The Relation between Flow Map Analysis and Residential Density Conditions in Sleman Regency, Special Region of Yogyakarta, Indonesia

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Abstract

The government of Sleman Regency has been actively implementing the Smart Living concept within the Smart Regency framework where its key achievements include developing type C terminal facilities, creating a transport licensing management information system, and collecting data on public transport modes and routes. However, complete access and integration of public transportation with all government facilities, such as hospitals, schools, and offices, remain unrealized. Thus, this research examines the relationship between flow map analysis and residential density in Sleman Regency, based on data from local residents, to address these integration challenges. The analysis was conducted using quantitative methods, especially ArcGIS. Research data were collected through interviews, questionnaire distribution, and observation throughout the regency. The results showed that the current form of movement patterns originates from residential areas with a high density (in terms of population), which has been visualized using flow map analysis and tends to determine no relationship between the daily movement patterns and the residential density conditions. It is because the current form of movement patterns in high-density areas, which are based on the respondent's preferences of transportation mode, has yet to be served well by existing urban bus services. Therefore, the tendency to choose the location of a residential area is independent of the absence or availability of public transportation itself. In the future, all of the unserviced areas should be part of the government's concern so that the idea of connected communities can be implemented and the idealization of the Smart Living concept in Sleman Regency.

Keywords: Flow Map, Heat Map, Residential, Density, Transport

I. INTRODUCTION

Sleman Regency, as an educational destination city and a residential/housing development area, means this region continues to develop rapidly. Of the six dimensions played in Smart City, Smart Living is one of the dimensions that has a significant influence on the lives of the broader community because it consists of three main components, namely harmony in the context of spatial planning, health services, as well as elements of population mobility that are closely related to the provision of transportation to make things easier—community accessibility [1]. Sleman Regency has successfully received the Smart Living Award from the Movement Towards 100 Smart City Awards, competing with all regions in Indonesia in 2019. The program's achievements are highlighted by success in utilizing spatial map data, spatial planning, standardization of health services, Online Patient Registration System, call center system and fast-response system, installation of CCTV and Early Warning System (EWS) in disaster risk areas, Sleman Emergency Service (SES) application services, and rehabilitation and maintenance of LLAJ infrastructure and [2].

With the recognition of the achievement of indicators in the Smart Living program, Sleman Regency still has to face various consequences, such as population growth and escalation of community activities. One of the consequences is increased movement, which needs to be balanced with an advanced transportation system to prevent other problems, such as movement problems or congestion. Population mobility or other matters related to managing regional transportation systems is essential to the Smart Living dimension. However, in the entire Yogyakarta Urban Area (KPY) alone, only about 52.24% can be reached by the community and connect settlement pockets with activity destinations (points of interest/POI) [3]. This percentage is only a tiny portion that accommodates the mobility needs of people living in Sleman Regency. This fact proves that the Smart Living component related to empowering community mobility still cannot be fully realized through the Bus Rapid Transit service.

This research reflects two previous studies that discussed the factors that influence Low-Income Communities (*Masyarakat Berpenghasilan Rendah*/MBR) and are still not served by public transportation services and choosing alternative private vehicles such as motorbikes to mobilize every day [4], abroad research that related to social exclusion and inclusion on mobility and transportation choice [5-7] and also other research related to the

Trans Jogja affordability on the distribution of activities in the Yogyakarta Urban Area (KPY) [3]. The two previous studies [3,4] were oriented towards KPY only. In addition, these two studies provide a reasonably strong background that factors related to location, cost, and choice of transportation modes play a significant role in optimizing the connectivity between the reach of public transportation services and the centers of existing residential areas. Several other studies that also address the public perception of the use of public transportation show that the main issue lies in the problem of inadequate integration between public transportation, which has resulted in delays in people's movements. Several studies have proven that differences in authority and regulations cause non-integration of public transportation. The integration of the public transportation system is marked by the availability of adequate facilities so that people can carry out their daily mobility more efficiently and comfortably but at an affordable cost [8-11].

The problem of community affordability in accessing public transportation services needs to be approached with two elements: residential spatial structure planning and developing networks and public transportation service systems integrated with residential activity centers. Transportation problems can be solved if public transportation services reach residential areas cheaply and adaptively. Smart Living, which emphasizes Smart Mobility elements, should be the answer to the development of programs that can link transportation and residential functions [12] and can solve the problem of high house selling prices due to the impact of location, traffic density, travel time inefficiencies, issues of dependence on energy use and degradation of environmental quality [13-16].

In America, research related to patterns and ways to integrate public transportation service systems with housing affordable by MBR has been carried out by actualizing five main foundations, namely (a) agreement by decision makers; (b) providing a choice of modes of transportation; (c) increasing accessibility of affordable housing [17,18]; (d) supports established residential environments [19]; (e) refocusing on financial sources. The problem-solving approach is seen from the choice of transportation mode, the perspective of residential location, and resources for the financing process. Everything is done to create an interconnected community [20].

Figure 1 Road Map of Connected Community [20]

Indeed, this current research aims to describe the relation between flow map analysis and residential density conditions in Sleman Regency based on data from respondents who have lived there. This mapping analysis might become a solution for depicting or visualizing current conditions. It can be modeled to see how high or low the value of service integration of public transportation modes or patterns of integrating them with other modes of transportation is in meeting the needs of today's urban or rural communities.

II. METHOD

A. Quantitative Method, and Spatial Analysis Method

The quantitative method analyzes all the data respondents have set up using the online form. Research data were collected through interviews, questionnaire distribution, and observation and distributed all over the regency by surveyors in this research. The data has been determined from the exploration of the place where the respondent is living right now (recognized as a sample of the start point) and the most visited place as a primary daily activity (recognized as an endpoint), and these points may reverse each other since people go and back again.

The data based on the point shapefile were used for spatial analysis, along with other spatial data that were relevant to the analysis. Spatial analysis will be carried out in two forms. The first is to map the spatial distribution and the assessment results of the respondents' answers based on the location situation of each observation area. This spatial analysis will later be derived into various forms of spatial analysis, such as Buffering and Overlay analysis using ArcGIS 10 software. Scoring and overlay are often used to produce certain conclusions in this spatial analysis process.

