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GIS Modeling accessibility of community facilities: A Study Case of Depok City, Indonesia

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Abstract

Improving community accessibility based on transport connectivity helps to address inequality issues. Geographical Information Systems (GIS) provide useful tools for capturing, maintaining and analyzing spatial data to redefining community issues. The objective of this study was to set up a model for accessibility of community facilities using GIS based on private, bus and train vehicles in the city area of Depok, Indonesia. The modeling study for accessibility using GIS and a geodatabase of community facilities included distributed locations of shopping malls, schools, hospital, prayer facilities (worship place) and natural recreational facilities (Lake), as well as supporting data, such as street and road networks, population density and land use types. This study covered redefining community transport facilities, modeling accessibility and analyzing the social pattern. The results obtained from the spatial pattern of accessibility based on various modes of transportation using the method of network analyses and buffering techniques underlined the existence of various patterns. Car transport mode was a commonly accessible mode of community-related to land use interpretation and social issues. In conclusion, there were differences in spatial models in terms of transport mode utilizations.

Keywords: Accessibility, Community Facilities, Geographical Information Systems (GIS), Social Pattern.

1. Introduction

There were previous studies regarding evaluating the accessibility of public and individual activities in urban areas. It was a concern in the geography of transportation (Wang and Chen, 2015; Le Vine et al., 2013; Munoz and Källestål, 2012). Equity of transportation effect social and economic favorable of a community (Farber et al., 2014; Karner and Niemeier, 2013; Sinha and Labi, 2011). Hence, improvement, urban transport accessibility on an urban scale is continuously used to address social inequality, especially for disadvantaged social classes (Delbosc and Currie, 2011; Manaugh et al., 2015; Taki et al., 2017b).

Transportation modes and community accessibility are the main studies among transport equity issues (Velaga et al., 2012; Lucas, 2012; Vasconcellos, 2014). Different transportation facilities produce a range of socioeconomic and environmental factors and this is an accessible spatial pattern of society (Hong et al., 2014; Rodrigue et al., 2016; Williams, 2017) thus, transportation facilities such as the use of different modes produce social, economic and environmental factors as well as result in an easily accessible of community structure (Wang and Chen, 2015).

Spatial analysis is easier with a map because it can examine the deeper study, especially in transport planning (Taki et al., 2017a). The intensity of spatial analysis may also vary based on community accessibility of different transport. Hence, transport policy designed to increase the accessibility of the public should consider not only advantageous effect but also the adverse effects.

Community accessibilities by three different transportation modes (car, bus, and train) are made for the city of Depok, Indonesia. The Regency is selected as the geographic unit. Three transportation modes are estimated to show community accessibilities among Regency groups while controlling social factors.

Analyzing for the spatial pattern is an interesting insight when comparing different spatial pattern intensities and extents. The spatial structure features street network, primary road network,

railway, population density, and settlement land use. Origin and destination factors are represented by the population number, type of the place of worship, level and ownership of the school, and type of hospital. The spatial patterns of these factors are compared to the population density of each regency to assess possible route location.

The study was organized as follows. The introduction provided background information and described a literature review of the study. GIS modeling was discussed in the method. The results of the spatial pattern were discussed in result and discussion section, while the end of the paper summarized the conclusion and recommendation.

1.1 Literature Review

1.1.1 Relationship between accessibility and social community

For many years, land use and transportation lead a major actor in shaping urban sustainability, human interactions, and economic mobility, hence, land use and transportation have important effects on social equity (Welch and Mishra, 2013; Taki, 2017). The issue of social equality, in general, is mainly influenced by transportation accessibility factors. For instance, Tribby and Zandbergen (2012) arguing in their study that accessibility is defined as the ability and ease in achieving activities, opportunities, services, and goods. The method used is using transit access to assess transport equity, and the results show that areas with low equity are associated with low transit connectivity, human interaction, and economic opportunities. Lucas (2011) suggested, based on his research, that all his study area lack of access to cars and transit and revealed that transportation investment can help access and can reduce the poverty rate.

