The Effect of Commercial Areas and Industrial Zone Improvement on Road Service Levels Between City Surabaya-Sidoarjo

Budi Sugiarto Waloejo
Urban and Regional Planning Department
Brawijaya University
Malang, Indonesia
budieswe@ub.ac.id

Abstract—The Regional Government Policy of Surabaya City which prohibits industrial zones outside industrial estates in Surabaya urban areas encourages the growth of new industrial zones in the hinterland area of Surabaya city or Gerbangkertosusilo region, including Gresik Regency, Sidoarjo Regency and Mojokerto Regency. The problem occurs because the development of industrial estates and reserves and services relies on primary arterial roads, so that there is a build up of continuous traffic flow and movement flows from generation / attraction from land use so that the road becomes congested. The purpose of this study is to find out land use interaction model, knowing network performance and knowing the travel time that must be passed. And analyze what components influence calculation of travel time. We descriptively described the road characteristics and analyzed quantitatively, correlation analysis and multiple linear regression analysis and other quantitative analyzes used to evaluate and formulate the model and its impact on the level of service of the road and travel time calculation. The research showed that along the Surabaya-Sidoarjo road segment, there are currently industrial dominated land use activities with a percentage of 66.2% and 14.8% of commercials, V_{total} = 69.029 pcu/day (internal) + 57.326 pcu/day (external) = 126.354 pcu/day. The trip higher than the road's capacity which 6.820 pcu/hour. The level of road service is bad at certain hours; noon (8:00 to 19:00) with F value. The influence of the pulling volume of movement from zona industry outside the Industrial Estate is 9.452 pcu/day or 13.69% of the total Land Use and the Commercials is 48.388 pcu/day or 53.42% of the total Lands Use.

Keywords: land use, commercials area, industrial area, level of service

I. INTRODUCTION

The Surabaya City Government policy in the era of the 1990s encouraged the development of industrial area to get out of the urban areas of Surabaya because the density was already very high in urban areas. This policy has an impact on the emergence of Industrial Area outside of Industrial Estates which are scattered in the Gerbangkertosusila area [1]. Jalan Waru Surabaya-Sidoarjo is one of the primary artery roads which is an area of industrial zone shifting from the city of Surabaya, which in turn causes an increase in movement on the road. The growth of Industrial Zones on the road triggers the development of other land uses such as residential areas, trade areas and services, offices and others.

There are 22 industrial zones and 122 trade and service areas recorded. Along the road from Surabaya to Sidoarjo, it is now filled with land use activities dominated by industry with percentage reaching 66.2 per cent, trade and service 14.8 per cent and the rest consists of housing, terminals, offices and other facilities. Of course, this road segment is a solid road segment with the use of land that can become a center of activity that is quite solid as well. Activities on the Surabaya-Sidoarjo road can be regarded as a road with a high level of activity. The rapid growth of land use along the road from Surabaya to Sidoarjo resulted in the emergence of a center of activities that occurred from morning to evening. The dominance of industrial land use has increased the potential for large or heavy vehicle movement to become more, besides it has not been added to the trade and service activities in the segment.

The existence of industry is inseparable from the existence of transportation in the flow of distribution of raw materials and finished goods requiring transportation equipment to be taken to the destination. Shipping activities by four-wheeled vehicles reach 15 to 25 percent of the volume of vehicles weighing on the road [2]. Industrial estates have caused several impacts related to transportation. One of the impacts is the loading and unloading of goods or raw materials that occur can cause congestion delays [3].

This is one of the reasons for the selection of central location of industrial, service, trade and other activities related to the level of accessibility. The road's level of service has a significant effect on the development of land use change or land use growth in certain roads [4]. The rapid development of land use on the primary arterial road corridor has an impact on increasing traffic movements both continuous flows and local movement flows from land use growth on frontage roads [5]. The concept of Mix Uses which was initially proposed to reduce the movement of traffic flow between land uses actually adds to the attraction and generation of traffic movements from the development of land use that occurs in the primary arterial road segment [6,7].

The accumulated flow of continuous traffic between the cities of Surabaya-Sidoarjo and the increase in the flow of movement from the attraction and generation of land use on the corridors of the primary arterial road causes the total flow of traffic movements beyond the capacity of the road [8].

