AN IMPROVEMENT IN THE MOBILITY OF MANGKUBUMI YOGYAKARTA AREA WITH URBAN MODELING INTERFACE SIMULATION

FA Galih Sih Hartanta[1*], Arif Kusumawanto[2]

[1,2]Department of Architecture and Planning, Universitas Gadjah Mada
*Correspondence: fagalih2018@mail.ugm.ac.id

Abstract

Mangkubumi Yogyakarta area is not only a strategic area in the city of Yogyakarta, which lies on the axis of philosophy, forming the spatial structure of the city of Yogyakarta but also a compact area with building facilities that function as offices, education, trade/services, worship, and settlements. The discourse of developing the site has long been announced as a supporting area for Malioboro tourism, and Tugu station developed into TOD (Transit Oriented Development), among others. In 2019, the research, development research aiming to find an area model supporting the realization of the maximum mobility value was carried out in Mangkubumi area to measure mobility levels in the area, and the results of this study found that the rate of mobility and walkability was 76 and 79 respectively.

The method used was a simulation of the Urban Modeling Interface (UMI) software to measure the value of mobility in regional models. The research step used area modeling, which was carried out in eight models. After the simulation, the best model with the highest mobility value was selected. The eight models were made based on the four road network patterns of Morlok's idea (Grid, Spiral, Hexagonal, and Delta), each of which was designed to be two types, namely, type A and type B. Type A was a form of modeling by conducting interventions focused on residential building facilities, and type B was focused on all area building facilities. The finding of this research was that the best road network pattern was the Delta network pattern after intervening in all building facilities and after carrying out land use by placing residential building facilities at the center of the area and placing other building facilities on edge the area. This simulation resulted in a walkability score of 92 and bike-ability of 92. The score is the highest in the walk score ranking level. A value of 92 means that there are walker's paradise, daily business not requiring a car, and biker's paradise, daily affairs done by cycling.

History:

Received: April 8, 2020
Accepted: June 12, 2020
First published online: July 15, 2020

Keywords:

Mobility
UMI
Road Network Pattern

1. Introduction

Every human being needs comfort, especially in doing activities and living. The Indonesian Planning Expert Association (2018) provided data that in 2017, the comfort level of Yogyakarta City was 63,6. Compared to previous years, Yogyakarta's city's comfort level decreased; in 2014, it reached a score of 67,39. Some reasons for the inconvenience were that most urban residents perceived the quality of pedestrian paths to be low, that city dwellers felt insecure with disasters, that congestion got worse, that housing prices were increasingly unaffordable for city dwellers, and that they were not much involved in planning. In line with IAPI's findings, the Government of Yogyakarta City (2017) also caught urban inconvenience issues. There were four strategic issue points, namely: (1). Regional poverty and inequality, (2). Parking and traffic congestion. (3). Waste management, waste reduction, perception, and participation. (4). Green open space.

One of the areas in Yogyakarta that will be developed is the Mangkubumi area, directly connected to the Malioboro area as the main tourist area of Yogyakarta City (Kusumawanto et al., 2019). Mangkubumi Street is planned as a bicycle park area and an expansion of Malioboro (Yogyakarta, 2012). In the Spatial Plan of Yogyakarta City from 2010-2029, Mangkubumi Street is a city lane that depicts a philosophical image and cultural heritage; image of passive tourism activities; and select areas for pedestrians (Yogyakarta, 2010). Yogyakarta's Regional Government (2018) explained that Tugu station would be developed as a TOD (Setiawan and Ikaputra, 2020). Mangkubumi area, which is located at a radius of 800 meters north of Tugu station, means that Mangkubumi area is oriented to be developed to support the TOD of Station Tugu area.

