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PERFORMANCE ANALYSIS OF PEDESTRIAN PATHS IN THE COLONIAL HISTORICAL AREA OF KOTA LAMA CIREBON

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ABSTRACT

Pedestrian path conditions are one of the factors that affect willingness to walk and play an important role in supporting historical tourism activities. This study analyzes the performance of pedestrian paths expressed by Pedestrian Level of Service (PLOS) in the colonial historical area of Kota Lama Cirebon. The method used in this study was to conduct a geometric survey of pedestrian paths, pedestrian flow surveys, and pedestrian travel time surveys in 10 segments scattered throughout the study area. The survey results were analyzed regarding the 1985 Highway Capacity Manual (HCM) and PLOS values generated based on available walking space. The study shows that in terms of walking space availability, most of the segments in the study area have a PLOS A score, which means they are performing well. In comparison, some segments have poor PLOS, such as Merdeka Street, Yos Sudarso Street, TJ Street, and Kebumen Street, due to the unavailability of sufficient walking paths to serve pedestrians or the presence of side obstacles that reduce the effective width of the pedestrian path. To overcome these problems, several things need to be done, such as: 1) issue a policy prohibiting selling on pedestrian paths to reduce side obstacles so that the effective width of the pedestrian path can increase; 2) widen the pedestrian path at least according to the applicable standards; and 3) provide pedestrian paths on segments that do not yet have pedestrian paths.

Keyword: *Pedestrian Paths, Kota Lama Cirebon, Pedestrian, Pedestrian Level of Service (PLOS), Highway Capacity Manual (HCM) 1985*

1. INTRODUCTION

Shifting modes of transport from private motorized vehicles to walking is one of the policies that can be implemented to encourage sustainable transport. This is supported by [1] which states that encouraging pedestrianization contributes to sustainable transport in terms of reducing motorized trips and energy consumption. Reference [2] states that walking is a mode of transport that is never separated from a chain of trips. Any mode of transport used to reach a destination must involve walking (whether by public transport or not). At [2] several factors influence the willingness to walk, which can be classified into two groups: internal and external factors. Internal factors relate to pedestrian characteristics such as health, time availability, trip purpose, and socio-economic conditions (age, gender, education, employment, income). External factors relate to walking distance, quality of the walking environment (condition of pedestrian facilities), safety, climate, and other factors.
According to [3], the condition of pedestrian facilities plays an important role in increasing the number of trips made by pedestrians. This is supported by [2] which states that people tend to walk further and more often if the quality of pedestrian facilities is good. The quality of the pedestrian network is key to improving walkability [4]**.** This is supported by [5], [6] which add that the quality and context of the walk are important criteria that influence the desirability of walking.
From the perspective of pedestrians, several aspects of pedestrian facilities can increase interest in walking, including comfort, safety, environmental conditions, aesthetics, sidewalk quality, and others.

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Reference [3] discovered that safety is the most crucial aspect affecting pedestrians' walking decisions among the sidewalk attributes, such as crossings, aesthetics and amenities, and connectivity. Reference [7] conducted a study on convenience, safety, and infrastructure on willingness to walk and cycle and found that planning with pedestrian priority and introduction of ROW at crossings, construction of tunnels and pedestrian bridges, and placement of street lights can increase the willingness to walk. From these studies, crossing safety and security were important attributes. The Guidelines for Planning, Provision, and Utilisation of Pedestrian Network Infrastructure and Facilities in Urban Areas (2014) explain that several environmental characteristics play a role in the level of service of pedestrian infrastructure, which are the basis of the design criteria for pedestrian network infrastructure and facilities, namely comfort, enjoyment, safety, security and economy.

This study analyses the performance of pedestrian paths in the colonial historical area of Kota Lama Cirebon. The development of colonial tourist areas is strongly influenced by the condition of tourist paths, both in terms of facilities and transport infrastructure. Planning infrastructure for pedestrians plays an important role in supporting historical tourism activities, where visitors will spend more time outside by going from one location to another. As for the existing, the connectivity of pedestrian paths in the area has not been created optimally. There is no coherence between the activities that take place in the area and the facilities and infrastructure available to pedestrians. So the existing infrastructure conditions have not been able to optimise the historical tourism activities in the area. This study aims to assess the level of service of pedestrian paths, as represented in the Pedestrian Level of Service (PLOS), and then provide technical recommendations that can be taken to improve service performance.

