The Effect of Land Conversion in the Medium-size City to the Transportation Network. A Case Study of City of Malang, Indonesia

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Abstract: The objective of the study is to investigate the transportation problems arising due to rapid land use change and conversion from agricultural to residential and business centers, and recommend a systematic policy that suits to the condition. To achieve the objective, a data collection was conducted, including land use change during the last 10 years, traffic data, and origin-destination data. To evaluate the land use change, aerial/satellite photos acquired at different years were used to identify the change. The results showed that the main cause of the transportation problems is due to rapid and lack of regulation concerning land use change. It has also caused changes in the functional road network system and difficulties in land acquisition program for road expansion. The study recommends the need for revitalization of functional road network, expansion of road network, and introduction of mass transportation in the future.

Keywords: land use change and transportation, functional road revitalization, origin-destination survey, road level of service

1. INTRODUCTION

Rapid development that occurs in the city of Malang and its surrounding area in the last 10 years has caused traffic congestions and delays on major road network system in the City. Malang, a city with 110 km^2 area and about 1.25 million inhabitants is the second largest city in East Java Province, Indonesia (see Figure 1). In addition to home of several universities, it is also a resort town. During weekend or holiday seasons, people flock to the City and its surrounding area for vacation. Its favorite location has also attracted people to settle or set up businesses. Therefore, in the last 10 years, major development on the business and residential areas have been visible not only in the City but also in its surrounding areas. A large chunk of agricultural land has been converted into residential and business. Unfortunately, it seems that this rapid development has not been carefully planned and anticipated by the City. No major transportation infrastructure, such as road expansion, has been constructed during the time. Likewise, no mass transport system has been in place, although such initiative has been recommended since 2002 (McDonalds, 2001). For a city with 1.25 million inhabitants, a mass transportation system should have been in operation (EPTA Project, 2014).

The consequence of such situation is noticeable. Almost everyday, particularly during peak hour morning and evening, traffic congestion is visible in almost every corner of the City. Worst, the problem not only occurs in the major road network but also in many local streets that are used to be just residential roads. Land use changes from agricultural to business and residential areas have in turn substantially increased the traffic volume and changed how people move around the City. This condition is not favorable for the quality of life. As in the case of Europe, according to European Commission (2011, 2013), urban congestion in some European cities is costing approximately €80 billion per year and with potential to increase in the coming decades (European Commission, 2011, 2013).

