Analysis of Walkability Index and Handling of Pedestrian Facilities of Slamet Riyadi Street, Surakarta

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Abstract. Slamet Riyadi Street is the main street in Surakarta. It is located in the city center, which connects the activity center or CBD. The rapid development of activities needs to be balanced with adequate facilities and infrastructure related to the existing pedestrian paths’ maintenance and rehabilitation. This research uses the walkability index method to compare the walking comfort index assessment based on the Global Walkability Index variables and SE PUPR 02/SE/M/2018 variables. The findings showed a very significant difference between the two. GWI got a score of 56.2, while SE PUPR got a score of 49.4. Demonstrating the effectiveness of GWI assessment when used to assess the pedestrian paths in Indonesia was poor. Then, determining several recommendations for handling facilities with pedestrian perceptions based on SE PUPR variables uses the Likert scale method. The result of the analysis included the facilities related to conflicts on the pedestrian paths and the behavior of the motor vehicle drivers at the crossing locations on the south and north sides of the pedestrian paths, as well as other facilities on the north side concerning the security from crime, complete facilities, disability infrastructure, maintenance and cleanliness, and pedestrian obstacles.

1. Introduction

The walkability index is an assessment method used in determining the environmental quality measures for walking activities [18]. The application of the walkability concept also plays a role in reducing air pollution in an urban area. As a result, people are more interested in switching to walking than using motor vehicles while doing their activities [7]. Slamet Riyadi Street is the main street in Surakarta. This street functions as a hub for the activity centers or CBD (Central Business District) in the urban areas. This area supports the economic, business, education, health, transit, and cultural tourism activities in Surakarta. The considerably fast development of activities has made the number of visitors on the street increases. This condition needs to be balanced with the availability of adequate facilities and infrastructure, one of which is the pedestrian path, making it easier for the pedestrians to move from one location to another.

To date, there is no assessment to measure the level of comfort on the use of the pedestrian facilities under the Indonesian pedestrians’ characteristics. Although many studies use the Global Walkability Index [8] concept in various cities in Indonesia, this concept is generally used to facilitate the pedestrian paths’ maintenance and rehabilitation. The Indonesian government only issues the Circular Letter of the Minister of Public Works and Public Housing PUPR
This regulation only describes the planning criteria. The previous research conducted by [6] has been in the form of a hypothesis theory study by comparing the characteristics between GWI [8] assessment and SE PUPR [11] criteria. The results show that there have been three variables that need more attention in Indonesia's pedestrian planning criteria that can affect the handling recommendations, which are supporting or complementary facilities, pedestrian facilities for people with disabilities, and the need for the space width for pedestrians. These results have shown an entirely different correlation when GWI [8] is used in Indonesia.

This research aims to develop the previous study by measuring the pedestrian paths’ feasibility level index based on the Global Walkability Index [8] and comparing it with the pedestrian facility planning criteria based on SE PUPR 02/SE/M/2018 [11]. The SE PUPR 02/SE/M/2018 [11] variable originally in the form of the planning criteria was designed and formulated to transform it into a measuring tool used to assess the pedestrian paths’ feasibility, the Global Walkability Index [8]. Besides that, it can be used to determine the level of effectiveness of each variable. Are the variables in question within the scope of the Global Walkability Index [8]? The value obtained is then used to determine the pedestrian path calculation, such as the case study index on Jalan Slamet Riyadi Surakarta. Additionally, an assessment analysis was also carried out based on the pedestrian path users’ perceptions. It could determine several variables categorized as the top priorities in handling the pedestrian facilities’ rehabilitation and maintenance.

2. Research Method

Global Walkability Index [8] assessment began with the preparation stage by determining the number of field personnel needed, the assessment form, and the survey equipment. Furthermore, the value obtained is used to determine the number of distances for walking users on Jl. Slamet Riyadi. The data found that the distance between the JnT Solo office on the west end to the Slamet Riyadi Public Monument at the east end was 3.6 km. The importance of an essential line along 400 m per segment with nine segments is obtained from this calculation. The segment division along 400 m was based on people’s maximum ability to walk in 5 minutes. This theory was also used by [20] and [18] to determine people’s ultimate ability to walk. Segment 1 was in front of JnT to Diamond Caffe, segment two was in front of Diamond Caffe to SBC, segment three was in front of SBC to Allianz, Segment 4 was in front of Allianz to Dinakerperin, segment five was in front of Dinakerperin to Ngapeman Bus Stop, segment six was in front of Ngapeman Bus Stop to CIMB, segment seven was in front of CIMB to BJB, segment eight was in front of BJB to the detention center, and segment 9 was in front of the detention center to Slamet Riyadi Monument. The sketch of the locations based on the segment division can be seen in Figure 1.