2. LITERATURE REVIEW

Pedestrian Level of Service (PLOS) is one method or approach that can be used to assess pedestrian perception of the condition of pedestrian facilities. The PLOS approach has been widely used in studies related to the assessment of pedestrian facilities in various areas. Reference [8] defines Pedestrian Level of Service or PLOS as the result of a comprehensive measurement of walking conditions on a route, path, or pedestrian facility. PLOS is directly related to factors that affect mobility, comfort, and safety, which reflect pedestrians' perceptions of how friendly a facility is for pedestrians. This is in line with [9] which defines PLOS as a measurement tool to evaluate the level of pedestrian accommodation on roadways to provide a comfortable and safe walking environment. Reference [9] provides a comprehensive framework for both qualitative and quantitative measurement of pedestrian facilities' influence on PLOS perception. The study modeled the triangular relationship between pedestrian facilities, road conditions (accessibility, safety, comfort, and attractiveness), and perceived PLOS to identify pedestrian facilities in Chittagong Metropolitan Area, Bangladesh. The study concluded that achieving a better PLOS depends on the availability, maintenance, and planning of various pedestrian facilities, as poor placement and condition of facilities increase the likelihood that the resulting PLOS will be at a lower level. Reference [10] examined the parameters and assessment aspects that can describe the condition of pedestrian facilities from four PLOS methods namely Trip Quality, Gainesville, Australian, and HCM (2000) in the university area of Institut Teknologi Bandung and concluded that pedestrian facilities can be assessed using 5 attributes/aspects namely dimensions, safety, security, comfort and convenience. Similar studies were conducted in [11], which evaluated the performance level of the pedestrian level of service (PLOS) for sidewalks on METU Campus using the Highway Capacity Manual (HCM), Gainesville, and Trip Quality methods. The study presented a comparison of results, on the strengths and weaknesses of each method, and provided a set of recommendations to improve walkability assessment. Reference [12] examines pedestrian level of service (PLOS) assessment methods by analyzing the relationship between pedestrian subjective perceptions and the quality of road infrastructure and traffic flow operations. The study differs from traditional research, which usually uses only traffic flow operations as the standard of assessment. In [12] they defined the main factors influencing the pedestrian level of service for sidewalks and then developed a stepwise regression model along with pedestrian level of service categories based on the main factors.

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3. METHODOLOGY

3.1. Research Location

The research location is located in the colonial area of Kota Lama Cirebon. **Figure 1** shows the delineation map of the study area which includes 2 (two) urban villages, namely Lemahwungkuk Village and Panjunan Village with the colonial buildings distributed on Yos Sudarso Street, Pasuketan Street, Kantor Street, Merdeka Street, and their surroundings.