In accordance with its function, the primary arterial road is a liaison between orde-1 traffic flow between cities to orde-1 or orde-2 city, between Surabaya City and Sidoarjo city, but coupled with the presence of traction movements and seizures of traffic flow movements from land use that is along the road corridor [8]. They combine land use models with transportation models to display the interaction of land use systems and urban road network systems over time in a combination of combined interaction models. The advantage of this approach is that exogenous data input is needed eg the land use model can be calculated directly on the local land use (internal volume) added by continuous current flow (external volume) and vice versa [9].

Transportation problems have begun since the 1960s and 1970s, some of the problems associated with transportation are congestion, air and sound pollution, accidents and also delays [10]. Therefore, if the land-use interaction with the existing transportation on the road from Surabaya to Sidoarjo is not controlled then it will cause many problems. So it is necessary to do the control related to the potential existence of Core Urbanism phenomenon in these road.

This study aims to determine the characteristics of the development of land use along the Waru Surabaya-Sidoarjo road segment, obtain a land use interaction model-road network system and measure the service level of the corridor and find out the effect of the contribution of the current flow of industrial zones to the level road services in the corridor.

Integration of land use planning and transport planning is increasingly being acknowledged as an important component of creating sustainable cities [11]. Land use development planning, infrastructure investment, and regulation in transportation planning need to accommodate about changes in land use behavior, in the future, and traveling behavior from land use activities [12]. The linkage between land use and transportation is in the trip generation and attraction factor. Increasing the trip generation and attraction is proportional to the increasing load of the existing road around the land [1]. Increasing the flow of traffic movement on the road has the potential to increase congestion, a condition where the traffic flow that passes through the road exceeds the planned road capacity resulting in free road segments approaching below 30 km/hour or even to 0 km/hour resulting in queue vehicles [13]. Congestion is a big problem in big cities in Indonesia. One of the causes of congestion is because the large number of traffic movements has exceeded road capacity. Reduced effective road space can also be a cause of reduced road capacity. Reduced effective road space can be caused by vehicles parked on the road or other activities such as street vendors, etc [14]. Congestion is also influenced by urban land use, that the land use function can form a resurrection zone pattern, a zone of pull movement or the volume of internal movement flows on the road segment [8].

II. METHOD

The research location is located in the corridor of Surabaya-Sidoarjo through several main roads along with the characteristics of land use. This research type is descriptive research by trying to explain how existing condition at research location relation with Core Urbanism. The descriptive approach taken to produce output is related to the general description of traffic conditions, land use, characteristics of road network, and land use growth in the corridor of Waru Surabaya-Sidoarjo (Fig. 1). The steps of research conducted in a systematic, factual and accurate based on existing conditions and phenomena that occur at the sites. The research step begins with literature study, preliminary study, data retrieval, data processing, data analysis, and conclusion (Fig. 2).
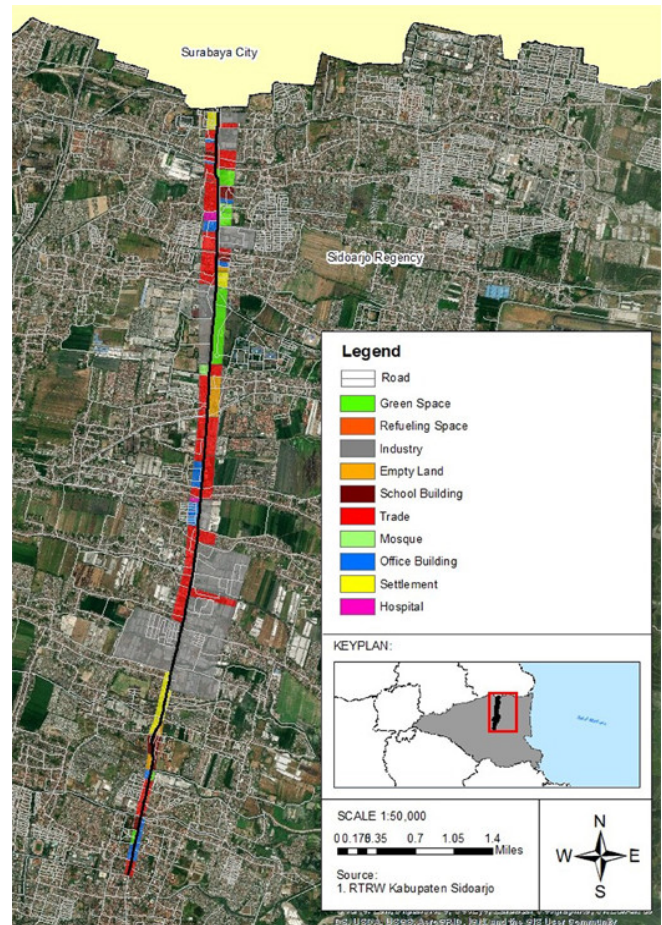

