Analysis on the Motorcycle-Exclusive Lane Implementation for the Urban Arterial Road in Banda Aceh City

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Abstract. A motorcycle-exclusive lane was implemented since 2015 at busiest urban arterial road in the city center of Banda Aceh. However, this policy seen to be ineffective as indicated by the low obedience by the motorcycle users. This study was, therefore, conducted to analyze the determinant of the implementation of motorcycle-exclusive lane. This involved infrastructure observation and road user direct interview through questionnaires survey. Target respondent was motorcyclist who used motorcycle-exclusive lane within the study area. A total volume of these users was observed to be 364 vehicles/day and drawn the sample as much as 170 samples were selected for data analysis using the Principal Component Analysis (PCA). The PCA found that the main factors influencing the implementation of the motorcycle-exclusive lanes include the sign, lane support, motorbike, and speed factors with each having its significant explanatory level. Finding depict that greatest factor had 26.419% variant of Factor 1 with technical improvement delivers to aspect of motorcycle-exclusive lanes must have traffic signs showing the entry and exit locations of motorbikes, must have motorcycle-exclusive lanes with information prohibiting the motorbikes from stopping, and motorcycle-exclusive lane signs must install in the needed place and easily visible to users.

1. Introduction

A motorcycle is a two-wheeled vehicle driven by a machine and observed to have become the dominant means of transportation used in almost all cities in Indonesia. Its population has been projected to be increasing every year and this means the potential for transport externalities in the city [1-2]. Considering the traffic accident, WHO [3] reported the number of deaths based on road users in Indonesia, where 74% of deaths were contributed by motorcyclists. The report noted that Indonesia is a developing country with a profoundly serious vulnerability due to two-wheeler accidents. Several factors such as driver behavior, road pavement conditions, traffic flows, vehicle conditions, and the environment could lead to the vulnerability. Furthermore, previous research has argued that the risk-taking behavior has influenced by riding behavior, and the awareness of motorcycle rider affected the riding behavior significantly [4].

One of the efforts proposed and implemented by the government to reduce the number of accidents and ensure safety is the provision of motorcycle-exclusive lanes. This method has also been applied in other countries such as Malaysia with the government reported to have provided the motorcycle-exclusive lanes on several normal and toll roads and placed next to the left lane of the road only to be used by motorbikes with engine capacities below 250cc. This effort was reported to be effective as indicated by a decrease in the number of accidents by 39% one year after its implementation [5]. Meanwhile, the lane was officially implemented for the first time in Indonesia by July 2007 at Raya Darmo road and has been reported to have reduced motorbikes accidents by 76.75% [6]. Following
this successfully implementation, the Government of Aceh has been implemented the motorcycle-exclusive lane to reduce accidents. However, it is observed that to be ineffective as evident with the low obedience level of the motorcycle users using the lane. The ineffectiveness was discovered to be due to the failure of the lane design to fully accommodate several factors associated with traffic, vehicle lane, roadside, side freedom, and signs and markings. Therefore, this study aims to evaluate the influencing factors from the perspective of the motorcycle users to gain deepest insight from the user perspectives, and this information could be used to design more effectively of the motorcycle-exclusive lanes.

2. Materials and Methods
2.1. Study Area and Sample Size

This work is focused on motorcycle-exclusive lane designed for motorcycles at the Tgk. H. Mohd. Daud Beureueh in the city of Banda Aceh, a capital province of Aceh. This road is busiest arterial road which connected the suburban area to the city centers. During peak hour traffic, this road has attracted many motorcycle users and experienced serious autos traffic. The motorcycle-exclusive lane within the city center of Banda Aceh is illustrates in Figure 1.

![Figure 1. The map of study area](image)

Target respondents in this study is motorcycle users passing through the targeted motorcycle-exclusive lane or motorcycle usage who parked near by study area. As for the sample size used in this study, according to Sekaran and Bougie [7] in multivariate research the sample size should be several times (preferably 10 times or more) as large as the number of variables in the study. Furthermore, Hair et al [8] the normality of the dataset can have serious effects for small samples fewer than 50 cases however this problem could be reduced when sample sizes reach 200 or more. In terms of absolute size, researchers generally would not factor analyze a sample of fewer than 50 observations, and preferably the sample size should be 100 or larger. In this study, 17 of indicators used as a determinant variable and measured them using the preference of the four-point Likert scale: 1 = strongly unsatisfied/importance to 4 = strongly satisfy/importance [9-10].

