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The Effect of Land Use on the Road's Level of Service In Lawang – Singosari Road Due to the Construction of Malang – Pandaan Toll Road

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Abstract:- The uncontrolled development of land use and the increasing of intercity transportation's movement in the main corridor cause the decreasing road's level of service in Lawang – Singosari Street. The policy of Malang – Pandaan toll road development is expected to be able to decrease the congestion on the artery road. The aim of this study is to count the impact of land use in the road's level of service on Lawang – Singosari street. The vehicle's movement from the land use's activities is analyzed using multiple linear regression, meanwhile, the analysis method used for the movement of continuous traffic and branching road is traffic flow and traffic diversion curve analysis. The result of this study shows the contribution of the attraction and generation volume of movement due to 33.5% of land use. The development of Malang – Pandaan toll road affects to the volume of the continuous traffic which is diverse through the toll road that reaches 61% and causes the increasing contribution of the attraction and generation volume of land use due to 50.1%.

Keywords:- *Movement Model; Land Use; Road's Level of Service; Toll Road.*

I. INTRODUCTION

In a developing country, the increasing of intercity transportations that are dominated by private vehicles and less public transportation support and the policy of land use can cause congestion (Fatemeh Salarvandian, 2017). The decreasing of function and road capacity is because of the traffic volume in the attraction and generation especially in trading and service (Waloejo, Surjono, & Sulistio, 2012). The development of trading and service area in the main corridor can give effect towards the road's level of service (Agustin, 2017). The integration of street modeling and land use becomes the tools to estimate land use's pattern and the increasing of traffic volume in the future (Mohammad Tayarani, 2018). The increasing road capacity and the formation of a new road can be several solutions to maintain traveled distance (Rahayu, 2016). The growth of the transportation network cannot balance the economic growth and land use makes overcapacity exists. The intensity of land use's activities which is increasing, push the increasing of the volume of transportation too which affects more in the traveled distance to cause a traffic jam. The policy of the development of Malang – Pandaan Toll Road was done to maintain travel distance and increase accessibility.

II. METHODOLOGY

This study uses the interaction between transportation subsystem concepts which is land use activity and network system which these interactions will produce movement system. This study is descriptive study using a quantitative approach so it can measure the effect from land use's variable and the development of Malang – Pandaan Road Toll statistically towards the level of service in Lawang – Singosari Street. The methodologies of this study consist of:

A. Research Variable

Variable and sub-variable in this study are determined based on the aim of the study through related theories and previous studies. The variables of the study are including:

1) Road Capacity

Variable of the road capacity consists of several sub-variables: road geometric, flow composition and road separator, sideways roadblock, and traffic regulation.

2) Traffic Flow

Variable of the traffic low consists of several sub-variables: external traffic flow (consistent flow and branching road flow) and internal traffic flow.

3) Attraction and Generation Modelling of Land Use

Variable of generation models and land use consist of sub-variables: generation of land use movements and attraction of land use movements.

4) Traffic Diversion

Traffic diversion variable consists of several sub-variables: external traffic flow (continuous traffic), distance (the length of the road), and traveled distance.

B. Data Collecting

The method of data collecting is done through primary and secondary surveys. The researcher of this study elaborates the method for every variable and sub-variable as follows:

1) Road Capacity

The variable of road capacity is done by field observation through measuring the road geometric, the volume of the vehicle, and sideways roadblock in the street of the study.

2) Traffic Flow

The variable of vehicle traffic flow is done by field observation by measuring the vehicles. The internal flow measuring is by counting the vehicles that were in and out in the land use. Meanwhile, the continuous traffic flow uses plat matching technique and external flow (branching road) through the counting of the vehicles that were in and out in the main branching road.

3) Attraction and Generation Modelling of Land Use

The variable of attraction and generation modeling of land use is done by field observation by identifying the type of land use and vehicle's volume measurement due to land use. Meanwhile, the data collecting is from a related questionnaire about the characteristic condition of land use that can affect the attraction and generation in it.

