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Mobility patterns consideration of educational facilities distribution model formulation in Southeast Malang Regional development plan

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ABSTRACT

Regional disparities, and urban sprawl, will cause inequality in mobility between regions—one of the causes of the uneven distribution of educational facilities. The study of mobility patterns provides an overview of student movement patterns from and to school. The analysis is needed to determine the potential problems due to spatial disparities in the settlement Development Area. The research purpose; is (1) to obtain a model for determining the location and distribution of public schools based on mobility patterns in urban settlement development areas and (2) to obtain the model formulation for spatial planning distribution of educational facilities. This research uses a descriptive exploratory method with Space Syntax analysis. The research location was selected using the Classified Purposive Sampling method with an observation scale in the Development Area. The school zoning system has implications for equal distribution of education, reducing the mobility gap between regions, reducing congestion, air pollution, and dependence on motorized transportation. The study results of patterns of connectivity, accessibility, and mobility become a consideration for the placement of educational facilities in the Development Area. This study will improve the arrangement of spatial patterns and distribution of educational facilities based on studies of connectivity, regional accessibility, and student mobility.

Introduction

Development planning in Indonesia consists of two products: Program Planning and Spatial Planning. The two types of planning products are integrated, integrated, and sustainable planning products. The implementation of program policies often has an impact on problems in spatial planning and vice versa. The superior product of spatial planning lies not in the beauty of the planning product but its integrated and sustainable implementation.

Spatial planning is currently not yet integrated with transportation planning. Inequality of mobility between regions triggers a significant problem in transportation planning (Wikantiyoso 2005). Regional disparities and urban sprawl occur due to imbalances in spatial planning. The solution to this problem is to regulate mobility patterns, reducing the movement of people across cities. The configuration of the road network and activity nodes as an attraction for regional accessibility will determine the physical mobility pattern of a site. The higher the road connectivity from each activity pull node (one of which is educational facilities), the higher the accessibility (Nes and Yamu 2021).

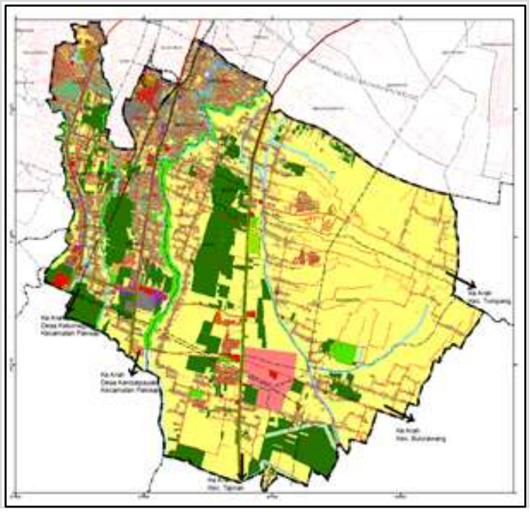

Figure 1. Spatial pattern of the detail spatial planning of South East Malang development plan

Figure 1 shows that settlement development dominates the allotment of the Southeast Malang area, resulting in increased population concentration and requires educational facilities prepared with a well-designed network configuration system. The phenomenon of the development of tiny clusters of settlements that grow organically will cause problems of mobility, road connectivity, and inefficient area accessibility. The distribution of small groups of urban settlements with limited public facilities is one of the causes of the density of mobility in the downtown area. Integrated system planning with mobility and sustainable systems will ensure sustainable regional spatial planning (Wikantiyoso et al. 2021).

The issue of equity and the quality of educational facilities is the focus of discussion in this study. Spatial planners have the challenge of participating in solving equal access to education for urban communities by studying urban mobility patterns. Observing the spatial pattern of the Southeast Malang City Development Plan in Figure 1, the development of this area has the potential to create a gap between education development program planning and future spatial planning.