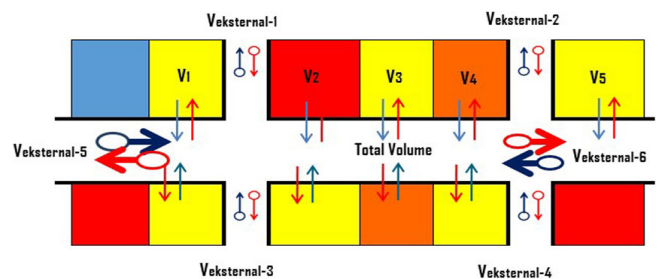Fig. 1. Location and Characteristics of Land Use on the road from Surabaya to Sidoarjo.

Fig. 2. Land use and road network model [14].

Some quantitative methods used include analysis of road loading characteristics (analysis of degree of saturation), analysis of generation and trip pull (multiple linear regression analysis), and modeling of land use interactions. From the interaction of the model it can be seen the level of road service that occurs [2].

Data collection methods used: Primary survey consists of; field observations, interviews/ questionnaires, traffic counting, recording vehicle license platesand and cross-

sectional measurements of the road. Secondary surveys consist of; literature surveys, agency surveys and similar research studies.

A. Capacity on Road:

$$C = C_0 \times FC_W \times FC_{SP} \times FC_{SF} \times FC_{CS} \qquad (1)$$

Notes:
C = Capacity (pcu/hour)
C_0 = Basic Capacity (pcu/hour)
FC_W = Traffic Length adjustment factor
FC_{SP} = Median Adjustment Factor or Direction Separator
FC_{SF} = Side Constraint Adjustment Factor
FC_{CS} = City Size Adjustment Factor

B. Road network performance or service level using the following calculation:

$$VCR = V/C \qquad (2)$$

C. Road Network – Land Use Interaction Model [14]

$$VCR = (\sum V_{internal} + \sum V_{external})/C \qquad (3)$$

Notes:
VCR = Ratio Volume Capacity (level of servive)
V = Traffic Volume (pcu/hour)
$V_{internal}$ = Amount of Vehicle Volume from Generation/Attraction of Land Use
$V_{external}$ = Amount of on-going Vehicle Volume on the Main Street
C = Road Capacity (pcu/hour)

D. The analysis used to find out how the relationship between land use and road network using the following equation:

$$V_{total} = V_{internal} + V_{external} \qquad (4)$$

Notes:

V_{total} = Total volume of vehicle movement per hour in the corridor on the main road.

$V_{internal}$ = Total volume of vehicle movement/hour from generation or attraction of land use.

$V_{external}$ = Total volume of external vehicle movement per hour in the main road corridor of vehicle movement volume per hour from neighborhood roads or alleys plus continuous volume of vehicle movement per hour on the main road.

$$V_i = e_1Y_1 + e_2Y_2 + e_3Y_3 + \dots e_nY_n \qquad (5)$$

Total volume of movement of vehicle / hour from land use in the corridor of the main road.
Notes:
e1 = V1/Y1 = Volume ratio of vehicle movement out or incoming from the land use at certain hours compared to the total volume of vehicle movement/day.

Y1 = Volume of vehicle movement/day of influence of the trip generation/attraction of land use for housing
Y2 = Volume of vehicle movement/day of influence of the trip generation or attraction for education
Y3 = Volume of vehicle movement/day of influence of the trip generation or attraction for healthy
Y4 = Volume of vehicle movement/day of influence of the trip generation or attraction for office
Yn = Volume of vehicle movement/day of influence of the trip generation or attraction for Land use

while:
$V_{external}$ = Total volume of vehicle movement external per hour present in the corridor of the main road

$$V_e = V_{Ex-1} + V_{Ex-2} + \dots + V_n \dots + V_{Ex-5} + V_{Ex-6} \qquad (6)$$