B. Population and Sample

The population observed in this research are people who have a permanent resident number (receipt number) of Sleman Regency and have also been living in Sleman Regency. It determined that the respondent has an actual daily activity representing the flow from their residence to the most visited place as a primary daily activity (e.g., school, office, bank, market, etc.). Moreover, the population must be people of specific age groups. This research uses the Slovin formula and a 90% confidence level to determine the sample size from the given population.

$$n = \frac{N}{1 + N(e)^2}$$

Where,
n = number of samples
N = total population
e = nilai *margin of erro*r

Furthermore, the total population of the three age groups in Sleman Regency is 910.055. Based on the population data and calculations using the 90% confidence level of the Slovin formula, 100 people are needed as samples for this study.

Table 1 Research Population and Samples based on Age Group [21]

Age Group	Population	Sample
15-19	84,323	9
20-64	714,479	79
Older than 65	111,253	12
Total	**910,055**	**100**

C. Data Collecting

Data collection was carried out using primary and secondary data collection methods. Primary data collection methods include field observations at points on public transportation routes that are operational throughout the Sleman Regency area. Apart from conducting field observations, primary data collection in the form of respondents' answers was obtained through searching for respondents online or offline using a questionnaire, according to the number determined based on the target number of each observation period throughout Sleman Regency. The parameters asked to respondents are: First, the distance between the affordability of public transportation modes and access to residences and workplaces/schools. Second, collection of respondent's trip destination. Last, information related to the respondent's occupancy and salary.

The population units observed are people who live in the Sleman Regency and have a population identity number registered with the Sleman Regency Population and Civil Registry Service, with the selection of the number of respondent sample units based on a 95% confidence level. Respondents will answer questions using questionnaires and online forms. The number of respondents will be seen from the proportion of each kapanewon (subdistrict) population, so the stratified random sampling technique is used. Meanwhile, the secondary data collection method was carried out by reviewing literature and various planning and policy documents related to programs in the Smart Living dimension, especially those related to the transportation service improvement program in Sleman Regency.

D. Data Analysis Techniques

An overview of the data analysis techniques in this research can be depicted in the following figure:

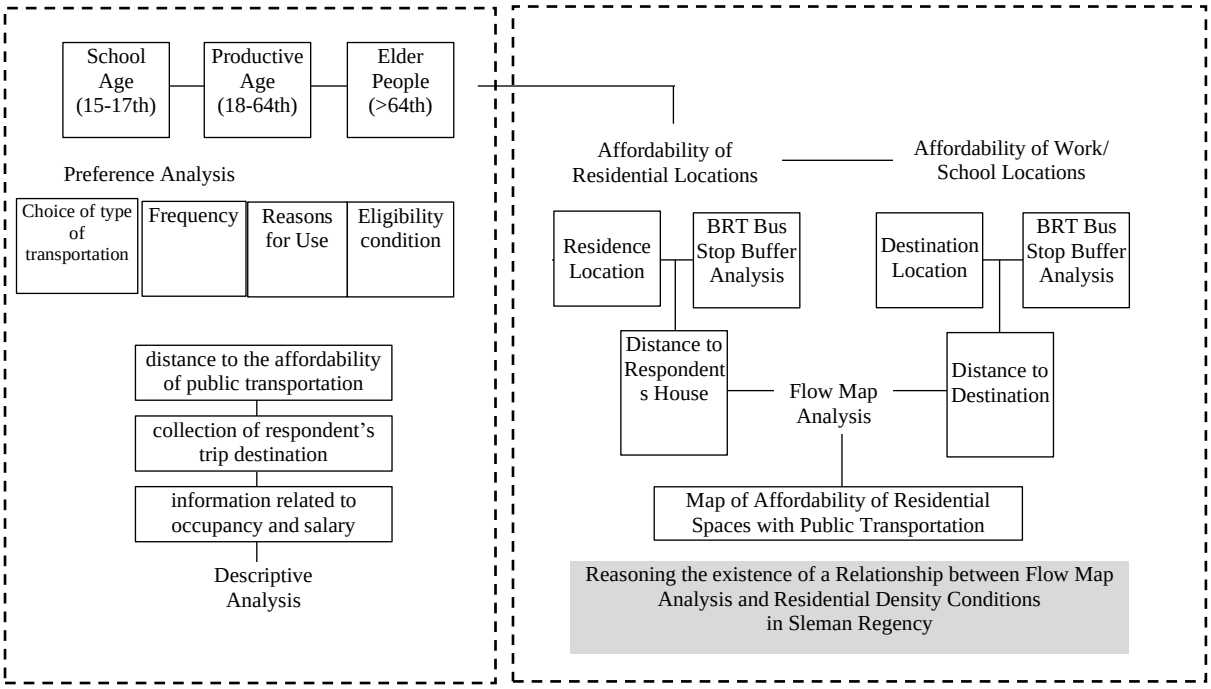
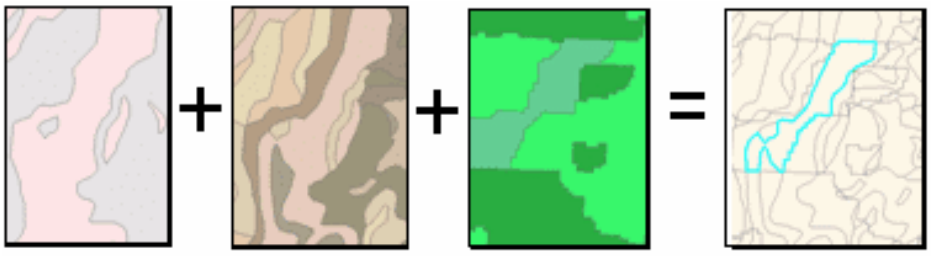


Figure 2 Data Analysis Techniques

Figure 2 shows that the analysis techniques used in this research are divided into two parts, they are Descriptive Quantitative Analysis and Spatial Analysis or Spatial Distribution of Quantitative Analysis Process. Descriptive Quantitative Analysis in this research means that data from respondents such as the distance between the affordability of public transportation modes and access to residences and workplaces/schools, respondent's trip destination, and any information related to respondent's occupancy and salary has been processed using Microsoft Excel, to be then developed for further data sorting based on predetermined parameters. Furthermore, Spatial Analysis or Spatial Distribution of Quantitative Analysis Process is used to carry out in two forms. The first is to map the spatial distribution and assessment results of respondents' answers based on the location situation of each kapanewon. This spatial analysis will later be derived into various forms of spatial analysis, such as Buffering and Overlay analysis using ArcGIS 10 software. Scoring and overlay are often used to produce certain conclusions in this spatial analysis process.