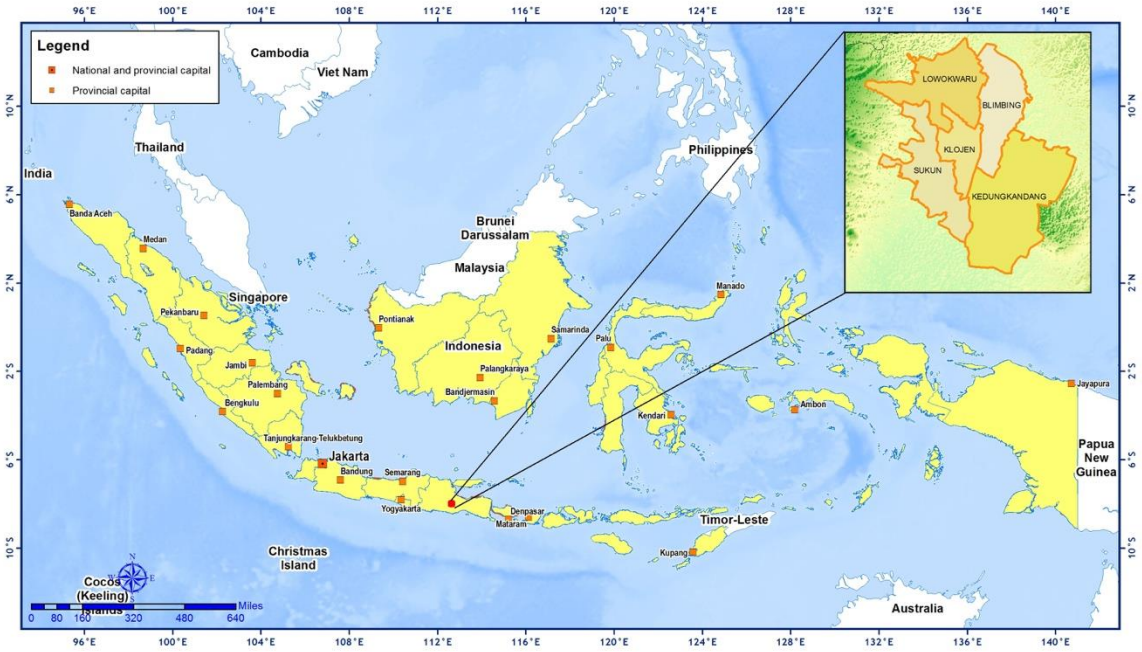

Figure 1 Location of Study

This condition is almost typical in many growing cities in developing countries. Lack of planning and its implementation, lack of funding, and weak in law enforcement have caused many transportation problems. In case of City of Malang, inability of City Government to provide transportation means in dealing with land use change and the increase of population has made most people switch to motor cycle. Recently, motor cycle accounts for more than 75% of road user (Halim, 2016). Relying on motorcycle as the main transportation means for people is not a robust decision, since it accounts for most of traffic accident (Machsus, 2014)

Facing with this problems, nevertherless, the City should come up with such robust solution. Otherwise, the transportation problems will plague the City and may cause people to move to others. The City should seek the optimum policy in dealing with such situation. In seeking the optimum policy, understanding relation and interaction among urban component (land use, infrastructure, and so on) is essential (Nan, 2016).

2. OBJECTIVE OF STUDY

The objective of the study is to investigate the transportation problems arising due to rapid land use change and conversion from agricultural to residential and business centers, and recommend a systematic policy that suits to the condition.

3. METHODS

Figure 2 depicts the schematic process of conducting the study. The author first assessed the existing condition of the transportation and land use system in City of Malang. It included collecting information from Malang Land-use Planning 2019-2029, known in Indonesia as *RTRW*. Field surveys were also conducted to review land-use condition. History of land-use change during the last 7 years was also examined using aerial or satellite photos available in the City. A traffic data from all major streets were secured, either from previous survey or by

primary survey conducted for this study. The street geometry was also measured for capacity analysis purposes. In addition, traffic and related surveys were also conducted in major intersections. To conduct the origin-destination survey, the study area was divided into 7 zones, based on administrative border (City of Malang has 5 sub districts known as *Kecamatan*), and 2 other sub districts were added from surrounding areas since they have strong link with the City. A home interview survey was conducted to collect the origin-destination information.

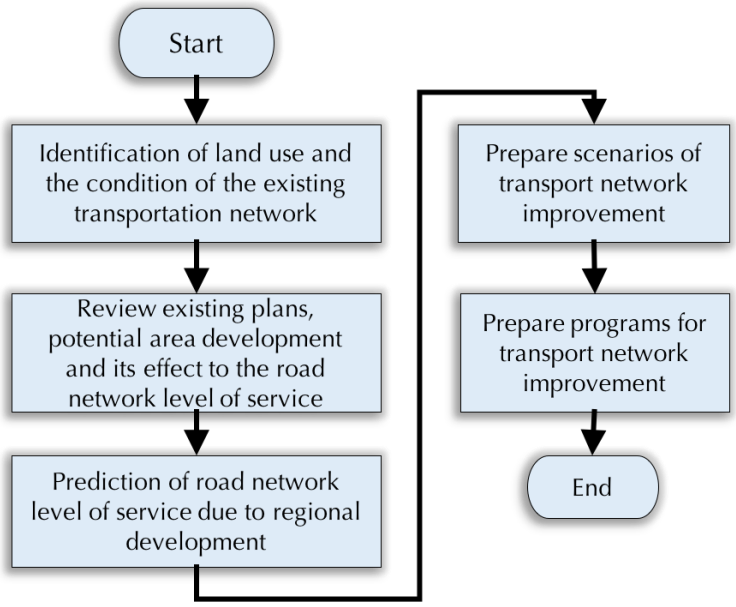

Figure 2. Flow Chart of the Study

Once all data required by the study has been secured, analysis was conducted to each of data group. Road capacity was analyzed using the following model (IHCM, 1997):

$$C = C_o + FC_w + FC_{SP} + FC_{SF} + FC_{CS}$$

where:

