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Land use development and its impact on airport access road

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Abstract

Land use development is following the needs of the community in a city. The development of land use and those usages could be difference from the Master Plan of the city. This may occur subject to the new policy or some new idea to adopt any general tendency of global change. The changing of land usage drives unmanageable traffic movement due to changing traffic generation or attraction of the new land use. This situation will increase travel time of the road network. The impact of increasing travel time is more affected to air travelers; increasing travel time in the access road to the airport may cause the lost of their flight. This research attempts to determine how much difference of travel time of road access to the airport from time to time that is caused by changing of land use. The result shows that the number of alternative routes to the airport is increased from six to eleven in year 2009 and 2014 respectively. However, the increasing number of access route is not followed by the reducing of travel time. Only two routes out of 11 that have less travel time from 2009.

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1. Introduction

The development of land use in Surabaya city grows rapidly and is not always accompanied by a change and a good road network arrangement. The development is also influenced by the level of the economy in a region which should be supported by the development of infrastructure and transportation planning. The developments of infrastructure and transportation system, sometimes, are left behind of the growth of centre of activities.

This situation causes increasing travel time and delay due to the number of traffic that occupy some routes in Surabaya. These routes are the share routes to Juanda International Airport.

Juanda international airport is a gateway for air traffic with total area 477.3 ha and equipped with 2 terminal buildings that can accommodate about 12.5 million passengers per annum. The high demand of air transportation is generated from all area of Surabaya city. These air travelers demand the high reliability of travel time along the airport access road.

The problem arises when the development of land use along the airport access road is not balance with the development of transport networks and systems. The route access serves numbers of travelers generated or attracted from the new land uses. These influence traffic movements to and exit from the airport. This research attempts to determine the difference of travel time of airport access routes that is caused by changing of land use.

1.1. Preview Changing of Land Use in Surabaya City

Development of urban areas follows the characteristic of inter-regional imbalance development and unequal distribution centre for community services. Those generate the problem as follows: the tendency of concentration of activities in certain areas (over concentration), mixed land use, land conversion of green and open spaces become awakened intensive region (residential, industrial, offices, infrastructure). In the last period, Surabaya City has conducted various development to meet the needs of the community along with the increasing number of population (Rianelly, Hariyanto, Sari, 2009). The following is a description of a gradual development of land use and road network in the city of Surabaya in year 2009 and 2014.

![Road Network Map in Surabaya 2009](image1) ![Road Network Map in Surabaya 2014](image2)

Figure 1 shows the use of land in the Surabaya City move horizontally dominated by residential area. Changing of land use also is followed by the development of the road network in the region causes an increase in activity due to the mobilization of the people. Figure for year 2014 illustrates the development of the region of West and East of Surabaya for both land use and transportation networks.

The development of road network in year 2014 indicates the changing in land use. The road networks facilitate the mobility of people in new development area. The area for housing for the last 20 years increases around 64.4% (Wahid et al, 2012). This means that the transportation system is not sustain since the number of traffic also increases. The quality of travel in the urban area is also affected, as well as the access to the airport. The accesses to
the airport become crucial due to the possibility of losing the flight caused by traffic jam or increasing travel time. Figure 2 shows the changing land use for year 2012 (left) to 2014 (right).

2. Land Use Development Interaction with Volume of Traffic and Capacity

Patterns of land use affected the transportation planning that are determined by the suitability of the transport facilities. These include road networks, parking areas, airports, and also affect the relativity of accessibility as well as increased travel costs at different locations. Evaluation of land use development patterns should be controlled regularly. It was due to unregulated land use can cause a burden on the road network. Increase the volume of traffic that weighed on the road segment if not supported by capacity expansion will result in reduced vehicle speed. Reduction of vehicle speed due to congestion will have an impact on the increase in travel time on vehicle.

![Fig. 2. (a) Land use map of Surabaya 2012 and (b) Land use map of Surabaya 2014](image)

The traffic congestion due to redevelopment is caused directly by the incoordination of transport demand and supply since after redevelopment the network capacity cannot afford the traffic demand (Yanli Wang et al, 2013). The demand for urban transport grew following the growth of the city population and its economy. The road network and public transport system interacts with land use changes, which significantly affects the traffic mobility. The quality of traffic mobility is determined by travel time. The increasing of travel time in urban transportation system is an issue to be solved by monitoring the changing of travel time. The high travel time that occurs frequently will reduce the quality of transportation system. The travel time monitoring system requires high accuracy that can be provided by using GPS-based technique (Suarez, et al, 2014). The GIS also able to determine the transport accessibility and to assess the sustainability of the transport system (Ford et al, 2015). The use of GIS is not new in integrating land use and transportation activities. Fang Zhao et al (2001) introduced VOLUTI 1.0 (Visualization Of Land Use and Transportation Interactions) to incorporate a variety of databases, multimedia imaging, travel demand models, and useful evaluation methods to support visualization of land use and transportation information, and evaluation of land use and transportation interaction.

The need of mapping the accessibility from origin to destination in the city is necessary to have better planning land use and transportation system (Vandenbulcke, 2009). The land use transport scenario affects travel pattern in the urban area (Liao et al, 2015). Therefore, the development strategies, how these differ from current practice, and how knowledge generation supported their development become the important variables integrating land use and transport knowledge (Broemmelstroet and Bertolini, 2010).