2.2. Data Collection Technique

Data were collected through observation and questionnaires and the process for each is described as follows: (1) Observation: this was used to determine the average daily traffic volume of motorbikes on the motorcycle-exclusive lane. This involved recording the number of motorbikes plying the route during rush hours of 07.00 – 09.00 for three consecutive days, Tuesday, Wednesday, and Thursday,
and the value was observed to be 364 vehicles/day; (2) Questionnaire: this was used to determine the perception of the respondents on the factors affecting the implementation of the motorcycle-exclusive lane. Some of those reviewed include traffic, vehicle lane, roadside, side freedom, and signs and markings and the responses were measured using the Likert scale. The questionnaires were distributed in person and the respondents were asked to select answers provided by using a checklist (√). It is important to note that assistance was provided during the survey with the researchers explaining unclear questions to the respondents.

2.3. Data Analysis Technique

The data was analyzed using Principal Component Analysis (PCA) with the focus on reducing the dimensions of a data set consisting of many interrelated variables while maintaining variation as much as possible. This was achieved by converting the data into a new set of variables with the uncorrelated main components sorted to ensure the first few variables retain most of the variations existing in all the original ones. The PCA was used to evaluate the factors affecting the use of the motorcycle-exclusive lane using a source to determine those associated with the research location area. The steps conducted for the PCA factor analysis using the SPSS version 26 software are as follows:

a. Matrix correlation: this was used to check the possibility of forming all indicators obtained from the source into a factor, to ensure the number of samples determined is sufficient for the PCA, and to select several indicators obtained from the source appear in the research area. The requirements for the correlation matrix parameters are, therefore, this consisted of several steps namely (a) if the Kaiser Meyer Olkin (KMO) value > 0.5 then all indicators from the source can be formed into a factor but if it is < 0.5 then all indicators cannot be formed into a factor; (b) if the value is Sig. < 0.05 then the specified number of samples of 170 respondents is sufficient for PCA but if it is > 0.05 the number of samples is insufficient. The follow-up when the Sig. > 0.05 is to ensure the maximum sample formula is 10 times the number of indicators; (c) if the indicator has an MSA value > 0.5 then it appears in the research area but if it is < 0.5 then several indicators from the source do not appear in the study area. The follow-up when several indicators have an MSA value < 0.5 is to conduct further experiments by eliminating the indicators with the smallest value.

b. Factor extraction: this was used to determine the number and contribution of factors formed as well as the presence of the dominant factors. The requirements for the factor extraction parameters are as follows (a) if the eigenvalue > 1 stops at the position of a certain component or indicator, then some factors can be formed according to the position of such component; (b) the component with the highest variance value is the dominant factor; (c) the final cumulative value shows the contribution of several factors formed expressed as a percentage.

c. Factor rotation: this was used to distribute the number of indicators to the factor groups formed. An alternative to this method is the orthogonal rotation which is a 90° rotation of the axis using the varimax method. The condition for the factor rotation parameter includes the inclusion of the indicator with the highest loading factor value in a factor.

d. Factor naming: this is the next stage after the factors have been formed and all existing indicators were considered to ensure they adequately represent the factors they were used to name.

3. Results and Discussion

3.1. Correlation Matrix of the Motorcycle-Exclusive Lane Determinants

Firstly, we checked whether all indicators obtained from a source can be factored or not provided the Kaiser-Meyer-Olkin (KMO) > 0.5. The second was to ensure the specified number of samples is sufficient for the PCA provided the Sig. < 0.05. The third was to select all indicators obtained from a source and determine whether they appear or not in the study area provided the Measure of Sampling Adequacy (MSA) > 0.5. We conducted five experiments to avoid insignificant parameters of motorcycle-exclusive lane determinants. Experiment 5 confirmed that all determinants is significant with KMO > 0.5, at Sig. < 0.05, and MSA < 0.5. Using the result of experiment 5 then we conducted
3.2. Extraction, Factoring and Naming Factor Of The Motorcycle-Exclusive Lane Determinants

