Traffic Flow in Segment 2, Direction Cianjur–Puncak, Monday, April 1*8*, 2022 (Vehicles/Hour)

This comparison highlights that although the dominance pattern remains the same — motorcycles being the largest portion, followed by light vehicles and then heavy vehicles — there are slight differences in the recorded values between the two datasets. Notably, the field observation data shows slightly lower motorcycle counts but higher light vehicle volumes compared to the traffic volume table. Heavy vehicles remained consistently low in both datasets.

4. RESULTS AND DISCUSSION

4.1 Identification of the Impact of Roadside Activities on the Condition of the Pasar Cipanas Road Segment

Roadside activities, such as parking, pedestrian movement, and commercial activities, have a significant impact on road performance and safety. According to a study conducted in Indonesia, the presence of roadside activities in areas with high social and economic activity, such as traditional markets, leads to frequent side obstacles that reduce road capacity and disrupt traffic flow. These obstacles include parked vehicles, pedestrian crossings, and slow-moving vehicles entering and exiting the area, all of which contribute to increased traffic density and decreased road performance (Adhitya, 2024). The study highlights that the assessment of side obstacles is crucial for understanding their negative effects on road efficiency and for developing strategies to mitigate congestion and improve overall road function.

In addition to traffic performance, roadside activities can also influence driver behavior and safety. Anciaes (2023) found that the roadside visual environment, including both natural and built elements, can affect drivers' well-being and behavior. For example, advertisements and commercial activities along the roadside are linked to increased driver distraction, while monotonous views can cause fatigue. The review emphasizes that roadside features not only impact the driving task directly but also have broader implications for road safety and the psychological state of drivers. Therefore, the identification and management of roadside activities are essential for enhancing both road efficiency and safety (Anciaes, 2023).

1) Analysis of the Types of Roadside Activities at the Pasar Cipanas Road Segment

In the analysis stage of roadside activities occurring along the Pasar Cipanas road segment, the data used were obtained from direct field observations. From these observations, the types

of roadside activities occurring along the Pasar Cipanas road segment, the causes of these activities, and the weighting factors for each type of roadside activity can be identified. The weighting factor for each roadside activity type reflects the influence of the activity type on the classification of roadside activities for the Pasar Cipanas road segment. The Types of Roadside Activities and Their Causes can be seen in Table 3.

Table 3 The Types of Roadside Activities and Their Causes

No.	Type of Roadside Activity	Description	Weighting Factor
1	Pedestrians (PED)	Roadside activities involving pedestrians occur because of the presence of street vendors occupying sidewalks or pedestrian paths along the Pasar Cipanas road segment, causing pedestrians to walk on the roadway.	0,5
2	Public Vehicles and Other Vehicles Parking and Stopping (PSV)	Roadside activities involving public and other vehicles parking and stopping on the Pasar Cipanas road segment occur due to: • Public vehicles parking and stopping on the roadway because of the absence of facilities such as bus stops, resulting in passengers being picked up and dropped off directly on the roadway, and drivers resting and parking on the road. • Other vehicles are parking and stopping on the roadway because the adjacent land use along the Pasar Cipanas road segment is dominated by commercial and service activities, such as shops, without providing dedicated parking areas, thus forcing people or drivers to use the road for parking or stopping.	1,0
3	Vehicles Entering and Exiting Adjacent Properties (EEV)	Roadside activities involving vehicles entering and exiting adjacent properties along the Pasar Cipanas road segment occur due to the land use along the sides of the segment, which is dominated by commercial and service activities such as shops, restaurants, Pasar Cipanas (Cipanas Market), and others that provide parking spaces, resulting in vehicles entering and exiting these properties.	0,7

Based on Table 3, it can be seen that the dominant types of roadside activities on the Pasar Cipanas road segment include pedestrian activities, parking and stopping of public and other vehicles, and vehicles entering and exiting adjacent land. Among these, the activity of parking and stopping vehicles has the highest weighting factor of 1.0, indicating that it has the greatest impact on the road's operational performance. Pedestrian activities and vehicle access to adjacent properties also contribute to disruptions, albeit to a lesser extent.

Roadside activities such as pedestrian movement, vehicle parking and stopping, and vehicles entering or exiting adjacent properties significantly affect road performance and safety. “Side friction events including PED, PSV, EEV, SMV simultaneously have a 96.46% impact on the average traffic speed on the Timor Raya Street and the frequency of parking and stop vehicles (PSV) have the greatest contribution to change when compared to another variable” (Sari et al., 2020). This shows that the presence of pedestrians forced onto the roadway due to sidewalk occupation by street vendors (PED), as well as frequent parking and stopping of public and other vehicles (PSV) due to inadequate parking facilities and commercial land use, are major contributors to decreased road capacity and increased congestion.