The integration between land use and transportation system return the focus to public transport to shift to environmentally friendly and sustainable cities (Min, Kurauchi, 2014). The design of sustainable cities is expected to be more liveable. This can be achieved by intervening urban policy in controlling urban structure that encompass residential areas, offices, schools, transportation networks and other facilities. The controlled urban development will promote the people behaviour in consumption the energy (Kii, 2014). Therefore the city become more able to develop sustainable strategies to improve the quality of life.
3. Measuring the Effect of Land Use Development

The population of Surabaya City increases every year. This is in line with the increasing of housing area. The land use development Increasing population will make a number of vehicle volume also increased. This is caused by a situation where public transports in Surabaya City are not been able to serve the needs of urban sprawl.

The volume of vehicle according to a survey of environmental agency showed that the volume of vehicles in Surabaya City reached 1.485.332 vehicles in 2006. While the volume of vehicles according to a survey of statistical center of the Surabaya City agency explained that the volume of vehicles in 2006 only reached 575.886 vehicles. The difference can be seen from differences in survey methods, namely survey of vehicle ownership and counting. The phenomenon illustrates that the Surabaya City made a trip attraction of surrounding area due to additional changes in land use as a central area of activity.

Figure 3. Population Growth Surabaya City in 2002 – 2014
Source : Registry of Inhabitants and Civil Registration Service of Surabaya City

Figure 4 shows the difference of number of vehicles in Surabaya city based on different data sources. Basically the number of vehicles in Surabaya is around 31% of population. However, data from Environmental Agency reported that the number of vehicles reached nearly 50% of the number of inhabitants in Surabaya. This figure is also picturing the number of people commute to the city center to work.

Figure 4. The differences in vehicle volume data according to a survey of Statistic Center Agency and Environmental Agency of Surabaya City

3.1. Analysis of Trip Generation due to Changing of Land use

An interesting part of different data related to the total number of vehicles in Surabaya requires supporting analysis from the changing land use. Development of new activity centres and apartments attract more traffic. The
different usage of some area will generate different number of vehicles. Table 1. shows the different area covered by each type of land use:

Table 1. Different usage of land use and those area for year 2009 and 2014

<table>
<thead>
<tr>
<th>Land use</th>
<th>2009 (m²)</th>
<th>2014 (m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MERR II-C (residential and agricultural land → roads and commercial)</td>
<td>780,378.54</td>
<td>830,366.54</td>
</tr>
<tr>
<td>Teluk Lamong (mangrove → industrial and residential)</td>
<td>922,800</td>
<td>715,000</td>
</tr>
</tbody>
</table>

Based on Table 1 the land use of MERR was intended for residential and agricultural land turned out to be converted into roads access and commercial areas of 49,988 m² in 2014 which is about 6.02%. On the other hand land use of Teluk Lamong which was designed for mangrove area as big as 922,800 m² in 2009 now become an area of 207,800 m² to serve residential and industrial areas. According to Isyana (2010), housing generates 0.39 pcu per 100 m², but only 0.25 pcu per 100 m² based on Tamin’s research (2000). Refer to Table 1, the additional housing area for almost 50,000 sqm will generate around 195 pcu per day. This is rough calculation since it depends on the classification of the housing area and the living style of the people there.

3.2. Analysis Route and Travel Time Airport Access Road

Determination the access route to the airport is limited to reviewing the arterial and collector road class. After mapping the route, running speed survey conducted to obtain the real speed of each access route to Juanda International Airport. The urban roads calculation performed by dividing each segment to get travel time per segment.

To obtain access to the travel time of airport access in 2009, should be re-mapping of the road network map in 2009 to determine the access route to the airport for reviewing the arterial and collector road class. Analysis speed can be determined by calculating the performance of the road (DS = volume/capacity). Traffic volume road segment in 2009 was obtained from the department of transportation of Surabaya city while the capacity of the road can be seen from the road class. So it can be described graphs Degree of Saturation (DS) and Speed (v) on the segment of access route to the airport in 2009 (Fig. 5.)

![Graph of Degree of Saturation (DS) and Speed (v)](image)

Fig. 5. Graphs Degree of Saturation (DS) and Speed (v) on the segment of route access to the airport in 2009

Figure 5 shows the correlation between the decreasing speeds of vehicles to the degree of saturation in the road networks in Surabaya City. This relationship is used to develop the model to estimate the speed of the vehicles in year 2009.
The routes to the airport are determined from the outer districts in Surabaya city. The selected segment roads are based on the function of the road, such as arterial road, secondary arterial road, collector road and secondary collector road. This limitation is aimed to control the trip assignment made by the travelers. There are eleven routes for year 2014 but only six routes for year 2009 since some road networks has not been established yet.

Figure 6 shows the differences between travel time in year 2009 and 2014. All routes available in year 2009 indicate the shorten travel time except route number 3. In year 2009, the access to the airport using route 3 was disturbed by some road projects. That is why the travel time for route number 3 is less compare to the same route in year 2014.

4. Conclusions

Land use change lead to the formation of a new road network in these areas. The increasing volume of vehicles every year is not always matched by capacity expansion of the road network. It causes additional travel time in each segment of the access road to the airport which will have an impact for air travelers. The result of the study it can be concluded that, there are 11 routes to the Juanda International Airport in 2014 and 6 in 2009 with the only way to take into account the arteries and collector class only. Reduced travel time indicated by route 1, route 2, 4 to 6 due to the number of traffic volume in 2009 fewer than in 2014.

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