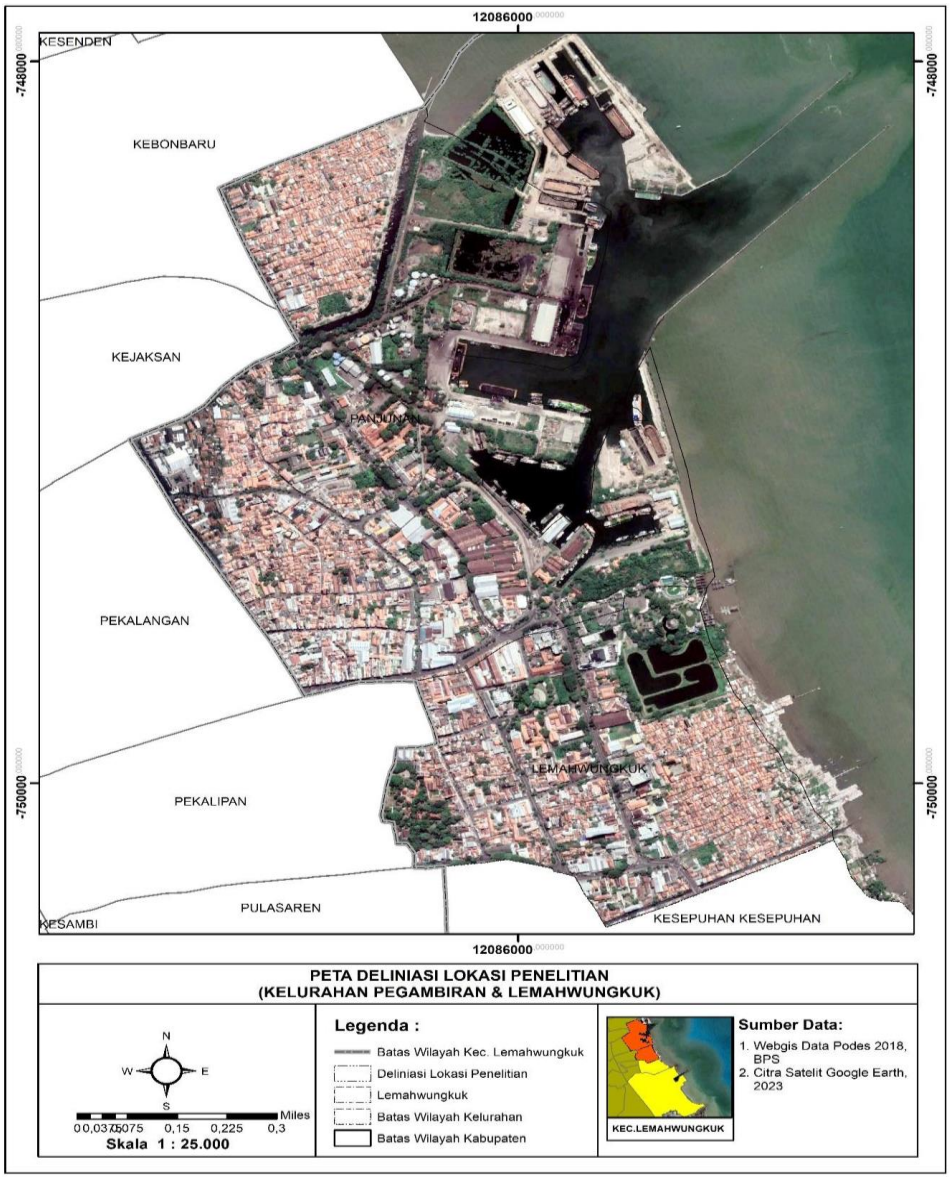

Figure 1. Research Location

3.2. Research Methods

Figure 2 shows the study activities from preparation, defining the objectives and assessment indicators, data collection, and data analysis to the production of technical recommendations based on the study results. In this study, primary surveys were conducted in the form of geometric surveys on pedestrian paths, pedestrian flow surveys, and pedestrian speed surveys. The results of the primary survey were then processed and analyzed to produce a Pedestrian Level of Service (PLOS) score, which represents the performance of pedestrian services at the site of the study. Subsequently, technical recommendations are planned based on the results of the study to improve the performance of pedestrian services.

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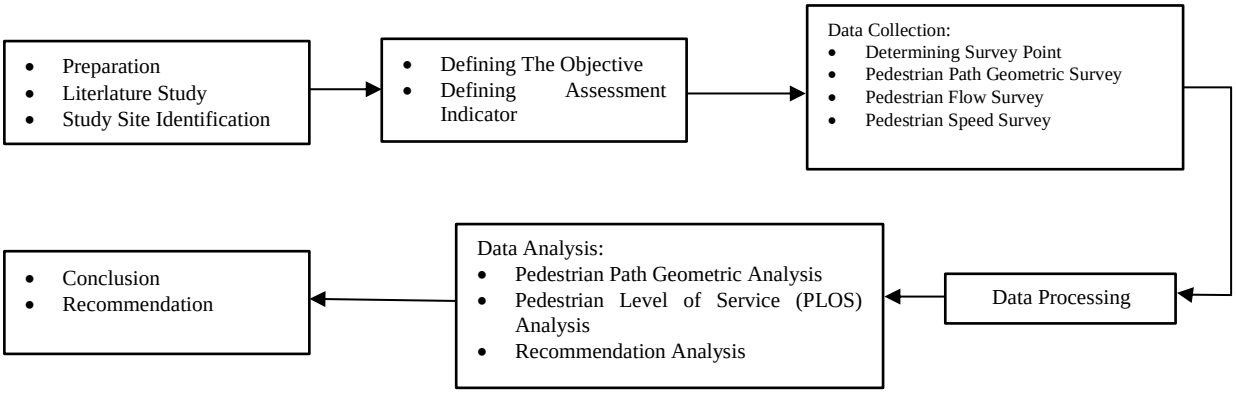

Figure 2. Research Methodology

4. RESULT AND DISCUSSION

4.1. Division of Segment in Study Location

In conducting data collection and analysis, it is necessary to identify and observe the study area so that the results of data collection and analysis can describe the overall condition of the study area. Based on the results of the identification of the study area, the data collection and analysis points are divided into 10 segments with a total of 19 sections spread across the study area.

