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An application of the bicycle lane on the complete street concept in efforts reducing global warming impact

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Abstract. The incomplete roads, designed only for cars, with limited transportation options make pedestrians, cyclists, and other transport users feel uncomfortable and safe and risk dangerous. The bicycle as a more environmentally friendly means of transportation which is an alternative mode of transportation that can replace motor vehicles to reduce the impact of global warming. Facilities for bicycle users provide a sense of security and comfort to the various users and is considered an important part of the complete street where a community of 100,000 people replacing their cars by bicycle a month will reduce 3.764 tons of carbon dioxide gas (CO₂) per year. Yos Sudarso Road in Mamuju City is a road segment with activities in various zones, the intensity of activities that occur on the road is very high at certain hours, due to the different activities of the diversity of building functions. Road conditions that do not provide facilities for bicycle users require assessment of the needs of bicycle lane and analyze how the design of the concept of bike lane on the road segment is based on the complete street concept. The type of research used is non-experimental descriptive with the qualitative and quantitative approach, using a survey method in the form of direct observation at research sites, interviews and questionnaires. The condition of the road lane is not yet based on the complete street concept because there is no bicycle lane available as one of the complete street elements so it does not provide a sense of security and comfort for bicycle users. The need for bicycle lanes based on the responses of respondents is the need to provide bike lanes, on segment 1 with bike lane type, on segment 2 and segment 3 with bike lane type, for provision of bicycle lane based on bicycle volume and volume the traffic needs of the bike lane on Yos Sudarso road segment is not yet necessary to be provided. The recommended implementation of bicycle lane based on the concept of Complete Street is a bike lane (width of 1.5 meters for a one-way lane with elevated surfaces that can still be passed by motor vehicles in an emergency condition. A safe and comfortable bike lane improves people's enthusiasm using bicycles as a mode of transportation that can help reduce carbon dioxide (CO₂) gas and improve clean air quality.

1. Introduction

A complete street is a policy in the field of transportation in the form of a planning concept that ensures security for all road users; this concept is very concerned about the physical aspects of the existence of the completeness of a road. When done properly, this policy has many benefits for the city, such as user safety, connectivity, better health, reduced stress and improving economic prosperity [1, 2, 3].

The incomplete roads, designed only for cars, with limited transportation allowance make pedestrians, cyclists, and other transport users feel uncomfortable and safe and risk dangerous.



Planning roads that cover pedestrian, public transport, and cyclists need to make roads safer and easier for road users to pass [1, 2, 3].

The bicycle as a more environmentally friendly means of transportation which is an alternative mode of transportation that can replace motor vehicles to reduce the impact of global warming. A bicycle lane is a path specifically dedicated to the traffic of bicycle users and non-engineered vehicles that require workforce, separated from motor vehicle traffic to improve the safety of bicycle users [4]. Facilities for bicycle users provide a sense of security and comfort to various users and is considered an important part of the complete street, where if a society of 100,000 people replaces their cars by cycling a month, it will reduce carbon dioxide (CO₂) by 3.764 tons per year [5] [6]. The Yos Sudarso Road in Mamuju City belongs to the category of secondary arterial roads [7] is a three-lane two-lane road. The artificial tourist area of the Manamaran Beach Land of Mamuju Subdistrict is located on this road [8], has activities in various zones, i.e., offices, hotels, open plaza, markets, ports, mosques, shops and restaurants [9]. The intensity of activities that occur on the road is very high at certain hours; this is due to the different activities of the diversity of building functions. Road conditions that do not provide facilities for bicycle users require assessment of the needs of bicycle lanes and analyze how the design of the concept of bike lane on the road segment is based on the complete street concept.

2. Methodology

The type of research used is non-experimental descriptive with the qualitative and quantitative approach, using a survey method in the form of direct observation at research sites, interviews and questionnaires. To facilitate sampling, the study sites were divided into three segments with segment boundaries based on varying activity levels, and the behavior of road users sometimes did not cross/visit locations on each segment.



Figure 1. Research Sites.

3. Results and discussion

3.1 Analysis of Existing Condition of Yos Sudarso Road of Mamuju City.

Road condition on Yos Sudarso segment 1 has a width of 21.85 m does not have a separator direction with the function of the surrounding buildings such as hotels, government offices, sports fields and settlements in the form of dormitories Kodim.