Moreover, the act of vehicles entering and exiting adjacent properties (EEV) along commercial corridors like Pasar Cipanas further disrupts traffic flow. As highlighted in another review, "The major factors causing roadside friction as identified in the reviews include: on-street parking, presence of slow-moving vehicles on roads, presence of non-motorized vehicles on roads, commercialization of roadsides, pedestrians' movement, among others. When side friction occurs, pedestrians suffer and road capacity and performance are greatly affected" (Yahaya, 2021). To observe the types of roadside activities and their distribution, refer to Figure 4.

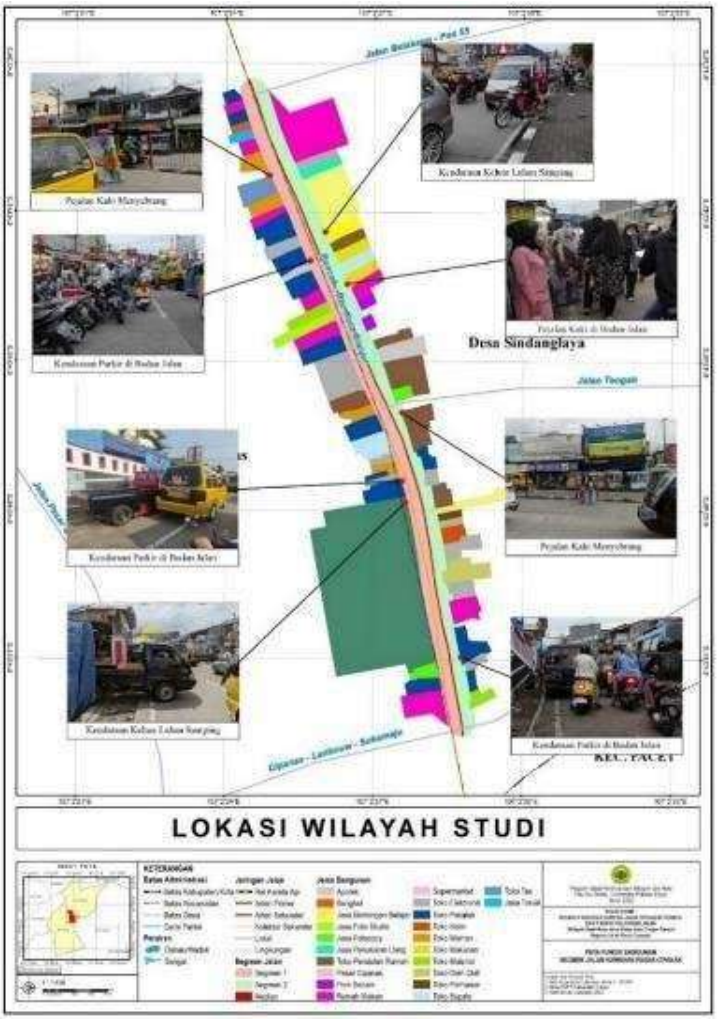


Figure 6. Spatial Distribution of Roadside Activities along Pasar Cipanas Road

The figure shows the spatial distribution of roadside activities along the Pasar Cipanas road segment. Various types of roadside activities are illustrated, including pedestrian movement spilling onto the road, vehicles parked or stopped on the road, and vehicles entering and exiting adjacent lands. The surrounding land use is predominantly for commercial purposes, such as shops, traditional markets, and eateries, contributing to high pedestrian and vehicle activity.

2) Analysis of Roadside Activities Class on the Pasar Cipanas Road Segment

In the stage of analyzing the class of roadside activity occurrences, it is first necessary to identify the types of roadside activities and their frequency. The frequency used is based on observations during the peak traffic hours of the Pasar Cipanas road segment on Sunday, April 17, 2022, and Monday, April 18, 2022, shown in Tables 4 dan Table 5.

Table 4 Table of Roadside Activity Frequency and Weight Factors, Sunday, April 17, 2022

Segment	PED	Weight Factor	PSV	Weight Factor	EEV	Weight Factor
Segment 1 (17:00–18:00)	307	0,5	520	1,0	184	0,7
Segment 2 (17:00–18:00)	184	0,5	115	1,0	916	0,7

Source: Field Survey, 2022, and MKJI Guidelines, 1997

Based on the roadside activity data collected on Sunday, April 17, 2022, Segment 1 (17:00–18:00) showed that parking and stopping vehicles (PSV) were the dominant roadside activities, with 520 occurrences and a weight factor of 1.0. This indicates that illegal parking and stopping on the roadway were the major contributors to traffic disruption in this segment. Pedestrian activities (PED) were also relatively high, with 307 occurrences, caused by pedestrians being forced to walk on the roadway due to sidewalk encroachment, although their impact on traffic was moderate, with a weight factor of 0.5. Vehicle entry and exit activities (EEV) were present but less significant compared to PSV, with 184 occurrences and a weight factor of 0.7.