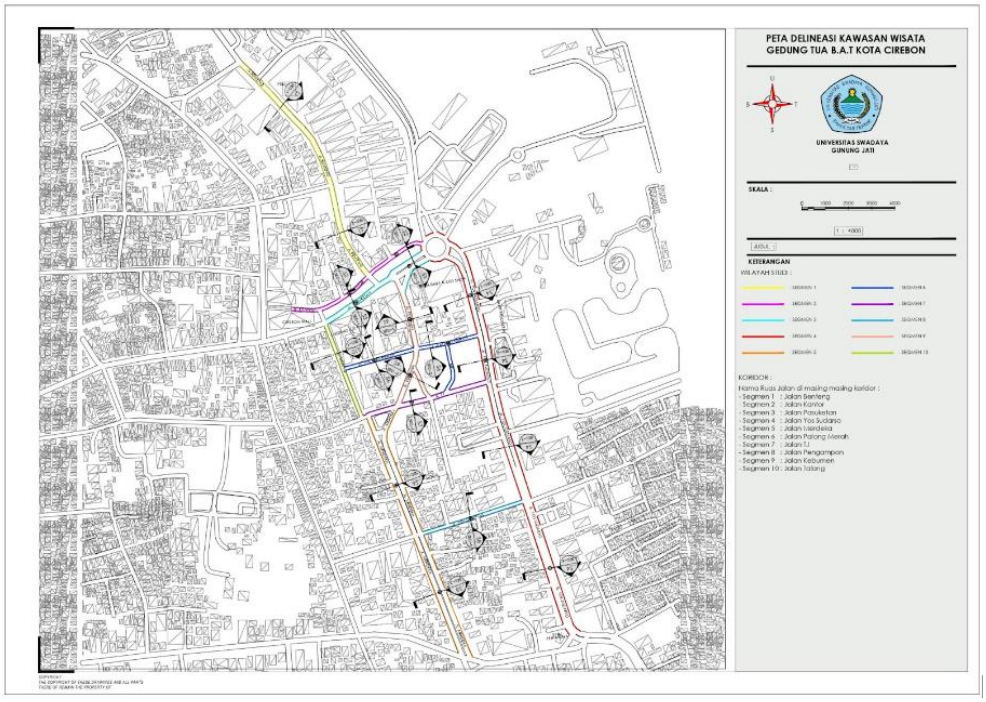

Figure 3. Distribution of Data Collection and Analysis Points

Figure 3 shows the division of data collection and analysis segments which include:
1. Benteng Street
2. Kantor Street
3. Pasuketan Street
4. Yos Sudarso Street
5. Merdeka Street
6. Palang Merah Street
7. TJ Street

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8. Pengampon Street
9. Kebumen Street
10. Telang Street

4.2. Pedestrian Path Geometric Analysis

Table 1 shows the results of the geometric data collection on pedestrian paths in the study area. The geometric data observed are the presence of pedestrian paths, the length of pedestrian paths, and the effective width of pedestrian paths.

Table 1. Pedestrian Path Geometric Condition

Segment	Location	Section	Presence of Pedestrian Path		Path Length (m)		Path Width (m)	
			Right	Left	Right	Left	Right	Left
Segment 1	Benteng Street	Sect. 1	Yes	Yes	258,98	258,98	1,60	1,50
		Sect. 2	Yes	Yes	166,97	166,97	1,50	1,40
Segment 2	Kantor Street	Sect. 1	No	Yes	0,00	147,26	0,00	1,95
		Sect. 2	No	Yes	0,00	101,94	0,00	1,30
Segment 3	Pasuketan Street	Sect. 1	No	Yes	0,00	138,58	0,00	1,00
		Sect. 2	Yes	No	91,61	0,00	1,20	0,00
Segment 4	Yos Sudarso Street	Sect. 1	Yes	Yes	147,68	147,68	2,40	3,60
		Sect. 2	Yes	Yes	73,65	73,65	1,40	1,50
		Sect. 3	Yes	Yes	206,04	206,04	1,40	1,50
		Sect. 4	Yes	Yes	240,11	240,11	1,50	1,50
Segment 5	Merdeka Street	Sect. 1	Yes	Yes	215,00	215,00	1,55	1,40
		Sect. 2	Yes	Yes	212,11	212,11	1,70	1,73
Segment 6	Palang Merah Street	Sect. 1	Yes	Yes	124,40	124,40	0,10	0,75
		Sect. 2	Yes	Yes	102,59	102,59	1,50	0,9
Segment 7	TJ Street	Sect. 1	Yes	Yes	219,80	219,80	1,90	1,9
Segment 8	Pengampon Street	Sect. 1	Yes	Yes	178,39	178,39	1,70	1,23
Segment 9	Kebumen Street	Sect. 1	Yes	Yes	119,40	119,40	1,00	1,00
		Sect. 2	Yes	Yes	97,43	97,43	0,90	0,10
Segment 10	Telang Street	Sect. 1	Yes	Yes	168,10	168,10	1,60	1,50