This stage also has 3 main objectives and the first was to determine the total factors formed by counting the number of components or indicators with eigen values > 1 (see bolded values in Table 1). The second was to determine the dominant factor by looking at the highest variance value on one of the factors, and the third was to determine the contribution of several factors formed by looking at the cumulative variance value as shown Table 1. Table 1 shows components 1 to 4 had eigenvalues > 1 and this means that there are 4 factors out of the 13 indicators in the study area. Meanwhile, the highest variance value, 26.419%, was recorded in component 1 and this means it is the dominant factor while the cumulative variance value was obtained at 60.692% which was the contribution of the four factors. The varimax method used as the alternative could reduce the initially small loading factor while the large loading factor is increased. Table 2 shows the highest loading factor was in each indicator for each factor.

| Component/Indicator | Total | Variance (%) | Cumulative (%) | Factor Extraction |
|---------------------|-------|--------------|----------------|-------------------|
|                     |       |              |                | Total             |
| 1                   | 3.435 | 26.419       | 26.419         | 3.435             |
| 2                   | 2.190 | 16.849       | 43.268         | 2.190             |
| 3                   | 1.175 | 9.036        | 52.304         | 1.175             |
| 4                   | 1.090 | 8.388        | 60.692         | 1.090             |
| 5                   | 0.836 | 6.433        | 67.125         |                   |
| 6                   | 0.744 | 5.722        | 72.846         |                   |
| 7                   | 0.677 | 5.209        | 78.055         |                   |
| 8                   | 0.671 | 5.165        | 83.220         |                   |
| 9                   | 0.580 | 4.463        | 87.683         |                   |
| 10                  | 0.518 | 3.985        | 91.669         |                   |
| 11                  | 0.435 | 3.346        | 95.015         |                   |
| 12                  | 0.375 | 2.886        | 97.901         |                   |
| 13                  | 0.273 | 2.099        | 100.000        |                   |

This last stage was used to attach names to the factors based on the tendency of the indicator characteristics to gather in the formed factors. The process was, however, more subjective to ensure several indicators in a factor are adequately represented. The names for each of the formed factors are, therefore, described as follows: (1) Factor 1: this factor consists of three indicators namely (a) motorcycle-exclusive lanes have traffic signs showing the entry and exit locations of motorbikes; (b) there are motorcycle-exclusive lanes with information prohibiting the motorbikes from stopping; (c) motorcycle-exclusive lane signs are installed in the needed place and easily visible to motorbikes; (2) Factor 2 consists of 4 indicators (a) for roads with very limited conditions, the roadside can be removed and replaced with a guard rail; (b) the motorcycle-exclusive lane side freedom should be able to provide visibility to ensure it does not interfere with the view of the rider; (c) the special side lane freedom arrangement should not interfere with the vehicle’s maneuvering operation; (d) motorcycle-exclusive lane traffic markings in the form of marginal strips should provide traffic directions; (3) Factor 3 consists of 3 indicators (a) the motorbikes volume in a motorcycle-exclusive lane is not more than 850 vehicles/hour/lane; (b) the width of motorbikes entering the motorcycle-exclusive lane is approximately 80 cm; (c) the motorbikes engine capacity in the motorcycle-exclusive lane is estimated at 125 cc; (4) Factor 4 consists of 3 indicators (a) motorcycle speed on motorcycle-exclusive lanes is not more than 33 km/h; (b) the motorcycle-exclusive lane width should be used to overtake one motorcycle; (c) design speed on motorcycle-exclusive lanes is not more than 40 km/h.
Table 2. Rotation of the motorcycle-exclusive lane determinants