The policy of equal distribution of quality and quantity of education is encouraged through the New Student Admission Policy (NSAP) using the zoning system. Implementing the NSAP Zoning policy in 2020 has become viral in several media. The pros and cons of this policy have been the subject of prolonged discussion. The pros and cons of zoning policies include the problem of the distance between prospective students' residences and schools, differences in regional interpretations of zoning rules, and misuse of certificates of incapacity (Safarah and Wibowo 2018). According to the Head of the Malang City Education and Culture Office, the implementation of NSAP 2021 is relatively smooth; the public has understood this policy well. According to (Safarah and Wibowo 2018), the school zoning program turns out to have not only implications for equitable distribution of education but also environmental impacts such as population mobility, reduction of traffic congestion, urban air pollution, dependence on motorized transportation and improvement children's health due to school habits on foot (Reyes, Páez, and Morency 2014; Safarah and Wibowo 2018). Spatially, this school zoning policy has positive implications related to the opportunity to regulate population mobility on a city scale (Krizek 2010).

The characteristics of the population are; Age, gender, level of education, family structure, location of residence, typology of settlements, and aspects of local settings that determine the pattern of activity and mobility of urban communities (Reyes, Páez, and Morency 2014). According to Reyes, Páez, and Morency (2014), facility distance and movement patterns are important factors in the mobility of individuals or communities in carrying out their activities. The shorter the distance between residence and school, the greater the opportunity for mobility by walking and non-motorized modes of transportation (Iacono, Krizek, and El-Geneidy 2010; Krizek 2010; Mandic et al. 2017). The level of connectivity and accessibility of facilities which is a representation of the configuration and structure of urban space (Iacono, Krizek, and El-Geneidy 2010) based on housing location, type and workplace, public facilities, and public spaces, affect mobility patterns (Alitajer and Molavi Nojoumi 2016; Giannopoulou, Roukounis, and Stefanis 2012; Koohsari et al. 2013). Accessibility can be measured as distance, cost, or time between two locations (Chica-Olmo, Rodríguez-López, and Chillón 2018). The pattern of population mobility on a local and city scale requires representation of physical space, travel time, and transportation modes according to the reach of the community (Alitajer and Molavi Nojoumi 2016; Mandic et al. 2017).

Analysis of movement patterns is closely related to activity intensity and community capacity (road class, distance, road topology, and road network). The urban network configuration is the primary generator of movement patterns in the city by determining routes that can use more often for various trips (Lamíquiz and López-Domínguez 2015). Educational facilities are one of the city's main generators of movement patterns. The configuration of the urban road network has an essential role in spatial mobility patterns (Maes et al. 2016). The spatial analysis of the road network aims to identify the efficiency of urban movement activities in urban space. Space syntax is one of the most popular methods for spatial analysis of road networks. There is a correlation between the movement of pedestrians and vehicles and the road network's spatial configuration (Brown 1997). The road network topology will affect towing nodes, and roadside obstacles determine the movement patterns of pedestrians and motorized vehicles (Nes and Yamu 2021).

According to Hillier et al. (Lamíquiz and López-Domínguez 2015), the urban grid configuration is the primary generator of movement patterns in the city by determining the more frequent routes to travel. Analysis of movement patterns is closely related to activity intensity and community capacity (road class, distance, road topology, and road network). Educational facilities (schools) are one of the main drivers of urban movement patterns. The Space Syntax Analysis makes it easy to perform mathematical analysis, which requires validation and facts about the mobility of the actual condition of the movement pattern through field survey activities so that a field survey about the characteristics of students in mobility to and from school is essential.

It is necessary to evaluate the Spatial Pattern of the Southeast Malang Sub-Region (figure 1) to integrate the policy of equitable distribution of educational facilities in this region. The success of the NSAP policy implementation, the distribution of educational facilities, and the student's mobility pattern are the considerations for evaluating Southeast Malang's spatial pattern. So, it is essential to study student mobility from and to their school with a field survey. The objectives of this study are (1) To obtain a model for determining the location and distribution of public schools based on mobility patterns in urban settlement development areas; (2) to obtain the distribution model of educational facilities and the pattern of mobility in the preparation of the spatial development plan.

Method

The spatial analysis of the road network aims to identify the efficiency of urban movement activities in urban space. This study uses a descriptive method, using Space Syntax analysis to analyze connectivity and accessibility of the study area's spatial pattern combined with Urban network analysis, and the student mobility survey results. Analysis of spatial configuration and road network connectivity is carried out on a regional macro scale to show the interrelationships between other sub-sections of the development area.