Completed complete street elements in the research location, on segment 1 of Yos Sudarso road segment are only available in Maleo hotel entrance area, i.e., pedestrian, lanes, complete street elements such as street parking, bicycle facilities, and public transport facilities and transit are not yet available on segment 1.



Figure 2. Road conditions in Segment 1

Road condition on Yos Sudarso road segment 2 has width 22 m has no directional separation with the function of the surrounding buildings is very diverse and is the center of activity on Yos Sudarso Road.

Completed complete street elements in the research location, on the 2 segments of Yos Sudarso Road are only available on Manakarra beach platform, which is a pedestrian street, the pedestrian area is equipped with street furniture and tree protector. Other complete street elements such as street parking, bicycle facilities, and public transport and Transit facilities are not yet available in segment 2.



Figure 3. Road conditions in Segment 2

On Yos Sudarso Road segment 3 has a width of 21.25 m. There is a narrowing at the end of the road to the east in front of the Mamuju harbor and Mamuju Al-Quba mosque with a width of 11.4m. Road conditions do not have a directional separator with various building functions.

Other complete street elements owned by Segment 3 are crossing facilities, public transport facilities in the form of bus stops, based on observations on segment 3, there are no public transports in the form of buses or damri routinely passing through these lanes, so bus stops are available not used according to function.



Figure 4. Road conditions in Segment 3

Traffic conditions in the Yos Sudarso Road section can be seen in table 1, using the Bicycle User Volume formula [10].

Where:

Q = flow of bicycle users (person/m/min)

N = number of passing bike users (person/m)

T = observation time (minutes)

Table 1. Number and average of bicycle users

| Direction | Observation Period | Time (T= Minute) | Segment 1 | | | | Segment 2 | | | | Segment 3 | | | |
|---|--------------------|------------------|---------------------|-------------------|-------------------|------------------|---------------------|-------------------|-------------------|------------------|---------------------|-------------------|-------------------|------------------|
| | | | Saturday (N-person) | Sunday (N-person) | Monday (N-person) | Total (N-person) | Saturday (N-person) | Sunday (N-person) | Monday (N-person) | Total (N-person) | Saturday (N-person) | Sunday (N-person) | Monday (N-person) | Total (N-person) |
| 1 | 06.00-08.00 | 120 | 20 | 58 | 1 | 79 | 22 | 47 | 10 | 79 | 25 | 45 | 8 | 78 |
| 2 | | | 32 | 67 | 4 | 103 | 14 | 21 | 2 | 37 | 26 | 36 | 11 | 73 |
| 1 | 08.00-10.00 | 120 | 7 | 19 | 0 | 26 | 8 | 0 | 3 | 11 | 10 | 16 | 4 | 30 |
| 2 | | | 11 | 22 | 0 | 33 | 5 | 3 | 0 | 8 | 11 | 12 | 4 | 27 |
| 1 | 10.00-12.00 | 120 | 1 | 4 | 1 | 6 | 2 | 2 | 2 | 6 | 0 | 19 | 5 | 24 |
| 2 | | | 0 | 4 | 4 | 8 | 0 | 2 | 1 | 3 | 0 | 27 | 6 | 33 |
| 1 | 12.00-14.00 | 120 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 3 |
| 1 | 14.00-16.00 | 120 | 17 | 2 | 0 | 19 | 8 | 0 | 5 | 13 | 26 | 12 | 6 | 44 |
| 2 | | | 15 | 2 | 4 | 21 | 6 | 1 | 5 | 12 | 20 | 0 | 3 | 23 |
| 1 | 16.00-18.00 | 120 | 6 | 39 | 12 | 57 | 27 | 48 | 2 | 77 | 35 | 41 | 11 | 87 |
| 2 | | | 6 | 40 | 18 | 64 | 18 | 30 | 2 | 50 | 30 | 38 | 6 | 74 |
| 1 | 18.00-20.00 | 120 | 4 | 3 | 7 | 14 | 3 | 4 | 12 | 19 | 0 | 1 | 1 | 2 |
| 2 | | | 4 | 3 | 11 | 18 | 2 | 4 | 16 | 22 | 4 | 1 | 3 | 8 |
| 1 | 20.00-22.00 | 120 | 2 | 0 | 1 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 3 |
| 2 | | | 0 | 0 | 2 | 2 | 0 | 0 | 4 | 4 | 0 | 0 | 3 | 3 |
| Total T and N | | | 125 | 263 | 65 | 453 | 115 | 162 | 64 | 341 | 137 | 249 | 76 | 582 |
| Total Person/Minute (Q=NT) | | | 0.19 | 0.27 | 0.07 | 0.47 | 0.12 | 0.17 | 0.07 | 0.36 | 0.19 | 0.26 | 0.08 | 0.53 |
| Average person/flow (Q=60 minutes) | | | 8 | 16 | 4 | 28 | 7 | 10 | 4 | 21 | 12 | 16 | 5 | 32 |