4) Traffic Diversion

The variable of traffic diversion is done by field observation through continuous traffic measurement using plat matching technique and also the margin of distance and traveled distance between Artery Street and the toll road.

C. Data Analysis

ATA analysis in this study uses evaluative analysis. The results of the analysis are as follows:

1) The Analysis of Road's Level of service

This analysis is done by comparing the capacities of the road towards the volume of the vehicle which passes on it so the researcher can get the road's level of service.

2) Road Capacity

The analysis of road capacity is done to count the level of the road's ability to accommodate the traffic flow by measuring the basic capacity, adjustment factor of the road's width, adjustment factor of the sideways' width, flow composition and direction separator, sideways roadblock, and the city's size as well as the traffic regulation.

3) Traffic Flow

The analysis of traffic flow is an analysis to count the volume of the vehicle that passes through a certain road. This analysis is used to find out the average daily traffic.

4) Analysis of Correlation and Linear Regression

The correlation analysis is the analysis to find out the level of the relationship between land use's characteristics and internal volume traffic. Meanwhile, analysis double linear regression in this study is used stepwise methods; this analysis is used to compose the best equation of the characteristic effects of land use towards the movement from the land use.

5) Traffic Diversion (Diversion Curve)

The measurement of vehicle diversion values in this study uses diversion curve of travel time and distance saving between the main road of Lawang – Singosari and Malang – Pandaan Toll Road.