Based on the results of the pedestrian path geometric survey, it was found that there are still many pedestrian paths in the study area that do not meet the minimum effective width (according to the minimum standard of 1.6 m for movement with goods and 1.8 m when using a special path for people with disabilities). The pavement condition of pedestrian paths in the study areas was damaged to a degree that reduced accessibility for walking activities. Therefore, it is necessary to improve the geometric structure of pedestrian paths in the study areas to allow pedestrians to walk comfortably and safely. In addition, in terms of facility availability, nearly all of the survey points do not have adequate pedestrian path-supporting facilities. The survey points that have certain facilities such as shade/trees and bins are in poor condition.

4.3. Pedestrian Path Performance Analysis

The performance of pedestrian paths is represented based on the Pedestrian Level of Service (PLOS) scores defined in the Highway Capacity Manual (HCM) 1985 and presented in **Table 2**. The assessment of PLOS scores can be based on available pedestrian space, pedestrian flow, pedestrian speed, or V/C ratio. In this study, the PLOS score is based on the available space for walking.

Table 2. PLOS Score Assessment Standard

Service Level	Space Available (m2/p)	Flow Rate (p/min/m)	Speed (m/sec)	V/C
A	>5.6	≤16	>1.30	≤0.21
B	>3.7 - 5.6	>16 - 23	>1.27 - 1.30	>0.21 - 0.31
C	>2.2 - 3.7	>23 - 33	>1.22 - 1.27	>0.31 - 0.44

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Service Level	Space Available (m2/p)	Flow Rate (p/min/m)	Speed (m/sec)	V/C
D	>1.4 - 2.2	>33 - 49	>1.14 - 1.22	>0.44 - 0.65
E	>0.75 - 1.4	>49 - 75	>0.75 - 1.14	>0.65 - 1.00
F	≤0.75	variable	≤0.75	variable

Source: *Highway Capacity Manual (HCM) 1985*

In determining the value of space, level of flow, speed, and V / C ratio, data on pedestrian speed, pedestrian flow, and geometric path data available from primary surveys were required. **Table 3** shows the average pedestrian flow data, while **Table 4** shows the average pedestrian travel time data.

Table 3. Average Pedestrian Flow in the Study Area

Segment	Lokasi	Section	Noon Peak Flow (ped/hour)		Afternoon Peak Flow (ped/hour)	
			Right	Left	Right	Left
Segment 1	Benteng Street	1	11	6	4	7
		2	3	6	10	4
Segment 2	Kantor Street	1	0	23	0	13
		2	0	28	0	5
Segment 3	Pasuketan Street	1	0	20	0	71
		2	27	1	12	0
Segment 4	Yos Sudarso Street	1	11	23	11	8
		2	36	35	33	17
		3	8	20	20	12
		4	18	21	6	6
Segment 5	Merdeka Street	1	33	64	49	50
		2	174	206	34	28
Segment 6	Palang Merah Street	1	36	27	11	8
		2	16	7	6	1
Segment 7	TJ Street	1	103	85	28	18
Segment 8	Pengampon Street	1	16	37	11	20
Segment 9	Kebumen Street	1	10	95	14	29
		2	14	13	4	19
Segment 10	Telang Street	1	29	76	10	38

Based on Table 3, the highest pedestrian flow value is in Segment 5 Section 2 (Merdeka Street) during the noon peak hour and Segment 5 Section 1 (Merdeka Street) during the afternoon peak hour. The reason for this is that Merdeka Street has educational and office activities so the pedestrian flow is dominated by students and workers in the noon peak hour and the afternoon peak hour.

