ConTraEmSis: The Congested Traffic and Emission Index Impact Analysis Amid the Large-Scale Social Restrictions (LSSR) of COVID-19 in Several Cities of West Java, Indonesia

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Abstract. In some metropolitan cities of West Java Province, the urban movability affects the congested traffic. This study analyzes the congested traffic during the large-scale social restrictions (LSSR) of the coronavirus disease 2019 (COVID-19) around some metropolitan cities of West Java Province in May-June 2020. The national government of the Republic of Indonesia declared a national’s LSSR just for some the essential and critical activities are being acquiesced still enforce. Our proposed method, namely, ConTraEmSis is contributed to analyze the congested traffic two months from May-June 2020. We exploit the geomatic of the congested traffic in the COVID-19 information & coordination center West Java province (PIKOBAR) dataset for Bogor, Depok, and Bekasi (Bodebek areas), Bandung areas, and whole West Java province areas. We exploit the road transport and traffic management center (RTTMC) and area traffic control system (ATCS) and index their data for the Bodebek and Bandung areas. The ConTraEmSis demonstrates that the congested traffic the LSSR of COVID-19 reduces around 18%-49% every month. Instead, the Java government always launch the many good governance policies to support the LSSR of the COVID-19 system. proposed model shows that after the LSSR in 2019 and 2020, is reduced between 3.27% and 5.27%. On the week- day afternoon, we scale down between 4.52% and 4.74% before and after LSSR of 2019 and 2020, respectively. The congested traffic trends get 24% and 41% in the weekdays and weekends, respectively, since the LSSRs. Onto the weekend afternoon, we perform 13.4% and 14.8% for reducing the CO2 emission index during the LSSR’s 2020. We achieve the important congestion get an emission index lower than 0.3.

Keywords: the congested traffic, large-scale social restriction, COVID-19, West Java, PIKOBAR, RTTMC, ATCS, geomatic, emission index.

1. Introduction

Working adaptability and natural conservation have over the lifetime grows into pre-eminence in movability outlining in the world. The rise of intelligent transportation systems (ITS) builds up the movability planning in the recent cities is regulated. In the last year of 2020, an overall COVID-19 pandemic drives to myriad countries ceasing their social-economic activities [1].
The COVID-19 transmits over inhaling droplets which are moved to other people by closing personal direct contact. To reduce the escalation of the COVID-19 and handle their transmission to let on the medical management systems teams enhance the health care systems, the national governments have the LSSR. Due to this LSSR policy, only the essential and critical traffics are allowed to pass during the LSSR. This system allows the traffic bureau to evaluate the impact of the essential and critical activities on the general hauling system. Working adaptability can be appraised for the congested traffic and surroundings conservation of the emission index.

Commonly, the congested traffic is examined as the appended driving time by the cutting across to a place during the moving on the driving time [2]. The micro aspects cause to the recent situations of roadway and the macro aspects relate to the request of the roadway management [3–5]. The LSSR lops the request of the roadway management of the essential and critical activities whose jolt justify to be investigated. Recently, depend on the driving time appraisal, the congested traffic can be qualified by the road transport and traffic management center (RTTMC) index for the Bodebek and Bandung areas [6–10]. Such traffic control systems count on the observed vehicle engine, and vehicle acceleration. The standard emission coefficients are analyzed by the monitoring suspended and particulate matter system [11–14]. That system is not precisely described to the congested traffic. It is crucial to analyze the congested traffic and emissions index inconsistencies, respectively.

The congestion traffic affirms to reinforce the transportation planners in the developing countries which has the respectable information to inform the decision making and movability models [14,15]. We propose the assessment models of the congested traffic and emission index impact analysis (ConTraEmSis) and CO₂ emission impact (CO₂ emission) in the West Java areas. The organization of our works is built as the subsequent sections: First, the 1 is the introduction. Section 2 presents the related work of the congestion and emission indexes. Section 3 shows our proposed method of the congestion and emission indexes, respectively. Section 4 exploits the congestion and emission index with No-LSSR and LSSR, and the last two is discussion in Section 5. The latest is the section 6 which presents the conclusion.