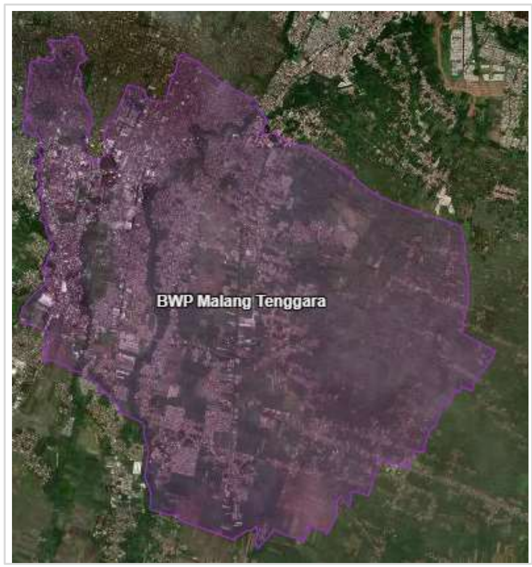

Figure 2. Southeast Malang development area

Most Southeast Malang Development Plan is located in the Kedungkandang sub-district (figure 2). So, the macro analysis of the site will be carried out on a regional scale of Kedungkandang District. The Kedungkandang district consists of two development areas: The East Malang development area and the Southeast Malang development area (figure 3).

Figure 3. The East and the Southeast Malang development area

This research uses a descriptive exploratory method with Space Syntax analysis. The research objectives are (1) to obtain a location-determining model and distribution of public schools based on mobility patterns in urban settlement development areas and (2) to obtain the model formulation for spatial planning distribution of educational facilities. The research location was selected using the Classified Purposive Sampling method by classifying the Malang City development area. The Southeast Malang development area was selected as the research location (figure 2), taking into account the following regional characteristics:

1. It is a Spatial development plan developed as a residential area with spatial connectivity problems;
2. It has the potential for problems in the development of academic areas and spatial configuration and accessibility of the site;
3. The Development Area section has needs gaps and inadequate educational facilities distribution;
4. The part of the Development Area in its development has the potential for spatial planning.

The research steps carried out are as follows:

1. First, review the Southeast Malang Development Plan Area. This stage is needed to identify the potential and problems of determining the area as a development center with the dominance of settlement development (almost 76% of the Development Area), see figure 1;
2. Second, review education development policies to obtain a comprehensive program plan to provide high school facilities. Identify the distribution of school-age and the distribution of educational facilities. The distribution of high school-age students in the research location used secondary data from the Malang City Education Office;
3. Third, analysis of student mobility patterns, using spatial syntactic analysis and urban network analysis at the research location to determine the pattern of service coverage of educational facilities. Primary data is used to describe the mobility behavior of students from home to school and vice versa. Space syntax data analysis is needed to obtain the behavioral attributes of school students and find out the distribution of school locations according to the affordability and mobility of students;
4. Fourth, the stage of developing the distribution model of educational facilities at the high school level. The synchronization stage between the community needs identifying in the previous step and the policies made by the city government.

Result and discussion

Characteristics of research sites

Malang City is the second largest city after Surabaya in East Java Province. Located 90 km South of Surabaya, the population is about 858,891, with an area of approximately 110.06 Km^2. One of the contents of the Malang City Vision is to become a quality education city to improve the quality of education for the entire community. Improving the quality of education implies providing quality education at all levels, developing quality human resources, and providing access to all levels of society to take public school education. The school zoning policy does not only have implications for equal distribution of education. The existence of a school zoning program encourages students to want to walk and cycle because it is close to where they live.

The conversion of space into a residential development area requires a comprehensive planning effort at the Southeast Malang development area (figure 4). The Malang City Spatial Planning comprises six development areas: Central Malang, West Malang, North Malang, Northeast Malang, East Malang, and Southeast Malang.