C	= capacity (pc/h/ln)
C_o	= basic capacity (pc/h/ln)
FC_W	= lane width adjustment
FC_{SP}	= lane division adjustment (for undivided lane)
FC_{SF}	= lateral clearance adjustment
FC_{CS}	= city size adjustment

Detailed discussion on this can be found elsewhere (IHCM, 1997). This parameter was used to evaluate the volume over capacity ratio (VCR) and degree of saturation for the road segment and intersection, expressed as the following:

$$VCR = \frac{V}{C}$$

where:

VCR	= volume over capacity ratio
V	= traffic volume (pc/h/ln), obtained from traffic survey
C	= capacity of the road segment (pc/h/ln).

The road performance can be measured by its level of service, as shown in Table 1.

Table 1. Level of Service (DOT, 2015)

Level of Service	VCR
A	0,00 – 0,20
B	0,21 – 0,44
C	0,45 – 0,74
D	0,75 – 0,84
E	0,85 – 1,00
F	>1,00

Origin destination data collected from the Home Interview Survey was analyzed to obtain the trip characteristics. This data is very valuable since it can show how people do the trip from one place to another, how many trips per day were produced, and what the purpose of the trip (work, school, shopping, and so on).

Further analysis was conducted to obtain the level of service of road network systems, the root cause of the transportation problems, potential problems in the future, and policy selections to tackle the problems. To achieve this, the author also applied transportation modeling as in Ortuzar (2011), and Tamin (2009).

4. RESULTS

Land Use Condition

Figure 3 presents the total area of agricultural land which were converted into residential and business areas. Although available data were only from 2012 to 2015, it still can show the trend of the conversion significantly. This land conversion caused substantial increases in the trip. Suppose the average area for one house in City of Malang is 110 m^2, then in 2012 there was at least 90,000 houses constructed. When per one household there were 2 trips per day, then there were additional 90,000 vehicles, either motorcycles or cars.

Figure 4 shows the area of converted land for each sub district. As can be seen from the Figure, north and south side area of the City (represented by Lowokwaru sub district in the north and Sukun Sub district in the south) became the most favorable area for housing and business centers. The business and other attraction centers steadily move from downtown area (Klojen sub district) to north side. This situation is actually unwanted since the north side is not well-prepared in terms of the transportation infrastructure, unlike downtown area that has been carefully planned as the business center since the colonial era.

The consequence of this condition is that congestion problem, bottlenecking in the intersection and other transportation problems occurred in the road network system in City of Malang. Although the City has regulations regarding building permit, its effectiveness is questionable. The regulation regarding building permit states that developer shall acquire permit before constructing housing. They shall not only prepare the housing but also the insfrastructure inside the housing area and also its surrounding. This regulation, however, only applies to those with more that 100 housing units, and does not apply for those less than that. What happens in reality was that the many developers tried one way or another to avoid the requirement. They opted to construct housing in 10 to 15 housings called “cluster”, thus no need for them to bind by the regulation. In addition, it was just in 2015 that the Government

started to issue regulation regarding the requirement for any infrastructure construction proposal to conduct traffic impact assessment (TAC) (DOT, 2015).