Lack of proper and fair transportation facilities to accessibility can lead to spatial disagreements between social groups in society as well as social benefits received by them (Jaramillo et al., 2012). For example, the spatial differences occurring in geographical regions based on the time and type of population groups. This has an effect on the accessibility that occurs, hence, it becomes an important measure for assessing the cumulative achievement by transport opportunities over long distances. Important focuses in the study are justice, a proxy for social mobility, community accessibility. Various concepts of accessibility implementation are carried out comprehensively as in the selection of the best access to a particular potential location, where the location is in the travel time (Lucas, 2011). Two factors used to assess the accessibility of facilities are transport impedance and travel time. Wang and Chen (2015) assess the modeling calculated for each community group tied to a certain distance based on the distance from the transit stop. In the case of the contributing factor is the transport impedance, the lack of network connectivity between the location of the residence and the workplace results in low accessibility of the facility.

1.1.2 The concept of transport system

In the recent years, the transportation system is a very important system of community life and can visualize as a collection of various relationships between several factors such as network, demand, and node. The derivative function of transportation derived from socio-economic consumptions is the delivery of goods and information as well as the demand for the movement of people. Important notions in transportation such as networks and nodes are as follows, the network is a series of linkages originating from the transport infrastructure while the node is defined as the location where the originating movement ends and is moved.

Three core relationships in transportation based on Rodrigue et al (2016) are (1) Terminal. Facilities that allow access to the network as a terminal are simultaneously characterized by the nodality and linkage radiated therefrom. The analysis of this concept depends on the methodology that is often developed by other disciplines such as economics, mathematics, and planning. The capacity of the transport terminals to handle currents is a major impedance factor. (2) Location. Impedance is largely a function of node accessibility to the queries they provide. The rate of spatial accumulation of socioeconomic activities together defines demand and where this demand occurs. (3) Flow. The current primarily depends on the friction of space, with the distance being the most significant impedance factor.

2. Method

2.1 Study area

Depok is a city in West Java province of Indonesia and located adjacent to the south of Jakarta. Depok is a satellite city of Jakarta capital city (Fig 1) and is a rapidly growing city. The changes that took place in this area is a lengthy process of a series of strategic planning that includes the development of schools, clinics, roads, thus the economy level of Depok grow above the national average. In order to anticipate the rapid growth of population and economy of the citizens, the construction of toll roads and other transportation networks are conducted.

Depok city roles as a commuter suburb with mobility supporting to the capital. Promoting the role of Depok is initiated by articulating the road networks and space based on origin and destination. There is three transportation network in Depok i.e., street for the car, bus tracking, and train railway. All of the transportation networks connect to the social mobility of the dweller in the settlement areas. The existence of community facilities and the road network have enormous potency relating to the environment, transportation, and socio-economics factor.

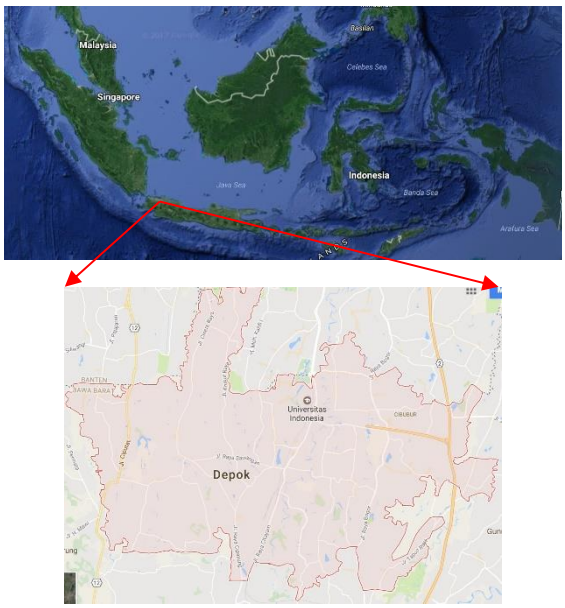

Figure. 1. The map of Depok City

Depok City consists of 11 regencies. Of these, the regency that has the highest population density is Sukmajaya, followed by Beji, Pancoran Mas, while the lowest population density is Sawangan **(Figure 2).**

