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Identifying Segmental Congestion Index along the Traffic Flow of Rizal Avenue in City Of Manila Using Travel Time Modeling

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Abstract
The study identifies where exactly the congestion exists along Ronquillo Street, Sta Cruz up to the intersection of Aurora Boulevard and Rizal Avenue in Manila City, and its characteristics and degree by identifying the congestion index per segment. The congestion index is the ratio of delay over the free-flow travel time. The delay is the difference between the actual travel time during peak hours and free-flow travel time. The study was divided into five segments of varying lengths and utilized two traffic survey methods: the moving observer and the travel time (using multiple linear regression) and delay survey. The independent variables used in the travel time model were flow, speed, density, and road length. It suggests that the model fits the data well, and the independent variables significantly affect the dependent variable, the travel time. Model validation was done using Mean Absolute Percentage Error with a value of 15.72, categorizing the model as good in terms of forecasting. Common causes of delay along the segments were: pedestrian crossing, stopping at the red-light signal, and maneuvering vehicles in the intersection, the loading and unloading of public utility jeepneys, on-street parking and bus stations, the presence of PNR Station, the lack of boundary between northbound and southbound roads, and the defective traffic signals at the end of the segment. Results show that segment 4 (Tayuman to Cavite St.) is the most congested, while segment 3 (Bambang to Tayuman St.) is the least congested.

Keywords: *Congestion Index; Multiple Linear Regression; Mean Absolute Percentage Error*

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I. INTRODUCTION

Transportation Engineering is the synthesis of applications from science and technology to the planning, management, design, and operation of various transportation facilities to deliver a safe, efficient, economic, environmental-friendly, and rapid movement both for people and goods [1]. An integral part of transportation engineering is traffic management. It is as meeting the needs of travelers by efficiently using the limited infrastructure and network capacity with various transport means and systems [2]. After designing roads and highways, it must implement proper management to use the facility safely in its maximum capacity. If not, rendering the use of that road would bring more problems rather than solutions. One significant problem of improper traffic management is congestion. In its 2018 report, the Japan International Cooperation Agency (JICA) stated that the country is bound to lose 5.4 billion Pesos per day by 2035 if there is no improvement in the traffic condition of Metro Manila. It shows how Metro Manila has been suffering from traffic congestion over the past years [3]. It also indicates the need for various traffic assessments and research to develop traffic plans and schemes to lessen the congestion on a microscopic level.

This study aims to find where exactly in Rizal Avenue congestion exists and its characteristics and degree by identifying the congestion index per segment. The study also expects to describe the causes of delays and characteristics of traffic per segment using various traffic and roadway parameters such as flow, density, average speed, number of signalized and unsignalized intersections, and road length; to develop a mathematical model that will represent the Travel Time along with various traffic and roadway parameters using Multiple Linear Regression; and to identify the most and least congested segment along the study area by determining the congestion indices of each part. The study was performed to determine the level of congestion of different segments in the chosen study area by including other parameters to increase the reliability of the results. The study will affect the following sectors: traffic management planners, community, environment, and future researchers.

Identification of segmental congestion indices was limited within the route of Ronquillo Street, Sta. Cruz up to the intersection of Aurora Boulevard and Rizal Avenue. The study developed a travel time model to identify the congestion index in each designated segment. For the volume counting, all types of vehicles traveling along the stream were counted, such as Jeepneys, Private Cars, Trucks, E-trikes, and Tricycle. The data gathered were used to make different traffic flow parameters. Other factors that might affect the traffic condition, such as the volume of pedestrians, sidewalk vendors, and psychological behavior of drivers within the study section, were excluded since they are beyond the study's capabilities. Due to the Enhanced Community Quarantine and other health protocols set by the Philippine government brought about by the Covid-19 pandemic and irregular transportation systems, the study was constrained to access available data such as volume count and vehicle classification collected.