In contrast, Segment 2 exhibited a different pattern, where entering and exiting vehicles (EEV) dominated with 916 occurrences and a weight factor of 0.7, suggesting that high commercial activity along the corridor led to intensive vehicle movements in and out of adjacent properties. Parking and stopping vehicles (PSV) activities were notably lower at 115 occurrences, while pedestrian activities (PED) also decreased to 184 occurrences. Overall, Segment 1's traffic disruption was primarily caused by parking/stopping vehicles, whereas Segment 2's issues were mainly due to frequent vehicle entries and exits.

Table 5 Table of Roadside Activity Frequency and Weight Factors, Monday, April 18, 2022

Segment	PED	Weight Factor	PSV	Weight Factor	EEV	Weight Factor
Segment 1 (17:00–18:00)	198	0,5	484	1,0	162	0,7
Segment 2 (17:00–18:00)	152	0,5	140	1,0	756	0,7

Source: Field Survey, 2022, and MKJI Guidelines, 1997

On Monday, April 18, 2022, roadside activity data for Segment 1 (17:00–18:00) showed that parking and stopping vehicles (PSV) dominated with 484 occurrences (weight factor 1.0), causing major traffic disruption. Pedestrian activities (PED) were recorded at 198 occurrences (factor 0.5), while vehicle entry and exit activities (EEV) reached 162 occurrences (factor 0.7).

In Segment 2, EEV activities were highest with 756 occurrences (factor 0.7), followed by PSV at 140 and PED at 152. Overall, Segment 1 disturbances were mainly due to parking/stopping, while Segment 2 was affected by vehicle entry and exit.

The total weight and roadside activity class for the Pasar Cipanas road segment reflect the traffic load and intensity of surrounding activities, which significantly impact road performance and maintenance needs. As a commercial hub, Pasar Cipanas typically experiences high roadside activity, contributing to increased wear and congestion. Detailed data are presented in Table 6.

Table 6 Total Weight and Roadside Activity Class for the Pasar Cipanas Road Segment

Day	Segment	Event Weight	Total Event Weight	Roadside Activity Class	Remarks
Sunday, April 17, 2022	Segment 1	802	1650	Very High (VH)	Roadside activities are very high, with market activities occurring along the roadside
	Segment 2	848			
Monday, April 18, 2022	Segment 1	696	1441	Very High (VH)	Roadside activities are very high, with market activities occurring along the roadside
	Segment 2	745			

Source: Analysis Result, 2022

The analysis of roadside activities along the Pasar Cipanas road segment shows that both on Sunday, April 17, 2022, and Monday, April 18, 2022, the level of roadside activity was classified as "Very High" (VH). On Sunday, Segment 1 recorded a total event weight of 1650, with 802 coming from various activities, while Segment 2 had a slightly higher total event weight of 848. These figures indicate that market activities heavily influenced roadside conditions, causing significant disturbances to traffic flow throughout both segments.

On Monday, the pattern remained consistent with slightly lower total event weights compared to Sunday. Segment 1 recorded a total event weight of 1441, while Segment 2 accumulated 745. Despite the minor decrease, the roadside activity class remained in the "Very High" category, underscoring the persistent impact of commercial and market-related activities and the need for improved traffic management and infrastructure.

4.2 Identification of Road Segment Service Level at Pasar Cipanas Road Due to Roadside Activity Impact

1. Traffic Volume Analysis Based on MKJI 1997

The traffic volume (Q) analysis involves calculating the number of vehicle flows per hour (Qkend) during peak hours on the Pasar Cipanas road segment, multiplied by the equivalent factor (emp) for each vehicle type based on the Indonesian Highway Capacity Manual (MKJI, 1997). These factors convert various vehicle types into a uniform unit called the Passenger Car Unit (PCU), allowing for consistent comparison across traffic flows. This standardization is essential, as different vehicle types impact road capacity in varying ways. The resulting value in PCU per hour offers a more accurate measure of total traffic impact during peak periods. Table 7 presents the traffic volume for the Pasar Cipanas road segment on Sunday, April 17, 2022, from 17:00 to 18:00.