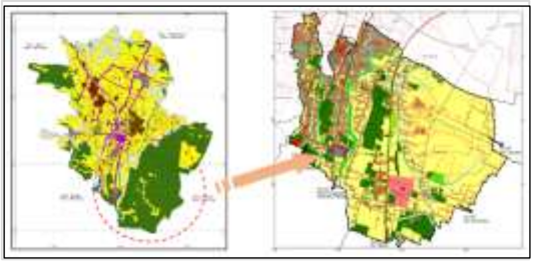

Figure 4. Changes in the designation of green open space to a residential function in the Southeast Malang City development area

Changes in planning through the transfer of the designation function from green open space in the City Spatial Plan to a settlement function can be considered an inconsistency in planning or demand for meeting new needs for housing and settlement facilities that are increasing in the Malang development areas (van Assche, Lo, and Beunen 2013). The implications of this development include; (1) an Increase in population, followed by changes in the age structure of the people. Increasing the school-age levels will increase the need for the number of schools (2) An increase in the number of public facilities as activity pull nodes in an area will increase the need for an increase in the road network in this Southeast Malang area. There must be a re-planning of the road network system with high connectivity to improve the accessibility of the room; (3) Distribution of educational facilities as one of the primary needs of the community.

Educational development program

The education development program is a priority program for the Malang City government, as stated in the Mission of the Malang 2018-2023 development. Education is the first Mission to Ensure access and quality of education, health, and other essential services for all citizens. Development is prioritized on increasing human resources by improving the quality, accessibility, and equity of education and health and increasing access to essential public services for all citizens of Malang City. This statement clarifies the Malang City Government's commitment to improving the quality, accessibility, and equity of education for all citizens of Malang City. Table 1 shows the number of educational facilities for all levels by District, which is spread over six development areas. The question is, what is the current actual condition and regional development planning in the future? It is necessary to plan a spatial pattern with the adequate distribution of educational facilities for all development areas, especially the Southeast Malang development area, which has limited access to the road network and has experienced significant land conversion. The distribution of educational facilities (Play Group/Kindergarten (PG/K), Elementary School (ES), Junior High School (JHS), Senior High School (SHS)) on a city scale, both public and private schools, shows that the distribution is quite adequate (table 1).

Table 1. Number of educational facilities for all levels by District

No	Districts	PG/K 2020/ 2021	ES 2020/ 2021	JHS 2020/ 2021	SHS 2020/ 2021
1.	Kedung kandang	105	89	32	23
2.	Sukun	92	75	22	21
3.	Klojen	68	50	32	32
4.	Blimbing	77	65	22	17
5.	Lowok Waru	100	68	33	31
	Total	442	337	141	123

However, the city government, which guarantees quality and equitable access to education, is responsible for the available educational facilities managed by the government (state schools). On the other hand, the community still has an orientation to send their children to public schools. So that the existence of public schools is the responsibility of the government to ensure equal distribution of quality and quantity (accessibility, affordability, and equity) for all citizens of Malang City. To conduct further analysis, the discussion of school facilities will focus on the availability of school facilities at the high school level. Based on the relatively limited availability of existing high school facilities, especially public high school facilities. Based on data from the Malang City Spatial Planning (BAPPEDA 2021), the distribution of educational facilities in Malang City by district area is depicted in Figure 6. Kedungkandang district is the most expansive area of 3,989 Ha (36%) of the size of Malang City, with a population of 207,428 people (25 %). However, it only has three Public

High Schools: Senior High School 6th in the development area. Southeast Malang, Senior High School 10th, and Vocational High School 6th in East Malang development area.

Inequality in the distribution of educational facilities, which is very prominent, occurs for educational facilities at the high school level. The development policy is based on an administrative area at the sub-district level. The distribution of high school level education facilities by sub-district shows a significant number. Looking at the trend of population growth and school age, the need for school facilities at the high school level until 2030 in the Kedungkandang district is at least 12 schools. It is necessary to determine how the new high school facilities will be distributed in the Kedungkandang sub-district, especially in the Southeast Malang development area.

Mobility, connectivity, and spatial accessibility patterns

The connectivity and accessibility of the development area, as a unitary spatial planning area up to the city scale. The mobility pattern, regional road network connectivity, and accessibility are analyzed on a district or sub-district scale. Although the spatial unit's object of research or analysis is the Southeast Malang development area, because the development policy is an administrative unit of the Kedungkandang District, the spatial area is carried out in the Kedungkandang sub-district scale. According to Lamíquiz and López-Domínguez (2015), the road network configuration is the primary generator of urban mobility patterns. It determines travel routes and the frequency of use of travel paths, also conveyed by Maes et al. (2016) that the configuration of the urban road network has an essential role in determining the spatial mobility pattern of an area (Maes et al. 2016). That means the practice of the road network, the hierarchy of road classes, and the geometry of the roads that make up the area's circulation path will determine the accessibility to and from public facilities, including educational facilities. Accessibility can be measured as distance, cost, or time between two locations (Chica-Olmo, Rodríguez-López, and Chillón 2018). Physical space, travel time, and mode of transportation will determine the pattern of community mobility on a local and city scale (Alitajer and Molavi Nojoumi 2016; Mandic et al. 2017).