2. Data and Methods

2.1 Congested Traffic Appraisal

Commonly, the congested traffic is appraised as the number of vehicle’s ratio-to-quantity. In the movability researchers, the availability data resources can analyze the transportation traffic systems [16–19]. The vehicle’s sequences of the roadway’s intersections are expressed as a movement quantity and the activity requirements. The other work, a constant mean value of congested traffic is let on to measure the congested traffic and vehicle quantity whelm [20].

The other congested traffic works desire to identify the sequence lengths by demonstrating location data of the vehicles [21–23]. They [21–23] introduce the compiled data from sensors which are located on the roadway to appraise the number and vehicle velocities. These sensors are applied to collect the number of vehicles and driving time data. They determine between repeating congestion in the daily routine and nonrepeating congestion, like bad weather or traffic mishap [24]. However, we adopt the models in [24,25] which offer to calculate the congested traffic as follow:

\[ C_t = \frac{V_s - V_a}{V_s} \]  

where \( C_t \) represents the congested traffic, \( V_s \) is the vehicle sequence velocity and \( V_a \) is the average velocity. To appraise the driving velocity, we apply the detectors around roadway or by using the vehicle’s global positioning system (GPS). Installing velocity locators around roadways is a high cost for the local city government authorities to compile the ground truth data on the roadways.

These work [26,27] assess the driving markings by deriving the daily starting and ending voyages from smart-phone application. This study shows that the modal movement to drive- share services reduce the congested traffic. Anyhow, this study is temporal, the proposed methods are effective in...
annunciating the congested traffic trends for various places and conditions. Unfortunately, they constrict to the specific places of sensors around roadways for the regulatory problems. The extension sources of driving pattern data are conducted by other works and traffic authorities. The function of the congested traffic is formulated as the ratio of extended driving time $\Delta D$ to stand to the sequence driving time $D_s$:

$$\varepsilon = \frac{\Delta D}{D_s}$$

We formulate the equation I for the average velocity $V_a$ and the vehicle sequence velocity $V_s$ as follows:

$$\varepsilon = \frac{V_s}{V_a} = 1 + \varepsilon$$

We illustrate that the congestion and emission parameters are presented as follows:

$$\varepsilon = \frac{C_t}{1 - C_t}; \text{ for } C_t \neq 0$$

Many mediator-corporate hand over the navigation systems like GPS which includes the direction software. These GPSs is escorting the driver by directing the shortest distance and time between an origin and destination area, respectively. The data on this driving show the movability and congested traffic trends. This represents a prosperous data resource, which researchers and local city government authorities could analyze and visualize the movability trends from one time to each other time. In this work, we exploit data from the congested traffic index to show the traffic trends for the Bodebek, Bandung, and whole West Java traffic areas.

2.2 Emission Appraisal

Recently, the many researchers have reduced the transportation system problems. The preeminent anthropological determinant are vehicular air pollution emissions [27–31]. Collecting the movability traffic trend is an important for the congested traffic systems. Nonetheless, the congested traffic data are burdensome for some cities in West Java. Some area in Bodebek cities, the roadways are characterized with the vehicle’s size and velocity, for example the long vehicle, jeep vehicle, picked up vehicle, and motorcycles [27–29,31,30].

Thus, calculating the vehicle volume, which are passing the roadways per unit time would be sketchy as many vehicles traffic features models. The emission index method introduces to recognize the emission effect and control at the Bodebek, Bandung, and whole West Java traffic areas [29,31]. Therefore, many researchers demonstrate the location control data to estimate the congestion trend [32,33].

The higher number of vehicles in the Bodebek, Bandung, and whole West Java traffic areas, the movability research is demonstrated to calculate the pollutant of vehicle emissions [34,35]. The cutback of the emissions management index induces an exceeded the savourity people life in the West Java areas. In [34,35] demonstrate the energy/emissions operational parameter set (EOPS) from a vast dataset of vehicle velocity, time characteristics, driving time, and the geographic area. We employ to adopt such models of the congested traffic and emission index.