To support the government's steps in realizing a comfortable Mangkubumi area as a support for the main tourist area of Yogyakarta City and to support the TOD of Station Tugu, Kusumawanto, Hartanta, and Hijriyah (2019) research the mobility level in Mangkubumi Area with the Urban Modeling Interface simulation and find the level of mobility, especially for the walkability score of 76 and the bike-ability score of 79. The score levels are less than optimal. According to walk score standards, the maximum mobility value is 100. Based on the findings in this study, Kusumawanto recommended that further research is necessary to find a model of the Mangkubumi area as a representation of the center of Yogyakarta City with a focus on maximum regional mobility. This local model can be input for Yogyakarta City Government in developing the Mangkubumi area and a reference for other mobility-based regions and cities.

Sustainable development is a development concept that integrates the natural, economic, and social environment. Haryadi and Setiawan (2002) emphasized that sustainable development has long been developed in developed countries by exploring and researching its concepts and indicators. In 2015, the United Nations held a general assembly in New York, which resulted in Sustainable Development Goals (SDGs) from 2015 to 2030. Indonesia (2017) has issued a regulation on implementing sustainable development to follow up the UN program. This is a testament to Indonesia's active role in supporting the targeting of the Sustainable Development Goals set out in this document Transforming Our World: The 2030 Agenda for Sustainable Development.

By 2050, it is estimated that the global population will reach 9 billion people. The challenge of sustainable development is to move forward so that each can enjoy a substantial quality of life without destroying natural resources. Sustainable development aims to minimize non-renewable resources, achieve sustainable use of renewable resources, and control local and global waste (Kusumawanto and Astuti, 2014).

The continuous increase in population development and urbanization, which causes urban population density, requires attention to regulate it. The Minister of Agrarian Affairs and Spatial Planning in 2017 issued guidelines for transit-oriented area development explaining that "Transit-Oriented Development (TOD) is a concept of regional development within and around transit nodes, so there is added value focused on not only integration between mass public transport networks and between mass transit networks and non-motorized transportation mode networks but also reduction of the use of motorized vehicles accompanied by the development of mixed and dense areas with moderate to the high intensity of space utilization. "(Indonesia, 2017: 3)

In the guidelines (Indonesia 2017: 4), it is also explained that the TOD area is in a radius of 400 (four hundred) meters to 800 (eight hundred) meters from the transit node for mass transportation modes. Furthermore, Setiawan and Ikaputra (2020) support this guideline, and, from the results of their research, the land-use formula for TOD areas is 30% -60% for housing and 40% -70% for non-housing.

Morlok (1978) explained that transportation is an inseparable part of a community function. Transportation is an interpretation of the lifestyle, the range, and location of productive activities, variations, and goods and services available for consumption. Transportation plays a vital role in the development of human civilization. Transportation technology continues to develop following times. Morlok further explained that the transportation network is closely related to travel patterns. There are six transportation network patterns—grid, radial, radial ring, spiral, hexagonal, and delta.

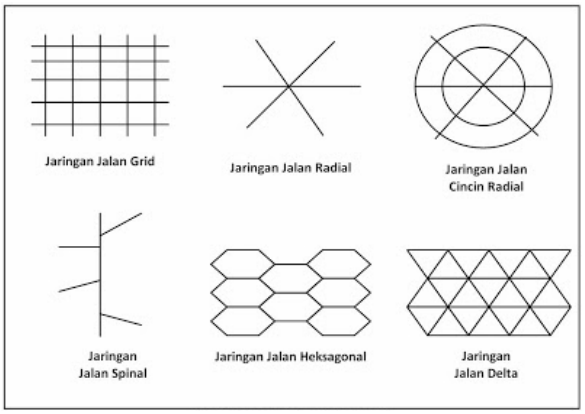


Figure 1. Road Network Pattern

Transportation cannot be separated from mobility. A good transportation network also ensures good mobility. The priority for mobility in environmentally friendly areas does not to use motorized vehicles. The comfort of the area for walking and cycling is measured against a standard developed by walk score. Pedestrian comfort is called walkability, and cycling comfort is called bike-ability. The method used by the walk score in determining the level is based on the location of each building, road network, and public facilities such as grocery stores, bookstores, schools, restaurants, coffee shops, and entertainment facilities (karaoke, online games, play station). The Walkscore assesses the distance of each building on the road. The distance with a maximum value of 0.25 miles (402 m) is assumed to be a 5-minute trip. The range of importance in the walk score (walkability & bike-ability) is 0 to 100. The higher the score, the better the mobility.

