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How much parking space is needed for park and ride facilities to support sustainable infrastructure

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ABSTRACT

Park and ride (P&R) is the right strategy to overcome transportation problems in metropolitan cities with high mobility levels to realize smart mobility. The three main goals of P&R are to reduce congestion levels, increase public transportation use, and improve urban space quality. The provision of parking capacity is one of the success factors in the planning of the P&R facility. Therefore it is necessary to calculate the parking space requirement in P&R. The research was conducted at Sidoarjo Station, the most significant origin station in Sidoarjo Regency, and a recommended P&R location. This study aims to calculate parking space requirements and facilities for the existing conditions and projections when P&R operates. Data were collected through primary surveys in the form of observations on parking characteristics at Sidoarjo Station and secondary surveys in literature studies. The results of the study indicate that the existing condition of the parking facility at Sidoarjo Station has exceeded the parking capacity, so to accommodate the need for parking space, it is necessary to increase the parking area of 96 m^2 in the existing condition up to 413 m^2 or 5,923 m^2 for the next ten years.

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INTRODUCTION

In the last five years, the increasing population density and the rapid development of business districts in metropolitan cities have prompted the emergence of new suburbs and satellite cities around the city. These cities are developing rapidly along with the increasing population (Zhou et al., 2019). Surabaya, as the capital of East Java Province as well as the second largest metropolitan city in Indonesia, has become a destination city for workers from outside the largest area in the Gerbangkertasusila Region (Irawati et al., 2021), reaching 170 thousand commuters every day in 2018 (BPS, 2018). Sidoarjo Regency is the area with the most commuters to Surabaya, 40% or 109 thousand commuters. The number of commuters continues to increase annually by 0.5% (Irawati et al., 2021; Nurkhariza & Nurlaela, 2019) in line with the increase of the population in Sidoarjo Regency, which has grown by 7% over the last five years (BPS, 2021).

The increasing number of commuters from suburban areas to the city center triggers various transportation problems, both at the place of origin and destination (Memon et al., 2021), such as traffic congestion and environmental degradation (Mills & White, 2018), which will impact on economic, social

and ecological conditions. Based on BPS (2021), the loss experienced by the city of Surabaya due to traffic jams reaches 12 billion per year. Meanwhile, in the environmental aspect, the transportation sector accounts for 14% of total global GHG emissions, 72.8% of which comes from land transportation activities (Obaid et al., 2021). This condition is then exacerbated by the low interest of the public in using public transportation (Handayeni & Ariyani, 2018). Traffic congestion and high air emissions in the city center are the main challenges to sustainable transportation development (Widayanti & Pattisinai, 2021).

Park and ride (P&R) is a form of Transport Demand Management (TDM) that is very popular in several developed and densely populated countries (Agustin et al., 2019). P&R is the right strategy to overcome transportation problems in metropolitan cities with high mobility levels to realize sustainable urban transportation development (Ortega et al., 2021; Widayanti & Pattisinai, 2021). P&R is in the form of parking facilities used by travelers to leave private vehicles (cars and motorcycles) to switch to public transportation modes (trains and buses) to go to activity locations in the city center (Macioszek & Kurek, 2020). P&R can effectively reduce commuters' use of private vehicles (Chen & Kim, 2018). The existence of P&R as a supporting facility for commuter movement provides an alternative mode of transportation that is more environmentally friendly while encouraging the use of public transport, especially in suburban areas with a high level of commuter mobility but not yet served by public transportation networks (Dirgahayani & Sutanto, 2020; Ortega et al., 2021).

Sidoarjo Station is the largest origin station in Sidoarjo Regency, with an average number of 1,200 passengers per day (Nurkhariza & Nurlaela, 2019), and is one of the recommended locations for the development of P&R facilities (Irawati et al., 2021). The existence of the P&R is expected to support improving the quality of the downtown environment, reduce traffic congestion, and increase the use of public transportation (Ibrahim et al., 2020; Macioszek & Kurek, 2020) for commuters in Sidoarjo – Surabaya. Based on Irawati et al. (2021), the implementation of P&R can reduce the number of the private vehicle used by commuters by up to 82.91%, accompanied by improvements in the transportation system and transportation policies in the Gerbangkertasusila Metropolitan Area.

One of the challenges in implementing P&R at Sidoarjo Station is providing parking spaces that accommodate the parking needs of commuters in Sidoarjo–Surabaya. The provision of adequate parking space is one factor that influences the success and effectiveness of using P&R (Handayeni & Ariyani, 2018). In existing conditions, research that examines the calculation of parking needs for P&R facilities in Indonesia and other developing countries in Southeast Asia is still limited. Several studies that were found only explain the estimation of P&R demand in general without calculating the parking space requirement of the total demands. Calculating parking space requirements needs to be done to minimize idle capacity, i.e. the unused capacity of a facility in planning activities for supporting public transportation facilities, which in this context is P&R planning.

In their findings, Ortega et al. (2021) and Shen et al. (2017) mentioned that one of the causes of the low utilization of M&R facilities is the physical condition of parking and the provision of parking capacity that is not following the needs of commuters. Therefore, this study aims to analyze the need for parking spaces at the P&R facility at Sidoarjo Station based on the projected results of P&R demand for the next 10 years using the calculation of parking accumulation and private vehicle ownership for Sidoarjo–Surabaya commuters. The results of this study can be used as a reference in determining the number of parking spaces needed by commuters effectively and efficiently to optimize the use of P&R.