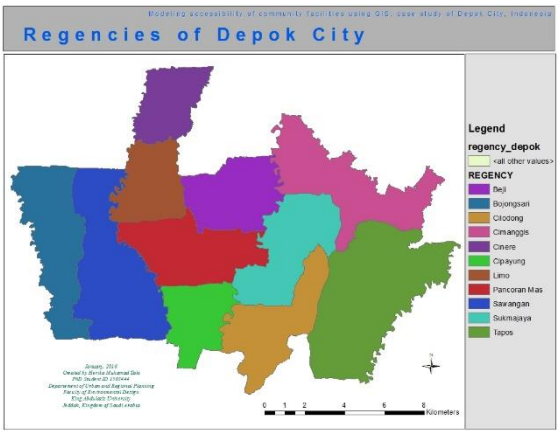

Fig. 2. Regencies of Depok City

In term of transportation, interestingly, there are six main lines connecting the city of Depok with Jakarta capital city, as well as one railway connecting Jakarta capital city with the city of Bogor through the city of Depok. Nevertheless, the roadways are found to be very crowded with private vehicles in the morning and afternoon on weekdays. The same thing also applied to the train **(Figure 3).**

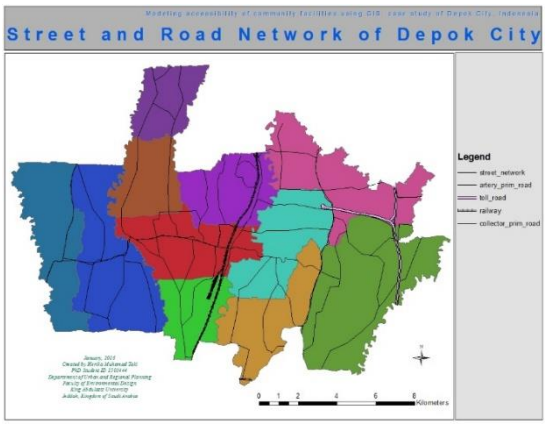

Figure. 3. Street and road network of Depok City

Land use in the study area **(Figure 4)** is largely dominated by settlements and shrubs. In addition, another land is used as the field, farm, forest, green open space, grass and rice fields. The land use of Depok City is dominated by settlements (housing) which is 12,416,5 Ha (61,52%), consisting of the housing with high, medium, and low density.

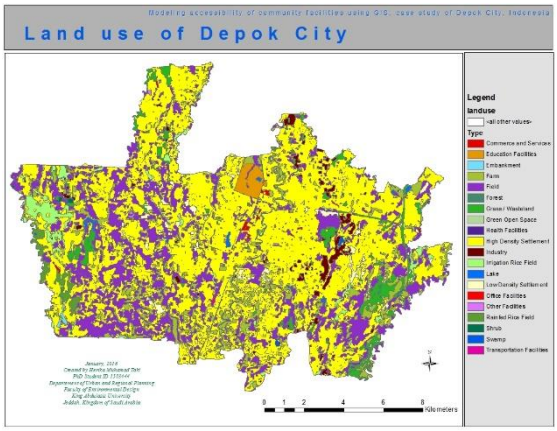

Figure. 4. Land use of Depok City

Depok City has many community facilities in residential areas. The facilities include the mall, school, hospital, mosque, natural recreational facilities (for example, Lake) and other public facilities. The facilities are spread throughout the city of Depok **(Figure 5)**.

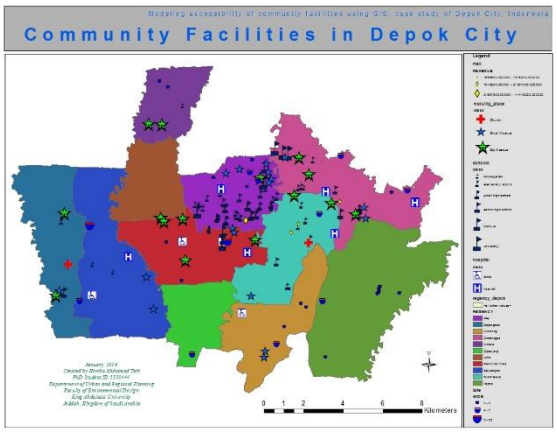

Fig. 5. Community facilities in Depok City

2.2 The relationship between the origin, destination, and mode of transportation

The relationship between the origin, destination, and mode of transport, largely corroborated in the literature of the interaction of land use and transport. The relationship was adopted for this study as a basis for establishing the methodology to assess and develop new findings for Depok City. Interaction is expected to achieve sustainable urban integration.