| Indicator                                                                 | Factor     |
|---------------------------------------------------------------------------|------------|
| The motorbikes volume on a motorcycle-exclusive lane is not more than 850 vehicles/hour/lane | -0.452, 0.137, 0.608, 0.241 |
| Vehicle speed on motorcycle-exclusive lanes is not more than 33 km/h | 0.406, 0.365, 0.149, 0.498 |
| The motorcycle-exclusive lane width should be used to overtake one motorbike | 0.004, -0.160, 0.812 |
| Design speed on motorcycle-exclusive lanes is not more than 40 km/h | 0.437, 0.350, -0.519, 0.135 |
| The width dimensions of motorbikes that enter motorcycle-exclusive lanes are around 80 cm | 0.437, 0.005, 0.681, 0.234 |
| The motorbikes engine capacity that enters the motorcycle-exclusive lane ranges from 125 cc | 0.249, 0.272, 0.792, - |
| For roads with limited conditions, the roadside can be removed and replaced with a guard rail | -0.064, 0.518, 0.409, 0.117 |
| The motorcycle-exclusive lane side freedom should be able to provide a clear view, therefore it does not interfere with the driver view | 0.010, 0.799, 0.088, 0.088 |
| The motorcycle-exclusive lane side freedom arrangement should not interfere with the vehicle operation for maneuvering | -0.157, 0.783, 0.035, 0.047 |
| Motorcycle-exclusive lanes have traffic signs with location information about the motorcycle entry and exit | 0.715, -0.221, 0.232, 0.005 |
| There are motorcycle-exclusive lanes with information about the prohibition of stopping and easily visible to motorbikes drivers | 0.616, -0.100, 0.015, 0.225 |
| Motorcycle-exclusive lane signs are installed in the needed place and easily visible to motorbikes drivers | 0.797, -0.102, - |
| Motorcycle-exclusive lane traffic markings in the form of marginal strips should provide traffic directions | 0.097, 0.485, 0.222, 0.360 |

The PCA analysis results showed the main factors influencing the implementation of the motorcycle-exclusive lanes include the sign, lane support, motorbike, and speed factors with each having its explanatory variant or level. It was, therefore, discovered that the sign factor had 26.419% variant with 3 indicators, lane support had 16.849% with 4 indicators, motorbikes had 9.036% with 3 indicators, and speed had 8.388% with 3 indicators. This means the dominant factor is the sign since it has the highest variant value of 26.419% and its indicators include the information on the entry and exit locations of motorbikes, traffic signs, information on stopping restrictions, as well as the signs installed on the place they are needed and easily visible to motorcyclists. It was also discovered that 13 out of 17 evaluated indicators needed for the implementation of motorcycle-exclusive lanes for motorcycle have been used by the Government. These indicators were grouped into 4 factors with an application rate of 60.69% while the remaining 39.31% was found to be associated with 4 indicators not implemented on the motorcycle-exclusive lane and they include traffic signs with information on speed limits, parking information signs at certain locations, traffic markers installed at the needed place and easy to understand, and the ability of the roadside to provide movement flexibility for motorcyclists.

Comparing with previous study, research conducted in Surabaya City showed the indicators of motorcycle lane implementation required to be maintained include the motorcycle lane safety, smoothness, comfort, and speed limit, and those observed to have excessive performance were lane guard rail and special signs [11]. Furthermore, another study in Jakarta City showed that 45% of motorcyclists were averagely spread out on the left and center lanes while the remaining 10% were on
the right side. The percentage of motorbikes in the left lane moved between 40% and 60% when the V/C ratio value was high regardless of the high and low number of motorcycles [12]. Further research conducted in Depok City also showed an increment in the performance of the Margonda Raya 2 road section after the implementation of special motorcycle lanes for non-motorcycle lanes while the degree of saturation decreased [13].

4. Conclusion

The principal component analysis found that the main factors influencing the implementation of the motorcycle-exclusive lanes include the sign, lane support, motorbike, and speed factors with each having its significant explanatory level. Finding depict that greatest factor had 26.419% variant of Factor 1 with technical improvement delivers to aspect of motorcycle-exclusive lanes must have traffic signs showing the entry and exit locations of motorbikes, must have motorcycle-exclusive lanes with information prohibiting the motorbikes from stopping, and motorcycle-exclusive lane signs must install in the needed place and easily visible to users. Findings further explore that factor 2 with variance explained 16,849% has shown significant contribution to improvement the motorcycle-exclusive lanes by considering lane width and removing roadside obstacles, the motorcycle-exclusive lane side freedom should be able to provide visibility to ensure it does not interfere with the view of the rider, the special side lane freedom arrangement should not interfere with the vehicle’s maneuvering operation and motorcycle-exclusive lane traffic markings in the form of marginal strips should provide traffic directions.

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