RESEARCH METHOD

The research was conducted at Sidoarjo Station, a class 1 train station in Sidoarjo Regency, located in Lemahputro Village, Sidoarjo District. Sidoarjo Station operates under the management of PT. KAI Operation Area VIII Surabaya (Figure 1). In this study, the P&R service radius is assumed to have an ideal service radius of 4 km (Cornejo et al., 2014; Ortega et al., 2021; Spillar, 1997). Regarding the radius, the areas included in the P&R service radius at Sidoarjo Station are Sidoarjo District, Candi District, and Buduran District. The study area was determined based on several points of consideration, including:

1. Sidoarjo Regency is the area of origin of commuters with the largest percentage, namely 40% of the total commuters in Surabaya City (BPS, 2018)

2. The construction of the Surabaya Regional Railway Line is planned to connect Surabaya – Sidoarjo and become an alternative mode of commuter transportation (Surabaya City Development Planning Agency, 2021)
3. Sidoarjo Station is the largest station of origin and has the highest number of passengers in Sidoarjo Regency with an average number of passengers per day of 1,200 passengers (PT. KAI DAOP VIII, 2019)
4. Sidoarjo Station is one of the locations recommended by the Sidoarjo Regency Transportation Service for P&R development (Sidoarjo Regency Transportation Service, 2020)
5. There are plans for the construction of P&R facilities for the Sidoarjo Station in several planning documents, including the 2019 National Railway Master Plan document, the 2009-2029 Sidoarjo Regency RTRW, and the 2019 Sidoarjo Regency Local Transportation System.

The research is a quantitative research that is used to produce a finding, where the findings can be obtained through statistical procedures or other measurement-based methods. This is because this study used statistical procedures and other measurements to identify and examine the variables that have been determined. In addition, this study included research instruments (data collection techniques and samples) prior to the field survey. The primary survey in the form of observations was carried out for two days (weekdays and weekends) to collect data on parking characteristics, such as parking space ownership, capacity, number of vehicles entrance and exit, and parking duration. Meanwhile, the secondary survey was carried out through literature studies on the probability of P&R users at Sidoarjo Station (Irawati et al., 2021).

Furthermore, the data were analyzed using an analysis of parking characteristics, including parking accumulation, parking capacity, and parking index (Parmar et al., 2020), as well as an analysis of parking needs based on parking accumulation (Putrato et al., 2021; Winayati et al., 2019) and private vehicle ownership (Hasibuan, 2019). Calculating parking needs based on parking accumulation was used to calculate parking needs in existing conditions. In contrast, vehicle ownership predicted future parking needs based on the projected probability of P&R users at Sidoarjo Station. The 5 steps that needed to be taken to calculate parking space requirements are as follows.