Table 1. The Range Of Walkability Value In Walkscore

Value	Explanation
0 – 24	Car dependent Almost all errands require a car.
24 – 49	Car dependent Most errands require a car.
50 – 69	Somewhat walkable Some errands can be accomplished on foot.
70 – 89	Very walkable Most errands can be accomplished on foot
90 – 100	Walker's paradise Daily errands do not require a car.

Table 2. The Level Of Bike-ability In Walkscore

Value	Explanation
0 – 49	Somewhat Bikeable Minimal bike infrastructure.
50 – 69	Bikeable Some bike infrastructure.
70 – 89	Very Bikeable Biking is convenient for most trips.
90 – 100	Biker's Paradise Daily errands can be accomplished on a bike.

UMI is a software used for simulation. Thus, the performance of a city / built environment in terms of energy, land use, and accessibility can be known. Simulations at UMI include FAR (Floor Area Ratio), Operational Energy, Embodied Energy, dan Mobility (Nugrahaini, 2016; Mahendra, 2018). The importance of sustainable development, which means maintaining an ecosystem, can meet the current needs without neglecting future generations' ability. The sustainability of a city can be measured through several parameters, namely compact (efficient land use, minimal use of motorized vehicles, good access, efficient use of resources, minimal pollution and waste, natural improvement systems, suitable housing and living environment, ecological public health, sustainable economy, the participation of community and environment, preservation of culture and local wisdom). The priority for mobility in environmentally friendly areas is not to use motorized vehicles.

The movement of everyone to change places is recommended for walking or cycling. The above description forms the basis of this research. The research to find a sustainable area model through an area model that focuses on regional mobility development is essential in supporting the government to create the Mangkubumi area comfortable for walking and cycling. The high restricted mobility indicates this.

2. Methodology

The experimental method was used through simulations using computer software. The simulation object was obtained from empirical measurements with a measuring instrument to get the existing simulation conditions using the Urban Modelling Interface (UMI) software. The simulation aims to determine the level of mobility of the area. According to Jaedun (2011), experimental research based on the positivistic paradigm generally emphasizes the fulfillment of internal validity, namely by controlling and eliminating the influence of factors outside those experimented, which can affect the experiment results.

The simulation method is handy to use when a study discusses scale and complexity. Simulation research is outstanding when used to simulate actual situations and artificial conditions, both micro and macro (Groat and Wang, 2002). Nugrahaeni (2016) explained that the difference between experimental research and simulation research is simulation research in causal relationships that are usually not visible in the real world and often involve variables and interactions that are difficult to recognize precisely.

Table 3. Research Variabel

Variabel	Parameter		Indicator
Road Network	Grid		Grid Road Network Pattern
	Spiral		Spiral Road Network Pattern
	Hexagonal		Hexagonal Road Network Pattern
	Delta		Delta Road Network Pattern
Building	Building Identity		The name of each building
	Building dimensions		Length, Width, Height
	Type	Office	Offices, schools, places of worship
		Retail	Shops, restaurants, stalls, cafes, industrial places
		Residential	Residence, hotel / lodging
Mobility Amenities	Grocery Stores		Minimarkets, supermarkets
	Restaurant		Restaurants, food stalls
	Café		Coffee shop, angkringan
	Shopping		Shops of Engineering supply, building, and painting
	Banks		Banks, saving and loan cooperatives
	Books		Bookstore, photocopy
	Entertainment		Internet Cafes, Play Station, Karaoke
	Schools		Play Group, kindergarten, elementary school, junior high school, high school, places of education and training

Table 3 describes the variables, parameters, and indicators in this study. The variables used are road network facilities, buildings, and mobility. The variables used are road network, buildings, and mobility amenities. The road network is a basic pattern that functions to shape land-use patterns in an area. The building variable is the building facilities in the area. Meanwhile, mobility amenities are regional facilities that support the creation of population mobility in the region.