Table 4. Average Travelling Time of Pedestrians in the Study Area

Segment	Location	Section	Average Travel Time (second)		Average Travel Time (second)	
			Right	Left	Right	Left
Segment 1	Benteng Street	1	127	110	124	109,8
		2	116,4	109,8	122,8	109,8
Segment 2	Kantor Street	1	0	108	0	105
		2	0	99	0	99
Segment 3	Pasuketan Street	1	0	91,6	0	91,2
		2	106	0	107,6	0

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Segment	Location	Section	Average Travel Time (second)		Average Travel Time (second)	
			Right	Left	Right	Left
Segment 4	Yos Sudarso Street	1	118,8	92	119,4	91,4
		2	121,4	99,2	123,2	95,8
		3	102,2	100,8	103,8	103,8
		4	109,8	106	117,2	111
Segment 5	Merdeka Street	1	109,2	94,4	108,4	95,4
		2	91,6	94	90	93,4
Segment 6	Palang Merah Street	1	116,6	106,8	116,2	107,4
		2	106,8	104,8	107,4	104,8
Segment 7	TJ Street	1	108	108,2	96,8	112,8
Segment 8	Pengampon Street	1	129,6	115,6	126,8	115
Segment 9	Kebumen Street	1	107,2	91,6	108,2	95,2
		2	102	102,2	102	102
Segment 10	Telang Street	1	122,4	117,6	118,2	117,4

Based on Table 4, it is observed that the average travel time of pedestrians in the study area varies between 90 - 130 seconds per 100 m. The difference is due to the different walking speeds of pedestrians, which are influenced by age, gender, walking interests, and the condition of pedestrian facilities.

Regarding the Highway Capacity Manual (HCM) 1985 and the results of the primary survey conducted, the Pedestrian Level of Service (PLOS) assessment results were obtained as described in **Table 5**. According to the results of the analysis, based on the available space, most of the PLOS score in the study location is A, which means that pedestrians can move in the desired pedestrian space without changing their movement in response to other pedestrians, and can freely choose the speed to walk. Some segments or sections have PLOS B and C values, which means that the condition of the pedestrian path in terms of space can still function optimally in terms of walking services. Some segments have a PLOS D score, where the walking speed of pedestrians needs to be limited because of interaction or conflict with other pedestrians. The poorest condition in the study area is PLOS E, which means that it is very difficult for pedestrians to precede or cut off other pedestrians because the volume of pedestrians is reaching the capacity limit of the pedestrian space due to the very limited walking space available.

Table 5. Pedestrian Level of Service (PLOS) Analysis Results

Seg.	Location	Sect.	Survey Time	Space (m^2/ped.)		Flow Rate (ped/min/m)		Average Speed (m/menit)		PLOS	
				Right	Left	Right	Left	Right	Left	Right	Left
Seg. 1	Benteng Street	Sect. 1	$12^{.00}$ - $13^{.00}$	23,54	43,16	0,12	0,07	47,24	54,55	A	A
			$16^{.00}$ - $17^{.00}$	64,75	37,00	0,04	0,08	48,39	54,65	A	A
		Sect. 2	$12^{.00}$ - $13^{.00}$	55,66	27,83	0,03	0,07	51,55	54,65	A	A
			$16^{.00}$ - $17^{.00}$	16,70	41,74	0,11	0,05	48,86	54,65	A	A
Seg. 2	Kantor Street	Sect. 1	$12^{.00}$ - $13^{.00}$	0,00	0,16	0,00	0,20	0,00	55,56	-	B
			$16^{.00}$ - $17^{.00}$	0,00	0,09	0,00	0,11	0,00	57,14	-	A
		Sect. 2	$12^{.00}$ - $13^{.00}$	0,00	3,64	0,00	0,36	0,00	60,61	-	C
			$16^{.00}$ - $17^{.00}$	0,00	20,39	0,00	0,06	0,00	60,61	-	A
Seg. 3	Pasuketan Street	Sect. 1	$12^{.00}$ - $13^{.00}$	0,00	6,93	0,00	0,33	0,00	65,50	-	A
			$16^{.00}$ - $17^{.00}$	0,00	1,95	0,00	1,18	0,00	65,79	-	D
		Sect. 2	$12^{.00}$ - $13^{.00}$	3,39	91,61	0,38	0,01	56,60	*)	C	-
			$16^{.00}$ - $17^{.00}$	7,63	*)	0,17	0,00	55,76	*)	A	-
Seg. 4	Yos Sudarso Street	Sect. 1	$12^{.00}$ - $13^{.00}$	13,43	6,42	0,08	0,11	50,51	65,22	A	A
			$16^{.00}$ - $17^{.00}$	13,43	18,46	0,08	0,04	50,25	65,65	A	A
		Sect. 2	$12^{.00}$ - $13^{.00}$	2,05	2,10	0,43	0,39	49,42	60,48	D	C
			$16^{.00}$ - $17^{.00}$	2,23	4,33	0,39	0,19	48,70	62,63	C	B
		Sect. 3	$12^{.00}$ - $13^{.00}$	25,76	10,30	0,10	0,22	0,04	0,10	A	A
			$16^{.00}$ - $17^{.00}$	10,30	17,17	0,24	0,13	0,10	0,06	A	A
		Sect. 4	$12^{.00}$ - $13^{.00}$	13,34	11,43	0,20	0,23	54,65	56,60	A	A
			$16^{.00}$ - $17^{.00}$	40,02	40,02	0,07	0,07	51,20	54,05	A	A
Seg. 5	Merdeka Street	Sect. 1	$12^{.00}$ - $13^{.00}$	6,52	3,36	0,36	0,76	54,95	63,56	A	C
			$16^{.00}$ - $17^{.00}$	4,39	4,30	0,53	0,60	55,35	62,89	B	B
		Sect. 2	$12^{.00}$ - $13^{.00}$	1,22	1,03	1,71	1,99	65,50	63,83	E	E
			$16^{.00}$ - $17^{.00}$	6,24	7,58	0,33	0,27	66,67	64,24	A	A