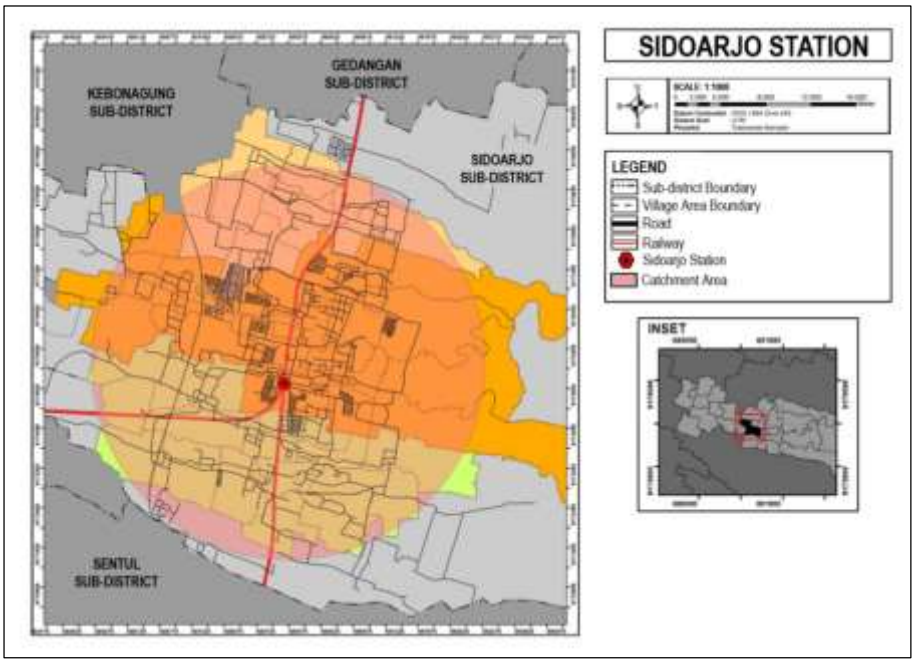

Figure 1. Study area

Table 1. Park and Ride Planning Standards at Sidoarjo Station

No	Component	Standard	Total	Units	References
Park and Ride Building					
1	Parking Area	Passenger Car Gol 1 Passenger Car Gol 2 Passenger Car Gol 3 Motorcycle	2,3 x 5 2,5 x 5 3 x 5 0,75 x 2	m^2	(Directorate General of Transportation, 1998; U.S. Department of Veterans Affairs, 2016)
2	Parking Pattern	Angle 30° Angle 45° Angle 60° Angle 90°	-	(°)	
3	Ramp	Single Threaded Design Double Threaded Design	-	-	
4	Circulation	One way Two ways	3,5 6,5	m	
5	Entrance and Exit	One track Two tracks Minimum Distance In/Out of Corner Intersection	b=3-3,5; d=0,8-1; R_1=6-6,5; R_2=3,5-4 b=6; d=0,8-1; R_1=3,5-5; R_2=1-2,5 22 – 30	m m	
Park and Ride Support Facilities					
1	Lighting	Illumination Lamp (LED) with Color Temperature Cool-White Atau Daylight Light sensor	≥ 60 -	lux -	(U.S. Department of Veterans Affairs, 2016; Metrolinx, 2021; Walker, 2008)
2	Information	Entrance Exit Information Parking Location Information Information on Parking Space Availability Parking Counter Information	-	-	(Spillar, 1997; VDOT, 2018; Victoria, 2020)
3	Safety	Camera CCTV Security Posts Security Fence Panic-Alarm Fire-Protection Assembly and Evacuation Points	1-2 1-2 - - - -	Units/Corner Units - - - -	(American Association of State Highway and Transportation Officials & Task Force on Public Transportation Facilities Design, 2004; Spillar, 1997; Vincentius et al., 2017)
4	Energy	Use of the Light Control System Green Roof/Green Building	- -	- -	(U.S. Department of Veterans Affairs, 2016; Metrolinx, 2021; Walker, 2008)
5	Environment	Vegetation Around the Parking Location	-	-	(VDOT, 2018; Vincentius et al., 2017)
6	Counter	Digital and Non Digital Ticket Counters	-	-	(Metrolinx, 2021)
7	Additional Facilities	Toilet Non-Motorized Parking Kiss and Ride Customer Service Center Waiting Room	-	-	(Spillar, 1997; Suryandari et al., 2015; Vincentius et al., 2017)

Step 1. Collecting data regarding parking characteristics at Sidoarjo Station, including parking area ownership, parking volume, parking duration, and parking capacity. In this study, the data were obtained through a secondary survey in accordance with the policy of limiting activities during the COVID-19 pandemic.

Step 2. Calculating the existing parking space requirements using the formula:

$$Ap = Parking\ Accumulation\ x\ SRP \quad (1)$$

In wihich Ap is parking needs based on parking accumulation, SRP is parking space unit in indonesia based on the regulation of the Directorate General of Transportation in 1998 (SRP Motorcycles: 0.75 x 2 m; SRP Cars: 2.5 x 5 m)

$$Vo = Vehicle\ Ownership\ x\ SRP \quad (2)$$

Vo denotes parking needs based on vehicle ownership, SRP is parking space unit in Indonesia based on the Regulation of the Directorate General of

Transportation in 1998 (SRP Motorcycles: 0.75 x 2 m; SRP Cars: 2.5 x 5 m)

Step 3. Calculating the projection of P&R users based on the probability of P&R users (Irawati et al., 2021) using the formula:

$$Pn = Po\,(1 + r.n) \quad (3)$$

Pn states number of commuters in the n year, Po is number of base year commuters, r indicates growth rate of commuters at Gerbangkertasusila, 0.5%, and n is year. In this study the n started from 5, 10, and 15.

Step 4. Calculating the projected need for parking space when the P&R facility at Sidoarjo Station operates based on the results from step 3, which are assumed to be the number of motorized vehicle owners in the next 5 years to 15 years using the formula:

$$Parking\ Space\ Requirement = Vehicle\ Ownership\ x\ SRP \quad (4)$$

Vp indicates accumulated parking during peak hours, SRP is parking space unit in Indonesia based on the Regulation of the Directorate General of Transportation in 1998 (SRP Motorcycles: 0.75 x 2 m; SRP Cars: 2.5 x 5 m)

Step 5. Knowing the total area needed for parking space at Sidoarjo Station to be used as one of the basis for planning the layout and design of P&R at Sidoarjo Station.

Parking requirements in existing conditions were calculated based on parking accumulation. The assumption used in this study is that the need for parking space is based on parking requests expressed by parking accumulation at Sidoarjo Station (Table 1).

RESULT AND DISCUSSION

Parking Characteristics

Sidoarjo Station has parking facilities covering an area of 450 m^2 divided into two parts: car parking area of 337.5 m^2 and motorcycle parking area of 112.5 m^2. Parking facilities at Sidoarjo Station have been operated using the e-Reska parking system and it is under the management of PT. Reska Multi Usaha, which is a subsidiary of PT. KAI engaging in parking services. Based on PT. Reska Multi Usaha (2021), the average number of parking users at Sidoarjo Station was 500 vehicles per day. Figure 2 and Figure 3 shows a plan of parking facilities at Sidoarjo Station and the location of Sidoarjo Station.

In this study, parking characteristics were identified based on parking accumulation, parking capacity, and parking index. Parking accumulation shows how many vehicles are in a parking lot at a specific time. Table 2 and Figure 4 explain about parking accumulation at Sidoarjo Station for motorcycles and cars, the highest parking accumulation occurred on weekdays from 13.00 to 14.00, namely 114 vehicles for motorcycle category and 30 vehicles for car category.