FID	Shape*	FID_soils	CODE	CLASS	FID_sl	SLOPE	FID_veg	DET_TYPE
3039	Polygon	508	38F	6	0	60	117	A
3040	Polygon	508	38F	6	0	60	119	SS
3041	Polygon	508	38F	6	0	60	157	U
3042	Polygon	508	38F	6	0	60	158	A
3043	Polygon	508	38F	6	0	60	160	FC

Figure 3 Overlay Analysis Process [22]

III. Results and Discussion

The respondents' profiles are dominated by people who live in Kapanewon Depok (the central part of the Yogyakarta Urban Area), where the percentage reached 20%. Kapanewon, with the fewest respondents, are Kapanewon Cangkringan and Kapanewon Moyudan, each having only 1%.

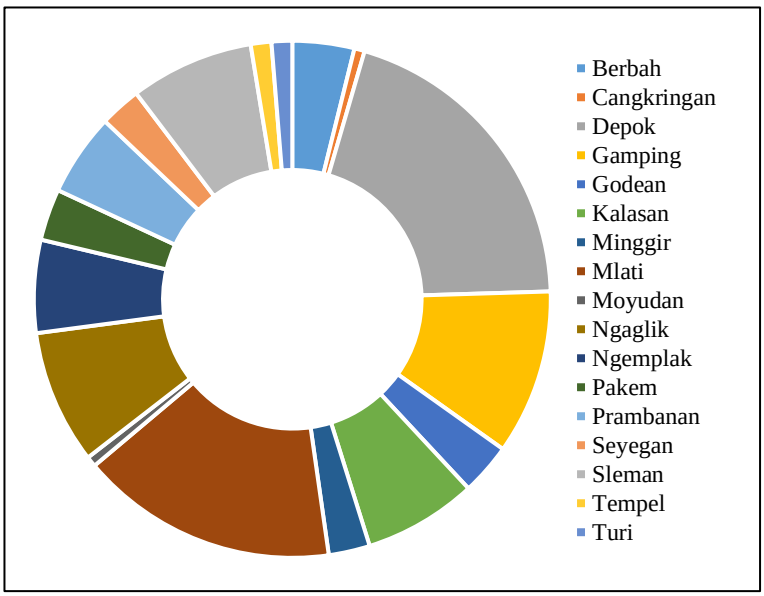


Figure 4 Distribution of Respondents' Residences

The majority of respondents' trips are to work or go to school. 34% chose Yogyakarta City as their destination, and the rest went inside the Sleman Regency. Kapanewon Depok has become the most visited place as a primary daily activity, followed by Kapanewon Kalasan and Mlati as the hub of Kabupaten Sleman.

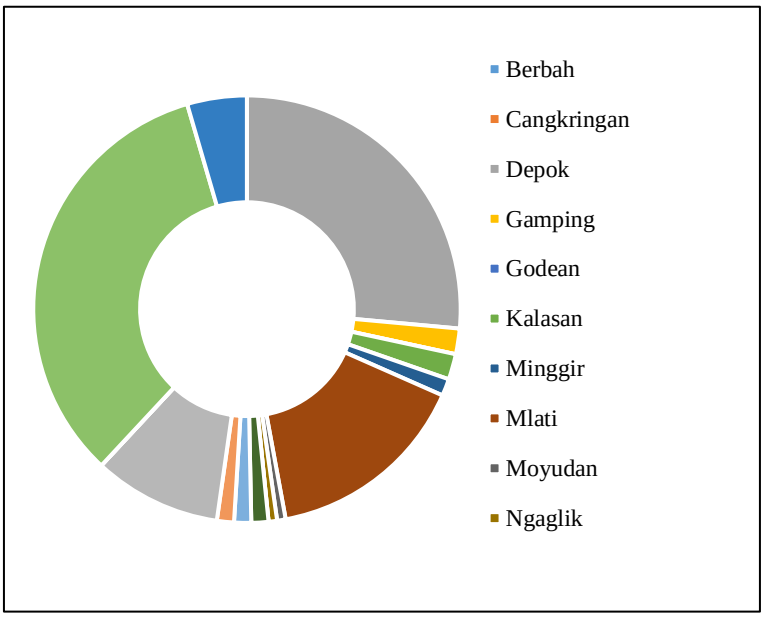


Figure 5 Respondents' Travel Destination in the Sleman Regency

Job information is needed in this research to determine each respondent's goals. As many as 41% of respondents were pupils and students, and the second largest number were respondents who worked as permanent workers. The fewest types of work are freelance or working from home, the percentage of which only reached 3%.