II. LITERATURE REVIEW

Congestion has always been the biggest challenge in the field of traffic management. If not adequately managed, various infrastructures, mass public transport, and traffic improvements would add to the congestion. In addition, congestion is affected by a lot of factors which can be categorized into (a) micro-level and (b) macro-level factors [4]. Micro-level factors are those concerning the high travel demand of people and resulting in too many vehicles plying on the limited road space, or it may be attributed to traffic and roadway parameters. Congestion Index (CI) was established by Taylor et al. [5] and is defined as the ratio of delay to the adequate travel time. The uncertainty here is computed as the difference between the actual and acceptable travel time. CI is one of the most detailed indexes regarding data gathering and interpretation. A CI closer to a zero value suggests that the traffic flow is not congested, while a CI equal to or greater than two resembles traffic congestion. Besides this broad categorization, CI can still be narrowed down to a specific explanation. To provide a basis of arguments for choosing the most suitable measure of congestion, a thorough examination of the context should be done since this will determine the succeeding steps of the study [6]. Besides this broad idea, the study listed three features that a congestion measure should have: provide comparable outcomes for different systems with a similar congestion level, precisely reflect the quality of facility for any category of system, and be clear, concise, and understandable to concerned people.

To assess traffic congestion in Agusan Del Sur, Philippines. The study used the Level of Service to measure traffic congestion along 41 provincial roads. As a result, most of the local roads are LOS A. The study results show that the volume of vehicles, number of business entities, job centralization, and population growth affect traffic congestion [7]. As the population and attractions of human activities increase, the demand for vehicle ownership and its use also grows. The need for road space is more than the roadway capacity because providing transport services is less than the rate of increase of vehicle rights and use, resulting in traffic congestion [8].

In 2019, Metro Manila Development Authority (MMDA) and the Local Government Units (LGUs) of Metro Manila identified the macro-factors causing the traffic congestion on major roads of Metro Manila. Saturated demand, mixed traffic with pedestrians, the current practice of loading/unloading passengers by public utility jeepneys (PUJs) at intersections, unruly driving behavior, and illegal roadside parking are the top causes of congestion identified both by MMDA and LGUs.

Travel and delay time are two commonly used traffic performance measures: level of service, speed, and the volume-capacity ratio [9]. People decide on what route to take depending on travel time and delay. Travel time is the primary measure used in transportation which is the total amount of time needed by a vehicle to travel from one place to another over a specific route with different traffic conditions. On the other hand, the delay is the time lost due to stops at an intersection, congestion, and various traffic management devices [10].

Thorough knowledge of traffic stream parameters and their mutual relationships is necessary to understand traffic flow behavior. These parameters provide information concerning the nature of traffic flow, which helps traffic engineers identify any flow characteristics variation [11]. The relationships between the traffic stream parameters help the traffic engineers evaluate the effectiveness of implementing necessary traffic engineering measures on a roadway system [12]. Traffic stream parameters can be classified into macroscopic parameters, such as volume or flow rate, speed, density, and microscopic parameters, such as time headway, speed of the individual vehicle, and space headway [13]. Microscopic parameters characterize the behavior of each vehicle to other vehicles in the stream, and macroscopic parameters describe the traffic flow as a whole [11].

III. FRAMEWORK

According to the European Conference Ministers of Transport (ECMT) (2007) in their report on *Managing Urban Traffic Congestion*, two principal categories of congestion are micro-level and macro-level factors. Micro-level factors are related directly to the road itself, while macro-level factors relate to the overall demand for road use. They are linked to land-use patterns, employment patterns, car ownership trends, infrastructure investment, regional economic dynamics, etc. In the study, congestion is prompted at the micro-level and focused on the macro level by factors that add to the incidence of congestion and its severity. The ECMT stated that measuring congestion is a necessary step to deliver better congestion outcomes and that it is essential to select metrics that are relevant to both road managers (e.g., speed and flow, queue length and duration, etc.) and road users (e.g., predictability of travel times, system reliability, etc.). Figure 1 shows the goal of only carrying out a study on the relationship of these micro-level factors and their effect on the traffic flow of roads in Metro Manila.