Figure 2. The location of Sidoarjo station

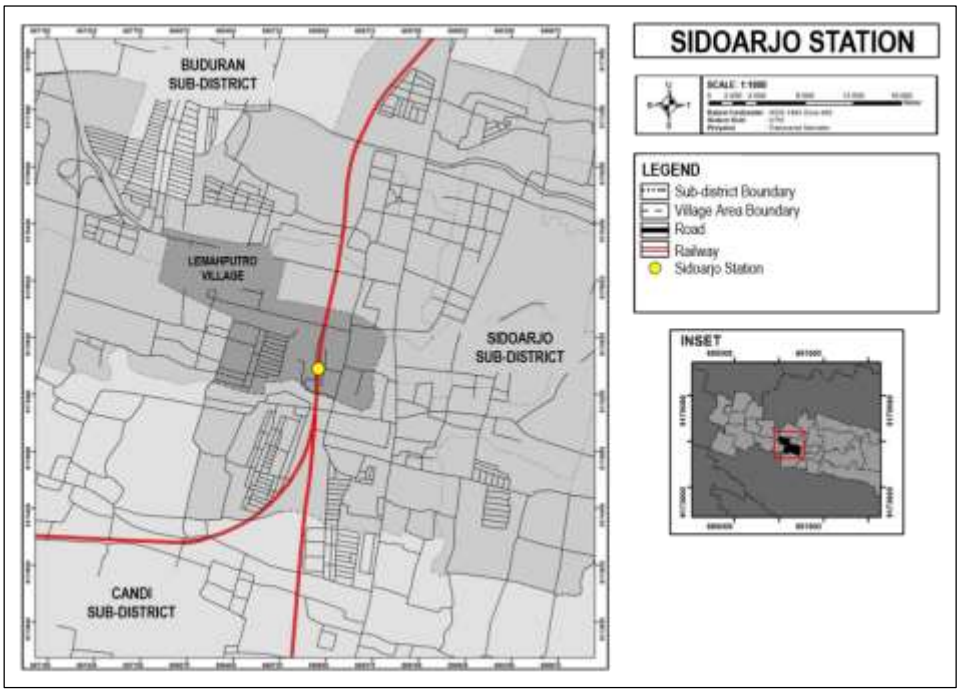

Figure 3. The location of Sidoarjo station

Table 2. Parking Accumulation at Sidoarjo Station

Type of Vehicle/ Workday		Peak Hour	Entry	Exit	Parking	Parking Accumulation
			..... Unit			
Car						
Weekday	Morning	05.00 - 06.00	11	1	7	17
		06.00 - 07.00	14	3	17	28
	Afternoon	12.00 - 13.00	12	3	20	29
		13.00 - 14.00	10	5	25	30
	Evening	17.00 - 18.00	7	8	15	14
		18.00 - 19.00	5	3	14	16
Weekend	Morning	05.00 - 06.00	7	1	7	13
		06.00 - 07.00	9	4	13	18
	Afternoon	12.00 - 13.00	8	7	14	15
		13.00 - 14.00	17	9	15	23
	Evening	17.00 - 18.00	4	3	11	12
		18.00 - 19.00	7	5	12	14
Motorcycle						
Weekday	Morning	05.00 - 06.00	65	12	18	71
		06.00 - 07.00	53	24	71	100
	Afternoon	12.00 - 13.00	41	24	75	92
		13.00 - 14.00	43	21	92	114
	Evening	17.00 - 18.00	20	29	44	35
		18.00 - 19.00	48	61	35	22
Weekend	Morning	05.00 - 06.00	48	7	21	62
		06.00 - 07.00	24	18	60	66
	Afternoon	12.00 - 13.00	41	18	61	84
		13.00 - 14.00	35	10	72	97
	Evening	17.00 - 18.00	17	21	57	53
		18.00 - 19.00	21	48	53	26