As stated earlier, conducting a field survey on student behavior is essential to provide a significant explanation for the connectivity analysis of an area. The main obstacle to implementing the student behavior survey is the problem of the COVID-19 pandemic. The school Face-to-Face Meeting (FFM) policy has not been fully implemented. The survey was conducted after the FFM policy (50% face-to-face) was implemented on September 9, 2021. They are using a sample of 150 for three schools (two High schools, and one Vocational High School) in a balanced manner, 50 students each. NSA policies of using a zoning model have implications for the close distance from home to school. The higher the quality of the school, the more prospective NSAP students register, and the shorter the distance from school to the homes of new students. Survey data from three public high school level schools in Kedungkandang District shows that 62% of the distance from school to students' homes is less than 400 m. As many as 83% of student houses are less than 800 meters, 12% 800-2,500 meters, and another 5% more than 2,500 meters. The distance from the respondent's house to the school affects the travel time and the mode of transportation used. The profile of the method of transport used for schools shows 34% walking, 13% cycling, 41% motorbikes, and 12% cars.

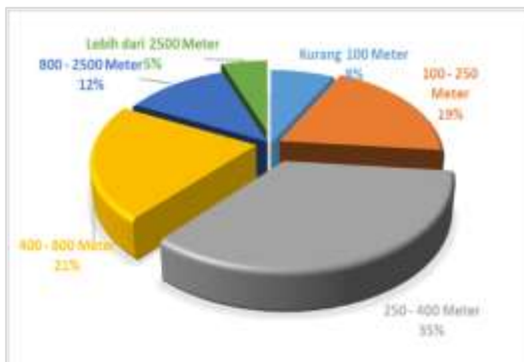

Figure 5. Distance from respondent's house to schools (Vocational High School, and Senior High School)

Student mobility from and to school, as presented by Reyes, Páez, and Morency (2014), that distance and movement patterns are essential factors in the mobility of individuals or communities in carrying out movements in urban space. The shorter the distance between residence and school, the more excellent the opportunity for mobility by walking and modes of Non-motorized transportation. In this study, motorized vehicle users were still relatively high at 53% (41% using motorcycles and 12% using cars). Further information found that the reason for using a motorized vehicle to school shows the fact that the distance from home to school is far (42%), road conditions are not comfortable for walking (35%), so you can get to school faster (13%). The school's proximity to home allows students to walk or cycle and reduce dependence on motorized transportation modes if road conditions are comfortable for walking.

Following the statement of Iacono, Krizek, and El-Geneidy (2010), the pattern of population mobility is influenced by the level of connectivity and accessibility of facilities that represent the configuration and structure of urban space (Iacono, Krizek, and El-Geneidy 2010). Road connectivity indicates the high possibility of connecting one road to another. The higher the road connectivity, the higher the accessibility, which encourages the smooth circulation and mobility of goods or people. Geometry factors, road characteristics, road width, pedestrian facilities, and landscape affect to the road comfort.

The Southeast Malang Development Area is mainly planned for settlement development. Figure 10 shows the location of the Southeast Malang Development area from satellite photos depicting part of the area as dry land (non-technical agriculture), with a road network that is still minimal. The space syntax analysis of the connectivity of the Kedungkandang area with a radius of 2500 meters shows that the road network in the Southeast Malang development area is still largely unconnected or has poor connectivity (figure 6). The road network plan in the Southeast Malang Spatial Planning uses an organic approach by increasing the existing road class. On the other hand, the area that has not been built has a significant place. Integrated planning is needed in this area to reduce the impact of accessibility disparities in the future.