Direction 1 = Direction to port; Direction 2 = Direction to arterial roads

From table 1, we can see the activity of bicycle users is quite high on Saturday and Sunday morning at 06.00-07.00 am, the majority of bicycle users take advantage of the road as a means of bicycle exercise in the morning, before noon, bicycle activity is reduced because the road conditions are not equipped with shade trees and unfavorable weather conditions for cycling activities.

Activities using the bike again increased by the afternoon, the majority of bicycle users also take advantage of this road as a means of cycling sport, it is influenced because the weather has started to support. Cycling activity again declines late in the night, this is influenced by the increasing activity of other vehicles on this line, and also because of the unavailability of the bicycle user path including enough lighting for cycling.

3.2. Needs Analysis of Bicycle Lane from Complete Street.

3.2.1. Concept Bicycle user's security perception. The criteria used in measuring the level of security are the design criteria and the characteristics of the bicycle path [11], the security measured is the security of accidents that may arise resulting, road conditions, barriers, visual, etc. The results of the responses of respondents can be seen in table 2.

Table 2. Perception of segment bike user safety

| How Often Respondents Crosses the Road | Do you feel safe passing on this road by bicycle | | | | Total |
|---|--|--------|----------------|---------------|-------|
| | Very Secure | Secure | Less Secure | Not Secure | |
| Segment 1 | | | | | |
| Very often (≥ 7 times a week). | 0 | 0 | 2 | 4 | 6 |
| Often (5 - 6 times a week) | 3 | 4 | 2 | 4 | 13 |
| Sometimes (3 - 4 times a week) | 0 | 0 | 5 | 18 | 23 |
| Rarely (1-2 times a week) | 0 | 3 | 6 | 9 | 18 |
| Total | 3 | 7 | 15 | 35 | 60 |
| Segment 2 | | | | | |
| Very often (≥ 7 times a week) | 0 | 1 | 0 | 2 | 3 |
| Often (5 - 6 times a week) | 0 | 1 | 4 | 8 | 13 |
| Sometimes (3 - 4 times a week) | 1 | 4 | 5 | 8 | 18 |
| Rarely (1-2 times a week) | 1 | 3 | 6 | 16 | 26 |
| Total | 2 | 9 | 15 | 34 | 60 |

| | | | | | |
|-------------------------------------|----------|-----------|-----------|-----------|-----------|
| Very often (≥ 7 times a week) | 4 | 4 | 2 | 2 | 12 |
| Often (5 - 6 times a week) | 0 | 2 | 4 | 8 | 14 |
| Sometimes (3 - 4 times a week) | 2 | 2 | 8 | 8 | 20 |
| Rarely (1-2 times a week) | 0 | 2 | 8 | 4 | 14 |
| Total | 6 | 10 | 22 | 22 | 60 |

Source: Results of the questionnaire, 2018.

Based on table 2, it can be seen that respondents feel unsafe passing through the road of research sites by cycling, the number of respondents who choose quite dominant with the intensity of crossing the road that is sometimes and often. Respondents who felt safe had fewer respondents where the intensity of the road was frequent and occasional. So, the overall response to safety passing through the streets on foot is unsafe.

3.2.2. Perceptions of the respondent comfort of bicycle users. The criteria used in measuring the comfort level are design criteria and bicycle lane characteristics such as bicycle-only lanes, physical separators, no slippery, no puddles, with signposts [11]. Measures measured are comfortable feelings when passing as measured by the availability of infrastructure, geometry, protection, visual and lighting.

Based on table 3, can be seen respondents feel uncomfortable crossing the road location research by cycling with intensity across the road that is sometimes. Respondents who felt safe were smaller with the intensity of crossing the road that sometimes, the overall response to the sense of comfort passing on the road by cycling was uncomfortable.