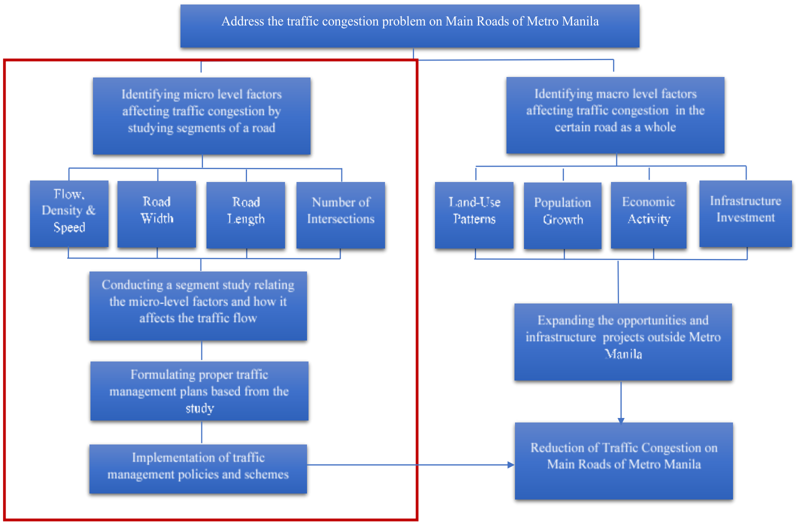

Figure 1 Theorical Framework

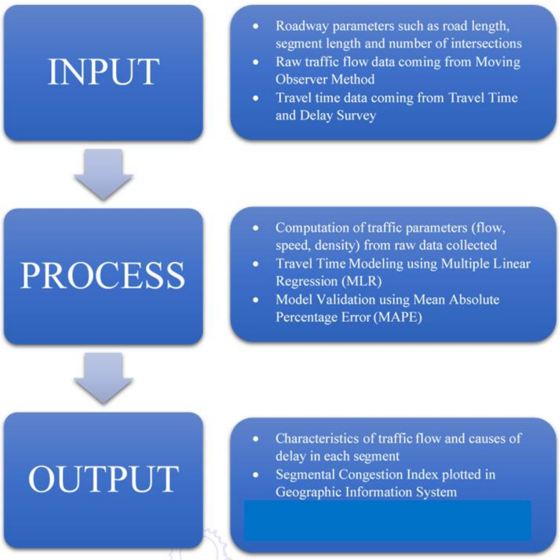

Figure 2 Analytical Framework

IV. DATA COLLECTION

The route of Ronquillo Street, Sta. Cruz up to the intersection of Aurora Boulevard and Rizal Avenue is part of Radial Road 9 (R-9). The locale follows the route of Light Railway Transit Line 1 (LRT-1). The study divided the route into five (5) segments. To define the relationship between the number of intersections and travel time, each segment was established to vary in the number of signalized and unsignalized intersections. Additionally, the number of lanes or the road width in each segment was also considered.

The traffic survey was done using a private vehicle for seven (7) days (Monday to Sunday). It was limited to six (6) hours each day, from 8 to 11 am for morning peak hours and 4 to 7 pm for the evening peak hours. An additional traffic survey was performed after the initial traffic survey from 12:00 am to 1:00 am to collect the free-flow travel time when the traffic density on the route is nearly zero. The data gathered in this separate time of the survey was used to compute the congestion index of each segment.

For the moving observer method, a car was driven through the segments at the average speed permitted by the traffic flow. The observers have counted the number of vehicles overtaken by the car, the number of vehicles overtaking the car, and the number of vehicles in the opposite direction of the stream.

A traffic survey was also done to obtain the actual travel time and delay along each segment. The study identified various benchmarks in the node points, which will indicate the start and end time of vehicle counting and recording of journey time. The travel time and delay survey recommended possible traffic management measures to mitigate congestion levels.

V. DATA PROCESSING

The volume counts collected from the moving observer method were converted to its passenger car equivalent to ensure the consistency of units. Passenger car equivalent factors (PCEF) were adapted from the Department of Public Works and Highways (DPWH). The flow and average speed in each segment were calculated using:

$$\mathbf{q} = \frac{\mathbf{m_a} + (\mathbf{m_o} - \mathbf{m_c})}{\mathbf{t_w} + \mathbf{t_a}} \qquad \text{(Equation 1)}$$

and $$\mathbf{u} = \frac{\mathbf{l}}{\mathbf{t_w}} \qquad \text{(Equation 2)}$$

where q is the Flow (PCE/hr), ma is the average number of vehicles counted while in the opposite direction of a stream (PCE), mo is the average number of vehicles overtaking the observer's car (PCE), mc is the average number of vehicles overtaken by the observer's car (PCE), tw is the average journey time along the stream (hrs.), ta is the average journey time along the opposite stream (hrs.), u is the average speed (km/hr), l is the segment length (km). After calculating the flow and average speed, density was derived using:

$$\boldsymbol{k} = \frac{\boldsymbol{q}}{\boldsymbol{u}} \qquad \text{(Equation 3)}$$

where k is the density (PCE/km), q is the flow (PCE/hr), and u is the average speed (km/hr). Multiple Linear Regression was carried out on all the independent variables: the segment length, number of intersections, segment volume, speed, and density, to the dependent variable, travel time.