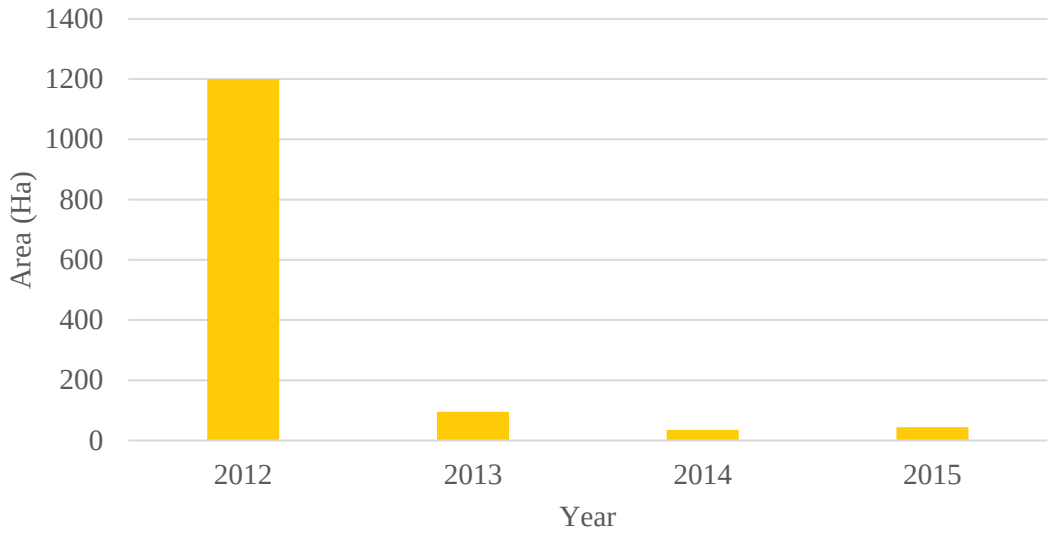

Figure 3. Area of converted land from agricultural to residential and business centers

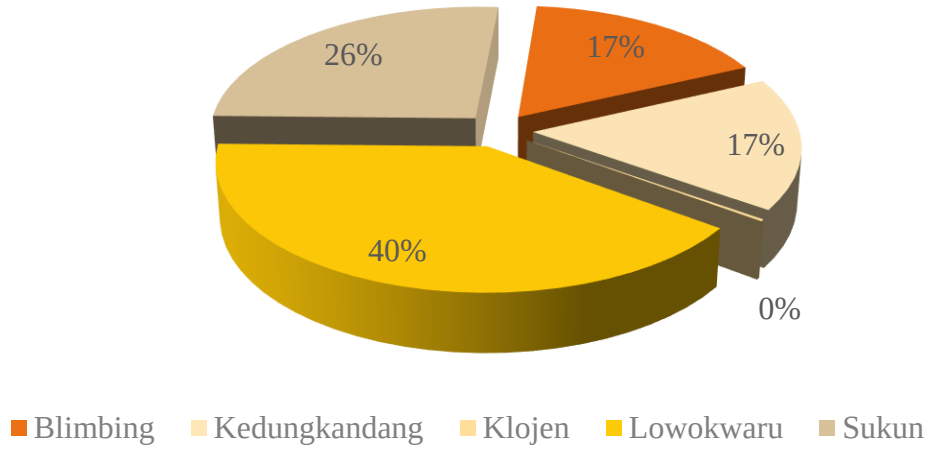

Figure 4. Comparison of converted land for each sub district

Level of Service of Road Network System

Figure 5 presents the level of service of road segment and intersection of the major road network in City of Malang. For the sake of clarity and simplicity, the level of service is depicted in the Figure with different color. Red color indicates poor level of service, yellow fair, and green indicates good. As shown in the Figure, the level of service of road network in general was in good to fair condition, except for the intersection where the problems were visible. As shown in Figure 5, most of the intersections were in red color, indicating poor level of service. The results found that the main problem of the intersection in City of Malang was its geometric. Most of the intersections have only two lanes for each leg, which make their capacity was overrun by the current traffic.

