Modeling Complexity of Urban Land use and Transportation In Semarang City

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Abstract. The development of urban areas will increase the travel demand of its population. Travel demand is often associated with the type of activity indicated by the type of land use. Travel demand can be predicted with developments in land use. The development of increasingly complex land uses will result in higher trip generation, so we need a model that can be used to estimate trip generation. The research objective is to understand the relationship between trip generation and travel attraction as a travel request with land use characteristics in the city of Semarang. The method used is spatial regression using variables Y (trip generation), X1 (housing area), X2 (trade area), X3 (industrial area), X4 (office area) and X5 (education area). All data uses spatial units in the kelurahan. Spatial regression results indicate that the movement in the city of Semarang is strongly influenced by housing activities, trade activities and offices. Industrial and educational activities make less significant contribution. The mathematical model of spatial regression of population movements in the city of Semarang can be denoted as follows $Y = 626,41 + 28,69X1 + 0,06X2 + 5,49X3 - 18,84X4 - 10,71X5$.

1. Introduction

Transportation is the movement of people, goods or both of them to meet human needs [1]. The transportation system consists of several systems, namely the activity system, the network system, and the movement system [2]. The activity system represents human activity in meeting their needs which in its development form a land use pattern. Increasingly complex land use developments have a significant influence on patterns of movement [3]. The resulting movement system is a form of meeting the needs of one land use to another land use. This relationship becomes important to be identified as the beginning of the transportation system that occurs in a city. The Influence of complex land use systems on movement can be described into a spatial model which use of several variables [5].

The spatial model can be used to estimate travel demand. These travel demand can vary in any types of the activity which is reflected in the type of land use. Estimated travel demand can be used to plan transportation systems and are useful in making transportation policy [6]. Land use has an important influence on travel demand [7][8]. The study of land use and population movements in various urban
areas shows the magnitude influence of land use on population movements. Knowing this relationship can be used to understand demand of transportation and providing transportation networks and modes. The city of Semarang is an example of a case that various of urban land uses reflect the activities of the inhabitants. These landuse are residential, trade and services, industry and others. The interaction of inter landuse will lead to travel demand which if not properly understood will lead to problems such as traffic jams and pollution as well as energy waste. The pattern of travel in the city of Semarang has a random character and is concentrated in areas that are centers of large-scale trade, industry and housing activities. The biggest movements resulted from land use interactions are movements that originate from the housing activities on the east side of Semarang City and industrial activities on the west and north sides of Semarang City.

Reflecting on the pattern of movement that tends to be random and concentrated in certain areas will make a contribution to the traffic burden on the existing road network system. The excessive burden of traffic movement can be anticipated by using a spatial model that is able to describe the complexity of land use which affect to the total movement of people. The development of the spatial model of the influence of the built-up land use to transportation in the City of Semarang can be use to describe not only the potential movement along with the dynamics of land use but also can be use as an input to the development of a reliable and sustainable urban transportation system.

2. Method

This study uses spatial statistical methods which include Ordinary least square (OLS) method and Geographic Weighted Regression (GWR) method. GWR is the development of linear regression methods to address the need to deal with the complexity of spatial data diversity in spatial regression results [9], [10], [11][8]. Urban population movement is a function of the system of land activities which are represented by the area of each type of land use [12], [13]. The population movement of Semarang City (Y) will be influenced by residential land use (X1), industrial land use (X2), trade land use (X3), office land use (X4) and educational land use (X5). Mathematically the movement of population in the city of Semarang can be symbolized as follows: 

\[ Y = A \pm b1X1 \pm b2X2 \pm b3X3 \pm b4X4 \pm b5X5 \]

The population movement variable uses the number of people per day which do a movement every day in each village as a parameter, while the land use variable in this study uses an area of each land use in each village as the parameter.

3. Result

The number of population movements in each village in the city of Semarang in a day reached 23995 people per day. The population movements are generated by housing activity, industry and trade activities. The concentration of movement is on the west side, the middle side and the north side of Semarang City. The largest population movements (symbolized by dots from small to large sizes) are...
along the main road network and the center of industrial and trade activity in the city of Semarang (figure 3).

One of the initial processes in conducting a regression analysis is to ensure that there is a relationship between population movements in the City of Semarang with each independent variable and to ensure that the independent variables are mutually independent. To find out the relation between variables, a graphical method is used which relates the dependent variable with each independent variable. Based on the graph, it can be seen that there is a relationship pattern between the number of movements and the independent variables used, the strongest relationship pattern is shown between the number of moves and the area of housing (figure 3).

Spatial regression models generated by the OLS method produce a linear regression equation model \( Y = 626.41 + 28.69X1 + 0.06X2 + 5.49X3 - 18.84X4 - 10.71X5 \). The coefficient of determination value of the OLS model is 79.28%.

Spatial regression models resulting from the GWR method produce a regression model which has a higher level of significance than the OLS method. The coefficient of determination in the GWR method reached 81.89%. The coefficient on each variable has a range of values that vary according to the geographical character of the land use distribution in each village in Semarang City (figure 4).
shows that the GWR method provides a more complete picture of the spatial contribution of each land use to the number of daily population movements in the city of Semarang.

Figure 4 The Coefficient of each Independent Variables using GWR method

4. Discussion
Based on the results of data processing using OLS and GWR methods shows that the population movement in the city of Semarang is influenced by the type of land use. This finding is in line with previous research which states that population movement patterns are strongly influenced by land use interactions and transportation systems [14], [15], [16].

The type of land use that contributes most significant value is the type of housing land use. The high contribution of housing land use in Semarang City is inseparable from the character of housing land that is evenly distributed in Semarang City. Based on Figure 4, housing activities on the south, west
and east sides of Semarang City have the potential contribution to increase population movements. Trade, industry, education and office activities have the potential contribution to population movements in the central part of Semarang City. This condition will give a consequence to the potential traffic burden which will increase along with the physical development of space in the edge of Semarang City. The complexity of land use development in rural areas will increase population movements and place a burden on local traffic in the city of Semarang. The simulation results show the potential movement in the city of Semarang is going to be large in centre of housing, industrial and trade activities (figure 5).

The GWR model provides a complete picture of increasing population movements due to increasingly complex land dynamics, especially in peripheral areas. The higher growth of population movement occurred on the southeast side of Semarang City which is a region with rapid development of housing activities. Population movements on the west side of Semarang City are influenced by the development of housing and industrial activities that growing along with the activities of industrial relocation in the western region of Java Island to Central Java. The northern region, especially the east side, has higher movement which is driven by longstanding industrial activity. The phenomenon of increasing population movements due to the increasing of more complex land use activities must certainly be a concern in the formulation of transportation policy in the city of Semarang, so that population mobility is easier and does not impose excessive burdens on the road network system in the city of Semarang.

5. Conclusion

Based on the results of the research, it can be concluded that the complexity of land use contributes significantly to the total number of population movement in the city of Semarang. The OLS and GWR methods both of them show that land use activities in the city of Semarang contribute 79% -81% to the population movement model in the city of Semarang. Land use activities that contribute significantly to population movements in the City of Semarang are residential land use activities, trade land use activities and industrial land use activities.

Areas that have higher movement rates are spread on the east side, west side, south side and north side of Semarang City. Land use patterns on the west side of Semarang City which are dominated by housing and industrial activities provide a significant opportunity for a very significant increase in population movement in the City of Semarang. Spatially high numbers of population movements are evenly distributed around the main corridor of the Semarang-Jakarta national road.

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