V_{Ex-1} = Volume of vehicle movement per hour from neighborhood streets / alleys - 1
V_{Ex-2} = Volume of vehicle movement per hour from neighborhood streets / alleys – 1
V_{Ex-5} = The continuous volume of vehicle movement per hour on the main road
V_{Ex-6} = The continuous volume of vehicle movement per hour on the main road

TABLE I. DEPENDENT VARIABLE AND INDEPENDENT VARIABLE FOR LAND USE

No.	Land Use	Dependent Variable	Independent Variable
1	Settlement/ Housing	$Y_{Housing}$	X_1 (Number of Family Members)
			X_2 (Number of Motor Vehicles)
			X_3 (Income)
2	Elementary School, Yunior High School, Senior High School	$Y_{Education}$	X_4 (Number of Students)
			X_5 (Number of Teachers)
			X_6 (Number of Classes)
3	University	$Y_{university}$	X_7 (Building Area)
			X_8 (Number of Student)
4	Office	Y_{Office}	X_9 (Number of Employees)
			X_{10} (Number of Visitors)
			X_{11} (Building Area)
5	Hospital	$Y_{Hospital}$	X_{12} (Daily Patient Amount)
			X_{13} (Number of In-Room Places)
6	Commercials	$Y_{Commercials}$	X_{14} (Building Area)
			X_{15} (Number of Visitors)
		$Y_{Fuel Stations}$	X_{16} (Number of Employees)
7	Industry	$Y_{Industry}$	X_{17} (Number of Employees)
			X_{18} (Parking Area)
			X_{19} (Land Area)
9	Terminal	$Y_{Terminal}$	X_{20} (Number of Vehicle)
			X_{21} (Agent/Visitor manager)

The population in the core urbanism control study is the path with arterial hierarchy in East Java (Surabaya-Sidoarjo). Arterial road connects the city level to one, with the city level unity, or connect the city level with the second level, or connect the city level with the third city level. The sampling technique used in this study is simple random sampling technique (simple random sample). The sample determination is assumed that all members of the population have equal opportunity to choose. The variable approach used in this research is conducted by using land based modeling approach and road network is shown in TABLE I.

III. RESULTS AND DISCUSSION

A. Corridor Characteristic of Surabaya-Sidoarjo

Characteristics of Surabaya-Sidoarjo Corridor road is a 4/2 D, with hotmix asphalt pavement. The Surabaya-Sidoarjo road corridor has a road median with a width of 1.5 meters along the road. Related to the width of road (Space Benefit Road) which is equal to 8 meters with the division of each lane is 4 meters. Effective road shoulder width for Surabaya - Sidoarjo road segment is < 0.5 meter. There are some side activities of the road (side barriers) such as on street parking activities ranging from two-wheeled vehicles, four wheels to heavy vehicles. Besides other side barriers that is the activity of the entry of the vehicle from the surrounding land. Associated with the calculation approach of road capacity coefficient has value C_0=6.600, FCw=1.08, FC$_{SP}$=1, FC$_{SF}$=0.92, FCcs=1.03, and has a capacity value of roads of 6754.493. Road network characteristic of Waru Surabaya-Sidoarjo is shown in TABLE II.

TABLE II. ROAD NETWORK CHARACTERISTIC OF WARU SURABAYA-SIDOARJO

Road Characteristic	Waru Surabaya-Sidoarjo
Type	4/2 D
Direction flow	North-South and South-North
Lane	4
Flow system	2 ways
Width of road (m)	8
Material	Asphalt
Width of road (m)	4
Sidewalk (m)	-
Road side	0,5 m and 0,5 m
Median (m)	1,5
Parking	*On Street and off Street*
Type of land use	Commercials, office and industry

B. Land Use Characteristic

Land use in the road corridor from Surabaya-Sidoarjo with total land use area of 5.967.019 m^2 dominated by Industrial land use with an area of 3.952.112 m^2 or 66.2 per cent of the total area while the smallest land use area is a terminal with an area of 12.000 m^2. The dominant land use is the type of industry as much as 66.2 per cent and commercials as much as 14.8 percent. It may invite employees working in the industrial sector as well as in the trade and services sectors, which will impact the volume of traffic vehicles passing along the Surabaya-Sidoarjo road.

C. Land Use Model

The results of modeling land use independent and dependent variables in land use modeling using multiple linear regression analysis along the corridor Surabaya-Sidoarjo generate the following data shown in TABLE III.