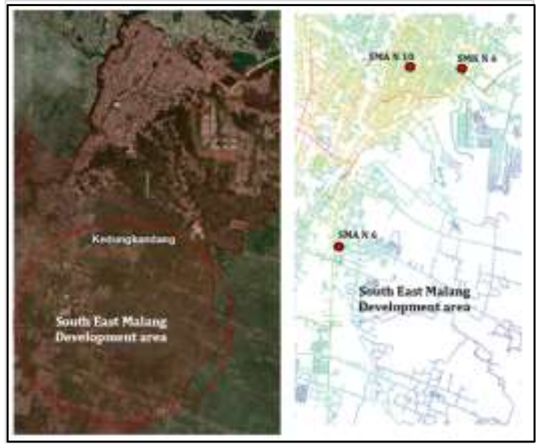

Figure 6. Road network connectivity in the Southeast Malang development area

The housing facilities development in the Southeast Malang Development area has increased the concentration of the school-age population in this area. The problem that stands out is the inequality of the population as a result of the rapid development of settlements, compared to the number of school facilities that are not adequate in terms of both quantity and quality. The problem will be even more severe if the provision of housing and settlements in this area is left to the market mechanism. The development of more and more small clusters at this time will add to the problem of increasing inequality in access in this region. Therefore, policy interventions are needed to plan road networks in this area that are integrated with settlement planning and the distribution of adequate public facilities, including the distribution of educational facilities at all levels of education.

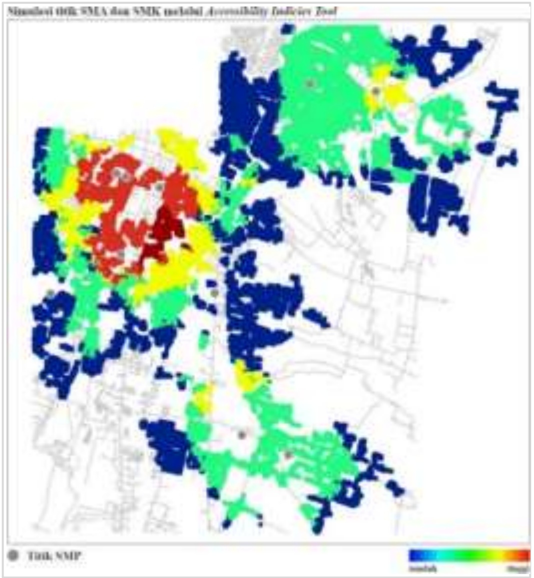

Figure 7. Accessibility pattern of student mobility possibility in the East and Southeast Malang development area

Accessibility patterns from and to schools (Senior Public High Schools) can be simulated visually through urban network analysis. Measurement of accessibility can use a range or reach gravity, attraction, and straightness indicator.

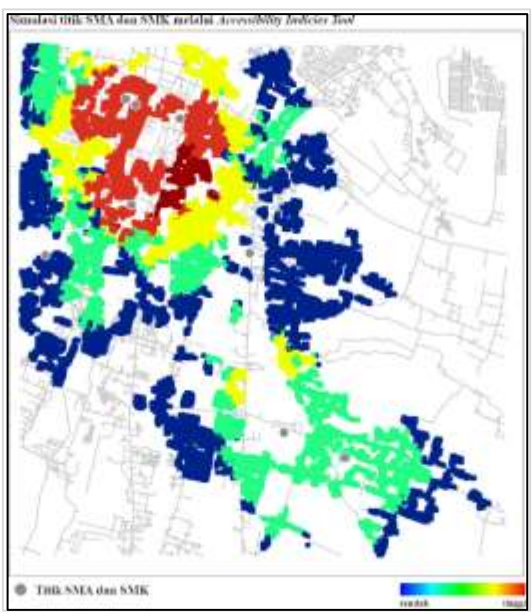

Figure 8. Illustration of educational facility accessibility in Southeast Malang area

The Visualization of Mobility Accessibility Patterns of senior high school students in East and Southeast Malang can be illustrated in figure 7. Accessibility inequality is caused by the distribution of residential areas and limited educational facilities in the region. These three indicators can provide an overview of the affordability and services of educational facilities at their housing location. Can describe the simulation of school facilities accessibility.

The reach indicator, also known as the "opportunity accessibility index" (Bhat et al. 2002; Geurs 2018; Lättman, Olsson, and Friman 2018; Sevtsuk and Kalvo 2022), captures how many points (in this simulation Senior High School and Vocational High School buildings) can reach from each end of origin (buildings) within a search radius of 2.5 km given on the network. Shown through the color chart, blue indicates a low degree and a high degree (figure 8).