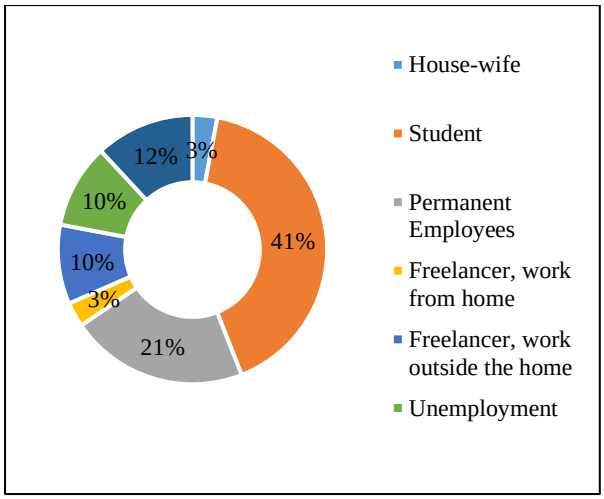


Figure 6 Respondents' Occupations

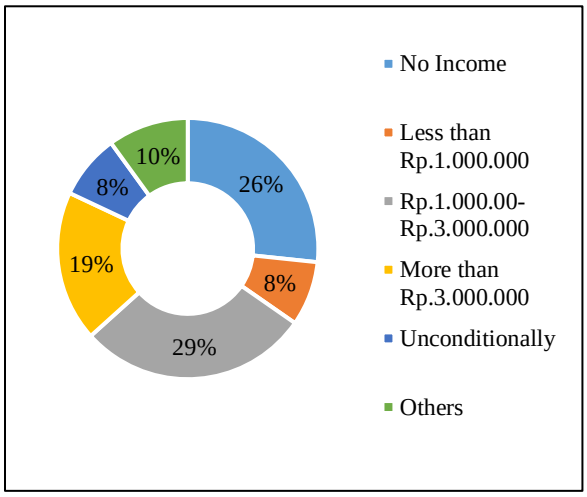


Figure 7 Range of Respondents' Salary

There is information on each respondent's income in one month to determine affordability in terms of costs. Obtaining income data is dominated by respondents with IDR 1,000,000-IDR 3,000,000, while 27% of respondents have no income. Information was also obtained regarding the type of transportation each respondent used. The majority of respondents, 66%, chose private motorbikes. Only 8% chose to use public transportation regularly.

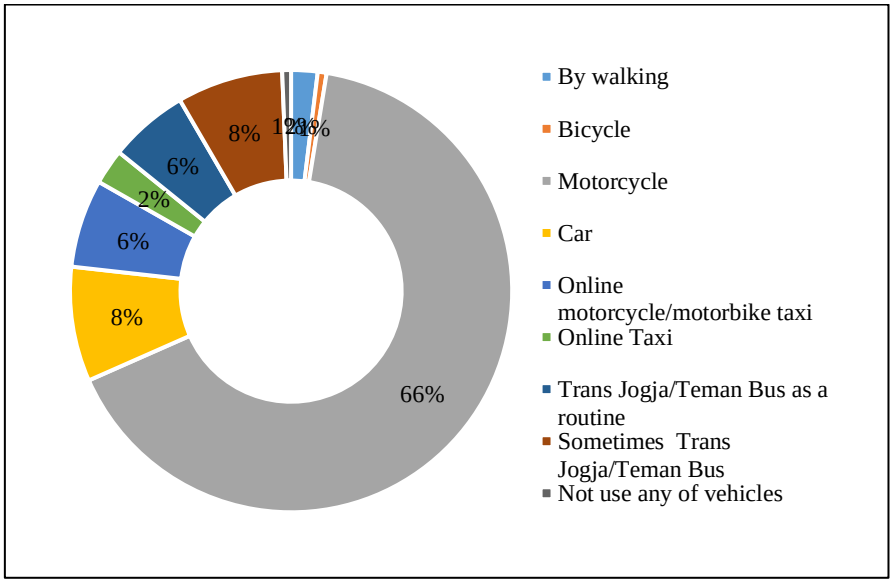


Figure 8 Respondents' Modes of Transportation

These data concluded that most people in Sleman Regency intended to use their private vehicles rather than public transportation as a daily routine. This finding was the fundamental issue that turned out to be an issue where the connection between the resident area and the workplace needs to be reviewed to create the best solution to reconstruct the function of public transportation as a daily transportation nowadays. In 2005, Sleman Regency had 82.852 private cars and 668.988 private motorcycles. The numbers increased, reaching 165.778 for cars and 713.475 for motorcycles by 2016 [23].

However, this issue has been confronted with other problems that must be addressed, such as the management of the transportation provider company, the service information that has to spread out to communities, and the issue of comfortableness and flexibility using public transportation. According to Trans Jogja users, the frequency of use, ticket prices, accessibility, and integration with other transportation modes positively influence Trans Jogja's effectiveness as a public urban transportation system that fulfills the community's mobility needs. Nevertheless, the condition of the buses, the state of the shelters/stops, and the fleet's speed, safety, and comfort are drawbacks, as users still perceive these aspects of Trans Jogja's performance as insufficient [24].

Trans Jogja management and Teman Bus have made many innovations in providing travel route services that cover areas with many residential pockets. The areas concluded in the 2022 Sleman Regency Population Density Map based on the dasymetric method have a correlation that shows that the current service area has attempted to accommodate the movement of people from rural areas such as Kapanewon Ngemplak and its surroundings.

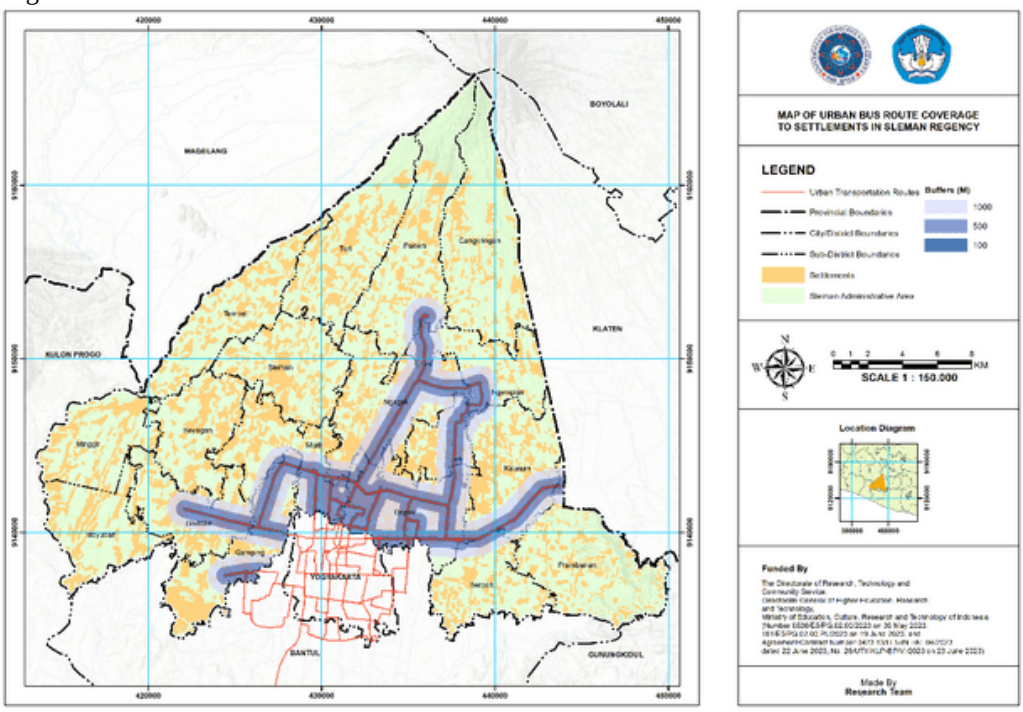


Figure 9 Map of Urban Bus Route Coverage to Settlements in Sleman Regency

However, the condition observed in this research is based on the population density in Sleman Regency, which represents the residential area that becomes the start and end of the respondents' daily trips. Since there are two methods to calculate the density, this research has tried to compare the situation and found an interesting issue, shown in the analysis map below.