Table 7 Traffic Volume for Pasar Cipanas Road Segment, Sunday, April 17, 2022

Traffic Flow	Light Vehicle (LV)		Heavy Vehicles (HV)		Motorcycles (MC)		Total Motor Vehicles (MV)	
Segment 1	Vehicles/ Hour	Emp = 1.0	Vehicles/ Hour	(Emp = 1.2)	Vehicles/ Hour	(Emp = 0.25)	**Vehicles/ Hour**	**PCU/Hour**
	1.764	1.764	22	26	2.856	714	**4.642**	**2.504**
Segment 2	Vehicles/ Hour	Emp = 1.0	Vehicles/ Hour	(Emp = 1.2)	Vehicles/ Hour	(Emp = 0.25)	**Vehicles/ Hour**	**PCU/Hour**
	1.802	1.802	16	19	2.769	692	**4.587**	**2.513**

Source: Analysis Result, 2022

The traffic flow analysis for the Pasar Cipanas road segments during peak hours reveals the distribution of different vehicle types and their equivalent impact on road capacity. In Segment 1,

the flow of light vehicles (LV) is 1,764 vehicles per hour, with a corresponding equivalent factor (emp) of 1.0, while heavy vehicles (HV) contribute 22 vehicles per hour with an emp of 1.2, and motorcycles (MC) account for 26 vehicles per hour, using an emp of 0.25.

The total motor vehicle flow in Segment 1 is 4,642 vehicles per hour, which translates to 2,504 Passenger Car Units (PCU) per hour. Similarly, in Segment 2, light vehicles flow at 1,802 vehicles per hour, heavy vehicles at 16 vehicles per hour, and motorcycles at 19 vehicles per hour, resulting in a total of 4,587 vehicles per hour or 2,513 PCU per hour. Meanwhile, Table 8 shows the traffic volume for the Pasar Cipanas road segment on Monday, April 18, 2022.

Table 8 Traffic Volume for Pasar Cipanas Road Segment, Monday, April 18, 2022

Traffic Flow	Light Vehicle (LV)		Heavy Vehicles (HV)		Motorcycles (MC)		Total Motor Vehicles (MV)	
Segment 1	Vehicles/ Hour	Emp = 1.0	Vehicles/ Hour	(Emp = 1.2)	Vehicles/ Hour	(Emp = 0.25)	**Vehicles/ Hour**	**PCU/Hour**
	1.455	1.455	15	18	2.487	621	**3.957**	**2.094**
Segment 2	Vehicles/ Hour	Emp = 1.0	Vehicles/ Hour	(Emp = 1.2)	Vehicles/ Hour	(Emp = 0.25)	**Vehicles/ Hour**	**PCU/Hour**
	1.420	1.420	25	20	2.280	570	**3.725**	**2.020**

Source: Analysis Result, 2022

The traffic flow analysis for the Pasar Cipanas road segment on Monday, April 18, 2022, shows a decrease in the number of vehicles compared to the previous day. In Segment 1, light vehicles (LV) flow at 1,455 vehicles per hour, heavy vehicles (HV) at 15 vehicles per hour, and motorcycles (MC) at 18 vehicles per hour. This results in a total motor vehicle flow of 3,957 vehicles per hour, equivalent to 2,094 Passenger Car Units (PCU) per hour. In Segment 2, the flow of light vehicles is recorded at 1,420 vehicles per hour, heavy vehicles at 25 vehicles per hour, and motorcycles at 20 vehicles per hour, leading to a total of 3,725 vehicles per hour or 2,020 PCU per hour.

When compared to the traffic flow on Sunday, April 17, 2022, it is evident that both the total number of vehicles and the corresponding PCU values on Monday are lower. On Sunday, the PCU values were 2,504 for Segment 1 and 2,513 for Segment 2, while on Monday, they decreased to 2,094 and 2,020, respectively. This indicates that traffic volume and congestion levels were higher on Sunday, likely due to increased market activities and weekend traffic.

2. Road Capacity Analysis for Pasar Cipanas Road Segment

According to Bina Marga (1997), the basic capacity of an urban road for a four-lane divided roadway or a one-way street is 1.650 PCU/hour per lane, resulting in a total of 3.300 PCU/hour for two lanes. The lane width adjustment factor (FCw) for an effective lane width of 3 meters is 0,92. The directional separation factor (FCsp) for a permanent median is 1,00. The roadside friction adjustment factor (FCsf) can be valued at 0,81, and the city size adjustment factor (FCcs) is 1,00.

