Performance road before and during pandemic COVID-19

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Abstract. The COVID-19 case was first identified in Makassar City, Indonesia on March 2020, then continued to experience an increase in positive cases and was designated as a red zone/epicenter of the spread of COVID-19. On April 24, 2020, the city government for the first time took steps to limit activities outside the home for the community to reduce the risk of spreading the COVID-19 virus. On April 29, 2020, Gowa Regency is bordered to the north of Makassar city also implemented mobility restrictions for the community from/to Gowa/Makassar. One of the intercity border roads between Makassar City and Gowa Regency and which is often used as connecting access for the two regions is Daeng Tata Lama Street, Makassar City. The purpose of this research is to compare the performance and traffic modeling of the intercity border road before pandemic condition and during the pandemic. Methods for traffic modeling are Green shields, Greenberg, and Underwood, while Indonesian Highway Capacity Guidelines 2014 method for traffic performance. The results showed that the traffic performance (degree of saturation value) before the pandemic occurred was higher than in the new normal and travel restriction conditions. However, the average speed is lower in the travel restriction and new normal conditions than in the before pandemic condition.

1. Introduction

Non-natural disasters, the COVID-19 pandemic affects people's mobility. The impact of the pandemic also occurred in Makassar City and Gowa Regency in South Sulawesi Province. The positive COVID-19 case was first identified in Makassar City in March 2020, then continued to experience an increase in positive case and was designated as a red zone/epicenter of the spread of COVID-19. Gowa Regency which is located in south of Makassar City, is one of the satellite cities for Makassar City. On April 24, 2020, the government of Makassar took step to limit outdoor activities for the community to reduce the risk of spreading the COVID-19 virus. On April 29, 2020, Gowa Regency participated in implementing mobility restrictions for people from Gowa to Makassar and vice versa. Restriction of people and goods using the mode of transportation is one of the steps in implementing the travel-social restriction [1].

During the implementation of travel restrictions, the authorities are closely guarding every border route between Makassar City and Gowa Regency. On August 2020 was implemented as the new normal during the pandemic. Changes in community mobility in South Sulawesi Province, in particular, have an impact on several sectors. Based on Google's mobility report data on November 17, 2020, specifically for South Sulawesi Province, community mobility for the retail and recreation sector experienced a 9% decrease, public transportation centers with a 28% decrease, workplaces with a 25% decrease in mobility, while those with increased mobility towards grocery stores and pharmacies, parks, and
residential areas, respectively 10%, 7%, and 7% [2]. South Sulawesi mobility report during pandemic (dated 17 November 2020) can be seen in figure 1.

One of the alternative roads which is the border route between Makassar City and Gowa Regency and which is often used as connecting access for the two regions is the Daeng Tata Lama, Makassar City. From Makassar to Gowa can be accessed the Sultan Hasanuddin section (Gowa Regency) via the Daeng Tata Lama section, or from the Daeng Tata Lama section to Pallangga District, Gowa, by using river transportation modes (raft/beseang boats - local transportation). The same section is also used for movement from Gowa to Makassar.

![Figure 1. South Sulawesi Province’s Mobility Report During Pandemic COVID-19 (dated 17 November 2020)](image)

The purpose of this research is to compare the performance and traffic modeling of the connecting roads between Makassar City and Gowa Regency in the pre-pandemic and pandemic periods. Several previous studies include traffic performance to measure the impact of COVID 19 on urban mobility with the Greater Seattle Washington case study changing traffic patterns, traffic needs, and driving behavior [3].

The effect of COVID-19 on driving behavior and safety indicators captured through a smartphone application developed specifically where this indicator is reflected in the spread of COVID-19 and the respective government countermeasures in two countries, namely Greece and the Kingdom of Saudi Arabia (KSA). That reduced traffic volume due to quarantine due to Covid-19 led to 6–11% increase in speed, cellphone use (up to 42%) during March and April 2020, which are the months when the spread of COVID-19 is at its peak. However, accidents in Greece were reduced by 41% during the first month of action triggered by COVID-19, and driving in the morning (00:00–05:00) which is considered dangerous fell by 81% [4].

The impact of quarantine due to the spread of the Covid-19 virus in Spain, public transport user fell by 93%, NO2 emissions were reduced by 60%, and traffic accidents by 67% in relative term. [5] Spatially and temporally changing due to the pandemic limiting people's activities and movements, where traffic has decreased vehicle volume by 47.5%. The decline occurred not only in urban areas but also in rural areas [6]. Traffic reduction occurs when an area is designated as an orange zone and decreases when the spread of the Covid-19 virus increases and becomes a red zone [7].