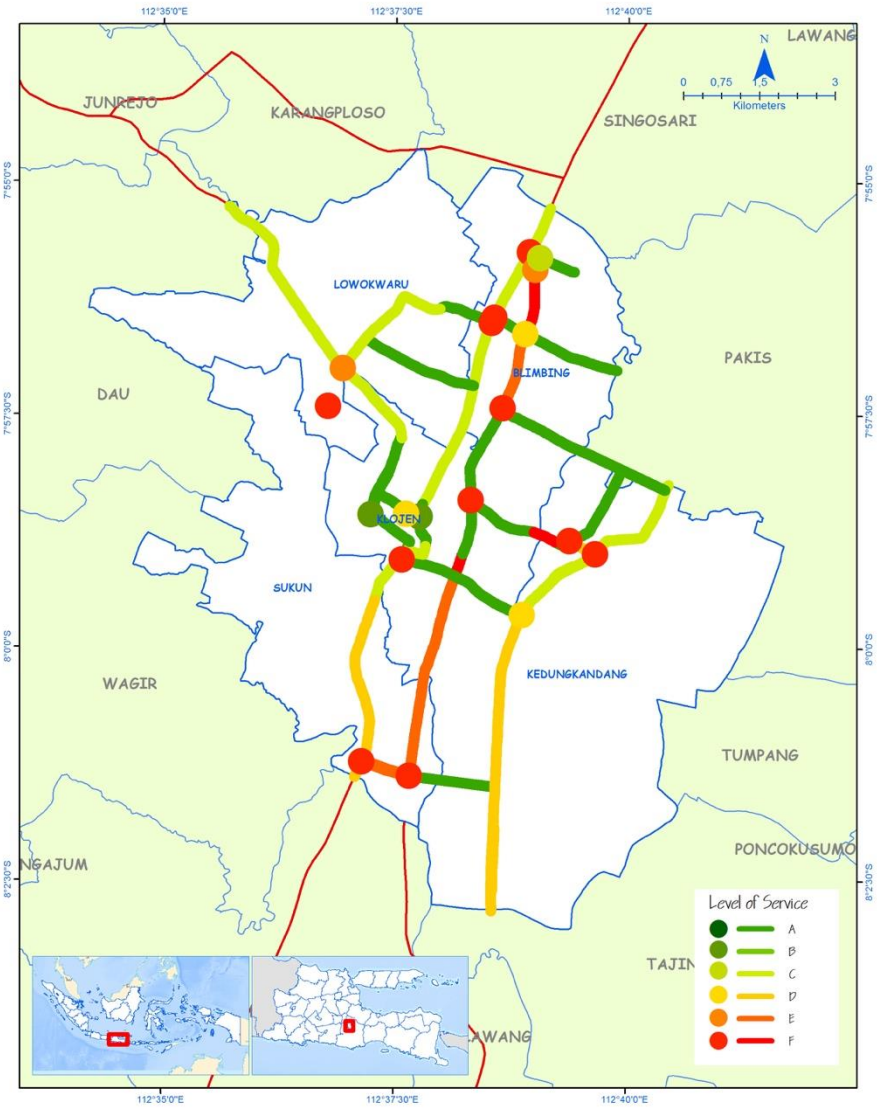

Figure 5. Level of Service of Major Roads, 2016

Travel Pattern in City of Malang

Figure 6 presents the origin-destination of travel in City of Malang. The result shows that the downtown area of Klojen sub district (shaded in yellow), was still the major trip attraction. However, as the City grows and expands its development into other areas, the travel pattern changes as well. As shown in Figure 6, although Klojen still becomes the main trip attraction but its role has been gradually decreasing. Lowokwaru (shaded dark yellow) is about to become the second main trip attraction, since this area is the site of many major trip attractors such as Universities (there are 5 major universities in the area), schools, and shopping centers. The Figure also shows that trip in Lowokwaru were dominated by internal trips. About 61% of trips in Lowokwaru were originated and destined within this area. One may also note from Figure 6 that many trips are originated from areas surrounding the City of Malang, since the majority of people living in this area are working or having daily activities inside City of Malang.