In each segment, a survey was conducted to calculate the number of pedestrians during the peak hours, both weekdays and weekends. Simultaneously, a pedestrian path facility inventory survey was also carried out with a scoring level assessment based on the Global Walkability Index [8] variables. The level was expressed on a scale of numbers 1 to 5 from worst to best categories.
The variables reviewed in the GWI [8] assessment consisted of conflicts in pedestrian paths, security from crime, pedestrian safety, motor vehicle drivers’ behavior, infrastructure for people with disabilities, maintenance and cleanliness, obstacles to pedestrian activities, and availability of crossing infrastructure. The final assessment result could determine the eligibility criteria for the index by calculating the formula as follows.

\[
 WI = \frac{\sum (X \cdot N \cdot 10 \cdot Y) \times 0.1}{K}
\]  

with \( WI \) = Walkability Index, \( X \) = Assessment variable, \( N \) = Segment length, \( Y \) = number of pedestrians per segment, and \( K \) = Total segment. Several categories determining the Global Walkability Index rating scale [8] can be explained in table 1.

| Walkability Score | Description                                      |
|-------------------|--------------------------------------------------|
| 90-100            | Activities do not require a vehicle              |
| 70-89             | Activities are carried out on foot               |
| 50-69             | Several facilities can be reached on foot        |
| 25-49             | Limited facilities to reach on foot              |
| 0-24              | Activities require a vehicle                     |

The next step assessed the pedestrian facility planning criteria based on SE PUPR 02/SE/M/2018 [11] by comparing several variables that had similarities in the Global Walkability Index [8]. Each variable was designed and formulated as in the GWI [8] assessment to determine the walking index’s eligibility criteria. Thus, the level of effectiveness of the two estimates could be identified. The final step was determining the recommendations for handling the pedestrian paths by selecting the variable assessment results of SE PUPR 02/SE/M/2018 [11], which had the same scale for the perception of pedestrian users in the moderate to worst categories. It was taken from the medium type since it still did not meet the walking comfort criteria on the Walkability scale. There were only a few facilities that were accessible on foot, and they were also limited. The perception assessment was carried out in each segment. The number of samples taken was 30 people per segment, with 270 people from 9 segments. The minimum number of samples was 30 people required to meet the research criteria [4]. Each variable was identified using the Likert scale method [14], by reviewing the percentage class interval to determine the selection of variables to be recommended for handling.

3. Results and Discussion

There are several researches of Walkability Index in Indonesia, such as Global Walkability Index [8] by [1], [3], [5], [9], [12], [19], and [21]. Then there is also Walkability US Department Health and Human Service by [2], [10], [15], [16, 22–24], and [17]. In research [13] analyzed several kinds of research of Walkability with a subjective and objective approach. The analysis results show from 40 methods of Walkability, which is suitable when used in Indonesia, Global Walkability Index [8]. This research chose the Global Walkability Index [8] to assess and compare with SE PUPR 02/SE/M/2018 [11], which has formulated the Global Walkability Index. Other than that conducted to calculate pedestrian perceptions with SE PUPR 02/SE/M/2018 [11] variables, determine recommended for the handling of pedestrian paths.