VI. DATA VALIDATION

Eighty percent (80%) of the processed data were randomly chosen for travel time modeling, while the remaining twenty percent (20%) were considered a validation data set for the model. Using Mean Absolute Percentage Error (MAPE), the travel time obtained from the model was compared to the actual travel time both gathered from the validation data set to determine the accuracy of the predicting model. According to Lewis (1982), MAPE value may be interpreted as highly accurate, good, reasonable, or inaccurate [14].

VII. CONGESTION INDEX

The congestion index is an effective way to quantify the magnitude of congestion in a specific segment. This index tells how much longer travel time is incurred during peak hours than in a free-flow condition. Based on the modeled traveled time, the congestion index of each segment will be quantified by equation:

$$\boldsymbol{CI} = \frac{\boldsymbol{T} - \boldsymbol{T_0}}{\boldsymbol{T_0}} \qquad \text{(Equation 4)}$$

where CI is the Congestion Index, T is the Travel Time as predicted by the model and T_0 is the Free Flow Travel Time of each segment. The computed congestion index will be categorized from least congested to highly congested. In categorizing the segmental congestion index, northbound and southbound directions will be considered separately.

VIII. RESULTS AND DISCUSSION

The study split the data set into 80:20 using a random number generator in MS Excel. 80% of sample size (112) were used to develop the travel time model while the remaining 20% (28) were later used in model validation. The dependent variable or Y range is the Travel Time while the independent variables or X range are Segment Length, Number of Intersections, Flow, Speed and Density. Using these variables, Model 1 was created:

$$\boldsymbol{T} = \mathbf{0.02245} + \mathbf{0.11428}\boldsymbol{L} - \mathbf{0.00212}\boldsymbol{I} - \mathbf{1.70072}\boldsymbol{x}\mathbf{10^{-5}}\,\boldsymbol{V} - \mathbf{0.00189}\boldsymbol{U} + \mathbf{0.00017}\boldsymbol{K} \quad \text{(Equation 5)}$$

where T is the travel time in hours, L is segment length in kilometers, I is the number of intersections, V is the flow (PCE/hr), U is speed (km/hr) and K is for density (PCE/km). After developing the model, the study checked the most important parts of the Regression analysis output as presented in Table 1. The Multiple R tells how strong the linear relationship of the dependent and independent variables was. A value close to 1.0 means that there is a strong linear relationship between the variables. The Coefficient of Determination (R^2) tells how good the model fits the data. Like the Multiple R, an R^2 value close to 1.0 means that the model fits good. The Adjusted R^2 is like R^2, the only difference is that the latter one appears to be the better version that was modified based on the number of predictors in the model. Therefore, the Adjusted R^2 is more suitable to be used in Multiple Linear Regression where there is more than one predictor. Based on Table 1, all the above-mentioned Goodness of Fit measures showed a good result which is close to 1.0.

Regression Statistics		*Variables*	*Coefficients*	*Standard Error*	*t Stat*	*P-value*
Multiple R	0.95696	Intercept	0.02245	0.00946	2.37308	0.01944
R Square	0.91578	Total Intersections	-0.00212	0.00191	-1.11035	0.26936
Adjusted R Square	0.91181	Road Length (m)	0.00011	0.00002	7.14553	0.00000
Standard Error	0.00893	Flow (PCE/hr)	-0.00002	0.00000	-6.38931	0.00000
Observations	112	Speed (kph)	-0.00189	0.00050	-3.81518	0.00023
		Density (PCE/km)	0.00017	0.00002	7.53359	0.00000

Table 1 Results of Regression Analysis

	df	*SS*	*MS*	*F*	*Significance F*
Regression	5	0.091948793	0.018389759	230.5271083	2.93941E-55
Residual	106	0.008455901	7.97727E-05		
Total	111	0.100404694			

Table 2 Analysis of Variance (ANOVA)