TABLE III. LAND USE MODEL

Land Use		Trip Generation Model	Coefficient of Determination
Settlement/ Housing	Settlement/ Housing	YHousing = -0,389 + 0,232 (X1) + 0,027 (X2) + 0,034 (X3)	1
Land Use		**Trip Attraction Model**	**Coefficient of Determination**
Education	Elementary School. Junior High School, Senior High School	YEducation = -0,254 + 0,141 (X4) + 0,112 (X5) + 0,024 (X6)	1
	University/ College	YUniversity= -0,355 + 0,008 (X7) + 0,149 (X8)	0,994
Office	Office	YOffice= 0,108 + 0,662 (X9) + 0,659 (X10) + 0,00007194 (X11)	1
Health	Hospital	YHospital=13,715 + 0,291 (X12) + 0,055 (X13)	0,999
Commercials	Commercials	YTrade and Services = -0,431 + 0,18 (X14) + 0,075 (X15)	1
	Fuel Stations	YFuel Stations = 0,447 + 142,318 (X16)	1
Industry	Industry	YIndustry= -0,497 + 0,363 (X17) + 1,184 (X18)	1
Terminal	Terminal	YTerminal = 206,338 + 0,004982 (X20) + 0,000115 (X21)	0,908

D. The Road's Level of Services

The total volume of vehicles passing through the Surabaya-Sidoarjo corridor is divided into local and continuous flows. The local flow is the flow leading to and out of the land along the corridor, while for the continuous flow is the current that passes only through the corridor (Fig. 3).

It was found that the increasing total vehicle volume will affect to the road's level of service along the corridor. Analysis conducted within the period of 08:00 to 19:00 obtained the results of the road's level of service that is in class F. If it is seen from the movement of vehicles that occur on average every hour has a volume of vehicles reaching the number 8.000-12.000 pcu/hour. Obviously if it is not controlled both in terms of transportation and land use will further exacerbate the road's level of service on the potential congestion that occurred.
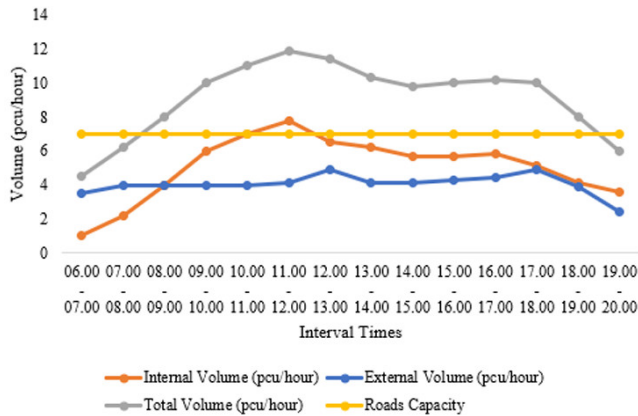
Fig. 3.   The continuous of vehicle movement, local and road capacity.

IV. Conclusions

From the result of the comparison of the volume of movement of vehicles from the trip generation/ trip attraction of land use in the Surabaya - Sidoarjo (69.047 pcu/day) road segment, the volume of continuous vehicle movement on the main road (57.326 pcu/day), indicates that; most of which dominate the movement of vehicles is the movement of generation/ attraction of land for 69.047 pcu/day. So the more land build in the main road will increase the level of congestion on the main road. In the Surabaya-Sidoarjo Road segment, the volume of vehicle movement from the trip generation/ attraction generated land (pcu per day) is greater than the volume of continuous movement on the main road (pcu per day). For land that contributes the largest volume of movement is the use of industrial and commercials land use.

The result of calculation of service level of corridor in the road section from Sidoarjo to Surabaya; Interaction Model of Land Use-Road Network, shows that; from 06.00am to 20.00pm the road's level of service is F. The current condition of the boundary between Surabaya and Sidoarjo is almost biased or connected to each other due to the rapid growth of land use. some solutions that can be given are as follows:

1. It is time for the Sidoarjo regency goverment to limit the growth of land use functions along the Coridor Surabaya-Sidoarjo in particular the use of industrial land and trade & services and encourage the development of industrial zones outside the main road corridors of Surabaya-Sidoarjo.

2. The separation of the flow of traffic must be carried out continuously with the flow of local movements due to generation and the pull of movement from land use by building the frogate road as has been done by the Surabaya City government on A. Yani Street.

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