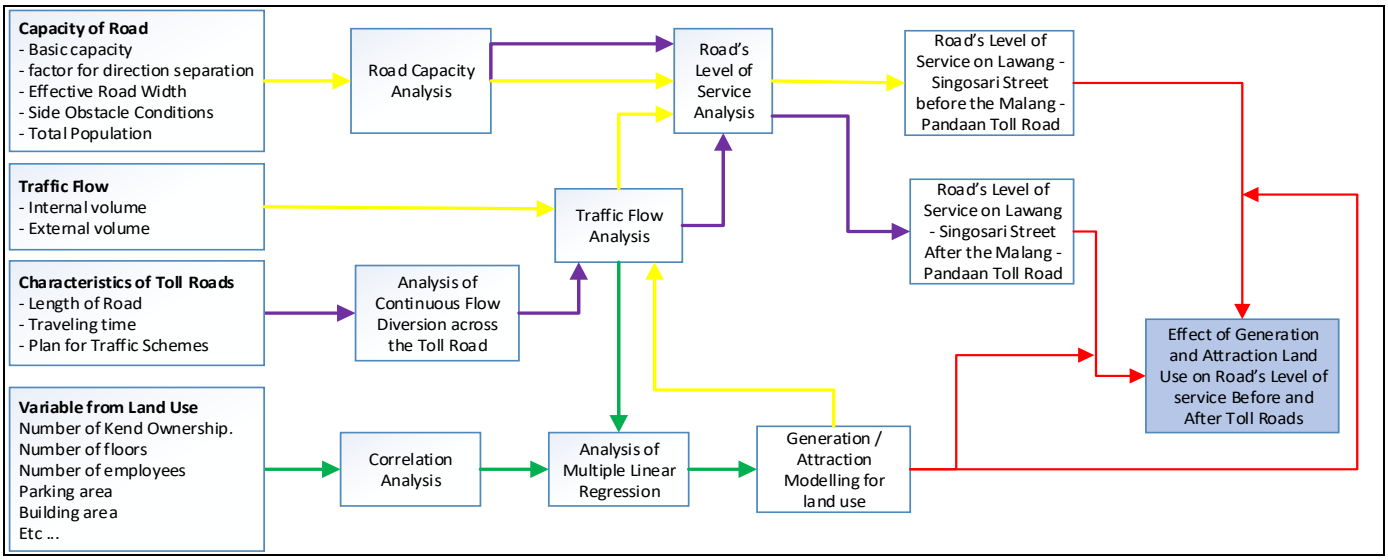

Fig 1:- Framework of research methods

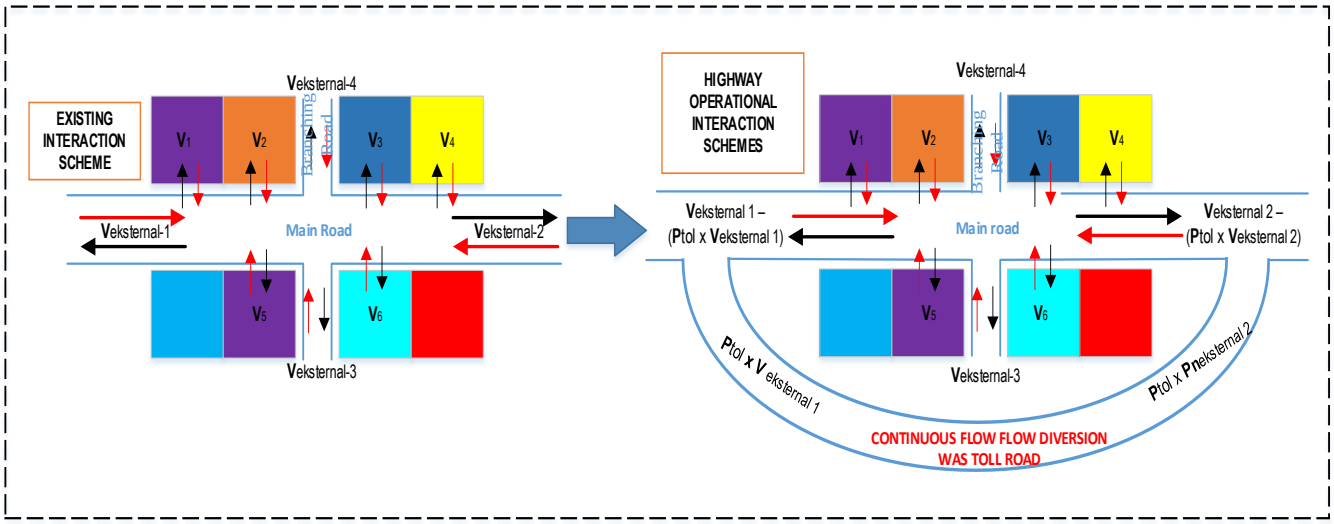

Fig 2:- Research concept (Waloejo, 2013)

In order to find out the interaction modeling between land use and road network, the formula that is used is (Waloejo, 2013) :

$$\mathbf{V}_{Total} = \sum \mathbf{V}_{internal} + \sum \mathbf{V}_{eksternal} \quad (1)$$

where :

$\sum \mathbf{V}_{total}$ = Total volume of vehicle's movement/ hour on the main road corridor

$\sum \mathbf{V}_{internal}$ = Total volume of the vehicle's movement/hour from the whole attraction and generation of land use

$\sum \mathbf{V}_{external}$ = Total volume of the vehicle's movement from the movement of the environment road volume and the continuous traffic on the main road.

So, to count the road's level of service (PKJI, 2014), the formula used is based on the model interaction as follows:

$$\textbf{Road's Level of Service } (D_J) = \frac{\textbf{V total (pcu/hour)}}{\textbf{C (pcu/hour)}} \quad (2)$$

where **V**total is the vehicle/hour movement volume which is on the corridor of the main street and C is the road's level of service.

III. RESULT

The location of this study is on the main road of Lawang – Singosari. The road network in that road is including in the national category of the road with the hierarchy as primer artery since it connects Malang and Surabaya. The location image of the study and the segment division on the road will be presented as follow.