3. Result and Discussion

Mangkubumi area, which is located in Jetis District in Yogyakarta City, is strategic because it is north of the Malioboro area and Station Tugu. The total area of the research location is 42.8 hectares. Existing data in the Mangkubumi area as research are shown in Figure 2, Figure 3, and Table 4.

Figure 2. The ground of Mangkubumi Area

Buildings that function as residences are scattered in the middle of the area. Commercial (business) facilities are located on the site's edge, along the main roads, particularly the two main roads: Margoutomo Street and Diponegoro Street. The function of the building as residences is 77.1%. This percentage shows the proportion of the enormous

building function. The next building function is trading 18.7%. While the following sequence is education at 2.2%, office at 1.5%, and the smallest is worship at 0.4%. Thus, the Mangkubumi area is a residential area that also functions as a trade (business) site. Trade (business) buildings are used for shops, hotels, banks, and offices.

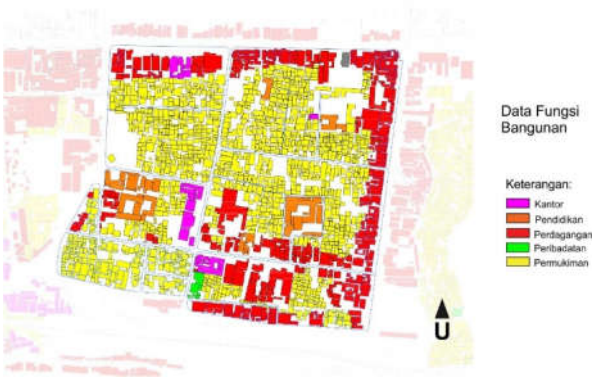


Figure 3. The function of the building of Mangkubumi Area

Table 4. the data of the function of buildings

No	The function of buildings	Quantity	
1	Office	27	1.5%
2	Education	41	2.2%
3	Trade	342	18.7%
4	Worship	8	0.4%
5	Residence	1.407	77.1%
Total		1.825	100%

The road network condition that connects one place to another in the Mangkubumi area consists of 4 types (Figure 4): (1) 5.1 m to. 12 m wide, (2) 3.1 m to 5 m wide, (3) 1.1 m to 3 m wide, and (4) 0.7 m to 1 m wide. The first types of roads include Student Army Street, Diponegoro Street, and Margoutomo Street. The streets are a city street that consists of 2 lanes, with a boulevard in the middle. The three roads are divided into two systems, a two-way system, and a one-way system. Diponegoro Street and Tentara Pelajar Street use a two-way system. Meanwhile, Margoutomo Street uses a one-way system, from North to South

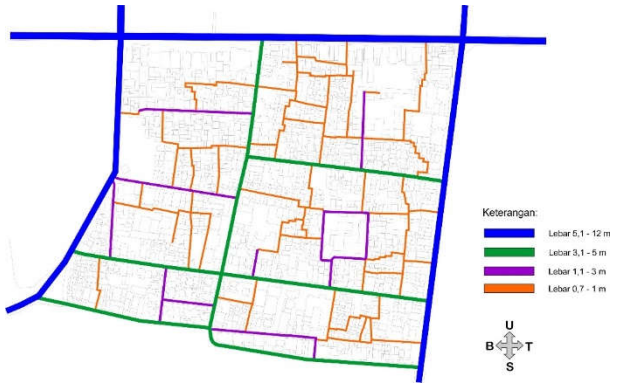


Figure 4. Road Network Map for The Mangkubumi Area

Previous research found findings of the level of mobility in the Mangkubumi area. In the UMI simulation, mobility consists of two analyze, walkability and bike-ability. Walkability is an analysis of regions supporting pedestrian mobility; bike-ability explores areas in people's mobility. After the simulation, the Mangkubumi area has 76 for walkability level and 79 for bike-ability. Based on the walk score, the walkability value is 76 in Figure 5 in the range 70 – 89, which means that it is very walkable (most tasks/jobs can be done on foot). Meanwhile, the level of bike-ability is 79 (Figure 5). This value is in the range 70 - 89, which means that it is very biking (cycling is comfortable for most trips).