3.1. Global Walkability Index Assessment

The pedestrian path condition’s assessment results based on the Global Walkability Index [8] can be seen in table 2.
Table 2. Assessment results of the southern side of pedestrian paths

| Assessment Indicator                          | Segment 1 | Segment 2 | Segment 3 | Segment 4 | Segment 5 | Segment 6 | Segment 7 | Segment 8 | Segment 9 |
|----------------------------------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| Conflicts on the pedestrian paths           | 4         | 3         | 3         | 4         | 4         | 5         | 4         | 4         | 4         |
| Security from crime                         | 4         | 4         | 4         | 4         | 4         | 4         | 4         | 4         | 4         |
| Pedestrian safety                           | 3.5       | 3         | 3.5       | 3.3       | 4         | 5         | 3         | 3         | 3.5       |
| Driver behavior                             | 3         | 3         | 3         | 3         | 3         | 3         | 3         | 3         | 3         |
| Complete facilities                         | 4.2       | 4.2       | 4.2       | 5         | 4.2       | 4.2       | 4.2       | 4.2       | 4.2       |
| Disability infrastructure                   | 4         | 5         | 4         | 5         | 5         | 4         | 4         | 5         | 4         |
| Maintenance and cleanliness                 | 4.5       | 4.5       | 4.5       | 4.5       | 5         | 4.5       | 4.5       | 4.5       | 4.5       |
| Pedestrian obstacles                        | 5         | 4.5       | 4         | 4         | 5         | 4         | 4         | 5         | 5         |
| Availability of crossings                   | 5         | 5         | 5         | 5         | 1         | 5         | 5         | 5         | 5         |
| Number of pedestrians                       | 53        | 44        | 76        | 39        | 40        | 36        | 39        | 25        | 53        |

The Walkability Index calculation for the south side of the pedestrian paths obtained a score of 63.4, indicating that the pedestrian paths’ condition was quite walkable. Meanwhile, the north side of the pedestrian paths was calculated using the same formula with 49.1 and had an appropriate walkable category. Overall, an average walkability score of 56.2 was obtained with an excellent walkable variety, or several facilities could be reached on foot.

3.2. Assessment of Regulation for Pedestrian Facilities in Indonesia

Before calculating the pedestrian paths’ assessment results, the researchers compiled several variables in SE PUPR 02/SE/M/2018 [11] that were similar to or becoming a reference for GWI [8] variables. The variable grouping can be described in table 3.

Table 3. Variable Grouping

| Code | GWI Variable                               | SE PUPR Variable                               |
|------|--------------------------------------------|-----------------------------------------------|
| A    | Conflicts on the pedestrian paths          | Road poles and safety fences                   |
| B    | Security from crime                        | Availability of lighting facilities            |
| C    | Pedestrian safety                          | Performance of the crossing facilities during the peak hours |
| D    | Motor vehicle drivers’ behavior at the crossing location | Warning signs, guideposts, and crossing facility markings |
| E    | Complete facilities                        | Shelters, green lines, seats, drainage, and bus stops |
| F    | Disability infrastructure                   | Pedestrian facilities for people with disabilities |
| G    | Maintenance and cleanliness                 | Sidewalk slopes, walkways, and trash cans     |
| H    | Pedestrian obstacles                        | The sufficient width of the pedestrian paths  |
| I    | Availability of crossings                   | Minimum requirements for the pedestrian paths in the urban areas |

The assessment results of the pedestrian paths’ condition based on SE PUPR 02/SE/M/2018 [11] can be seen in table 4.

The index criteria calculation results for the south side of pedestrian paths obtained a score of 55.4, indicating that the pedestrian paths’ condition was quite walkable. The north side
Table 4. Assessment results of the south side of pedestrian paths

| Variable Code | Segment | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---------------|---------|---|---|---|---|---|---|---|---|---|
| A             |         | 1.0 | 2.7 | 1.0 | 2.7 | 1.0 | 2.7 | 3.3 | 3.3 | 1.0 |
| B             |         | 3.0 | 3.0 | 3.0 | 2.0 | 2.0 | 3.0 | 2.0 | 2.0 | 3.0 |
| C             |         | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 |
| D             |         | 3.6 | 2.3 | 2.3 | 2.5 | 2.5 | 2.5 | 2.5 | 2.6 | 0.8 |
| E             |         | 4.0 | 4.0 | 3.6 | 3.6 | 3.6 | 3.2 | 3.2 | 3.6 | 3.6 |
| F             |         | 3.9 | 3.2 | 3.3 | 3.5 | 3.9 | 3.3 | 3.5 | 3.5 | 4.1 |
| G             |         | 4.1 | 3.0 | 3.0 | 3.0 | 3.4 | 2.8 | 3.2 | 2.9 | 3.0 |
| H             |         | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 |
| I             |         | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 |
| Number of pedestrians |         | 53 | 44 | 76 | 39 | 40 | 36 | 39 | 25 | 53 |