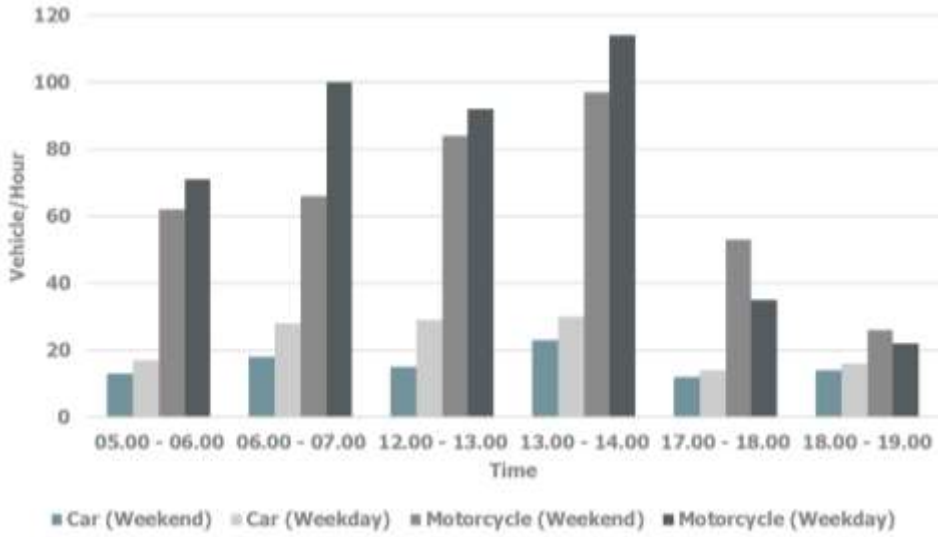

Figure 4. Parking accumulation at Sidoarjo station

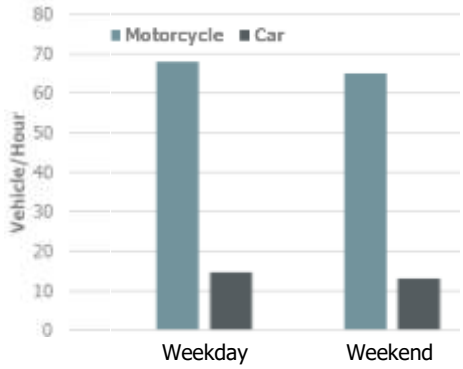

Figure 5. Parking capacity at Sidoarjo station

Furthermore, the parking capacity at Sidoarjo Station shows the maximum number of vehicles that can be accommodated by a parking facility in a certain time. Table 3 and Figure 5 explain the parking capacity at Sidoarjo Station, which shows that the maximum number of vehicles on weekdays could be adjusted to 65 motorcycles and 13 cars per hour. Meanwhile, on weekends, there were three additional units in the motorcycle parking area and two in the motorcycle parking area. This is because the average duration of vehicle parking on weekends is more extended than on weekdays.

The parking index at Sidoarjo Station shows the ability of parking facilities to accommodate vehicles based on parking accumulation and capacity. The results of the parking index calculation are displayed in percentage form, where if the parking index value is more than 100%, it can be interpreted that the parking demand is greater than the parking capacity (Table 4).

Table 3. Parking Capacity at Sidoarjo Station

Type of Vehicle/ Day	Parking Area	Parking Lots	Average of Parking Duration	Parking Capacity
	m^2	vehicle	hour	vehicle/ hour
Car				
Weekday	337.5	30	2.31	13
Weekend			2.40	15
Motorcycle				
Weekday	112.5	100	1.54	65
Weekend			1.47	68

Figure 6 shows that the parking index calculation results show that at certain times, especially during peak hours, the parking index value at Sidoarjo Station had a value of more than 100%, which means that the available parking spaces at Sidoarjo Station cannot accommodate vehicle parking needs. Based on this, it is necessary to expand or add parking areas at Sidoarjo Station to accommodate the increasing parking demand and the operation of P&R facilities at Sidoarjo Station.

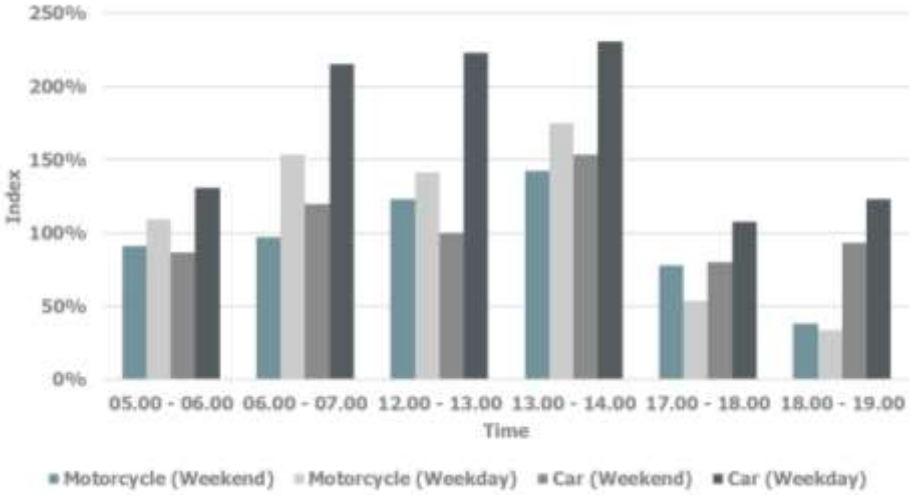

Figure 6. Parking index at Sidoarjo station

Table 4. Parking Index at Sidoarjo Station

Type of Vehicle/ Workday	Peak Hour	Parking Accumulation	Parking Capacity	Parking Index
		unit	Unit/hour	%
Motorcycle				
Weekday	05.00 - 06.00	71	65	109
	06.00 - 07.00	100	65	154
	12.00 - 13.00	92	65	142
	13.00 - 14.00	114	65	175
	17.00 - 18.00	35	65	54
	18.00 - 19.00	22	65	34
Weekend	05.00 - 06.00	62	68	91
	06.00 - 07.00	66	68	97
	12.00 - 13.00	84	68	123
	13.00 - 14.00	97	68	143
	17.00 - 18.00	53	68	78
	18.00 - 19.00	26	68	38
Car				
Weekday	05.00 - 06.00	17	13	131
	06.00 - 07.00	28	13	215
	12.00 - 13.00	29	13	223
	13.00 - 14.00	30	13	231
	17.00 - 18.00	14	13	108
	18.00 - 19.00	16	13	123
Weekend	05.00 - 06.00	13	15	87
	06.00 - 07.00	18	15	120
	12.00 - 13.00	15	15	100
	13.00 - 14.00	23	15	153
	17.00 - 18.00	12	15	80
	18.00 - 19.00	14	15	93

Probability of Park and Ride Users

Sidoarjo Regency is one of the districts/cities in the Gerbangkertasusila Metropolitan Area, with the City of Surabaya as the center of its activities. One of the impacts of this condition is the high number of commuters in the Sidoarjo Regency, along with the increasing number of jobs available in Surabaya. A commuter is a type of worker who moves back and forth from the place of origin to the destination in another district/city in a day, both for work and education purposes (Irjayanti et al., 2021; Setyodhono, 2017). In this study, the commuters in question were workers who lived in Sidoarjo Regency and worked in Surabaya City using private vehicles (cars and motorcycles).