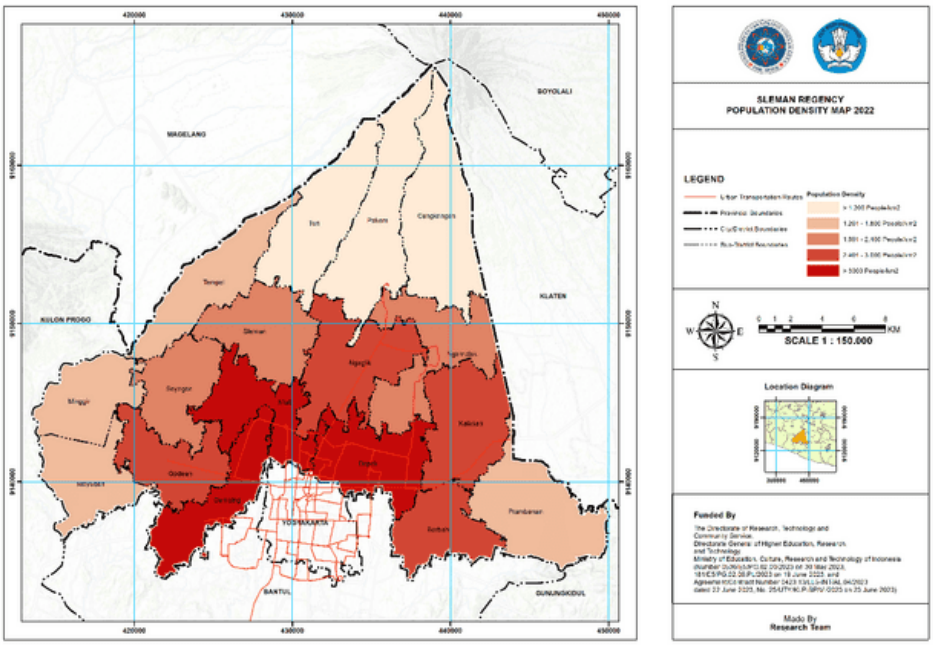


Figure 10 Sleman Regency Population Density Map 2022

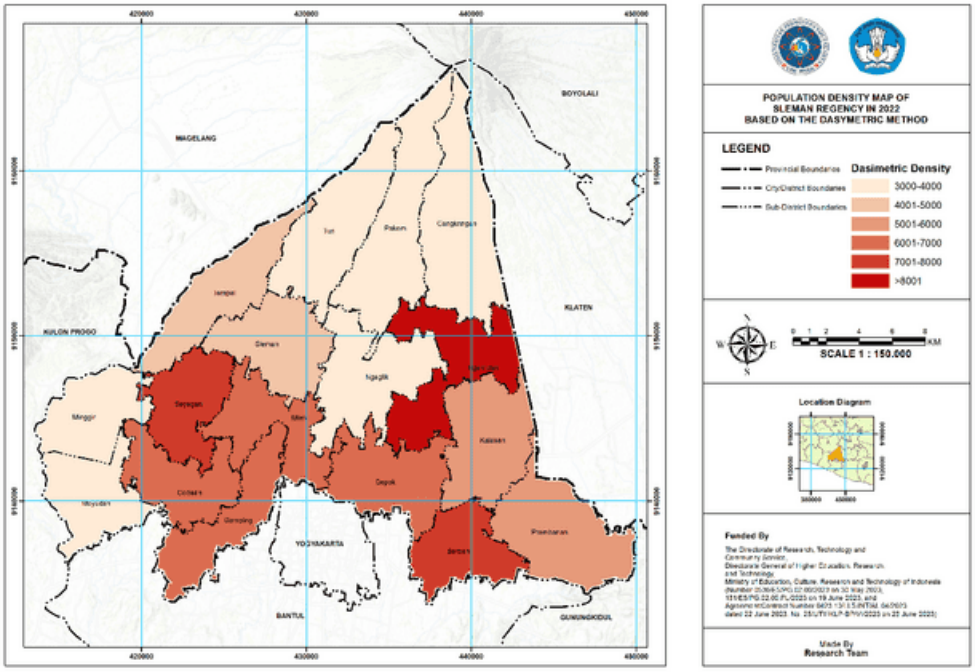


Figure 11 Population Density Map of Sleman Regency in 2022 Based on the Dasymetric Method

The comparison results of the Population Density Map of Sleman Regency in 2022 based on the general formula (Figure 9) and the dasymetric method (Figure 10) showed that the areas that are filled with residential buildings, in particular, are not located in Kapanewon Depok, Mlati, and Gamping. However, it is pressing in the areas behind it, such as Kapanewon Ngemplak, Berbah, and Seyegan. Further evidence will be considered from a sample of the movement of respondents who live in this area towards the distribution of their primary activity places in the Sleman Regency area and its surroundings. Suppose the conditions were observed using the dasymetric method or population density in residential areas. In that case, the current condition of urban bus route services is highly relevant to providing maximum service in parts of Sleman Regency. Its correlation indicates that the current service area has endeavored to accommodate the movement of people from rural areas such as Kapanewon Ngemplak and its surroundings.