Table 3. Perception of segment bike user convenience

| How Often Respondents Crosses the Road | Do you feel safe passing on this road by bicycle | | | | Total |
|---|--|-------------|---------------------|--------------------|-------|
| | Very Comfortable | Comfortable | Less Comfortable | Not Comfortable | |
| Segment 1 | | | | | |
| Very often (≥ 7 times a week). | 0 | 1 | 2 | 3 | 6 |
| Often (5 - 6 times a week) | 3 | 4 | 1 | 5 | 13 |
| Sometimes (3 - 4 times a week) | 0 | 0 | 8 | 15 | 23 |
| Rarely (1-2 times a week) | 0 | 2 | 9 | 7 | 18 |
| Total | 3 | 7 | 20 | 30 | 60 |
| Segment 2 | | | | | |
| Very often (≥ 7 times a week) | 0 | 1 | 1 | 1 | 6 |
| Often (5 - 6 times a week) | 1 | 1 | 5 | 6 | 13 |
| Sometimes (3 - 4 times a week) | 1 | 6 | 5 | 6 | 18 |
| Rarely (1-2 times a week) | 0 | 3 | 10 | 13 | 26 |
| Total | 2 | 11 | 21 | 26 | 60 |
| Segment 3 | | | | | |
| Very often (≥ 7 times a week) | 4 | 3 | 3 | 2 | 12 |
| Often (5 - 6 times a week) | 0 | 1 | 5 | 8 | 14 |
| Sometimes (3 - 4 times a week) | 2 | 2 | 5 | 11 | 20 |
| Rarely (1-2 times a week) | 0 | 2 | 5 | 7 | 14 |
| Total | 6 | 8 | 18 | 28 | 60 |

Source: Results of the questionnaire, 2018

3.2.3. Perception of the bicycle lane. Perceptions of bicycle lanes on the segment is taken from bicycle user respondents. From the questionnaire results for the first question on segment 1, there was 1 respondent answered did not feel the need provided bicycle lane where the intensity of the respondent crossed the street frequently, and 59 respondents answered felt necessary with the intensity of respondents cross the road frequently. In segment 2 there were 5 respondents answered did not feel the need to be provided by bicycle path with intensity across the road divided by the number of frequencies and 55 respondents answered felt necessary where the intensity of respondents frequently crossed, while in segment 3, all respondents answered felt need to be provided bike lane with the intensity of respondents across the street is quite diverse with the dominant number of respondents

who pass very often and often. Overall for the first question, respondents expect on the road, provided bike path, the responses of respondents can be seen in figure 5.

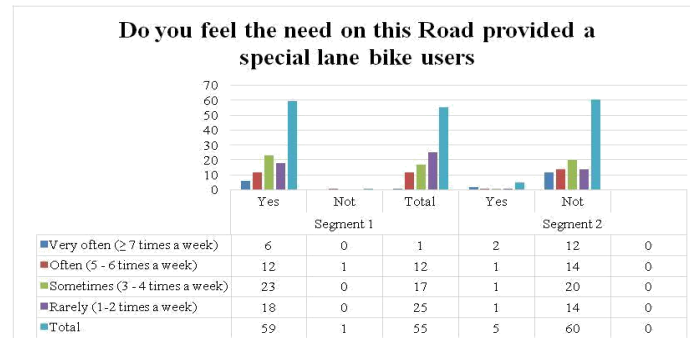


Figure 5. Graph of bicycle user response to the bicycle lane.

For the next question, in segment 1, there were 31 respondents chose bicycle lane consisted of bike lane intensity that is sometimes and often, from the result. It can be concluded that the respondents who cross the road in segment 1 expect to be provided bicycle lane with bike lane type (bike lane).

In the second segment, there were respondents who chose almost the same number of bike lanes and bike lanes of 27 respondents and 26 respondents respectively, but what if respondents responded based on the intensity of crossing the road, the number often and very often choose the bike lane more than the respondents choose the bike line (bike lane), so from the results it can be concluded that the respondents who cross the road in segment 2 expect to be provided bike lane with the type of bike path (bike lane).

Response on segment 3, that is 30 respondents choose the bicycle lane bike lane with the intensity of respondent passing very often and often, so it can be concluded that respondents who crossed hoped provided bicycle path with the type of bike lane (bike lane), the responder can be seen in figure 6.