was calculated using the same formula with 43.4 and had a less walkable category. Overall, an average walkability score obtained was 49.4 and had a less walkable type, or showed that there were limited pedestrian facilities that could be reached on foot. In contrast, the assessment results of SE PUPR 02/SE/M/2018 [11] variables showed a significant difference with the Global Walkability Index [8] variables, where the assessment index was lower or worse. Accordingly, the GWI [8] assessment’s effectiveness for assessing the pedestrian paths in Indonesia was inadequate.

3.3. Recommendations for Handling Pedestrian Paths

The assessment indicators used in determining the recommendations for handling the pedestrian paths were several variables that had the same rating category between the Index criteria of SE PUPR 02/SE/M/2018 [11], and the perceptions of pedestrian users which calculated use Likert scale with moderate to lower or moderate to the worst rating scale. The reasonable criteria for Walkability were rated 79 and below, while the perception percentage was 59 and below. The results of the variable comparison calculation can be seen in table 5. Based on the calculation results, the variables on the south side of pedestrian paths that should be evaluated were the facilities related to the conflicts on the pedestrian paths and the motor vehicle drivers’ behavior at the crossing locations. On the other hand, the north side was calculated using the same method in which several variables that needed to be evaluated were the facilities related to the

Table 5. Variable comparison calculation of the south side of pedestrian paths

| Variable Code | Index Criteria | Perception percentage | Description |
|---------------|----------------|-----------------------|-------------|
| A             | 31.2           | 58.7                  | Evaluated   |
| B             | 41.3           | 61.3                  |             |
| C             | 79.3           | 61.0                  |             |
| D             | 40.6           | 49.6                  | Evaluated   |
| E             | 57.5           | 64.0                  |             |
| F             | 55.7           | 62.3                  |             |
| G             | 50.5           | 67.5                  |             |
| H             | 79.3           | 62.4                  |             |
| I             | 63.5           | 65.9                  |             |
conflicts on the pedestrian paths, security from crime, motor vehicle drivers’ behavior at the crossing locations, complete facilities, disability infrastructure, maintenance and cleanliness, and pedestrian obstacles.

At the south and north side of pedestrian paths, several pedestrians feel uncomfortable when walking activity. There are many motor vehicle drivers who conditioning, so it takes Road poles and safety fences. Pedestrians feel dangerous at the crossing locations, be required completeness of warning signs, guideposts, and crossing facility markings. On the other hand, the north side facilities lack lighting at night, and pedestrians feel insecure against the dangers on the surface pedestrian paths or security from crime. Availability Shelters and green lines are also limited so that pedestrians feeling hot when walking. Disabilities can not do activities properly because there are no warning tiles at sidewalk and several bus stops are not disabled-friendly. At several points, can not availability sidewalk slopes. This condition made pedestrians, especially disabilities feel uncomfortable when up and down the sidewalk. The unavailability of trash cans along the sidewalk is also a problem for pedestrians because it spoils the walking’s beauty and atmosphere. Due to piles of flowerpots or other obstacles at several sidewalk points, narrow sidewalks also reduce the pedestrian paths’ sufficient width significantly inhibit pedestrians’ movement.

4. Conclusions
The walking comfort index analysis results showed a very significant difference between the Global Walkability Index [8] and SE PUPR 02/SE/M/2018 [11]. GWI [8] scored 56.2, while SE PUPR [11] scored 49.4. The index calculation calculated based on the criteria for the pedestrian facilities in Indonesia was lower, meaning that the GWI [8] assessment was inadequate when used for assessing the pedestrian paths in Indonesia. The recommendations for handling the pedestrian paths consisted of facilities related to the conflicts on pedestrian paths and the motor vehicle drivers’ behavior at the crossing locations on the south and north sides of the pedestrian paths, as well as other facilities on the north side concerning the security from crime, complete facilities, disability infrastructure, maintenance and cleanliness, and pedestrian obstacles.

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