It is imperative that public authorities ensure equal access to transport, invest in resilient infrastructure (taking environmental and health externalities into account), and support active mobility...
The COVID-19 pandemic will produce positive and negative indirect effects on the environment. Increase in waste during a pandemic is harmful to the environment (air, water, and land). An increase in travel time of 5-10 minutes is possible in cities with high transit, which adds up to hundreds of thousands of hours of additional travel time each day when quarantine conditions due to COVID-19 are no longer enforced.

The application of working from home during a pandemic has indirectly helped reduce the level of congestion on the roads. Public transport passenger safety awareness during a pandemic is the biggest predictor of passenger safety behavior followed by behavioral control, vulnerability, and subjective attitudes and norms. Using the Richards model, predicted the best scenario in South Sulawesi, the current data tends to slow down where the COVID-19 pandemic is expected to end in November 2020 with a cumulative number of cases between 10,000 and 12,000 cases.

2. Methodology
Traffic survey conducted on weekdays, for 10 hours, and at 5-minute intervals at the end of January 2020 before the pandemic, early May 2020 for travel-restrictions, and August 2020 for new normal condition. The Daeng Tata Lama road section has a geometric type 2/2 UD road without sidewalks and shoulders, has a width of 5 m, the condition of the pavement was good. Analysis methods of the 2014 Indonesia Highway Capacity Guidelines for road performance (degree of saturation) and the Green shields, Greenberg, and Underwood models for modeling the relationship between traffic parameters. Study location is presented in Figure 2.

3. Results and Discussion
3.1 Traffic Modeling
The condition before the pandemic, the speed-density, flow-density, and flow-speed relationship using the Green shields model, were 35-0.432k, 35k-0.432k², and 81V-2.31V² respectively. The maximum capacity, maximum density, and free flow velocity values of the Green shields model, respectively 708.75pcu/h, 81pcu/km/ln, and 35 km/h. The Greenberg model, for the relationship of speed-density, flow-density, and flow speed, respectively Ln k/-15,65- Ln 0,234, k (Ln k/-15,65) - k. (Ln 3.66/15.65), and 3.66V. e (15.65V). Underwood's model, the speed-density relationship is 35e (-k/3,06), 81k (ln 35 - ln V) for flow-speed relationship, and for flow-density relationship, namely 35k.e (-k/3.06). Traffic modeling before pandemic COVID-19 is presented in Figures 3, 4, and 5.
From the Green shields model, for travel restriction conditions, the relationship between flow-density is $37k-1,276k^2$, flow-speed is $29V-0.784V^2$, and speed-density is $37-1,276k$. Whereas with the Greenberg model, the relationship between flow-density, flow-speed, and speed-density is $k. (\ln k/5.76) - k (\ln 0.29), 1.68V e (5.76V)$, and $\ln k/5.76 - \ln 0.29$. While analyzed with Underwood's model, the
relationship between flow-density, flow-speed and speed-density is \(28 \text{k} \exp\left(-\frac{k}{29}\right), \ 29 \text{k} \left(\ln 28 - \ln \text{V}\right),\) and \(28 \exp\left(-\frac{k}{-0.347}\right).\) Traffic modeling during travel restriction is presented in Figures 6, 7 and 8.

In the new normal condition, the flow-speed relationship with the Green shields model is \(28\text{V}-0.78\text{V}^2;\) Greenberg model is \(3,193\text{V} \cdot e\left(-17,772\text{V}\right);\) and Underwood model is \(28 \ln (36 - \ln \text{V}).\) Meanwhile, the flow-density relationship from the Green shields is \(36\text{k} - 1.28571\text{k}^2;\) Greenberg is \(\text{k} \left(\ln (\text{k})/17,771\right) - \text{k} \left(\ln (3,193/-17,771);\right)\) and Underwood is \(36 \text{k} \cdot e\left(-1/5,0123\right).\) The speed-density relationship of the Green shields model is \(36 - 1.2857\text{k},\) Greenberg is \(\ln (\text{k})/-17,772 - \ln 3,193/-17,772\) and Underwood which is \(36 \cdot e\left(-\text{k}/-5,0123\right).\) Traffic modeling during travel restriction is presented in Figures 9, 10, and 11.