Table 5 shows that the commuters from Sidoarjo to Surabaya were dominated by males, and the age range was 20-30 years. The average level of final education of the commuters was undergraduate, and they worked as private employees. Most commuters from Sidoarjo to Surabaya used motorcycles as their primary mode of transportation.

The probability of P&R users at Sidoarjo Station was obtained through the assumption that 90% of the probability of commuters from Sidoarjo to Surabaya who want to move by train is a user of P&R, so the potential for P&R users at Sidoarjo Station was obtained through modeling the choice of train mode using multinomial logit analysis. These assumptions were determined by considering the location of the respondent's residence or commuters from Sidoarjo to Surabaya. Based on these calculations, it was found that the probability of commuters from Sidoarjo to Surabaya using cars and motorcycles who moved by train was 49.2%. Therefore, the probability of using P&R facilities was based on the assumption that 90% of the total opportunities for choosing the train will use parking facilities, which is 44.3% (Irawati et al., 2021).

Table 5. Characteristics of Sidoarjo – Surabaya Commuters

Characteristic	Description
Gender	73% male; 27% female
Age	4% less than 20 years old; 37% 20 – 30 years old; 31% 30 – 40 years old; 20% 40 – 50 years old; and 8% more than 50 years old
Education	5% junior high school; 31% senior high school; 19% diploma; 34% bachelor degree; and 11% master degree
Occupation	7% student; 15% government employees; 2% tni/polri; 34% private sector employees; 12% teacher and lecturer; 10% seller; 14% enterpreneur; and 5% others
Modes of transportation	28% car users; 72% motorcycle users
Distance from residence to station	10% less than 1 km; 17% 1 – 2 km; 42% 3 – 4 km; and 31% more than 4 km
Distance from station to destination	5% less than 1 km; 19% 1 – 2 km; 44% 3 – 4 km; and 32% more than 4 km

Sources: Irawati et al. (2021)

Park and Ride Parking Needs

In existing conditions, especially during weekdays and peak hours, the parking facilities at Sidoarjo Station have exceeded the available parking capacity, thus triggering new parking areas that are not following their placement. This can be seen through the parking index at Sidoarjo Station, which has exceeded 100%. The imbalance between the availability of parking spaces and the increasing need for parking at Sidoarjo Station often causes problems between vehicle users and station visitors.

On the other hand, when viewed from the probability of P&R users at Sidoarjo Station based on Irawati et al. (2021) of 44.3%, it can be seen that there will be an increase in parking needs along with the rise in the number of parking users at Sidoarjo Station. So, in planning parking facilities, especially in this case, the P&R at Sidoarjo Station requires additional parking areas for motorcycles and cars. Based on this, it is necessary to calculate parking needs at Sidoarjo Station for the existing and projected conditions when P&R operates.

1. Existing parking space needs

Parking needs in existing conditions will be calculated based on parking accumulation (Putrato et al., 2021; Winayati et al., 2019). The assumption used in this research is the need for parking space based on parking demand expressed by parking accumulation at Sidoarjo Station. The parking area at Sidoarjo Station is 450 m2, comprising 112.5 m2 of motorcycle parking and 337.5 m2 of car parking. The average number of vehicles per day is 444 motorcycles and 156 cars (Table 6).

Based on the results of the calculation of parking needs at Sidoarjo Station in existing conditions, it can be seen that parking facilities at Sidoarjo Station required the addition or expansion of parking areas to accommodate parking needs. The shortage of parking space required was 96 m^2 consisting of 58.5 m^2 for motorcycles and 37.5 m^2 for cars. In addition, from Table 5, it is known that the area of parking lots at Sidoarjo Station still did not follow the Parking Space Unit (SRP). The size of the existing parking lot is 0.5 x 1.9 m for motorcycle parking and 2.2 x 4.5 m for car parking. Therefore, it is necessary to increase the area of the parking lot to match the SRP and facilitate parking activities for station visitors.

Table 6. Existing Parking Space Needs

Aspect	Car	Motorcycle
Maximum parking accumulation	30	114
Parking area	337.5 m^2	112.5 m^2
Existing parking lots	30	100
Ideal parking lots*	25	75
Parking space needs	375 m^2	171 m^2
Lack of Parking Space	37.5 m^2	58.5 m^2

*) = Parking Space Unit in Indonesia based on the Regulation of the Directorate General of Transportation in 1998 (SRP Motorcycles: 0.75 x 2 m; SRP Cars: 2.5 x 5 m)

2. Projected parking space needs

The projection of parking space needs at Sidoarjo Station when P&R operates was calculated based on vehicle ownership (Hasibuan, 2019). The assumption used in this study is that there is a relationship between vehicle ownership and the required parking area. Vehicle ownership was identified through the number of commuters from Sidoarjo to Surabaya. Thus, as the number of commuters from Sidoarjo to Surabaya increases, the number of parking spaces required will also increase. The projection of parking space needs is carried out for the next 10 years.