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Seg.	Location	Sect.	Survey Time	Space (m^2/ped.)		Flow Rate (ped/min/m)		Average Speed (m/menit)		PLOS	
				Right	Left	Right	Left	Right	Left	Right	Left
Seg. 6	Palang Merah Street	Sect. 1	$12^{.00}$ - $13^{.00}$	3,46	4,61	6,00	0,60	51,46	56,18	B	B
			$16^{.00}$ - $17^{.00}$	11,31	15,55	1,83	0,18	51,64	55,87	A	A
		Sect. 2	$12^{.00}$ - $13^{.00}$	6,41	14,66	0,18	0,13	56,18	57,25	A	A
			$16^{.00}$ - $17^{.00}$	17,10	102,59	0,07	0,02	55,87	57,25	A	A
Seg. 7	TJ Street	Sect. 1	$12^{.00}$ - $13^{.00}$	2,13	2,59	0,90	0,75	55,56	55,45	D	C
			$16^{.00}$ - $17^{.00}$	7,85	12,21	0,25	0,16	61,98	53,19	A	A
Seg. 8	Pengampon Street	Sect. 1	$12^{.00}$ - $13^{.00}$	11,15	4,82	0,16	0,50	46,30	51,90	A	B
			$16^{.00}$ - $17^{.00}$	16,22	8,92	0,11	0,27	47,32	52,17	A	A
Seg. 9	Kebumen Street	Sect. 1	$12^{.00}$ - $13^{.00}$	11,94	1,26	0,17	1,58	55,97	65,50	A	E
			$16^{.00}$ - $17^{.00}$	8,53	4,12	0,23	0,48	55,45	63,03	A	B
		Sect. 2	$12^{.00}$ - $13^{.00}$	6,96	7,50	0,26	2,17	58,82	58,71	A	A
			$16^{.00}$ - $17^{.00}$	24,36	5,13	0,07	3,17	58,82	58,82	A	B
Seg. 10	Telang Street	Sect. 1	$12^{.00}$ - $13^{.00}$	5,80	2,21	0,30	0,84	49,02	51,02	A	C
			$16^{.00}$ - $17^{.00}$	16,81	4,42	0,10	0,42	50,76	51,11	A	B