**Figure 6.** Flow–Speed Relationship During Travel Restriction

**Figure 7.** Flow–Density Relationship During Travel Restriction
Figure 8. Speed–Density Relationship During Travel Restriction

Figure 9. Speed–Density Relationship During New Normal

Figure 10. Flow-Density Relationship During New Normal
Traffic modeling for the relationship between flow, speed, and density of the Green shields, Greenberg, and Underwood models present in Table 1.

### Table 1. Flow-speed-density relationship

| Model                  | Green shields | Greenberg | Underwood |
|------------------------|---------------|-----------|-----------|
| **Flow-Speed**         |               |           |           |
| 1. Before Pandemic     | 81V-2.31V²    | 3.66V. e (15.65V) | 81k (ln 35 - ln V) |
| 2. Travel Restriction  | 29V-0.784V²   | 1.68V e (5.76 V) | 29k (ln 28 - ln V) |
| 3. New Normal          | 28V-0.78V²    | 3.193V. e(-17.772V) | 28k (ln 36 - ln V) |
| **Flow-Density**       |               |           |           |
| 1. Before Pandemic     | 35k-0.432k²   | k (ln k/15.65) - k (ln 3.66/15.65) | 35k.e(-k/3.06) |
| 2. Travel Restriction  | 37k-1,276k²   | k (ln k / 5.76) - k (ln 0.29) | 28 k e (-k/29) |
| 3. New Normal          | 36k-1,28571k² | k (ln k/17.771) - k (ln 3,193/-17,771) | 36k.e (-k/28) |
| **Speed-Density**      |               |           |           |
| 1. Before Pandemic     | 35-0.432k     | Ln k/-15.65 - Ln 0.234 | 35e (-k/3.06) |
| 2. Travel Restriction  | 37-1,276k     | ln k / 5.76 - ln 0.29 | 28 e (-k/-0.347) |
| 3. New Normal          | 36-1,28571k   | Ln k/-17.772 - Ln 3,193/-17,772 | 36.e (-k/-5.0123) |

### 3.2 Traffic Performance

Before the pandemic, the peak hour occurred between 07.20 - 08.20 am, with a share of 78% for Makassar City and 22% for Gowa Regency. Compared to the traffic conditions before the pandemic, the flow experienced a decrease of 56% when travel restrictions were implemented, with a share of 55% for Makassar City and 45% for Gowa Regency. Peak hours occur at 1.45-2.45 pm in new normal conditions, consisting of 38% for Gowa Regency and 62% for Makassar City. Compared to the conditions before the pandemic, the traffic volume under new normal conditions decreased by 36% but increased by 28% from the traffic volume under travel resistance conditions. Movements to Makassar City were greater for all three conditions.

Furthermore, the traffic split portion for the three conditions is presented in Figure 12. Motorcycles remain the dominant vehicle in all conditions, followed by light vehicles, heavy vehicles, and non-motorized vehicles. In normal conditions, the composition of vehicles at the highest flow consists of 94.33% motorcycles, 4.95% light vehicles, 0.13% heavy vehicles, and 0.59% non-motorized vehicles. The composition of vehicles in the highest travel flow restriction conditions consisted of motorcycles 92.97%, light vehicles 6.37%, heavy vehicles 0.49%, and non-motorized vehicles 0.16%. The traffic composition is presented in Figure 13.
The performance of the road [14], which can be seen from the amount of flow and the degree of saturation in the pre-pandemic conditions, appears to have decreased compared to the travel restriction conditions, where the current value in normal conditions is 455pcu/h and the degree of saturation is 0.53. The value of current and degree of saturation under travel restriction conditions are 199.35pcu/h and 0.103, respectively. However, the average speed and delay before the pandemic were better than the travel restriction conditions, namely 28.57 km/h and 15.93pcu/km/ln. The travel restriction condition causes the average speed value to decrease to 11.09 km/h and a delay of 17.98pcu/km/ln.

This is because on the first day the travel restriction was set, many motorists did not know yet, so that most drivers who had entered the traffic flow were trapped in the current and reversed direction as a result of the road being closed, resulting in a decrease in average speed. With the enactment of a new policy to accelerate the handling of Covid-19 (new normal), several business sectors began to carry out normal activities but adjusted to the Health protocol, so that the traffic flow began to approach the conditions before the pandemic. The performance of the border section when new normal is that the average speed has increased compared to the travel restriction conditions, to 26.45km/h, density decreases to 10.51pcu/km/ln, and degrees of saturation 0.20. The performance of the border sections of
Gowa Regency and Makassar City before the pandemic, travel restriction and new normal are presented in Table 2.