Table 7. Number of Commuters from Sidoarjo to Surabaya based on the Mode of Transportation Used

Category	Percentage	Total
	%	people
Motorcycle Users	87	4,454
Car Users	9	461
Public Transport Users	4	204

In this study, the P&R service radius used an ideal service radius of 4 km (Cornejo et al., 2014; Ortega et al., 2021; Spillar, 1997). So, when referring to the radius, the areas included in the P&R service radius at Sidoarjo Station were Sidoarjo District, Candi District, and Buduran District. The number of commuters from Sidoarjo to Surabaya who lived in Sidoarjo District, Candi District, and Buduran District was 5,119. Furthermore, it was calculated using the probability percentage of P&R users at Sidoarjo Station (Irawati et al., 2021). In that case, the probability of P&R users in the three sub-districts was 2.268 people consisting of 1.973 motorcycle users and 204 car users.

Based on the calculation of the projected parking demand at Sidoarjo Station by considering the probability of P&R users in existing conditions of 44.3% and the growth rate of commuters in Sidoarjo to Surabaya of 0.5% per year, it was known that the need for parking space in 2022 was 5.510 m^2 consisting of 2.960 m^2 parking motorcycle and 2.550 m^2 car park. Meanwhile, the need for parking would increase by 413 m2 to 5,923 m2 in the next 10 years.

Furthermore, from the land ownership of Sidoarjo Station, it can be seen that the entire land is owned by PT. KAI. The land that can be developed as a P&R facility is only 80 x 30 m2 (Figure 5). This is because some part of the said land, in its existing condition, is used by the local community to build houses, parking lots, and roads. Any development plan requires a process of land acquisition and socialization among the community, local government, and PT. KAI. Therefore, to overcome obstacles regarding the fulfillment of parking needs at P&R Sidoarjo Station, efforts to provide and develop P&R at Sidoarjo Station can be made vertically. Based on Government Regulation of the Republic of Indonesia Number 16 of 2021 on the Implementing Regulations of Law Number 28 of 2022 concerning Buildings (Peraturan Pemerintah Republik Indonesia Nomor 16 Tahun 2021 tentang Peraturan Pelaksanaan Undang-Undang Nomor 28 Tahun 2022 tentang Bangunan Gedung), the maximum number of floors for a parking building is 8 floors.

Table 8. Projected Parking Space Needs

Year	Commuter		Parking Space Needs*	
	Car	Motorcycle	Car	Motorcycle
	..... People		..... m^2	
2017[1]	204	1,973	2,550	2,960
2022	209	2,022	2,614	3,033
2027	214	2,072	2,678	3,170
2032	219	2,121	2,741	3,181

[1]base year

*Parking Space Unit in Indonesia based on the Regulation of the Directorate General of Land Transportation 1998 (SRP Motorcycles: 0.75 x 2 m; SRP Cars: 2.5 x 5 m)

Park and Ride Implementation

From the results of the analysis based on the suitability of the existing conditions of parking facilities with standards referring to the Decree of the Director General of Land Transportation Number 272/hk.105/DRJD/96 on Technical Guidelines for the Implementation of Parking Facilities, as well as P&R Guidelines, in general, Sidoarjo Station has complied with 16 of the 25 existing indicators. While 9 other indicators are still not suitable, such as the width of the vehicle opening, the width of the parking space, the circulation path does not meet the minimum width, there are no CCTVs in parking facilities, there are no lighting lamps with sufficient lighting intensity, there is no parking space for non-vehicles motorized and persons with disabilities, there are no pedestrian paths yet, and there are still conflicts between vehicles and parking users and other station visitors.

Regarding the intention of Sidoarjo to Surabaya commuters to use P&R at Sidoarjo Station, it can be influenced by several factors. The results of the research show that policy influences subjective norms and can indirectly influence attitudes and behavior of commuters. Therefore, one of the solutions to increase the use of P&R based on the results of this research is to increase the level of public trust and acceptance of the government and the programs it arranges. A high level of public trust can affect the condition of the people in an area and accelerate changes in attitudes and behavior, in this context, attitudes and behavior that can encourage the use of P&R.

The research findings explain that the success of implementing P&R is determined by several factors including the availability of parking lots and complementary facilities. The better the quality of P&R services, including regarding security, safety and ease of obtaining information, the greater the public's trust and satisfaction with the implementation of P&R. In addition, the availability of public transportation modes encourages the formation of a certain behavior, namely using P&R.

Furthermore, a person's attitude and behavior in general is related to the policies that apply in a region. The existence of a policy will suppress and limit a person's actions, which influences his attitude and behavior. In addition, policies that are implemented evenly and fairly, accompanied by outreach to the public, can accelerate changes in attitudes and behavior. On the other hand, related to the condition of the COVID-19 pandemic that has occurred since the beginning of 2019, it has certainly had a lot of influence on people's behavior, as well as their perception of public transportation. The research findings show that the better the implementation of the policy on using public transportation during a pandemic and the application of health protocols, the higher the strictness of the policy and the public's trust so that it can encourage the intention of Sidoarjo - Surabaya commuters to use P&R. This is also supported by research results which show that the condition of public transportation around P&R during the COVID-19 pandemic made it easier for commuters to use P&R.