4.4. Technical Recommendations

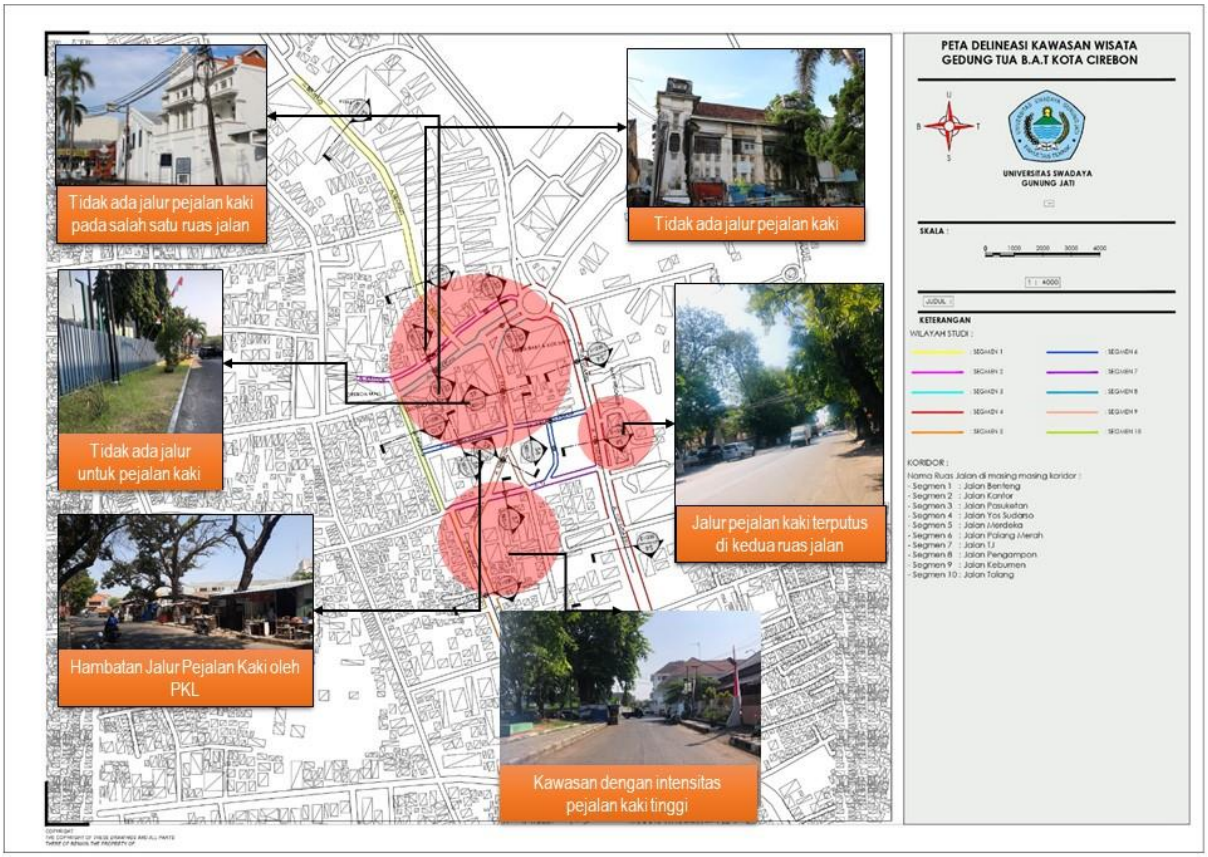

Figure 4. Distribution of Sites with Low PLOS Score

Figure 4 shows the distribution of locations in the study area with low PLOS scores. The segments with low PLOS include the pedestrian paths on Merdeka Street, TJ Street, Yos Sudarso Street, and Kebumen Street. After comparing the geometric conditions of the pedestrian paths, the low PLOS scores are caused by:

1. Unavailability of pedestrian paths on one side or both sides
2. Disconnected pedestrian path
3. Obstruction of pedestrian path by street vendors
4. The study location is in an area of high pedestrian intensity with educational and office activities.

Based on this, the technical recommendations that can be given to overcome the low PLOS score at the study location are to issue a policy prohibiting selling on pedestrian paths, to reduce side obstacles so that the effective width of the pedestrian path can be increased, widen the pedestrian path at least to the applicable standards, and provide pedestrian paths on segments that do not yet have pedestrian paths.

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5. CONCLUSION

Based on the results of the analysis, it can be concluded that in terms of space availability, most of the segments in the study area have a PLOS A score, which means they have good performance. Some segments have low PLOS scores, such as Merdeka Street, Yos Sudarso Street, TJ Street, and Kebumen Street, which is caused by the unavailability of sufficient walking paths to serve pedestrians or the presence of side obstacles that reduce the effective width of the pedestrian path. To overcome these issues, it is necessary to implement certain measures, such as implementing a no-selling policy on pedestrian paths or ensuring that the width of pedestrian paths meets the standard requirements.

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