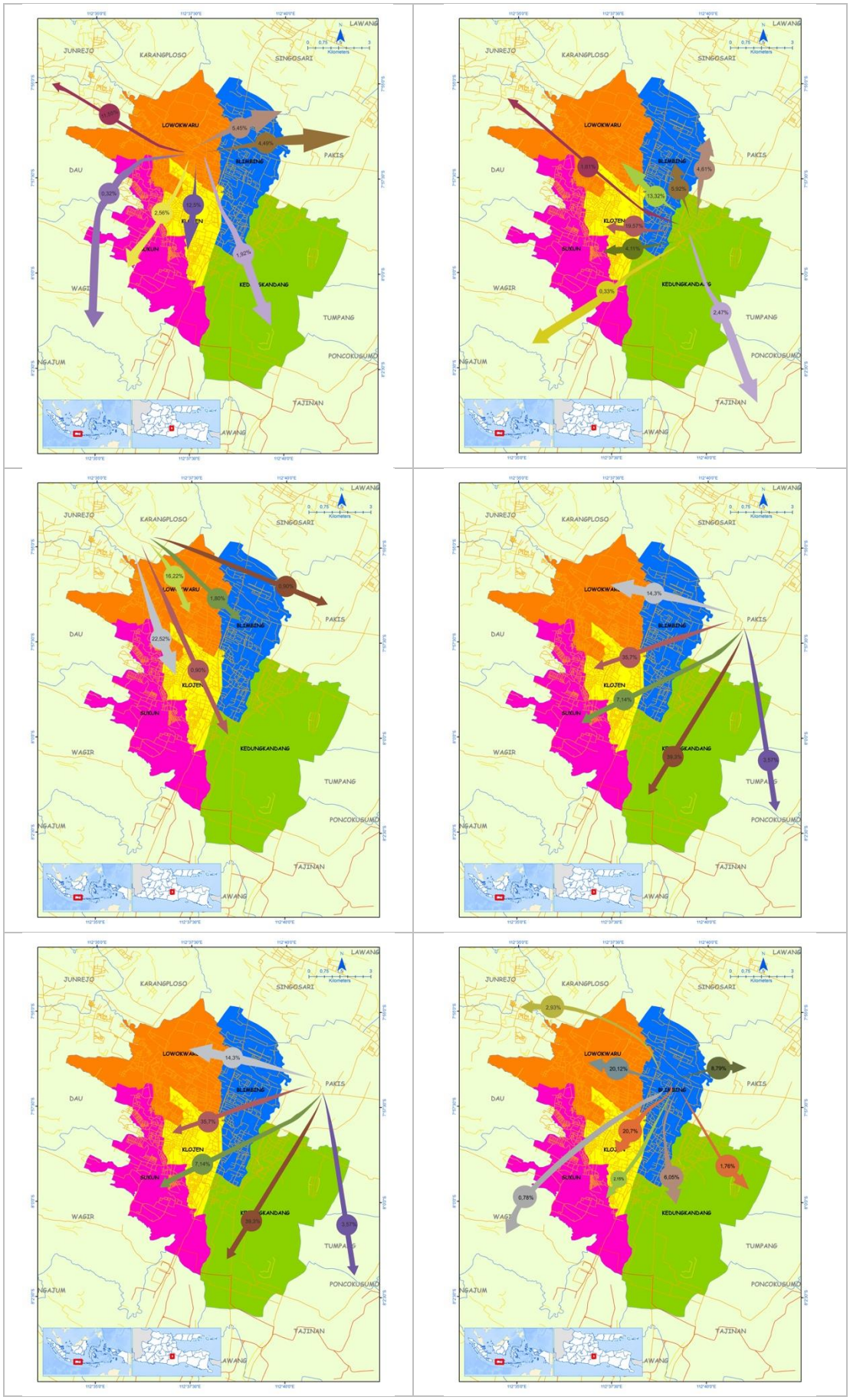

Figure 6. Trip pattern in City of Malang

Prediction of Future Road Network Performance

In order to be able to prepare a transportation masterplan effectively, one should not only consider the current condition of the transportation infrastructure system but also the future condition of the system. Therefore, one should be able to predict the future condition of the infrastructure given some scenarios such do nothing, and so on. A transportation modeling using four-step model has been conducted. The growth factor used in the study was based on the economic growth factor in the area. Figure 7 shows the predicted condition of the infrastructure. The analysis assumed no road construction or road expansion projects have been underway, except toll road that connects City of Surabaya – City of Malang, since it has been targeted to be operational in 2019. As can be seen from the Figure, when nothing was done to the transportation infrastructure in the City, the level of service of the majority of the road network gradually turned from green to red. The condition would become crucial in 2025.