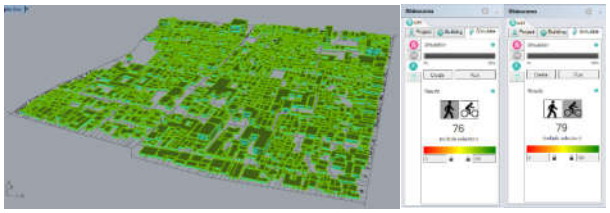


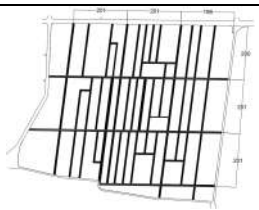
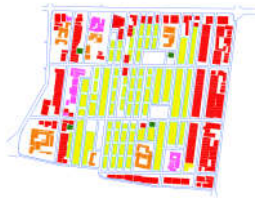
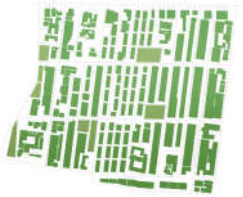
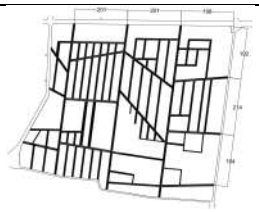
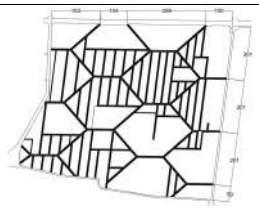
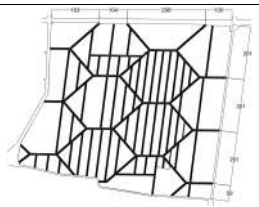
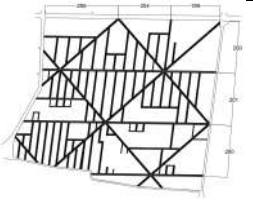
Figure 5. Mobility simulation results for the Mangkubumi area

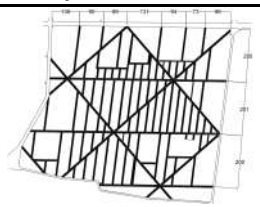
Many residents do mobility by walking and cycling. The travel time from people's homes to public facilities (grocery, restaurant, coffee, books, schools, shopping, entertainment, and banks) ranges from 300 meters to 600 meters. A distance of 300 meters to 400 meters is still a comfortable number according to the walk score, which assesses pedestrians' comfort level with a distance of 0.25 miles or 402 m. A distance of more than 400 m to 600 m makes pedestrians less comfortable. This affects the walkability score of 76.

Modeling is done based on the theory of road network patterns (Morlok, 1978). Morlok explained that the road network has six patterns--grid, radial, radial ring, spiral, hexagonal, and delta. This study uses four patterns--grid, spiral, hexagonal, and delta. The radial road network patterns and the radial ring are not used because they refer to the explanation of the theory that both patterns are only suitable for the central business district (CBD). The Mangkubumi area is not a central business district. Based on the building function data, the Mangkubumi area is dominant in residential areas.

Of the four patterns, each is made of 2 types, type A and type B. Type A is an area model with intervention only in residential buildings. Type B is an area model with interventions in all buildings. Thus, this study produces eight regional models, and the best model based on its mobility value was selected. The data of the regional model and its simulation results Table 5 are as follows:

Table 5. Model Simulation of Mangkubumi Area

Model	Map of Road Network	Building Function Plan	Simulation Figure	Walkability	Bikeability
Existing				76	79
I A				90	92
I B				91	92
II A				90	92
II B				91	92
III A				90	92
III B				91	92
IV A				91	92