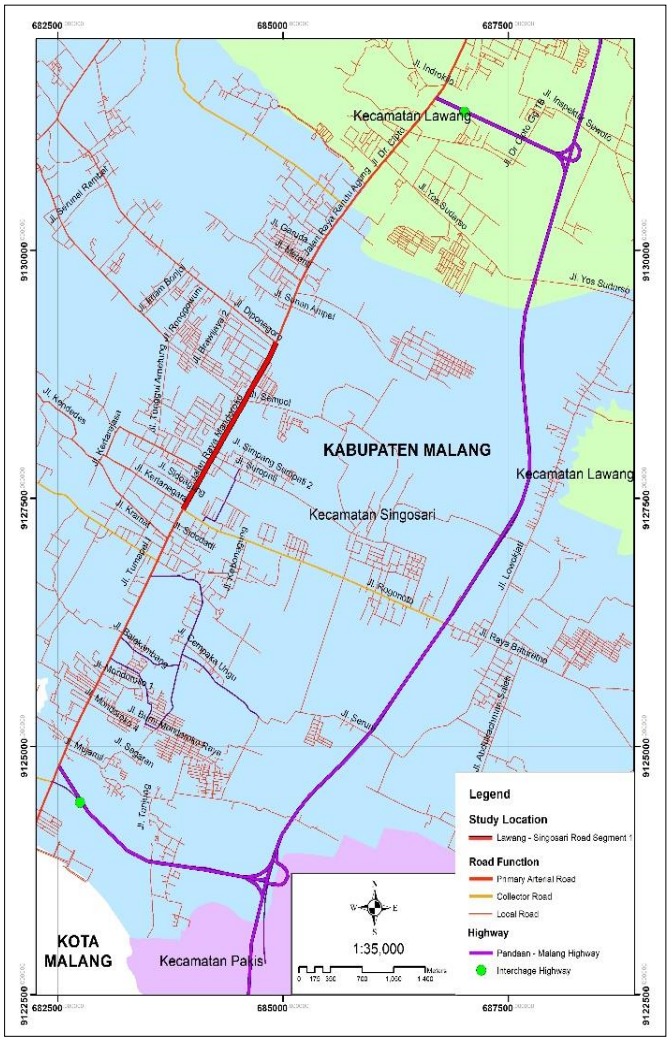

Fig 3:- Research Location Mapping on Lawang – Singosari Street

This land uses along the main road of Lawang – Singosari. They are including:

No	Type of Land use		Population
1	Housing		65
2	Trading and Service		320
	1	Mechanic Shop and Buying/Selling Vehicles	48
	2	Supermarket	17
	3	Printing and Convection Service	16
	4	Cafe and Restaurant	22
	5	Daily Needs Shop	39
	6	Clothing and Accessories Shop	16
	7	Handphone and Credit Shop	17
	8	Small Shop	70
	9	The building, Furnishing, and Electronic Shop	45
	10	Gas Station	2
	11	Other Trading and Service	28
3	Education		8
4	Officce		36
5	Worship Place		4
6	Industry and Warehouse		29
7	Health		17
Total			**479**
	Empty Building		65

Table 1:- Type Identification of Land Use

Based on Table 1, the dominating land use in the area of the study is trading and service with total amoung 67% and 14% for housing so the effect of land use towards the road's level of service will focus more on that land use.

A. Road Capacity

The main road of Lawang – Singosari has the basic capacity (Co) with the total amount of 6.600 pcu/hour, the value of capacity adjustment factor for direction separation (FC_{PA}) is 1. Meanwhile, the value of capacity adjustment for sideways roadblock (FC_{HS}) is 0.96 and the value of capacity adjustment for lanes' width/traffic lanes (FC_{LJ}) is 0,96. Last but not least, the capacity adjustment factor for the city size (FC_{UK}) is 1 so it can be drawn that the capacity on Lawang – Singosari Street is 6.209 pcu/hour.

B. Attraction and Generation of Land Use Modelling

1) Land Use Housing

Based on the result of the analysis, the model shown from the result with the equation *Y = 1.208 + 0.023 (building area) + 0.407 (the number of family members) + 0.335 (vehicle ownership)* with the average land use's characteristic, the building area is 66.37 m^2. On the other hand, the number of family members is 4 people and the number of vehicle ownership is 4 units.