On the other hand, the Significance F in Table 2 from the Analysis of Variance (ANOVA) as well as the P-values in Table 1 are used to tell if an independent variable contributes significantly to the model. The study used a $P \leq 0.05$ significance level. This means that there should only be less than 5% chance that the null hypothesis is correct, or else the independent variable with $P \geq 0.05$ should be removed. Null hypothesis states there is no significant relationship between the travel time and the independent variables. In this case, the Total Intersections in Model 1 showed a P-value of 0.26936 while all other P-values and Significance F is less than 0.05. The study removed the said independent variable, reanalyzed the data and generated another model. The second model generated without the total intersection is represented by equation:

$$\boldsymbol{T} = \mathbf{0.01931} + \mathbf{0.09756}\boldsymbol{L} - \mathbf{0.00002}\,\boldsymbol{V} - \mathbf{0.00160}\boldsymbol{U} + \mathbf{0.00018}\boldsymbol{K} \quad \text{(Equation 6)}$$

where T is the travel time in hours, L is segment length in kilometers, I is the number of intersections, V is the flow (PCE/hr), U is speed (km/hr) and K is for density (PCE/km).

In the second model, Adjusted-R^2 is 0.91 and all the P-values and Significance F were less than 0.05 as shown in Table 3 and 4. Because of this, the model has been accepted and was further validated using Mean Absolute Percentage Error (MAPE).

Regression Statistics		*Variables*	*Coefficients*	*Standard Error*	*t Stat*	*P-value*
Multiple R	0.95645	Intercept	0.01931	0.00904	2.13648	0.03492
R Square	0.91480	Road Length (m)	0.00010	0.00001	18.08782	0.00000
Adjusted R Square	0.91162	Flow (PCE/hr)	-0.00002	0.00000	-6.71699	0.00000
Standard Error	0.00894	Speed (kph)	-0.00161	0.00042	-3.78648	0.00025
Observations	112	Density (PCE/km)	0.00018	0.00002	7.99993	0.00000

Table 3 Results of Regression Analysis for Second Model

	df	*SS*	*MS*	*F*	*Significance F*
Regression	4	0.091850443	0.022962611	287.2255108	2.99477E-56
Residual	107	0.008554252	7.99463E-05		
Total	111	0.100404694			

Table 4 Analysis of Variance (ANOVA) for Second Model

After the model was developed, it was used to predict the travel time of the 28 observations that were initially separated in model development. Validation was done to see how good the model can predict or forecast values. The model was validated using the Mean Absolute Percentage Error (MAPE) and the result is shown in Table 5. The result showed a 15.72124 MAPE which is equivalent to Good Forecasting based on Table 6. From this, the study was able to develop a Travel Time Model with a significant level of accuracy. The predicted travel time from the model was then used to calculate the congestion index of each segment.

Travel Time	***Predicted Time***	**MAPE**	***Travel Time***	***Predicted Time***	**MAPE**
0.03694	0.04043	0.09436	0.05433	0.05389	0.00821
0.06433	0.06900	0.07261	0.07189	0.07665	0.06617
0.02689	0.01962	0.27031	0.03333	0.02893	0.13222
0.02050	0.00133	0.93531	0.06344	0.07155	0.12770
0.04106	0.04104	0.00043	0.05456	0.05373	0.01505
0.08183	0.08252	0.00842	0.02356	0.01326	0.43689
0.09072	0.08928	0.01589	0.02911	0.01967	0.32437
0.04000	0.04407	0.10173	0.03106	0.03316	0.06779
0.04833	0.05197	0.07532	0.18778	0.15077	0.19709
0.03722	0.03810	0.02353	0.02906	0.02698	0.07144
0.03022	0.02821	0.06647	0.04656	0.04812	0.03352
0.04294	0.04431	0.03169	0.02089	0.00585	0.72010
0.04328	0.05656	0.30684	0.03094	0.03107	0.00397
0.03889	0.04319	0.11057	0.03700	0.04011	0.08393
					15.72124

Table 5 MAPE Values

MAPE VALUE	INTERPRETATION
< 10	Highly Accurate Forecasting
10 – 20	Good Forecasting
20 -50	Reasonable Forecasting
> 50	Inaccurate Forecasting