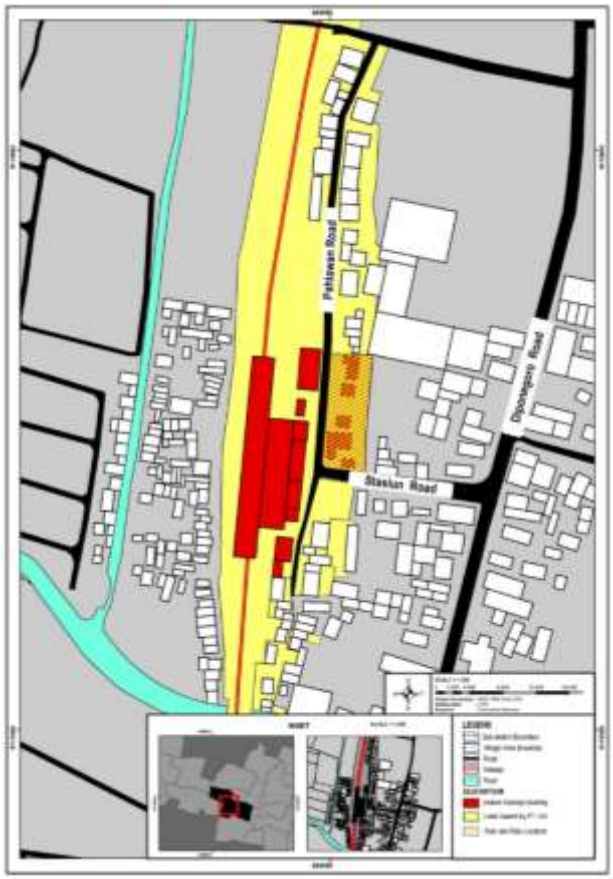

Figure 7. Land ownership of PT. KAI at Sidoarjo station

Research Implication

The growth in the number of private vehicle use that is increasing along with the improvement in the economic condition of the community intensively encourages the government to seek innovations in controlling transportation problems, such as traffic congestion, and so on (Ling et al., 2022). In recent years, sustainable transportation has become a hot issue discussed by urban designers (Porru et al., 2020). Various innovations regarding sustainable transportation planning to realize smart mobility have been raised in multiple forums, one of which is regarding traffic regulation in the city center through parking facilities (Rosenblum et al., 2020). The provision of parking facilities or P&R in sub-urban areas effectively reduces the number of the private vehicle used in the downtown area, thereby reducing traffic congestion levels and improving the quality of urban space.

In planning a P&R facility, two main challenges must be faced by the government or developers, namely determining the location of the P&R and the parking capacity that P&R can provide (Annisa et al., 2019; Ortega et al., 2021). These two things significantly influence the success rate of P&R (Handayeni & Ariyani, 2018). This study analyzes the number of parking spaces required by a P&R facility. The research findings indicate that the parking space needs in P&R can be calculated based on parking characteristics and the probability of commuters. In this case, commuters as the primary target for implementing P&R. The calculation of parking needs aims to minimize the emergence of idle capacity from P&R planning (Buana, 2019) and determine the direction of parking development in the area (Jog et al., 2015).

Meanwhile, the findings of this study can also complement the results of previous studies, where some research on P&R can only accommodate calculations regarding projected P&R demand without clearly stating the number of parking spaces required following the projections of P&R users (Asapa, 2014; Irawati et al., 2021; Nurkhariza & Nurlaela, 2019; Palupiningtyas, 2019). Irawati et al. (2021), in their research, state that the probability of P&R users at Sidoarjo Station is 44.3%. This figure is obtained by modeling private vehicle users who want to switch to using public transportation. Furthermore, the findings of this study can explain the area of parking space needed by P&R at Sidoarjo Station, which is obtained from the significant probability of P&R users, which is 5.923 m2 in the next 10 years.

On the other hand, in recent research on P&R, many efforts to plan and implement P&R have been carried out in developed countries (Macioszek & Kurek, 2020; Shen et al., 2017; Song et al., 2017), even some P&R locations have high levels of relatively high success. However, this is different from the implementation of P&R in developing countries. Apart from differences in regional, community, and socioeconomic characteristics, one of the obstacles to implementing P&R in developing countries is the limitation of studies that include planning activities, prediction of P&R demand, implementation, and evaluation of the effectiveness of these facilities (Hussain, 2020; Ibrahim et al., 2020). Therefore, this research is expected to be one of the references by governments and developers in developing countries in planning for the required parking space in a P&R facility effectively and efficiently.

CONCLUSION AND SUGGESTION

This study aims to analyze the need for parking spaces at the P&R facility at Sidoarjo Station based on the projected results of P&R demand for the next 10 years using the calculation of parking accumulation and private vehicle ownership for Sidoarjo – Surabaya commuters. From the results, it is known that the existing condition of the parking facility at Sidoarjo Station has exceeded the parking capacity, so to accommodate the parking needs, it is necessary to increase the parking area of 96 m^2 consisting of 58.5 m^2 to motorcycle parking and 37.5 m^2 of car. Meanwhile, the number of commuter parking needs when the P&R facility operates is 5,510 m^2 consisting of 2,960 m^2 for motorcycle parking and 2,550 m^2 for car parking. The need for parking will increase by 413 m^2 to 5,923 m^2 in the next 10 years.

On the other hand, the calculation of parking needs can also be influenced by other variables, such as land use and economic conditions. In this study, parking needs analysis is only calculated based on ideal conditions using parking accumulation and the probability of P&R users without any intervention from other variables. So that further research can add additional variables that have the potential to affect P&R parking needs. The research results on the need for parking spaces in P&R can be used as a reference in conducting a study of P&R planning in Indonesia

and other developing countries. The findings of this study can also complement the results of previous studies so that it is expected to maximize the ability of P&R facilities to meet parking needs.

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