2) Land Use Trading and Service

Based on the result of double linear regression analysis, there is attraction movement modeling in the trading and service land use. The several types of that modeling based on the activities are as follow:

a. *Mechanic Shop and Buying/Selling Vehicles*

Based on the result of the analysis, the equation drawn from it is *Y = 0.863 + 0.401 (building area) + 0.549 (number of the visitor)* with the land use's characteristics average around 63.3 m^2 and the number of the visitors are around 54 people.

b. Supermarket

Based on the result of the analysis, the equation drawn from it is *Y = - 0.443 + 0.403 (parking lot area) + 0.357 (building area) + 0.323 (number of the visitor)* with the land use's characteristics average around 74 m^2, 108.7 m^2 for the building area and 191 visitors.

c. Printing and Convection Service

Based on the result of the analysis, the equation drawn from it is *Y = 2.907 + 0.415 (parking lot area) + 0.822 (number of the visitor)* with the land use's characteristics average is 42.6 m^2 for the parking lot area and 49 visitors.

d. Cafe and Restaurant

Based on the result of the analysis, the equation drawn from it is *Y = - 7.501 + 0.677 (parking lot area) + 0.466 (number of the visitor)* with the land use's characteristics average is 63 m^2 for the parking lot area and 120 visitors.

e. *Daily Needs Shop*

Based on the result of the analysis, the equation drawn from it is *Y = - 20.532 + 0.735 (building area) + 0.423 (number of the visitor)* with the land use's characteristics average is 64.7 m^2 for the building area and 203 visitors.

f. Clothing and Accessories Shop

Based on the result of the analysis, the equation drawn from it is *Y = - 30.755 + 0.795 (building area) + 0.498 (number of the visitors)* with the land use's characteristics average is 72.7 m^2 for the building area (X_{35}) and 170 visitors (X_{36}).

g. Handphone and Credit Shop

Based on the result of the analysis, the equation drawn from it is *Y = 21.873 + 1.484 (parking lot area) + 0.133 (number of the visitors)* with the land use's characteristics average is 22.6 m^2 for the parking lot area and 91 visitors.

h. *Small Shop*

Based on the result of the analysis, the equation drawn from it is *Y = 2.628 + 0.687 (building area) + 0.130 (number of the visitors)* with the land use's characteristics average is 39.6 m^2 for the building area and 96 visitors.

i. *The building, Furnishing, and Electronic Shop*

Based on the result of the analysis, the equation drawn from it is *Y = - 21.423 + 0.272 (building area) + 0.816 (number of the visitors)* with the land use's characteristics average is 75 m^2 for the building area and 163 visitors.

j. *Gas Station*

Based on the result of the analysis, the equation drawn from it is *Y = - 3.255 + 12.867 (building area)* with the land use's characteristics average is 230 m^2 for the building area.

k. Other Trading and Service

Based on the result of the analysis, the equation drawn from it is *Y = - 30.860 + 0.300 (building area) + 0.708 (number of traffic)* with the land use's characteristics average is 81 m^2 for the building area and 145 visitors.

3) Land Use Office

Based on the previous study, the equation drawn from it is *Y = - 64.733 + 1.257 (building area) + 0.240 (number of the visitor)* with the land use's characteristics average is 586 m^2 for the building area and 45 visitors.

4) Land Use Education

Based on the previous study, the equation drawn from it is *Y = - 8.762 + 0.111 (number of the student) + 0.163 (building area)* with the land use's characteristics average is 842.6 m^2 for the building area. Meanwhile, there are 321 students.

5) Industry and Warehouse Land Use

Based on the previous study, the equation drawn from it is *Y = - 5.104 + 0.736 (number of the employee) + 1.832 (delivery frequency)* with the land use's characteristics average is 56 employees and the delivery frequency is 18 delivery in a day.

6) Land Use Public Health

Based on the previous study, there is attraction movement modeling in health land use. The several types of that modeling based on the activities are as follow:

a. Hospital or Health Center

Based on the previous study, the equation drawn from it is *Y = - 2.354 + 0.360 (number of the daily patient) + 0.038 (inpatient room area)* with the land use's characteristics average is 220 patients and 625 m^2 for the inpatient room area.

b. Drug Store / Clinic

Based on the previous study, the equation drawn from it is *Y = - 11.700 + 1.501 (number of the visitor) + 0.114 (building area)* with the land use's characteristics average is 33 visitors and 108 m^2 for the building area.