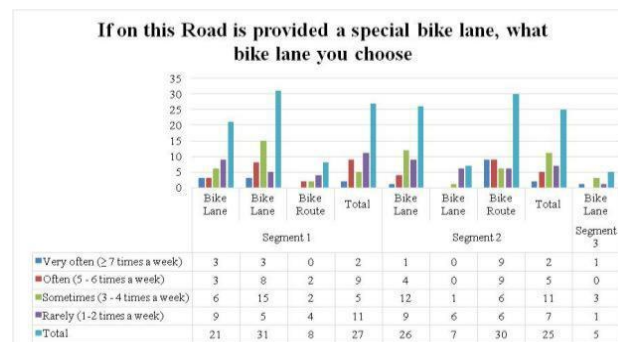


Figure 6. Graph of bicycle user response to bike lane type.

3.2.4. *Needs Bicycle Lane*. Based on the volume of bicycle users, the recommended bike lane width [12,13] is:

Table 4. Recommended bike lane width

| Bicycle User Volume | Configuration | Bicycle Lane Width |
|-----------------------|-----------------------|--------------------|
| <1,500 cyclists / day | In the same Direction | 2,25m |
| | Two-way direction | 2,75m |
| <1,500 cyclists / day | In the same Direction | 2,50m |
| | Two-way direction | 3,00m |

While one of the provisions of the bike lane that is when the volume of the bicycle exceeds 200 per 12 hours and traffic volume exceeds 2000 per 12 hours should be provided special lane bicycle [14].

In table 1, the number and average of bicycle users have obtained only on weekdays in segment 1 and segment 3 with number > 200 cyclists while on other days on each segment <200 cyclists. The daily traffic volume on the Yos Sudarso road segment taken on Saturdays, Sundays, and Mondays found <2000 per 12 hours [15].

About the provision of bicycle lanes, based on the volume of bicycles and traffic volume, the need for a bicycle path on the Yos Sudarso road is not yet necessary to provide.

3.2.5. Implementation of Bicycle Lane from Complete Street Concept. The existing condition of the Yos Sudarso road does not occur on the bike lane, the activity of bicycle users is quite high on Saturday and Sunday morning, the majority of bicycle users take advantage of the road as a means of cycling sports in the morning, during the day bicycle activity is reduced due to road conditions that do not equip with shade trees and unfavorable weather conditions for cycling activities. From the analysis of existing conditions on the road segment, respondents felt unsafe and uncomfortable crossing the road of research sites by cycling.

Recommended bicycle lane as a complete road element that can meet Elements of bicycle facilities and characteristics of bicycle path is bike lanes, a part of road marked with marker for bicycle use is made in the direction of the motorway flow, located at the far left of the motorized traffic lane, by reducing the width of the traffic lane. The recommended width of 1.5 meters for one-way lanes, the bicycle lane is separated by physical barriers to motorized traffic lanes with a design that allows bike lanes to pass through motor vehicles in an emergency condition of altitude disclosure [11, 14]. The application of the concept of a bicycle lane as a safe and comfortable complete street element based on design criteria for bicycle users can increase the enthusiasm of people using bicycles as modes of transportation to improve the quality of clean air and help reduce carbon dioxide gas (CO₂) [6].

4. Conclusion

- The condition of the road lane is not yet based on the complete street concept because there is no bicycle lane available as one of the complete street elements, so it does not provide a sense of security and comfort for bicycle users.
- The need for bicycle lanes based on the responses of respondents who crossed the road felt the need to provide bike lanes, with bike lane segment 1 type, in segment 2 and segment 3 with bike lane type. While the provision of bicycle lane based on the volume of bicycles and traffic volume obtained the need for bike lanes on Yos Sudarso road segment is not yet necessary to be provided.
- Recommendation of bicycle lane as a complete road element that can fulfill the element of bicycle facilities and characteristic of bike lane is bike lanes, recommended 1.5 meter width for one way lane, bicycle lane separated by physical barriers to motorized traffic lane with a design that allows the bike lane can still be passed by motor vehicles in an emergency condition of altitude discrimination.
- The application of the concept of bicycle lane as a safe and comfortable complete street element based on the design criteria for bicycle users can increase the enthusiasm of people using bicycles as modes of transportation to improve the quality of clean air and help reduce carbon dioxide gas (CO₂).

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