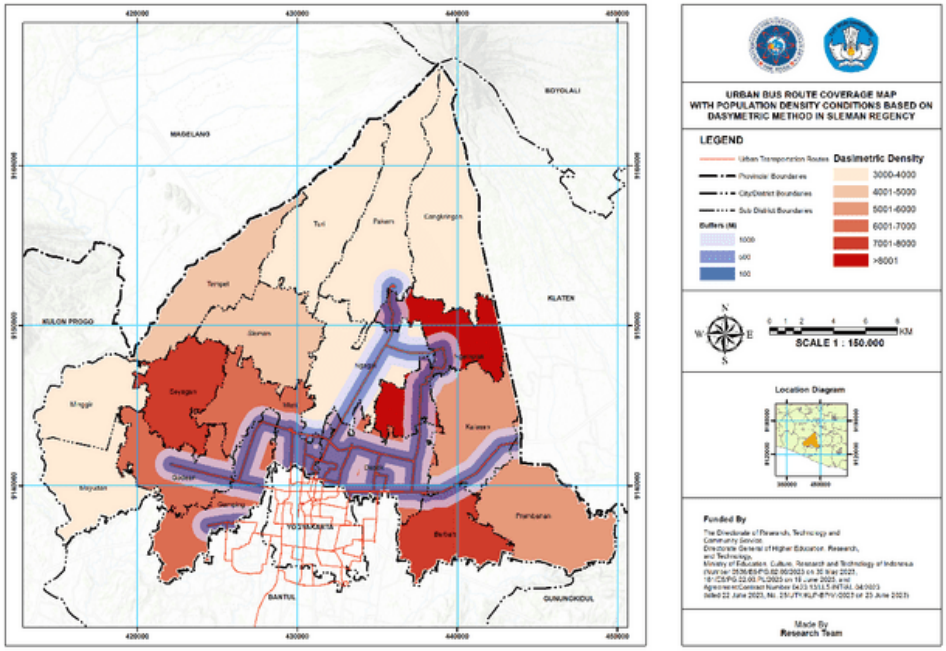


Figure 12 Urban Bus Route Coverage Map with Population Density Conditions based on Dasymetric Method in Sleman Regency

Some spatial analysis from the results of data collection and existing conditions related to the condition of built-up areas for settlements can be mapped below that the conditions of residential areas, which are interpreted using a building density heatmap analysis, still do not serve as a whole by urban bus stop facilities (routes from service urban bus itself). The spatial side that has yet to be served is the western side, such as Kapanewon Moyudan, Minggir, Seyegan, Tempel, Turi, and even Sleman as the administrative capital of Sleman Regency.

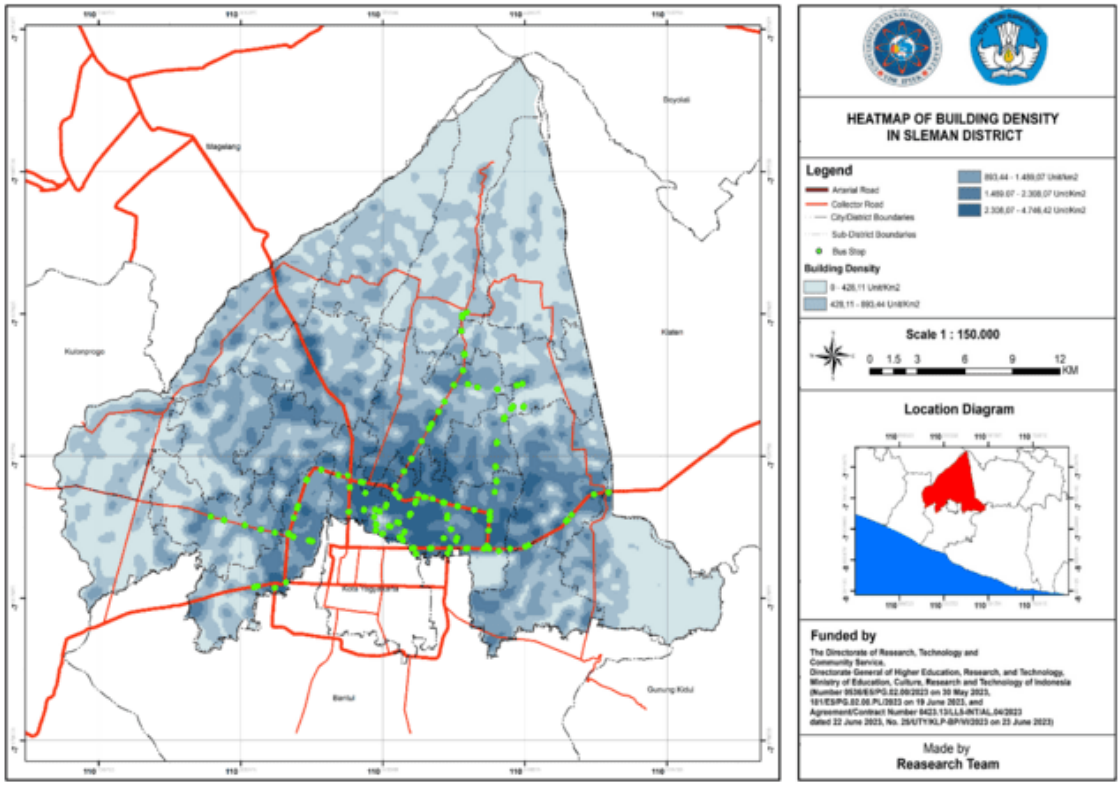


Figure 13 Sleman Regency Building Density Heatmap

Some spatial analysis from the results of data collection and existing conditions related to the condition of built-up areas for settlements can be mapped below that the conditions of residential areas, which are interpreted using a building density heatmap analysis are still not served as a whole by urban bus stop facilities (routes from service urban bus itself). The spatial side that has yet to be served is the western side, such as Kapanewon Moyudan, Minggir, Seyegan, Tempel, Turi, and even Sleman as the administrative capital of Sleman Regency. The above condition also needs to be translated into another description: residential enclaves in the Yogyakarta Urban Area (KPY) are the main focus of urban bus services as the only public transportation currently being developed in the Special Region of Yogyakarta. Areas such as Kapanewon Depok, parts of Kapanewon Gamping, parts of Kapanewon Berbah, and parts of Kapanewon Ngemplak are the areas easily reached by urban bus services such as the current Trans Jogja and Teman Bus modes.