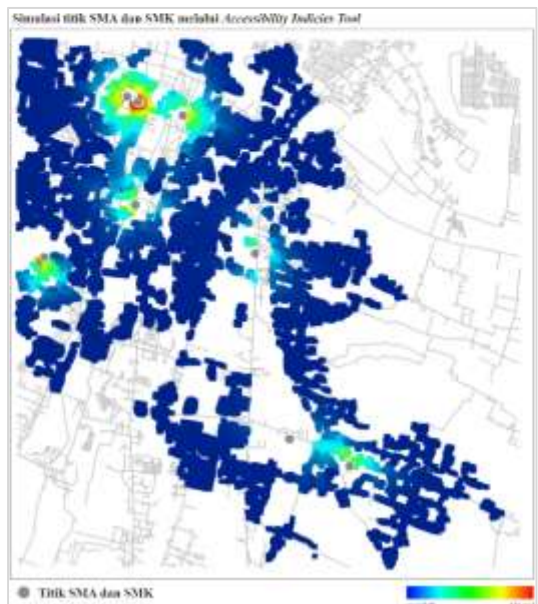

Figure 9. Illustration of the attractiveness of education facilities

Simulations with gravity indicators assume that accessibility at the point of origin (residential buildings) is proportional to the level of attractiveness (attractiveness) at the destination point (Senior High School and Vocational High School buildings) and inversely proportional to the distance or travel costs between origin and destination. Shown through the color chart, blue indicates a low degree of gravity, and red indicates a high degree of gravity (figure 9).

The straightness indicator (Vragović and Louis 2006) describes the extent to which the shortest path from the origin point (residential buildings) to the destination point (Senior High School and Vocational High School buildings) is in a straight line. Shown through the color chart, blue indicates low straightness, and red indicates high straightness (figure 10).

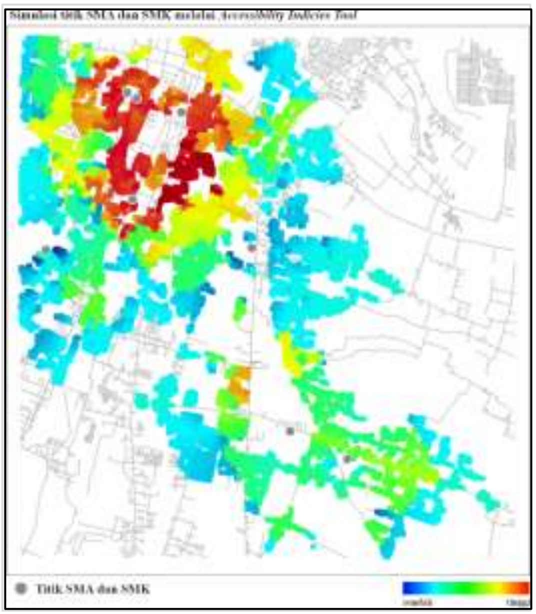

Figure 10. Illustration of straight-line access to education facilities

A low Straightness value may indicate places that require complex routes to reach them. Facilities that reach more destination points on a straight line get the highest straightness value.

Spatial pattern planning for Southeast Malang development area

In response to the planning problems mentioned above, it is necessary to evaluate the Spatial Pattern of the Southeast Malang Sub-Region to integrate the policy of equitable distribution of educational facilities in this region. The intervention of re-planning the Southeast Malang Development Area's spatial pattern must be considered. Developing an integrated and integrated site is very much needed to ensure the implementation of sustainable spatial planning. According to van Assche and Djanibekov (2012), the integrated policy is an essential effort in sustainable development (van Assche, Lo, and Beunen 2013). The integrated spatial planning policy has characteristics; (1) policy integration uses the perspective of stakeholder interests, (2) policy integration is closely related to the principles of good governance of relevant agencies, and (3) policy integration is dynamic and responsive. Spatial planning as a public policy requires specific and integrated regional studies (van Assche and Djanibekov 2012). Spatial pattern planning is part of preparing an integrated spatial plan—the consideration factors in planning urban spatial patterns in the Southeast Malang development area.