2.3 Method

We apply the RTTMC and the ATC for the congested traffic in some West Java areas for two periods from 6-9 May 2020 and 1-20 June 2020 and compare this data to 2019’s data in the same time periods from 6-19 May 2020 and 1-20 June 2020. To appraise the $CO_2$ emissions, we adopt the vehicles emission model [36].
\[ E(V_a) = \frac{\alpha}{V_a} + \sum_{k=0}^{2} \beta_k V_a^k \]  

We define \( V_a \) is the mean value of the velocity, \( \alpha \) and \( \beta_k \) criteria are the constant values where \( \alpha = 4780 \), \( \beta_0 = 111 \), \( \beta_1 = -1.24 \), and \( \beta_2 = 2.37 \times 10^{-2} \). This convex functions \( E(V_a) \) is a lower sole value \( V > 0 \) which is indicated as \( E_m \). The \( V_m \) correlates the average velocity. So, \( E(V_m) = E_m \), and \( \varepsilon_m \) is the congested traffic which correlates with \( V_m \). We propose a new mathematical estimate for the emissions on the congestion index and the vehicle sequence velocity as follows:

\[ E(\varepsilon, V_s) = \frac{\alpha(1 + \varepsilon)}{V_a} + \sum_{k=0}^{2} \beta_k \left(1 + \varepsilon\right)^k \]

where, we appraise the CO₂ emission index as follows:

\[ \omega(\varepsilon, V_s) = \frac{E(\varepsilon, V_s)}{E_m} - 1 \]

where \( \omega(\varepsilon, V_s) \) is the emissions on the congestion index and the vehicle sequence velocity as follows:

\[ E(\varepsilon, V_s) = \frac{\alpha(1 + \varepsilon)}{V_a} + \sum_{k=0}^{2} \beta_k \left(1 + \varepsilon\right)^k \]

Based on the several cities of West Java roads traffic in the roadways, we justify that the vehicle sequence velocity is around 40 km/hour. So, we estimate the CO₂ emission index to be:

\[ \omega(\varepsilon, 40) = 230.5 \left[ \frac{\varepsilon^2}{15.6} + 1.9\varepsilon + 1 \right] \]

3. Results and Discussion

The Bodebek, Bandung, and whole West Java areas are the buffer cities for the capital city of Jakarta (see Figure 1). Based on the economic activities, many citizens cut across these cities. This causes the roadways have the higher congested traffic. The global COVID-19 pandemic in 2020, when the national government of Republic Indonesia declares a national LSSR which only came into effect on May-June 2020 [28,37].

One factor of the LSSR, people migration from one district, cities, and province to other areas are being prohibited. The essential and critical workers are restricted by the local government rules and the important documents. On the April 1\(^{st}\), 2020 the traveller quantity is reduced from 100\% to 50\% [38]. Table 1 shows the agenda of the LSSR in West Java since the first released COVID-19. In the work, we visualize the movability trends that are occurring during the LSSR in the West Java.

Movability people within the West Java cities areas has diminished after the LSSR (see Figure 2). Particularly, the essential congested trend of the essential and critical activity could be presented with movability and travelling at ±22\% and working in urban areas at -16\% [39].

Figure 1. Bandung & Bogor, Depok, and Bekasi (BoDeBek) Areas [11]
Figure 2. Community mobility reports: Indonesia [39]

Figure 3. The mean value congestion index No-LSSR (2019) Vs LSSR (2020)
Figure 4. Time progression of congestion index of LSSR’s week (2020)

Figure 5. CO2 emission index: the mean values of normal situation (2019) (top) vs the LSSR (2020) (bottom) trends
Figure 6. Time progression of CO\textsubscript{2} emission index

Figure 7. Aggregated rationing function of CO\textsubscript{2} emission index no-LSSR (Normal) (2019)

Figure 8. Aggregated rationing function of CO\textsubscript{2} emission index LSSR (2020)
3.1 The Congested Traffic