The origin was presented by the area showing the location of low and high-density settlement as well as the number of population of each regency, while the destination is community facilities such as mosques, schools, hospitals, places of recreation (lake). The mode of transportation that will be examined and being models are the car, bus, and train. The relationship between the origin and destination through the transport mode in the definition of this study is accessibility.

2.3 GIS techniques for analysis the accessibility community of Depok City.

GIS techniques run by first collect the data, complete the data with value attribute that important and very useful when the analysis was performed **(Figure 6)**. Completing all the facilities in the form of a data point and then run the analysis accessibility using the road as far as 1 km buffer, buffer analysis followed by dissolving to further sharpen the analysis of information. All of the analysis was conducted by the aid tools, i.e. ArcGIS software using shp data format. A buffer area of service coverage of each mode of transport was used. Eventually, the analysis of accessibility was complemented with an analysis of social patterns with the additional data, such as population size and density, and location of housing with high and low density.

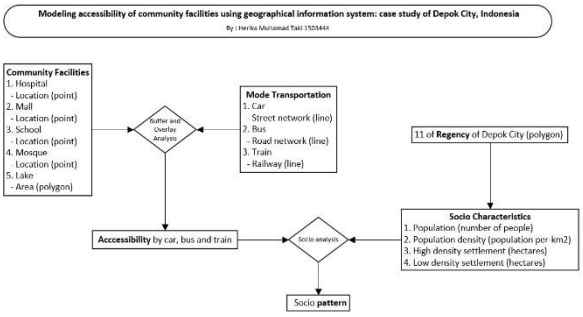

Figure 6. Methodological chart of research

2.4 Measurement of social patterns

The nature of the society can be observed with sightings of land use and demographic data such as population density. The concept of origin and destination in the transportation can be described with the accessibility based on the type of transportation mode. Broader service area covering transportation modes is a beneficial value for the mode of transportation itself. In addition, the broader service can also be useful for the analysis of the existence of social patterns in space.

3. Result and Discussion

3.1 Model for community facilities by car

The model map below shows that the car ridership can grab the whole territory of the city of Depok **(Figure 7-11).** Many community facilities are located spreadly in the middle population. It can be said that the visitors of community facilities come from the entire population of the Depok City.