Here is the recapitulation of attraction and generation land use modeling's application along the main road of Lawang – Singosari.

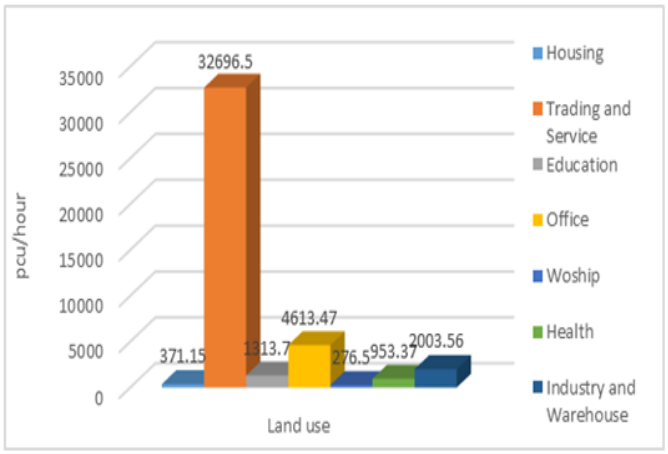

Fig 4:- Graph of Application of Vehicle Movement Model due to Land Use on Lawang – Singosari Street

Based on figure 4, it can be seen that the biggest land use vehicle's movement modeling that attraction or generation the movement is land use trading and service which is 32696.5 pcu/day. The second biggest land use is from the office which is 4613.47 pcu/day. The least land use movement modeling that attracts the movement in place of public worship which is only 276.5 pcu/day.

C. External Traffic Flow (Continuous Traffic)

The measurement of traffic flow is done to find out the vehicle's movement that has traveled continuously in every segment. Here is the continuous traffic flow on Lawang – Singosari Street.

Time	Continuous Volume (unit)			Total of continuous volume (pcu/hour)
	MC	LV	HV	
06.00 - 07.00	6126	2513	323	4432.1
07.00 - 08.00	5632	2580	310	4360
08.00 - 09.00	4772	2486	269	4001.8
09.00 - 10.00	2509	2178	247	3101.65
14.00 - 15.00	3141	2124	267	3229.65
15.00 - 16.00	3023	2530	273	3613.35
16.00 - 17.00	3571	2226	259	3429.55
17.00 - 18.00	4823	2444	367	4090.15
18.00 - 19.00	4384	2318	349	3832.8
Total	**37981**	**21399**	**2664**	**34091.05**

Table 2:- Continuous Traffic Volume on Lawang - Singosari Street

Based on Table 2, the volume of the continuous traffic on Lawang – Singosari street that facing the density of vehicles is in the morning starts from 06.00 – 07.00 am. The vehicle's volume is around 4432.1 pcu/hour. On the other hand, the volume of the vehicle in the afternoon starts from 5.00 – 6.00 pm is 4090.15 pcu/hour. The indication of this event is caused by the movement of people who go to school or office along on Lawang – Singosari Street. It can also because of the intercity movement through that road.

D. External Traffic Flow (Branching Road)

The total vehicle's volume on the whole branching road especially is analyzed every hour.

Time	Branching road Volume (pcu/hour)
06.00 - 07.00	302.6
07.00 - 08.00	322.1
08.00 - 09.00	281.45
09.00 - 10.00	294.85
14.00 - 15.00	258.2
15.00 - 16.00	269.7
16.00 - 17.00	309.5
17.00 - 18.00	350.65
18.00 - 19.00	372
Total	**2761.05**

Table 3:- Branching Road Traffic Volume On Lawang – Singosari Street

Based on Table 3, the traffic's volume of branching road on Lawang – Singosari Street faces its rush hour in the morning starts from 07.00 – 08.00 am and 05.00 – 08.00 pm in the afternoon.