Figure 3 demonstrates the mean value of congested traffic in two scenarios: (1) the first period is the No-LSSR (2019) and (2) the second period whereby the LSSR (2020). We also adopt the collecting data of [40–43]. In 2019, according to the RTTMC and the ATC, the congested index for the cities of West Java is shown in the Figure 3 that in the weekday morning, the congested traffic averaged between 47% to 77% in the rush hour from 06:00-08:00, and 68% to 65% in the weekday afternoon on the rush hour between 15:00-18:00. In the weekend morning, the congested traffic averaged between 1% to 18% in the rush hour between 06:00-08:00, and 8% to 12% in the weekend afternoon in the rush hour between 15:00-18:00.

This appraisal estimates the national LSSR effect on the congested traffic in the cities of West Java. It is meaningful that at the COVID-19 outset, the movability one district, city, and province to other areas is undisturbed even so many peoples entangle the COVID-19 impact. The RTTMC and the ATC’s data of the congested traffic in some West Java areas is analyzed and reflected for two periods from 6 – 19 May 2020 and 1 – 20 June 2020. In 2020, figure 3 demonstrates that in the weekday morning, the congested traffic averaged between 14% to 34% in the rush hour from 06:00-08:00, and 20% to 19% in the weekday afternoon on the rush hour between 15:00-18:00. In the weekend morning, the congested traffic averaged between 1% to 18% in the rush hour between 06:00-08:00, and 8% to 12% in the weekend afternoon in the rush hour between 15:00-18:00.

Figure 4 illustrates an unexpected transition in the congested traffic trends in some of West Java city areas. In the weekday’s morning for the rush hour 06:00-09:00, the congested traffic is averaged between 8% to 12 % and 11% to 21% at the afternoon time for the rush hour between 15:00-18:00. In the weekend’s morning for the rush hour 06:00-08:00, the congested traffic is averaged between 7% to 12% and 35% to 30% in the time of the afternoon for the rush hour between 15:00-18:00.

The unlikeness of the 2020 data trend is that the congested traffic trends are lower 24% and 41% in the weekdays and weekends, respectively. However, it’s only on the weekends (2019). The lower congested traffic trends in 2020 are caused by the LSSR unless to the essential and critical activities are being acquiesced in the weekdays and weekends. The emission index measures the emission percentages and the policy of the city authorities in the prevention of COVID-19. Figure 5 describes the trends in the CO₂ emissions during the LSSR period in 2020.
Table 1. COVID-19 and The LSSR Timeline in Indonesia

| Date               | Description                                                                                                                                 |
|--------------------|---------------------------------------------------------------------------------------------------------------------------------------------|
| March 2nd, 2020    | The President of the Republic of Indonesia and the Minister of Health announce the 1st case of COVID-19 in Indonesia [44].                     |
| March 17th, 2020   | The National Disaster Management Agency (BNPB) extends the emergency period for the COVID-19 in Indonesia [45].                                |
| April 7th, 2020    | The capital city of Jakarta enforces the LSSR and the working from home (WFH) [46,47].                                                      |
| April 21st, 2020   | President of Republic of Indonesia prohibits people from going the homecoming for Eid [48].                                                |
| May 2nd, 2020      | The Governor of West Java imposes the LSSR in West Java on 6-19 May 2020, which has Bodebek areas (Bogor District/City, Bekasi District/City, Depok City) and Bandung areas (Bandung City, Bandung District, Cimahi City, West Bandung District, Sumedang District) [49]. |
| June 1st, 2020     | The Governor of West Java launches the adaptation of new habits (INH) or the other term is adaptasi kebiasaan baru (AKB) in West Java which is started from June1st, 2020 [50]. |

3.2 CO₂ Emission Index

The emission index measures the emission rates and informing the city planner on the prevention of COVID-19. Figure 5 describes the trends in the CO₂ emissions during the LSSR period in 2020. The emission index measures the emission rates and informing the city planner on the prevention of COVID-19. Figure 5 describes the trends in the CO₂ emissions during the large-scale social restriction period in 2020.