IV B				92	92

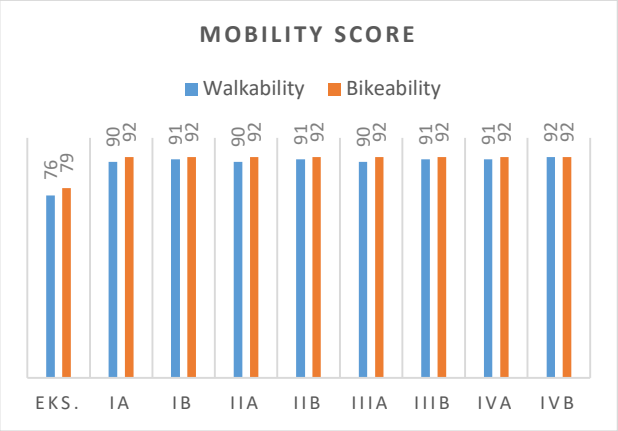


Figure 6. The mobility Score of the Mangkubumi area model

From the general model area, the model that produces the highest mobility value is model IV B. This model has a walkability value of 92 and bike-ability of 92. This model uses the Delta road network pattern. From this, it can be said that the road network pattern that produces the best mobility value is the Delta road network pattern. In model IV B, building facilities are carried out by intervening in all building functions. The arrangement is carried out with a centralized design where the area's center is a residential building. Impresa (2009) stated that the maximum point is obtained if the distance between the settlement and other facilities is less than or equal to a quarter-mile (400 m).

There are no points if the distance is more than a mile. This statement is an essential factor for model IV B to obtain the highest walkability value. With the center of the area as a residential area, the distance between the settlement and other facilities gets closer. People who live in settlements will find different facilities easier and quickly. Not only are settlements in the center of the area, but another factor supporting the high mobility value is the road network pattern. This can be compared with other models that also apply settlement layouts which become regional centers.

Model IV B has higher scores due to the differences in road network patterns; therefore, it can be seen that the delta pattern can provide a lot of access to the area. This finding follows the opinion of Azmi et al. (2013), which states that accessibility is an essential factor for measuring walkability in an area. Accessibility is the key to building connectivity between one facility and another. In line with Azmi's opinion, Nugraheini (2016) stated that opening road access to several building functions can reduce the time and distance traveled from one building to another, so it is more efficient.

Abley & Turner (2011) state about the walkable characteristics: connected (access network for pedestrians related well to public transport); legible (a road network that is easy to understand and to find on the map); convenient (efficient route); accessible. In line with this opinion, Spoon (2005) added that walkable elements are also formed with continuity (design patterns and land use that unite pedestrians). Mangkubumi area, by applying the IV B model, will fulfil the elements of being connected, legible, comfortable, and easy to reach. The delta road network pattern has these elements. This can be seen clearly by comparing the existing road network with the road network in model IV B. The road network can connect the area with public transportation. The road network is also easy to understand, efficient, and easy to reach.

4. Conclusion

Mangkubumi Yogyakarta area is a strategic area in Yogyakarta, which lies on a philosophical axis. This area is a densely populated area with offices, education, trade/service facilities, worship, and settlements. The dominant land use is used for settlement (77.1%), trade (18.7%), while the rest is for other facilities.

After the research, several findings were obtained:

a. The road network pattern that supports creating a high level of mobility is the Delta road network pattern. This road network pattern produces large nodes that facilitate access within the area. Travel routes in this area become more effective and efficient. With the existence of these large nodes, regional accessibility can be created well.
b. The maximum mobility value in the Mangkubumi area is 92. This applies to both walkability and bike-ability. Compared to existing mobility scores, a score of 92 indicates increased walkability by 16 points and bike-ability by 13 points. This score is the highest level in the walking score methodology. It is in Walkers Heaven's category (daily affairs not requiring a car) and Biker Heaven (daily experiences done by cycling).
c. The factors that influence the formation of a value of 92 are applying the Delta road network pattern and intervention in the layout of the building function. Land use is carried out centrally, where the center of the area is a settlement, and other facilities are arranged on the area's edge.

References

Abley, S. & Turner, S. (2011) Predicting Walkability. NZ Transport Agency Research Report 452.114 pp.