E. The Effect of Land Use towards Road's Level of Service before the Development of Malang – Pandaan Toll Road

Based on the result of the capacity measurement and traffic flow volume on Lawang – Singosari Street, it can be concluded that the result of the road's level of service and the effect of land use on that main road before the development of the toll road is as follows:

Time	Total Volume (pcu/hour)	Volume of Land use (pcu/hour)	DJ	LOS	Effect of Land Use (%)
06.00 - 07.00	5141.29	406.59	0.83	D	7.9
07.00 - 08.00	5894.87	1212.77	0.95	E	20.6
08.00 - 09.00	6109.19	1825.94	0.98	E	29.9
09.00 - 10.00	5173.58	1777.08	0.83	D	34.3
14.00 - 15.00	5235.25	1747.40	0.84	D	33.4
15.00 - 16.00	5521.81	1638.76	0.89	E	29.7
16.00 - 17.00	5515.25	1776.20	0.89	E	32.2
17.00 - 18.00	5896.59	1455.79	0.95	E	24.7
18.00 - 19.00	5109.93	905.13	0.82	D	17.7

Table 4:- Road Level of Service and Effect of Land Use on Lawang Singosari Street

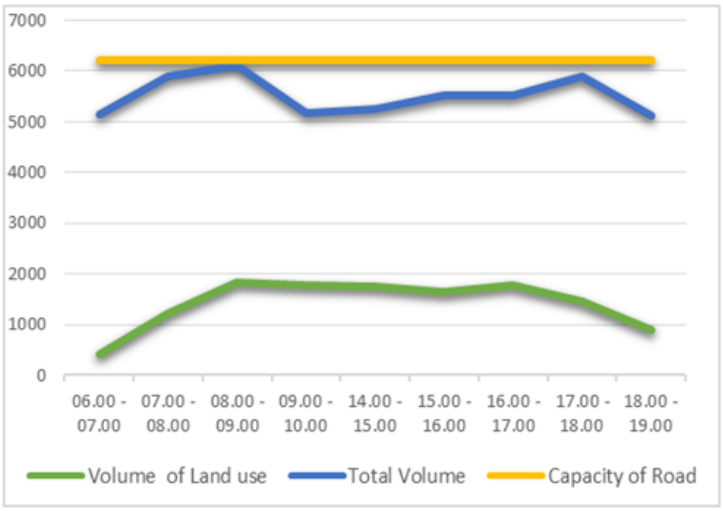

Fig 5:- Graph of comparison of attraction and generation volume of land use, total volume and capacity of road

Based on Table 5, it can be seen that the vehicle's movement due to land use towards the total vehicle volume in every segment on Lawang – Singosari Street before the operational hour of Malang – Pandaan Toll Road has percentage around 7.9 – 34.3% with different contribution in every hour of observation.

It shows that before the toll road was opened, the contribution of external traffic flow (continuous traffic) was more dominating compared to local flow (land use). On segment 1, the biggest volume contribution due to land use happens in the morning starts from 09.00 – 10.00 am is 34.3%. Meanwhile, the volume percentage around 32.2% happens in the afternoon starts from 04.00 – 05.00 pm. It is happened because of the high intensity of people's activities in trading and service aspects in the morning till afternoon.

F. Continuous Traffic Flow Diversion

This study uses diversion curve to determine the estimation of separation traffic that chooses Malang – Pandaan Toll Road and traffic that is left behind through on Lawang – Singosari Street. This curve uses the variable that consists of the difference between distance and traveled distance between vehicle's movements which go through the main road of Simpang Karanglo – Purwodadi Toll Gate and those vehicles on the Karanglo – Purwodadi Toll Road.