The following analysis results from a review of the visualization results of sample respondents' movement from their residence to their main activity (and vice versa). The map below shows a visualization of the flow of respondents' movements from their residence in the Sleman Regency area to their primary places of activity (such as schools, workplaces, or other places of activity in the form of banks, markets, etc.) inside or outside the Sleman Regency area. The movement flow of respondents shows the density or number of movements within the Kapanewon Depok area, then movement between Kapanewon Mlati and Depok, as well as movements with a reasonably high density from areas such as Kapanewon Pakem, Kapanewon Ngaglik and surrounding areas towards Yogyakarta City or more precisely the Yogyakarta Urban Area (because Most respondents indicated that the choice of destination or central activity location was in Kapanewon Depok and its surroundings). This movement map is based on the choice of transportation modes respondents use, which vary considerably. Therefore, it needs to be detailed again in the following visualization.

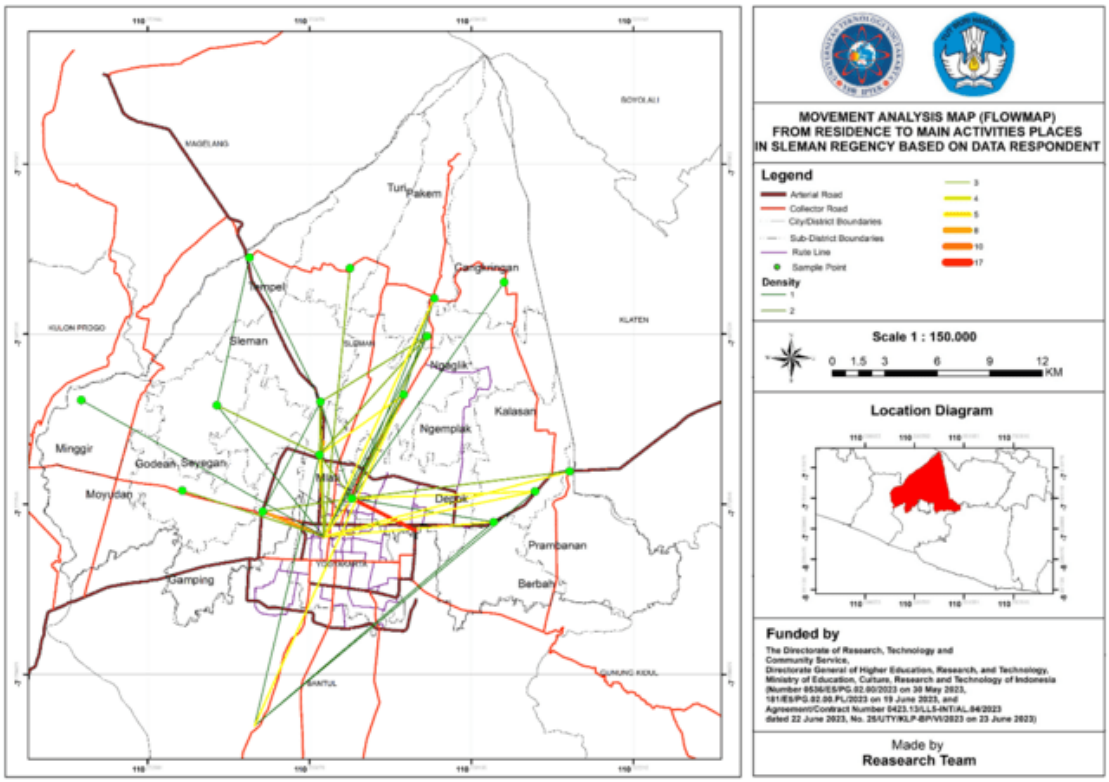


Figure 14 Movement Analysis Map (Flowmap)
from Residence to Main Activities Places in Sleman Regency based on Respondent Data

The conditions of the respondent's movement flow above were then translated in detail based on the choice of transportation mode used by the respondent with a map depiction as shown below.

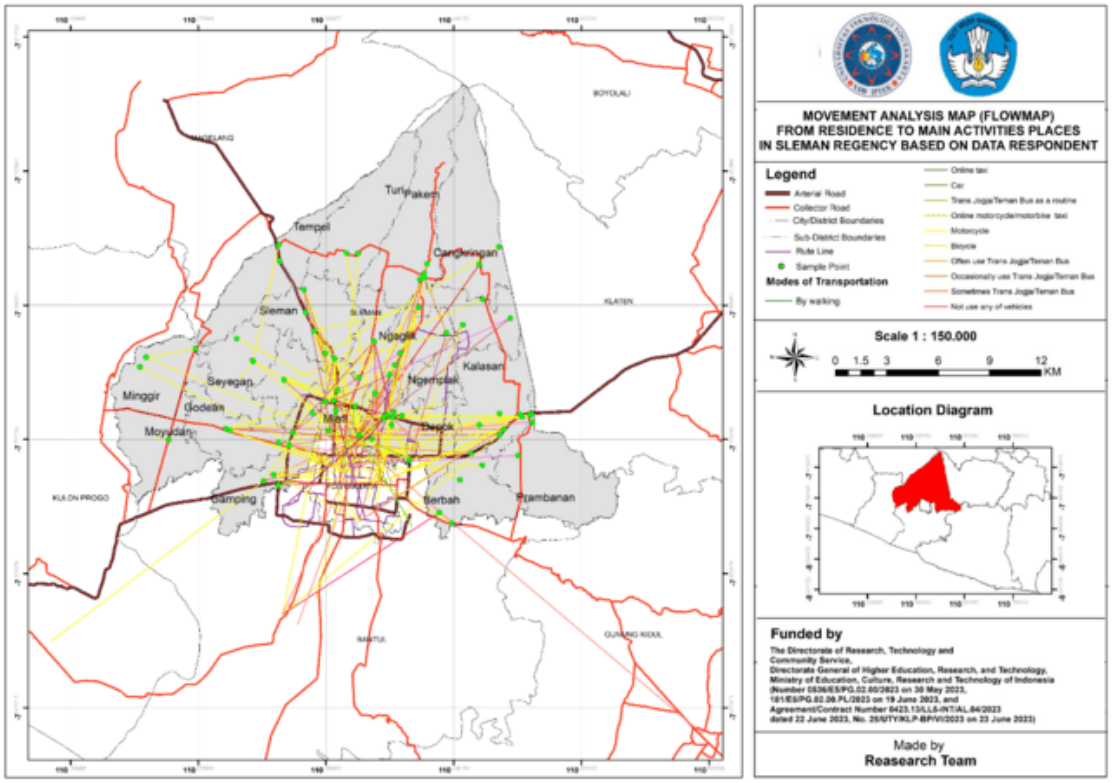


Figure 15 Movement Analysis Map (Flowmap)
from Residence to Main Activities Places in Sleman Regency based on the Data Respondents

In the results of mapping respondents' movements (flow map) above, the dominance of private motorbikes is very high compared to other modes of transportation. This condition also needs to be seen from the issue of the distance that connects the point of residence to the place of primary activity. In the absence of public transportation route services such as urban buses, respondents tend to use modes of transportation with the most efficient use of estimated time and more affordable costs. This condition shows that areas that have yet to be touched by the reach of urban bus service routes tend to seek ownership of private transportation to support daily activities.