Azmi, D.I., Kaya, F., & Ahmad, P. (2013). Comparative Study of Neighbourhood Walkability to Community Facilities between two precincts in Putrajaya. Asia Pacific International Conference on Environment-Behaviour Studies. London: Elsiver.

Bappeda Kota Yogyakarta. (2017). Perencanaan Pembangunan Kota Yogyakarta Tahun 2018.

Disampaikan pada forum gabungan kabupaten/kota, 6 April 2017

Groat, L., & Wang, D. (2002). Architectural Research Methods. Canada: John Wiley and Son.

Haryadi & Setiawan, Bakti. (2002). Penyusunan Indikator-indikator Keberlanjutan Kota di Indonesia. Jurnal Manusia dan Lingkungan. Vol. IX. No. 3. November 2002, hal. 115 – 125.

IAP (Ikatan Ahli Perencanaan Indonesia). (2017). Indonesia Most Livable City Index 2017. Jakarta: IAP

Impresa, Joe Cortright. (2009). Walking the walk: How Walkability Raises Home Values in U.S. Cities. CEOs for Cities.

Indonesia, Menteri Agraria dan Tata Ruang/Kepala Badan Pertanahan Republik. (2017). Peraturan Menteri Agraria dan Tata Ruang/Kepala Badan Pertanahan Nasional Nomor 16 Tahun 2017 tentang Pedoman Pengembangan Kawasan Berorientasi Transit.

Indonesia, Presiden Republik (2017). Peraturan Presiden Republik Indonesia No. 59. Tahun 2017 tentang Pelaksanaan Pencapaian Tujuan Pembangunan Berkelanjutan.

ITDP (2013). Indicators for Sustainable Mobility.

Jaedun, Amat. (2011). Metodologi Penelitian Eksperimen. Yogyakarta: Fakultas Teknik UNY

Kota Yogyakarta. Peraturan Daerah Kota Yogyakarta No. 2 Tahun 2012 Tentang Bangunan Gedung

Kota Yogyakarta. Peraturan Daerah Kota Yogyakarta No. 2 Tahun 2010 Tentang Rencana Tata Ruang Wilayah Kota Yogyakarta

Kusumawanto, Arif dan Astuti, Zulaika Budi. (2014). Arsitektur Hijau dalam Inovasi Kota. Yogyakarta: Gadjah Mada University Press

Kusumawanto, Arif., dkk. (2019). Menuju Yogyakarta yang Berkelanjutan. UGM: Proposal Rispro

Kusumawanto, Arif., Hartanta, FA Galih Sih., Hijriyah, Linda. (2019). Tingkat Floor Area Ratio (FAR) dan Mobilitas Ramah Lingkungan pada Kawasan Mangkubumi Yogyakarta. UGM: Penelitian Studio Riset 2.

Morlok, Edward K. (1978) Pengantar Teknik dan Perencanaan Transportasi. Jakarta: Erlangga

Nugrahaini, Fadhila Tri. (2016). Titik Nol Kilometer Yogyakarta Menuju Pusat Kota Yang Berkelanjutan Melalui Simulasi Urban Modelling Interface (UMI). Tesis S2 Teknik Arsitektur Jurusan Teknik Arsitektur dan Perencanaan Fakultas Teknik Universitas Gadjah Mada.

Setiawan, Agus & Ikaputra. (2020). Tipologi pengembangan kawasan berbasis transit di kawasan station Maguwo, Yogyakarta. Jurnal Arteks. Vol. 5 – 402

Spoon, Steven Chadwick. (2005) What Defines Walkability: Walking Behavior Correlates. A Master of Regional Planning of the University of North Carolina

Yogyakarta, Pemerintah Daerah. (2018). Pemda DIY Sepakat Kembangkan Station Tugu Berbasis TOD https://www.jogjaprov.go.id/berita/detail/pemda-diy-sepakat-kembangkan-station-tugu-berbasis-tod. Diakses: Senin, 09 September 2020

Yogyakarta, Pemerintah Kota (2017). Isu Strategis Kota Yogyakarta.