Time	Difference in Travel Time (minutes)	difference in distance (km)	Flow Diversion (%)
06.00 - 07.00	6.1	-3.5	47%
07.00 - 08.00	10.2	-3.5	58%
08.00 - 09.00	10.2	-3.5	58%
09.00 - 10.00	7.5	-3.5	52%
14.00 - 15.00	6.1	-3.5	47%
15.00 - 16.00	7.5	-3.5	52%
16.00 - 17.00	9.2	-3.5	56%
17.00 - 18.00	10.2	-3.5	58%
18.00 - 19.00	6.1	-3.5	47%

Table 5:- Diversion Flows On Karanglo - Purwodadi Main Road And Karanglo - Tol Purwodadi Toll Road

Based on the picture above, the traffic flow diversion that is predicted will go through Malang – Pandaan Toll Road is 47% – 58%.

G. The Effect of Land Use towards Road'sLevel of service after the Development of the Toll Road

Based on the counting of traffic flow diversion, the road's capacity and traffic flow volume on Lawang – Singosari Street, the result of the road's level of service and the effect of land use on that road after the development of the toll road are as follows:

Time	Total Volume (pcu/hour)	Volume of Land use (pcu/hour)	DJ	LOS	Effect of Land Use (%)
06.00 - 07.00	3777.99	406.59	0.61	C	10.8
07.00 - 08.00	4182.67	1212.77	0.67	C	29.0
08.00 - 09.00	4480.09	1825.94	0.72	C	40.8
09.00 - 10.00	3886.93	1777.08	0.63	C	45.7
14.00 - 15.00	4086.40	1747.40	0.66	C	42.8
15.00 - 16.00	4035.86	1638.76	0.65	C	40.6
16.00 - 17.00	4094.60	1776.20	0.66	C	43.4
17.00 - 18.00	4223.64	1455.79	0.68	C	34.5
18.00 - 19.00	3823.63	905.13	0.62	C	23.7

Table 6:- Road's Level of Service and Effect of Land Use on Lawang Singosari Street

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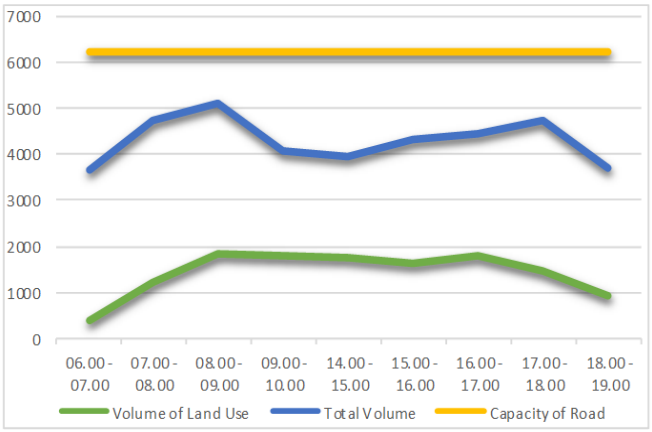

Fig 6:- Graph of comparison of attraction and generation volume of land use, total volume and capacity of road

According to Table 6, it can be seen the vehicle's movement due to land use towards the total volume of whole vehicles in every segment on Lawang – Singosari Street after the toll road was opened is 10.8% - 45.7% with different effect contribution in every hour of observation. It shows that after the toll road of Malang – Pandaan was opened, the contribution of internal traffic flow (land use) is almost balance compared to external traffic flow (continuous traffic) and it is bigger than before. On segment 1, the biggest contribution volume of land use happens in the morning starts from 09.00 – 10.00 am which is 45.7% and 43.4% in the afternoon starts from 04.00 – 05.00 pm. It is happened because of the high intensity of people's activities in trading and service aspects in the morning till afternoon.

IV. CONCLUSION

The conclusions of this study about "the effect of land use and the development of Malang – Pandaan Toll Road" are as follows:

1. The effect of land use towards the road's level of service before Malang – Pandaan Toll Road was opened is 7.9% - 34.3%. It shows that the external traffic flow (continuous traffic) contribution is more dominating than local flow (land use).
2. The impact of Malang – Pandaan Toll Road's development can diverse the continuous traffic flow around 47% - 61%.

The effect of land use towards road's level of service after Malang – Pandaan Toll Road was opened is around 10.8% - 45.7%. It shows that the external traffic flow (continuous traffic) contribution is more dominating than local flow (land use).

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