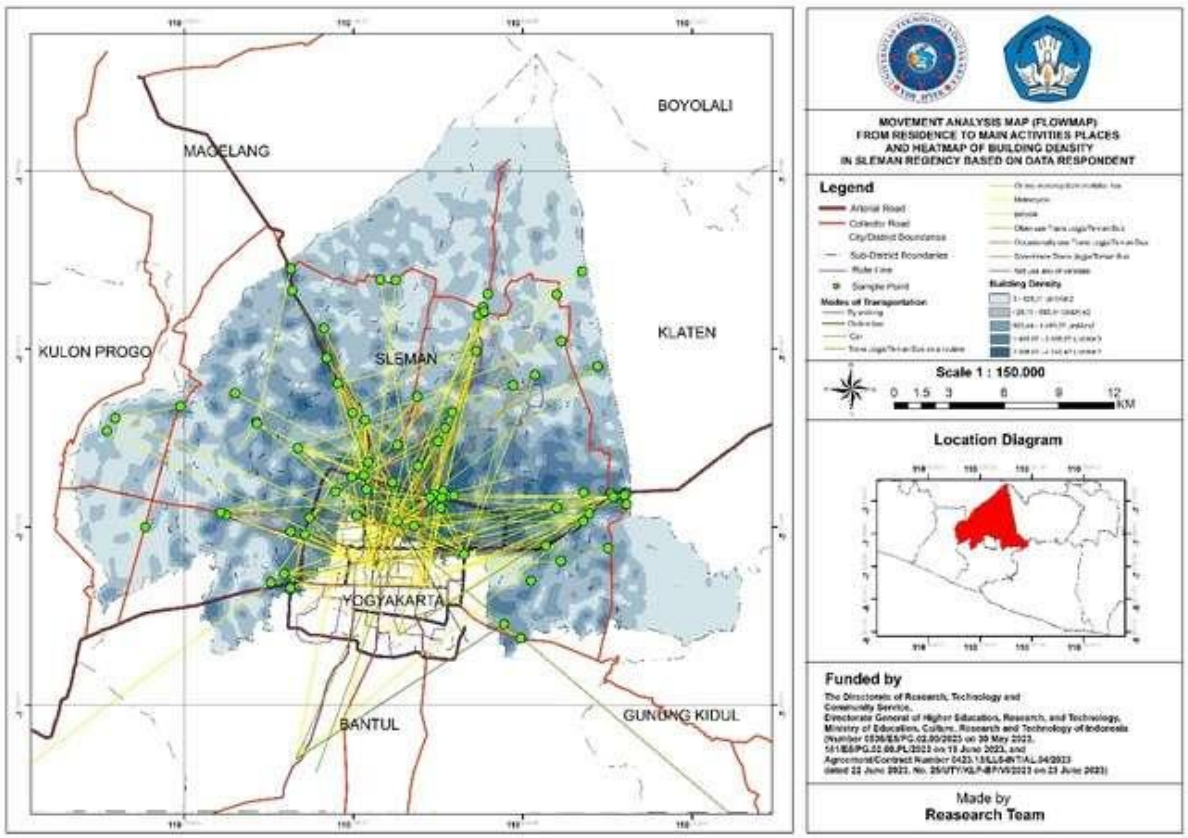


**Figure 16 Map of Movement Analysis (Flowmap)
from Residential Areas to Main Activities and Heatmap of Population Density in Sleman Regency
based on Respondent Data**

The following analysis will overlay the population density conditions read through the building density heatmap map with the movement conditions from the respondents' data collection results. This visualization shows that the current form of movement patterns originate from the area of settlements with high density (from a population perspective). However, not all of them are served by existing urban bus services. What needs to be the focus of attention from the mapping results below are the departure points or sample points of residence or main activities (because the departure and destination points can be reciprocal round trip). This finding indicates that respondents chose the residential area as the availability of public transportation does not influence it; as mentioned before, residential location type had little impact on residents' travel behavior [25]. Although the majority of these points are still operating in main service areas, such as in the Yogyakarta Urban Area, there are still many areas that are not yet served, such as Kapanewon Moyudan, Minggir, Seyegan, Tempel, Turi, and even Sleman, as the administrative capital of Sleman Regency.

IV. CONCLUSION

The results showed that the current form of movement patterns originates from residential areas with a high density (in terms of population), which has been visualized using flow map analysis and tends to determine no relationship between the daily movement patterns and the residential density conditions. It is because the current form of movement patterns in high-density areas, which are based on the respondent's preferences of transportation mode, has yet to be served well by existing urban bus services. Therefore, the tendency to choose the location of a residential area is independent of the absence or availability of public transportation itself.

The advice that can be given to the local government from the findings above is to provide opportunities for the integration of transportation services that are wider than what has been realized at present because, after all, the growth of residential pockets in Sleman Regency will continue to grow and develop following the flow of movement. Mobility. This form of more integrated transportation service space can be accommodated through an applicable model between urban bus users with online motorcycle taxis or environmentally friendly vehicles such as bicycles or electric motorbikes, which should be provided free of charge at transit node spaces such as terminals or bus stops. Thus, the main recommendation that can be conveyed is to open access to public transportation in the western sector (such as Kapanewon Sleman, Seyegan, Tempel) and northern (mostly Kapanewon Cangkringan, a small part of Kapanewon Pakem, and Ngemplak northeast side) of Sleman Regency in addition to increasing access for communities that have not been served optimally at this time. The unserviced area should be part of the government's concern so that the idea of connected communities can be implemented and the idealization of the Smart Living concept in Sleman Regency can be realized.

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