Thus, the road capacity for both segments of Pasar Cipanas Road, Segment 1 (Cianjur–Puncak/Northbound) and Segment 2 (Puncak–Cianjur/Southbound), for Sunday, April 17, 2022, and Monday, April 18, 2022, is calculated as follows:

$$Co \times FCw \times FCsp \times FCsf \times FCcs = C \quad (1)$$

$$3.300 \times 0{,}92 \times 1{,}00 \times 0{,}81 \times 1{,}00 = 2.459\ PCU/Hour$$

Based on the calculation, the final capacity (C) of the Pasar Cipanas road segment is

determined to be 2,459 PCU/hour. This result reflects the influence of various adjustment factors, including lane width, directional separation, roadside activities, and city size. Although the basic road capacity for two lanes is initially 3,300 PCU/hour, the adjustments, particularly the significant impact of roadside activities, reduce the effective capacity. This adjusted capacity serves as an important reference for evaluating the current traffic performance and planning necessary improvements to manage congestion more effectively.

3. Saturation Degree Analysis Based on MKJI 1997

According to the Indonesian Highway Capacity Manual (MKJI) 1997, the degree of saturation is defined as the ratio between traffic volume and road capacity, which serves as a key indicator in evaluating road performance. The degree of saturation value should ideally not exceed 0.75 to maintain smooth traffic flow (Bina Marga, 1997). The table of road segment service levels at Pasar Cipanas Road on Sunday, April 17, 2022, is presented in Table 9.

Table 9 Road Segment Service Levels at Pasar Cipanas Road, Sunday, April 17, 2022

Segment	Peak Hour Traffic Volume (PCU/Hour)	Road Capacity (PCU/Hour)	Saturation Degree (DS = V/C)	Road Service Level	Remarks
Segment 1	2.504	2.459	1,02	F	Forced flow, congestion, low speeds, long queues, and major disturbances
Segment 2	2.513	2.459	1,02	F	Forced flow, congestion, low speeds, long queues, and major disturbances

Source: Analysis Result, 2022

Based on the analysis table above, the service level of the Pasar Cipanas road segment during peak hours shows that on Sunday, April 17, 2022, both Segment 1 (Cianjur–Puncak direction) and Segment 2 (Puncak–Cianjur direction) reached a saturation degree (DS) of 1.02, classified as Service Level F. This indicates forced flow conditions with severe congestion, low speeds, and long queues. Meanwhile, the table of road segment service levels at Pasar Cipanas Road on Monday, April 18, 2022, is presented in Table 10.

Table 10 Road Segment Service Levels at Pasar Cipanas Road, Monday, April 18, 2022

Segment	Peak Hour Traffic Volume (PCU/Hour)	Road Capacity (PCU/Hour)	Saturation Degree (DS = V/C)	Road Service Level	Remarks
Segment 1	2.094	2.459	0,85	E	Traffic volume approaching unstable conditions, frequent stops
Segment 2	2.020	2.459	10,82	D	Flow approaching instability, speed still controllable, but most drivers are restricted or disturbed

Source: Analysis Result, 2022

Based on the table, during peak hours, Segment 1 recorded a traffic volume of 2,094 PCU/hour against a road capacity of 2,459 PCU/hour, resulting in a saturation degree (DS) of 0.85. This value corresponds to a Level of Service (LOS) E, indicating that traffic flow is approaching unstable conditions, characterized by frequent stops and limited maneuverability.

Meanwhile, Segment 2 showed a peak hour traffic volume of 2,020 PCU/hour, also with a road capacity of 2,459 PCU/hour, yielding a saturation degree of 0.82. This corresponds to Level of Service D, where traffic flow is still controllable, but drivers experience significant restrictions and disturbances, and the system is nearing unstable flow.

5. CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The influence of roadside activities on the service level of the Pasar Cipanas road segment affects its capacity. Compared to the traffic volume occurring on the Pasar Cipanas road segment, the service level or quality of the segment becomes suboptimal, as indicated by traffic congestion, long vehicle queues, and drivers experiencing significant disruptions due to major obstructions.

5.2 Recommendations

Recommendations to complement and enhance the objectives of this study and to provide suggestions aimed at improving the performance or quality (service level) of the Pasar Cipanas road segment include the following: The implementation of activities related to the management of the Pasar Cipanas road segment, covering regulation, development, construction, and supervision of roads based on Law Number 2 of 2022 concerning the Second Amendment to Law Number 38 of 2004 on Roads.

The purpose of road management is to achieve: order, security, smoothness, and safety of passenger and goods traffic, as well as legal certainty in road administration; road management that promotes economic growth, accelerates logistics distribution, ensures equitable development, and supports the implementation of sustainable road construction; the optimal role of road management in providing services to the public; reliable and excellent road services that prioritize public interests by ensuring functional and competitive road performance; an efficient and effective road network system to support an integrated transportation system; and a sustainable road network system.

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