Table 6 MAPE Interpretation

Figures 3 and 4 show overall congestion index for morning and evening peak hours, respectively for the whole study route. In general, segments 1, 3 and 5 have a low to moderately congested conditions during the morning peak hours of 8:00 – 10:00 am. The average values of their congestion index lie between 0.131 to 1.248. On the contrary, segments 2 and 4 show moderate to high congestion conditions; with CI values higher than 1 but less than the considered extreme congestion index value of 2. These results show that during morning peak hours, traffic flow conditions in the whole study area is tolerable but improvements in traffic management system may still be implemented especially in segments 2 and 4. As for the evening peak hours which is from 4:00 – 7:00 pm, congestion indexes were generally higher than that of the morning peak. Most of the CI values were more than 1 except for segment 3 and the southbound direction of segment 1 and 5. Other than those, a moderate to highly congested segments can be observed during these hours. Northbound direction of segments 1 and 4 exceeds CI value of 2 which means that longer travel time can be expected when passing through these segments; delays that are much longer than the travel time itself. Unlike in the morning peak hours, CI values in the evening indicates that traffic flow during these hours are not tolerable and needs a lot of concern in terms of its management.

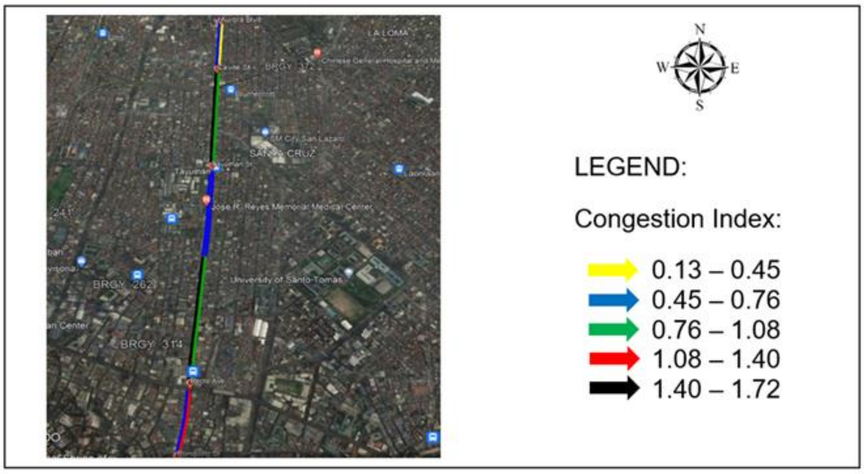

Figure 3 Overall Congestion Index – Morning Peak Hours

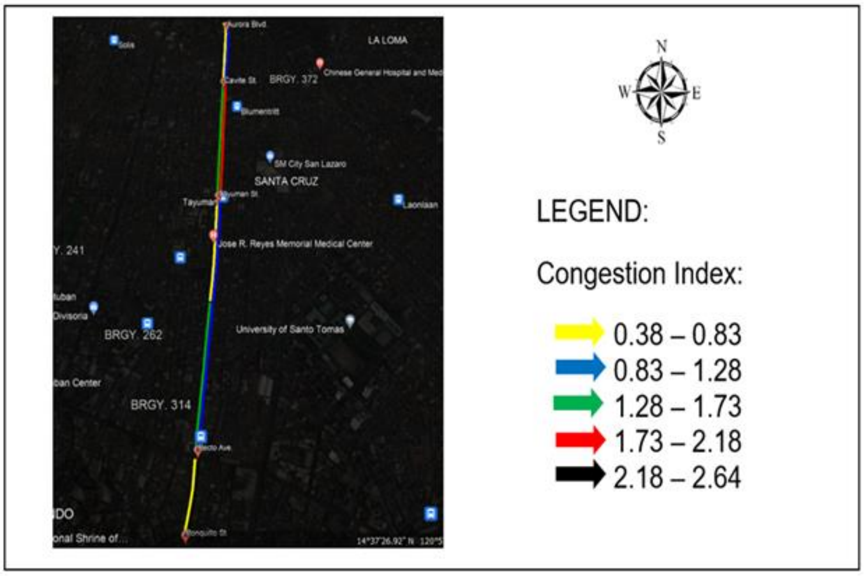

Figure 4 Overall Congestion Index – Evening Peak Hours

IX. CONCLUSION

From the results presented, the study had arrived at the following conclusions: Results show that Segment 4 (Tayuman to Cavite St.) is the most congested. In contrast, segment 3 (Bambang St. to Tayuman St.) shows a low to moderate congestion index throughout the week, making it the least congested segment. Common causes of delay along the segments were: pedestrian crossing, stopping at the red-light signal, and maneuvering vehicles in the intersection. In segment 1 (Ronquillo St. to Recto Avenue), the loading and unloading of public utility jeepneys were mainly at fault for causing heavy traffic. For segments 2 and 3 (Recto Avenue to Bambang St. to Tayuman St.), on-street parking and bus stations at segment two cause heavy delays, especially when vehicles pass through unsignalized intersections. As for segment 4 (Tayuman St. to Cavite St.), consistent delays were not only recorded due to red-light at signalized intersections but also in unsignalized ones like in Herrera and Blumentritt St. The presence of PNR Station and the lack of boundary between northbound and southbound roads trigger congestion in segment 4. Lastly, delays in segment five (Cavite St. to Aurora Blvd) were primarily due to defective traffic signals at the end of the segment.