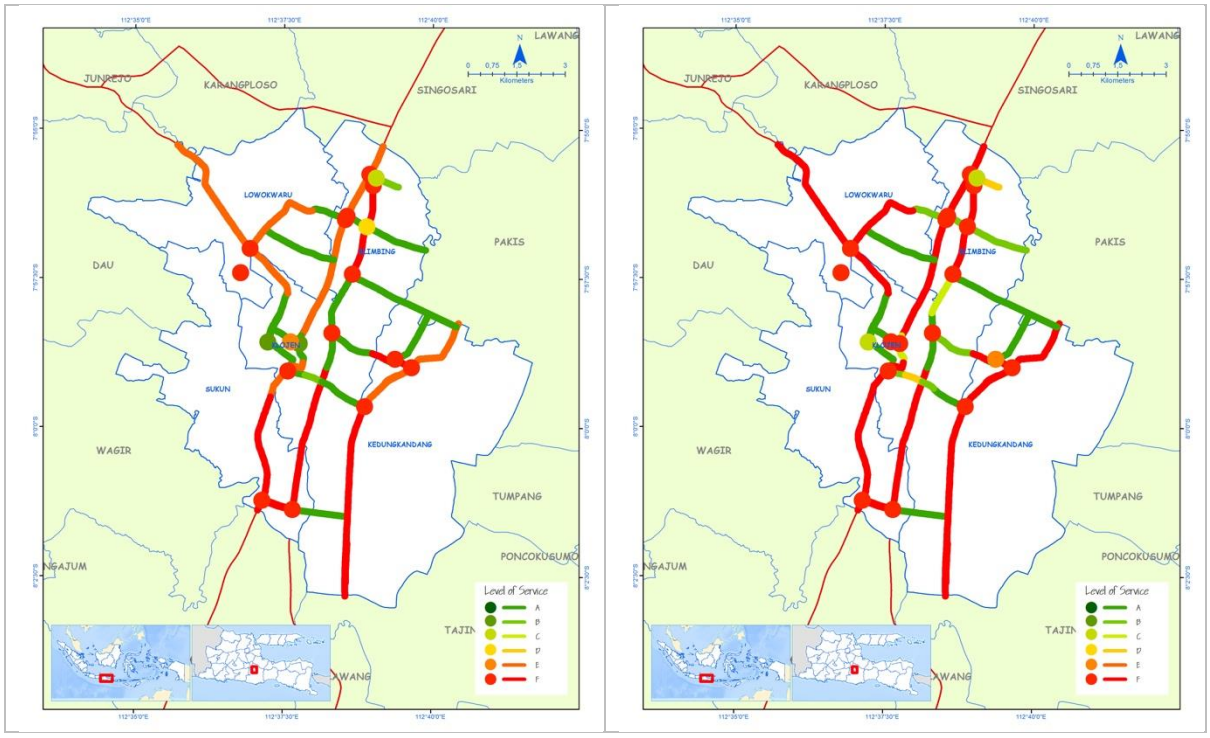

Figure 7. Predicted level of service: (a) 2020, (b) 2025

Having information of predicted condition of the transportation infrastructure will be very useful to the City since it can be used to convince the legislature on the need of transportation investment. The City can also present the case even to the people to raise their awareness about need of transportation investment, and the consequences when no programs are in place.

5. RECOMMENDATION

Based on current and predicted condition, the author proposes four options to anticipate the transporation issue, today and in the future, as follows: (a) integrating land use development with transport planning, (b) revitalization of the road hierarchy of existing road network, (c) construction of new road networks, particularly in the north side city area where transportation problems are most visible, and (d) introduction of mass transportation systems in City Malang. The following paragraphs discuss these recommendations.

a. Integrating Land Use Development and Transport Planning

The City should revise the regulation on building permit to avoid people on making a way around with the regulation. In addition, more integrated land use and transportation infrastructure development should become the center of the program, since the integration of planning and the development of public transport, other modes of transport, and land use is increasingly recognised as a potentially effective mechanism for achieving long-term public-transport goals of functionality and competitive capacity (Hrelja, 2014).

b. Revitalization of Road Hierarchy

The original road hierarchy system in City of Malang is based on the south-north trip, in which residential areas were located in north area and downtown in the south. The existing roads were built to serve this arrangement. As the City grows at all directions, the travel pattern changes accordingly. This has also caused the change the way people travel. Roads that used to be designed to carry local traffic now have served not only local traffic but also those from other areas. The functional changes that occur in several roads would certainly generate transportation problems since most of these roads do not meet the requirements as a collector road, such as width requirement. Therefore, the City should redesign and revitalize the road hierarchy systems, and meet the requirements accordingly. Figure 9 presents the proposed new hierarchy system of the City road network. Several local roads should be improved to become collector roads (colored in magenta in Figure 8).

c. Construction of new road network

Basically, the poor level of service that occurs in many roads in the City is caused by the substantial increase in the traffic volume due to land use conversion from agricultural to residential and business centers. In addition, lack of alternative roads where users can choose for their trips while the traffic has increased in recent years has led to traffic jams in several roads. On the other side, the stagnancy of road expansion program within the City in recent years to accommodate this traffic increase has made this worse. Therefore, the development of new road network is essential to do. The new road network expansion is actually planned in Malang RTRW 2010-2030. However, its implementation has been so slow.

d. Introduction of mass transportation systems

As the number of population has increased, the introduction of mass transportation system to serve City of Malang becomes essential. As new road construction usually has many problems in land acquisition, this mass transportation, may become the second or combined alternatif with road expansion to deal with transportation problems in City of Malang in the future.