In 2019, Figure 5 shows the emission value index on the weekday morning reaches between 80% to 77% during the rush hour 06:00-08:00 and 84% to 82% on the weekday afternoon during the rush hour between 15:00-18:00. In the weekend morning, the emission index has 10% to 31% during the rush hour 06:00-08:00 and 50% to 44% the weekend afternoon during the rush hour between 15:00-18:00. The most travelling are during the weekend for touring day, so the emission index rationing is almost equal throughout whole days.

Figure 5 shows the emission index data from 6-9 May 2020 and 1-20 June 2020 is lower than 41% weekly, this is equal to the congested traffic (see Figure 6). In the weekday morning, the emission index has 24% to 23% during the rush hour 06:00-08:00 and 25% on the weekday afternoon during the rush hour between 15:00-18:00. In the weekend morning, the congested traffic has 7% to 12% during the rush hour 06:00-08:00 and 35% to 30% on the weekend afternoon during the rush hour between 15:00 to 18:00.

To appraise the similarities between the two trends in 2019 in Figure 7 and 2020 in Figure 8, we employ an aggregated rationing function. For the normal situation with no-LSSR (2019), whole days could be bundled into the weekday and weekend. Practically, on the weekend, the emission index time is deterred than 36%. The improvement of the LSSR to decrease emission index can be reflected by the Figure 8 in correlation with 2019. Whole days of the week C 02 emission are less than 0.3. We achieve the important congestion get an emission index lower than 0.3.

Figure 9 illustrates the estimated emission reduced in the 2019 is 47,081,207,817 kg CO₂/year and 23,540,604 tons CO₂/year, respectively. The estimated vehicle km travelled (VKT) reduced is 119,252,590,000 tons CO₂/year. However, in 2020 of the LSSR regulation, the estimated emission reduced is 27,529,752,814 kg CO₂/year and 13,764,876 tons CO₂/year, respectively. The estimated vehicle km travelled (VKT) reduced is 69,740,620,000 tons CO₂/year.

4. Conclusion
This work is raised an appraisal of the indispensable congested traffic impact on transportation systems using the congested traffic and CO\textsubscript{2} emission indexes of the West Java City areas. The traffic management authorities could adopt these works to make an enhancement future policy of movability models.

The difference of the mean value of congested traffic on the weekday morning before and after the LSSR in 2019 and 2020, is reduced between 3.27% and 5.27%. On the weekday afternoon, we scale down between 4.52% and 4.74%. On the weekend morning, we cut down between 1.3% to 1.5% before and after LSSR of 2019 and 2020, respectively. The time progression of congestion index for LSSR’s week in 2020 demonstrates that the congested traffic trends are descended between 24% and 41% in the weekdays and weekends, respectively. The difference of the CO\textsubscript{2} emission index on the weekday morning before and after the LSSR in 2019 and 2020, is reduced between 5.37% and 5.60%. On the weekday afternoon, we scale down between 5.74% and 5.88%. On the weekend morning, we cut down between 3.1% to 13.4% before and after LSSR of 2019 and 2020, respectively. Onto the weekend afternoon, we perform 13.4% and 14.8% for reducing the CO\textsubscript{2} emission index during the LSSR’s 2020. The time progression of CO\textsubscript{2} Whole days of the week CO\textsubscript{2} emission are less than 0.3. We achieve the important congestion get an emission index lower than 0.3. The emission index time is detruded than 36% Our proposed method shows that in the 2020 emission index has reduced emission index level during the national LSSR. This leads to the better air quality. Overall, the LSSR has many effects the difference of estimated emissions is reduced in the group (kg CO\textsubscript{2}/year) more than 50% for the estimated emissions reduced at the group (kg CO\textsubscript{2}/year) Anyhow, the LSSR are not being the main choice to scale down the emission index as an indicator of the negative impact of the economic life. The other technique, we could assign the working hour to decrease the congested traffic in the morning and afternoon rush hour.

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6. References

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