The solutions to traffic congestion and countermeasures to be applied along the study area are: strict implementation of existing traffic law, regulating the schedule of the arrival and departure of buses in segment two by scheduling it in off-peak hours, adding concrete barriers along segment four, particularly in the intersection of Rizal Ave and Blumentritt St., pedestrian lane in the entrance or exit of LRT Blumentritt Station, traffic signals should be fixed and replaced by a newer one since its visibility is difficult, especially during the night, and increasing penalties and traffic fines against offenders likely to reduce traffic accidents and deaths.

REFERENCES

[1] Roess, R. P., Prassas, E. S., & McShane, W. R. (2004). Traffic Engineering. New Jersey: Pearson Education Inc. Retrieved from https://www.slideshare.net/hronaldo10/04-traffic-stream-characteristics-traffic-engineering-prof-saad-algadhi.W. H. Hsieh, "An Experimental Study on Cam-Controlled Planetary Gear Trains," Mechanism and Machine Theory, vol. 42, no. 5, pp. 513-525, May 2007.

[2] Jimenez, F. (2018). Intelligent Vehicles. Butterworth Heinemann.

[3] CNN Philippines Staff. (2018, September 19). PH traffic may worsen, to cost ₱5.4 billion daily - JICA. Retrieved from CNN Philippines: https://cnnphilippines.com/news/2018/09/19/JICA-study-traffic-5-billion.htm

[4] Rao, K. R., & Rao, A. M. (2012). Measuring Urban Traffic Congestion - A Review. *International Journal for Traffic and Transport Engineering* , 286-305.

[5] Taylor, M. P. (1992). Exploring the Nature of Urban Traffic Congestion: Concepts, Parameters, Theories and Models. Australian Road Research Board Conference, 83-105.

[6] Turner, S. M., Lomax, T. J., & Levinson, H. S. (1996). Measuring and Estimating Congestion Using Travel Time-based Procedures. *Transportation Research Record Journal*, 11-19.

[7] Niog, B. D., & Taganahan, J. (2011). Traffic Survey. *Technical Paper Series ARNDP - Volume II*.

[8] Raheem, S. B., Olawoore, W. A., Olagunju, D. P., & Adeokun, E. M. (2015). The Cause, Effect and Possible Solution to Traffic Congestion on Nigeria Road (A Case Study of Basorun-Akobo Road, Oyo State).

[9] Quiroga, C. A. (1997). An Integrated GPS-GIS Methodology for Performing Travel Time Studies. *LSU Historical Dissertations and Theses*.

[10] Macababbad, R. J., & Regidor, J. F. (2011). A Study on Travel Time and Delay Survey and Traffic Data Analysis and Visualization Methodology. *Eastern Asia Society for Transportation Studies*.

[11] Mathew, T. V. (2010, January 7). Fundamental parameters of traffic flow. Retrieved from https://www.civil.iitb.ac.in/tvm/1100_LnTse/501_lnTse/plain/plain.html

[12] Garber, N. J., & Hoel, L. A. (2009). Traffic & Highway Engineering (Fourth Edition).

[13] Roess, R. P., Prassas, E. S., & McShane, W. R. (2004). *Traffic Engineering.* New Jersey: Pearson Education Inc. Retrieved from https://www.slideshare.net/hronaldo10/04-traffic-stream-characteristics-traffic-engineering-prof-saad-algadhi

[14] Lewis, C.D. (1982). Industrial and business forecasting methods. London: Butterworths.