Table 2. The Performance of the Intercity Border Road Before and During Pandemic COVID-19

| Condition          | Average Speed km/h | Delay pcu/ln/km | Flow pcu/h | Degree of Saturation C pcu/h |
|--------------------|---------------------|-----------------|------------|-----------------------------|
| Before Pandemic    | 28.57               | 15.93           | 455.00     | 0.53                        |
| Travel Restriction | 11.09               | 17.98           | 199.35     | 0.13                        |
| New Normal         | 26.45               | 10.51           | 277.95     | 0.20                        |

4. Conclusion

The number of flows and the degree of saturation before the pandemic have decreased compared to the travel restriction and new normal conditions. This is due to the fact that on the first day the travel restriction was set, many motorists did not know yet, therefore most drivers who had entered the traffic flow were trapped in the traffic and reversed direction due to the closure of the road, resulting in a decrease in average speed. The enactment of a new policy to accelerate the handling of Covid-19 (new normal), several business sectors began to carry out normal activities but adjusted to the health protocol, thus the traffic flow began to approach the conditions before the pandemic. In new normal condition, the average speed has increased compared to the travel restriction condition, but the degree of saturation is not better than the travel restriction condition.

References

[1] Satgas Penanganan Covid-19, 2020, “Peraturan Pemerintah Republik Indonesia Nomor 21 Tahun 2020 tentang PSBB - Regulasi”

[2] Mobility Report During Pandemic COVID-19, 2020, https://www.google.com/covid19/mobility/

[3] Zhiyong Cui et al, 2020, “Traffic Performance Score for Measuring the Impact of COVID-19 on Urban Mobility.” Cornell University

[4] Christos.K., Eva., M.,, Marios.S.,, and George.Y., 2020, “A Descriptive Analysis of The Effect of The COVID-19 Pandemic on Driving Behavior and Road Safety.” Elsevier, Volume 7, doi.org/10.1016/j.trip.2020.100186

[5] A. Aloi et al., 2020, “Effects of the COVID-19 Lockdown on Urban Mobility: Empirical Evidence from the City of Santander (Spain),” Sustainability, Volume 12, No. 9, doi: 10.3390/su12093870

[6] Scott. P., et al, 2020, “Traffic Impacts of the COVID-19 Pandemic: Statewide Analysis of Social Separation and Activity Restriction”, Natural Hazards Review, Volume 21, No 3.

[7] H. Lee et al., 2020, “The Relationship Between Trends in COVID-19 Prevalence and Traffic Levels in South Korea,” Int. J. Infect. Dis., Volume 96, doi: 10.1016/j.ijid.2020.05.031.

[8] Giacomo.F., and Michel. N., 2020, “The Impact of COVID-19 on Transport Demand, Modal Choices, and Sectoral Energy Consumption in Europe,” IAEE Energy Forum

[9] Manuel A., Maria. A.R., and Luis. S., 2020, “Indirect Effects of COVID-19 on The Environment', Elsevier, Volume 728, doi.org/10.1016/j.scitotenv.2020.138813

[10] Yue.H., William.B., Samitha. S., and Dan.W., 2020, “Impacts of Covid-19 Mode Shift on Road Traffic. Cornell University.

[11] Matthew. J.B., and David.A.H., 2020, “Insights Into The Impact of COVID-19 on Household Travel and Activities in Australia – The Early Days of Easing Restrictions”, Elsevier, Volume 99, https://doi.org/10.1016/j.tranpol.2020.08.004
[12] Xueqin.W., Kum.F.Y., Wenming.S., and Fei.M., 2020, “The Determinants of Passengers’ Safety Behaviour on Public Transport”, Journal of Transport and Health, Elsevier, Volume 18, https://doi.org/10.1016/j.jth.2020.100905

[13] F. Zuhairoh and D. Rosadi, “Real-time Forecasting of The COVID-19 Epidemic Using The Richards Model in South Sulawesi, Indonesia,” Indonesian Journal of Science and Technology, Volume 5, No.3, DOI: 10.17509/ijost.v5i3.26139

[14] Indonesia Highway Capacity Guidelines, 2014.