Educational facilities are an essential requirement in the development of residential areas. The development of settlements with a small cluster pattern with minimal public facilities impacts inequality in access to public facilities, including educational facilities. Based on the previous discussion, there are three main variables for the equitable distribution of educational facilities in a development area: education development program planning, integrated spatial planning, and community mobility patterns. Connectivity, spatial configuration, topology, and road structure greatly determine the level of accessibility and mobility for the spread of education—planning the configuration of the road network in the new development area of Southeast Malang for settlement development. Figure 11 is the Distribution Model of Education Facilities in the Urban Spatial Planning Scheme. The scheme provides an overview of the interrelationships of the three variables that contribute to preparing the distribution model of educational facilities.

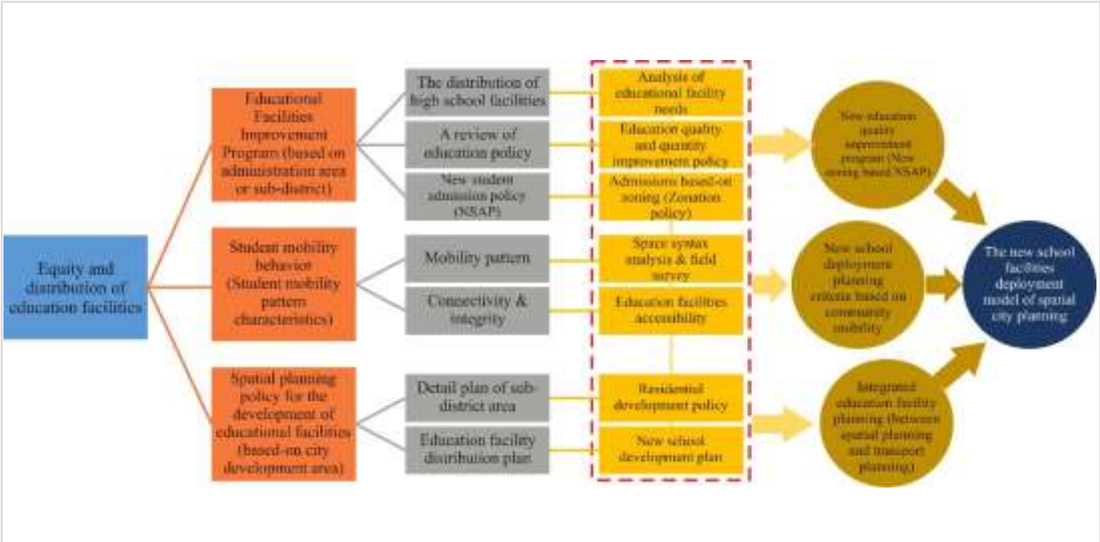

Figure 11. The educational facilities deployment model of spatial city planning

Spatial planning is an integrated planning product between program planning and spatial planning. The implementation of spatial planning in Malang City has not integrated the program implementation and spatial planning. Program planning is based on administrative areas at the sub-district level, while spatial planning refers to delineation boundaries of development areas that are different from administrative boundaries; this often creates problems. The level of integration and road connectivity will greatly determine efficiency (speed, convenience, and cost) and comfort. Determination of the location of educational facilities in the development of new residential areas must pay attention to three approaches; The program approach, spatial planning approach, and student mobility approach, which follow the characteristics of educational facilities. The three approaches and their attributes become the criteria for planning a new school placement policy based on mobility as a model for spatial planning of educational facilities in urban development units.

Conclusion

The distribution of educational facilities requires an integrated, integrated, and sustainable approach. Increasing the quality and quantity of academic services that are evenly distributed and accessible to all communities is the main criterion in planning the spatial pattern of educational functions. The zoning-based NSAP policy is one of the considerations to reduce disparities and mobility gaps between regions and reduce dependence on motor-based transportation modes. The pattern of student mobility, connectivity, and accessibility in the development of residential areas on a large scale must be a consideration for the placement of educational facilities in the Development Area. The results of this study will provide input for structuring spatial patterns in the Southeast Malang Development area. This approach model for distributing educational facilities can be developed to distribute other public facilities within the framework of fulfilling public facilities in the development of urban areas. This research can be a starting point for making a study on a City scale based on the NSAP Zoning policy.

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