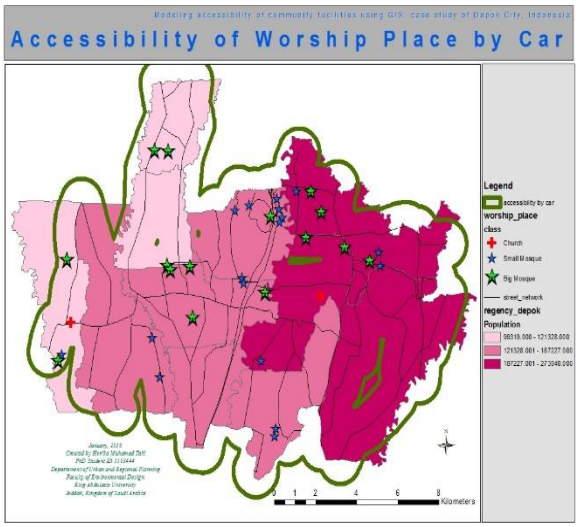

Figure. 7. Accessibility of worship place by car

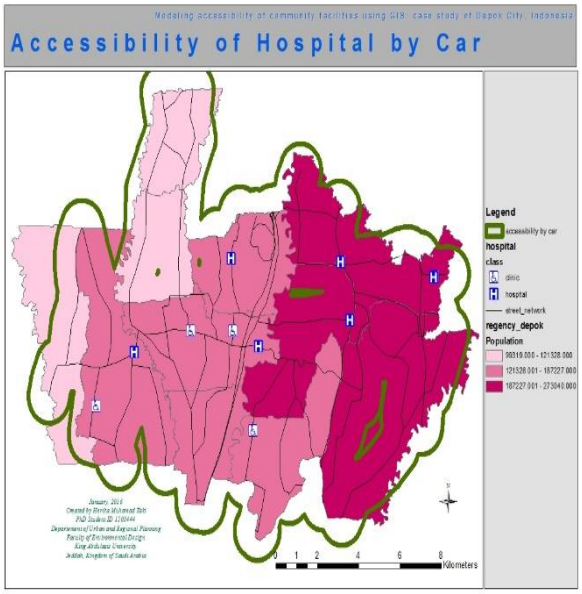

Figure. 8. Accessibility of hospital by car

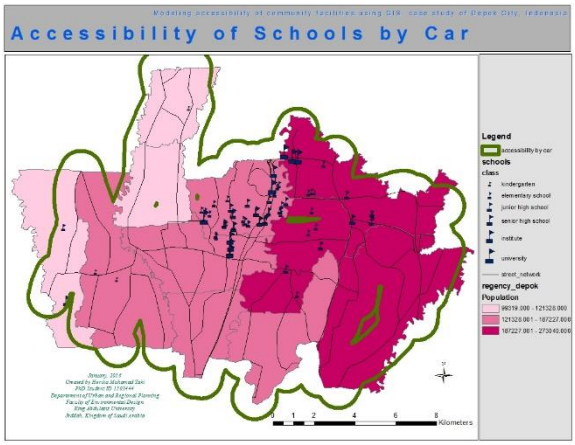

Figure 9. Accessibility of schools by car

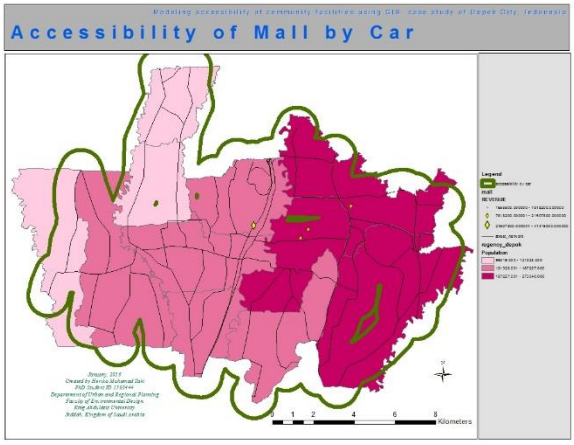

Figure. 10. Accessibility of mall by car

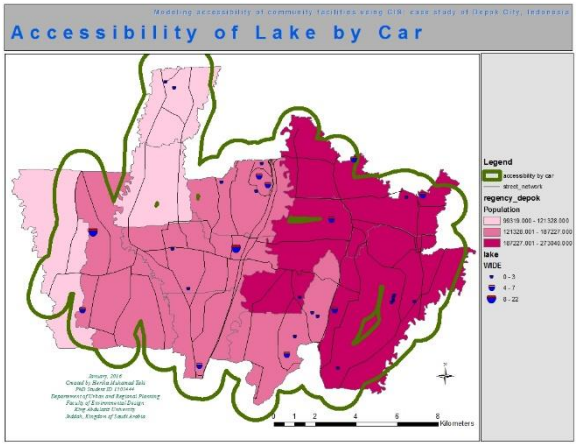

Figure. 11. Accessibility of mall by car

The map above **(Figure 7-11)** shows all community facilities that can be accessed by car because there is a complete road network in Depok city. Similarly, the nearby community facilities with the street network are exhibited. The car is a representative of the high-income level society.

3.2 Model for community facilities by bus

The area coverage of bus service is limited only to the central part of the city Depok (Fig 12-16), with a covered area is dominated by the high and middle population.