6. CONCLUSION

The recommendation for transportation improvement in City of Malang will only be realized properly if it is supported by the following:

a. The plan should be confirmed by legislation

To be able to create development plans for the road network must be a frame or a strong legal basis for government agencies. Therefore, it is recommended to draw up new rules, or at least a mayoral decree for Road Network Master Plan

b. Availability of Priority Plan

Due to the huge budget that should be provided for the program, it is necessary to have prioritization based on budget availability.

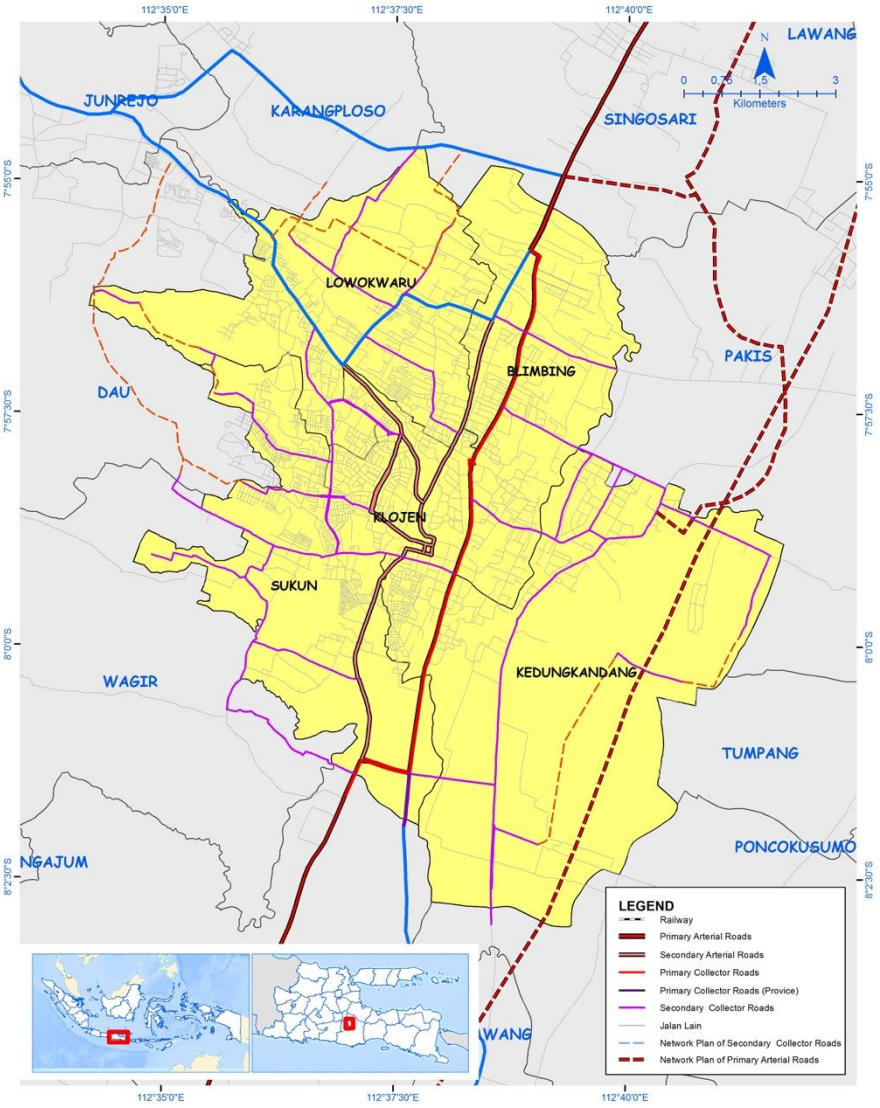

Figure 8. Proposed new hierarcy system for the City road network

7. ACKNOWLEDGMENT

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