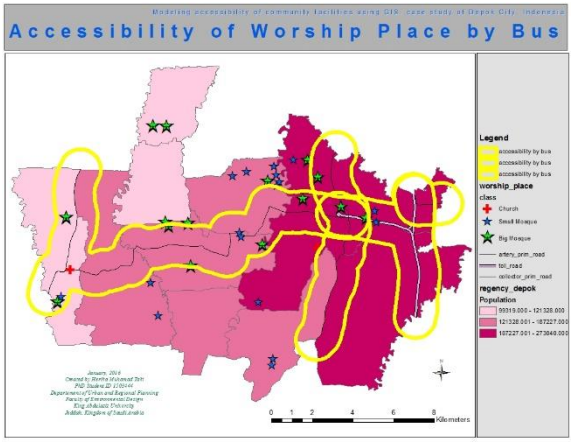

Figure 12. Accessibility of worship place by bus

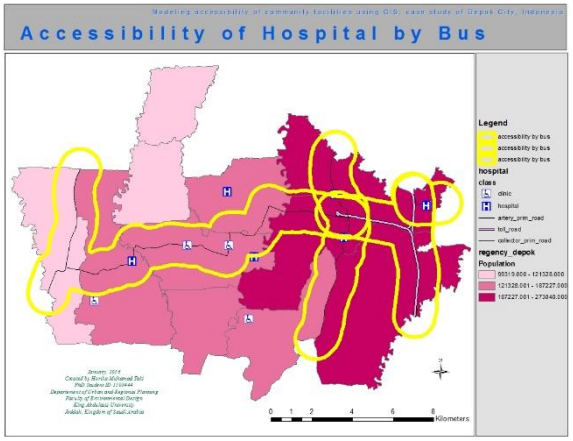

Figure. 13. Accessibility of hospital by bus

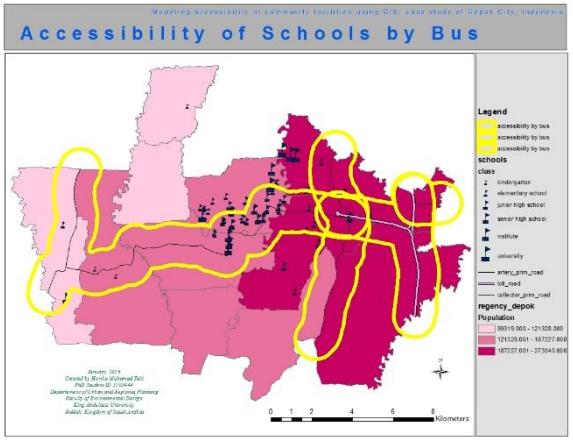

Figure. 14. Accessibility of schools by bus

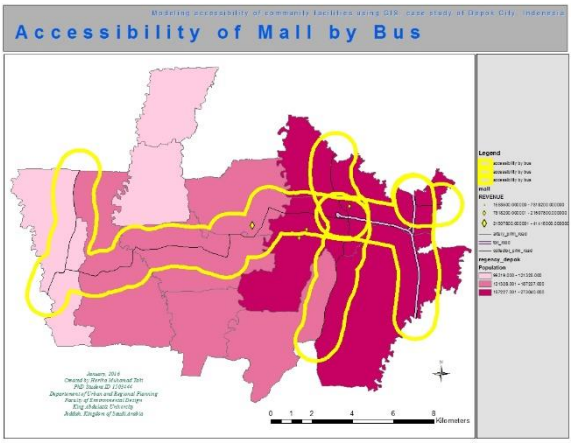

Figure. 15. Accessibility of mall by bus

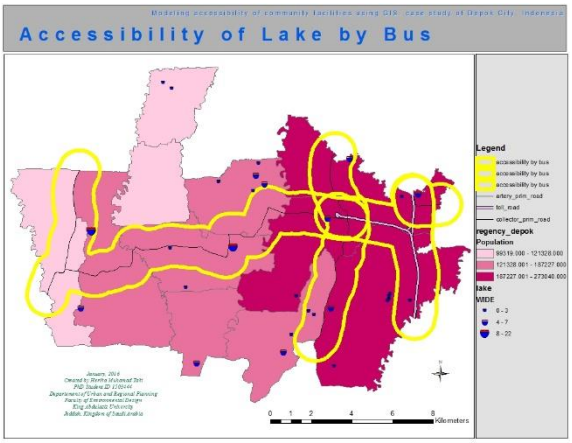

Figure. 16. Accessibility of lake by bus

Bus is the popular choice of transport mode that intended for the public. As seen from the map above **(Figure 12-16)**, the bus only covers a portion of the social facilities, especially the central region of Depok City, where a lot of accessible facilities such as large mosque, schools, and clinics are present. The remaining area is not covered.

3.3 Model for community facilities by train

The coverage area dominated by high and middle population coverage area of the train service is very limited since many areas with low and middle population number are far from railway access. The low-population also appear slightly covered. See Figure 17-21 for the coverage area of the passenger train below.

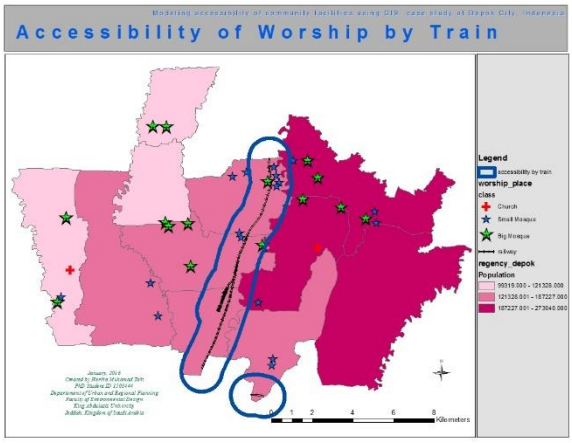

Figure. 17. Accessibility of worship place by train

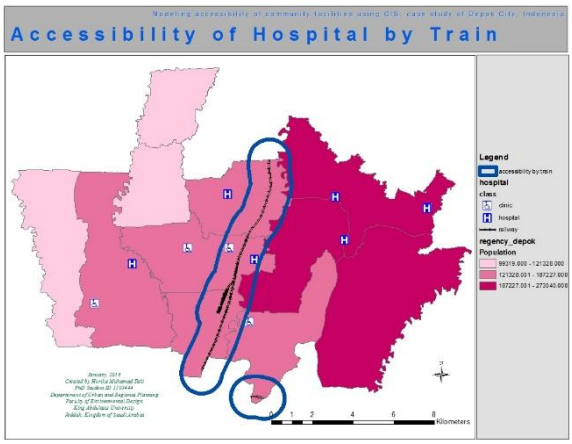

Figure. 18. Accessibility of hospital by train

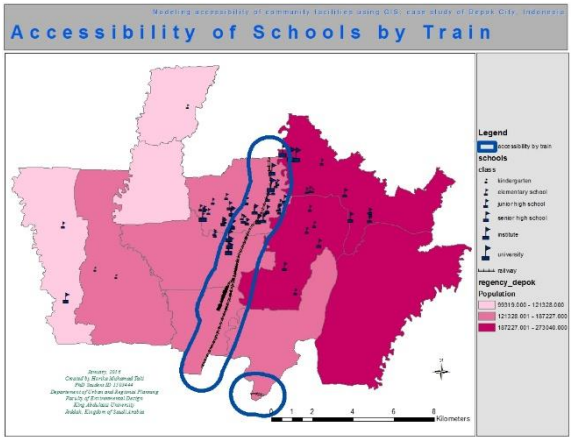

Figure. 19. Accessibility of schools by train

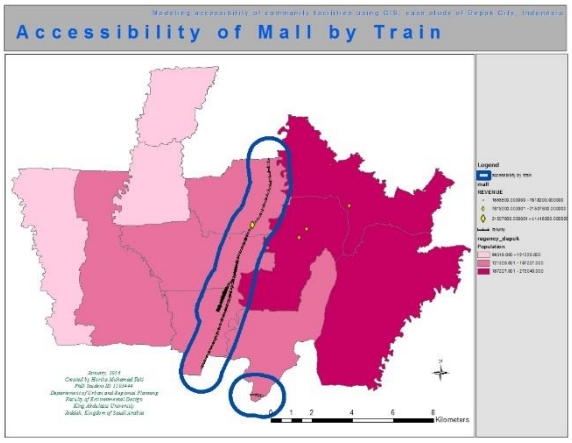

Figure. 20. Accessibility of mall by train

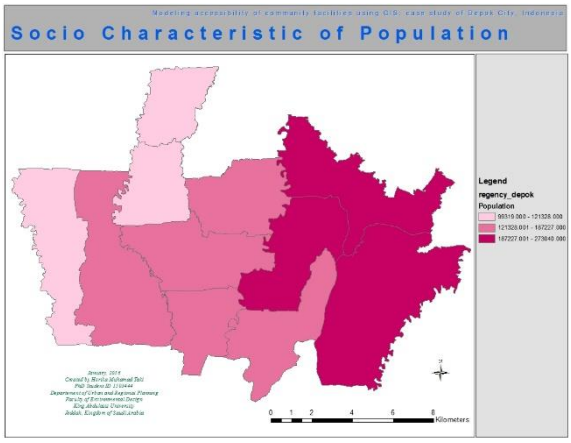

Figure. 22. Socio characteristic of population

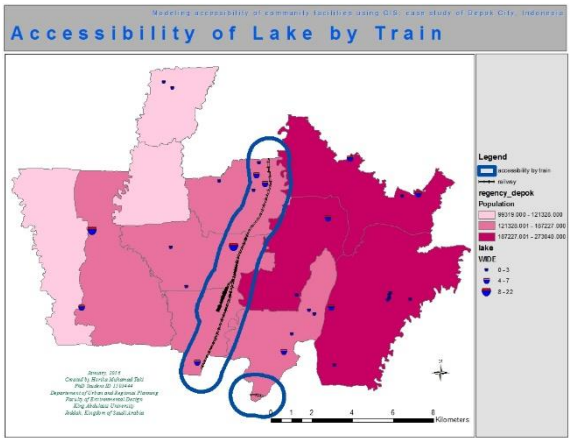

Figure. 21. Accessibility of Lake by train

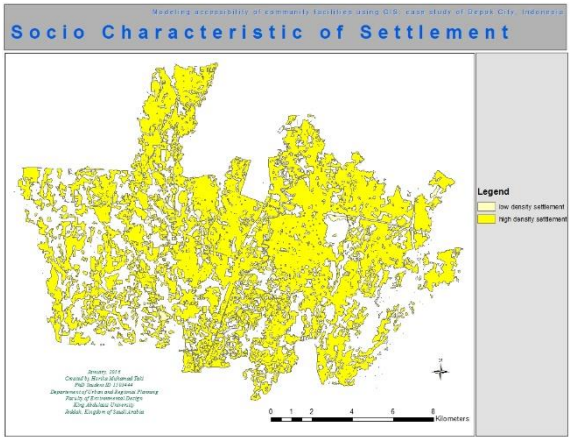

Figure. 23. Socio characteristic of settlement

Few of community facilities can be accessed by the rail modes. Many large hospitals, schools, and mosques are out of reach of the train service mode, as it can be seen on the map above **(Figure 17-21)**.

3.4 Social pattern analysis

From all the obtained result map, the social analysis can be conducted as follows. All community facilities are accessible by transport modes of the car and it is easy to access by the group of high income. While with the bus, not all community facilities can be accessed. The mode of the bus as a mode of the public is closely related to the social class of low income that are presented with high-density settlement **(Figure 22-23)**. Regarding with the train, fewer community facilities were covered since only a few rail lines passing this Depok area.

There is a potency for susceptive social related to public access in the future to the bus and train since not all community facilities are affordable. For example, access by the bus mode, there are several clinics cannot be reached.

3. Conclusion

Among the three access models, access by car is the best model of access since it can access all the community facilities, compared with the access by bus and train.

There is remains an inequity accessibility of community facilities in Depok City due to the fact that the majority of the inhabitants of Depok which are low-income and located in high-density settlements can not access all social facilities using public transportation such as bus and railway.

The recommendation from this study for the government is to provide more services network of public transport to serve the low-income population to access all of the community facilities. All location of community facilities expected to be near the bus and train, especially for large hospitals, mosques since these facilities are very beneficial not only to inside residents but also to outside resident.

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