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TOWARDS SMART TRANSPORTATION: THE IMPACT OF TRANSPORTATION POLICIES ON MOBILITY IN THE OUTSKIRTS (Case Study: Mijen Suburban Area In Semarang City)

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ARTICLE INFO	ABSTRACT
Keywords: *suburban mobility, smart transportation, BRT, online transportation*	*This study evaluates the success of transportation policies in addressing increased travel frequency, expanded travel distribution, and changes in transportation mode choices to achieve sustainable suburban transportation. The research was conducted through a mobility analysis survey in Mijen District, Semarang City, Indonesia. Data collection focused on two main areas: first, travel frequency was analyzed using a trip generation model (Y), factoring in variables such as car ownership (X1), motorcycle ownership (X2), travel efficiency (X3), safety (X4), comfort (X5), and environmental friendliness (X6) of public transport. Second, travel distribution and mode choice were analyzed to understand community preferences for travel destinations and modes of transport. The findings revealed that land use changes in Mijen resulted in a 32% improvement in road quality and increased mobility. Recent transportation policies, such as the introduction of Bus Rapid Transit (BRT) and online transportation services, significantly influenced mobility. Mobility grew by 23.8% per year, with changes in the travel frequency model: Y = 1.957 before BRT (2012-2014), Y' = 1.927 after BRT (2014-2016), and Y'' = 1.860 after online transportation (2016-present). Transportation service demand and capacity were balanced, with load factors of 69.7% before BRT, 54.1% after BRT, and 72% after online transportation. The share of public transport users increased from 36% before BRT to 60% after online transportation services. This research contributes to developing smart city and transportation concepts by providing insights into the impact of transportation policy changes in suburban areas.*

INTRODUCTION

In the era of globalization, urbanization, demographics, and climate change demand greater attention from city planners in efficiently managing energy, materials, and human resources. One strategy to maintain city sustainability is implementing Smart City policies, which integrate information and communication systems into various technical and infrastructural aspects of a city (DuPuis & Rainwater, 2016). This allows flexible control over the supply networks for goods, electricity, water, and gas, providing new solutions for mobility, administration, and public services. The business community, institutions, and governments are constantly interacting and improving the quality of life and cooperation through efficient and integrated information flow. The city will serve its residents and businesses with smooth and transparent administrative processes. A smart city is a city that possesses networks for information, mobility, security, convenience, and sustainability (Schieferdecker et al., 2017)

Smart City policies significantly influence suburban development, which previously existed as areas distanced from the city. With new urbanism, population density increases, land use changes, and shifts in community behavior occur (Clapson, 2000). New urbanism, smart growth, and ecological city development are three approaches to sustainable urban growth. Smart growth focuses on protecting natural resources, regional collaboration, and economic development based on local capacities and the effects of settlements. New urbanism is more focused on improving quality of life through spatial structure and open spaces. In urban ecology, policies interconnect land use, renewable energy, diverse transportation options, shorter commutes, and city density (Chourabi et al., 2012). To achieve urban sustainability, governments use information technologies like the internet and mobile computing to enhance connections with citizens, the private sector, and other government sectors. The benefits of e-government include reducing corruption, cutting costs, increasing transparency, convenience, revenue growth, and accelerating regional development (Khansari et al., 2014).

Suburban development impacts travel mobility, travel patterns, mode choice, and route selection. High urbanization from city centers to suburban areas (new housing) and the shift of jobs towards the suburbs lead to increased travel generation and attraction (mobility). Changes in suburban community behavior due to urbanization result in wider travel distribution, greater transportation needs, and more travel route choices.

High suburban mobility requires smart transportation infrastructure and modes. Smart infrastructure is essential for providing easy movement, connecting activity centers with suburban areas. Smart transportation modes or public transportation are needed to provide safe, efficient, comfortable, and environmentally friendly means of moving people and goods according to the needs of society in terms of both quantity and quality (Figueiredo et al., 2001). Transportation services must reach all areas and be affordable for all community levels to achieve transportation sustainability (Shi & Yang, 2013).

Current travel characteristics can be classified into two major groups: captive travel (by those who cannot afford personal or rented vehicles) and choice travel (by those who can afford personal vehicles or rentals). Therefore, the government and operators must provide smart transportation modes that attract public transport users to reduce private vehicle usage (Warpani, 1990). As urban traffic congestion increases and pollution worsens from motor vehicle emissions, dominated by private cars and motorcycles, efforts are needed to shift preferences towards healthy and sustainable transportation modes (Guo et al., 2013).

The operation of Bus Rapid Transit (BRT) routes to the Mijen suburbs in 2014 aimed at meeting the needs of public transportation users. However, many people still do not use BRT, as evidenced by the low load factor, high private vehicle usage, and the increasing number of unregulated online transport services not yet accommodated by the Semarang City Government.

METHOD

Required Data

The data needed for this research consists of primary data (data obtained directly) and secondary data (data obtained through information or literature).

Data Collection Techniques

1. Secondary Data

   Secondary data is collected from:

   a. Government agencies (City Government, Department of Transportation, Public Works Department, Regional Development Planning Agency, Statistics Indonesia, and the Police);
   b. Public transportation companies and online transportation operators; and
   c. Literature related to the research.

2. Primary Data

Primary data is obtained through a Household Travel Survey. This survey requires significant data to determine activities and transportation systems (Beirão & Cabral, 2007). The primary need is data that defines travel behavior, collected through various survey efforts. The household travel survey, focusing on daily travel activities, provides much of the data needed to calibrate the Four-Step Model.

RESULTS AND DISCUSSION

Analysis of Regional Development in the Outskirts of Mijen

The indication of regional development is typically marked by a shift in land use from agricultural, plantation, forest, and open spaces to residential areas, industries, and commerce. This aligns with the theory proposed by (Muller, 1976), which suggests that the rapid growth of industrialization and dense concentrations of working-class housing in cities deteriorate the physical and social environments, prompting many middle-income urban residents to migrate to suburban areas. As reurbanization flows into industrial areas and new housing developments, it creates ongoing pressure on governments to improve intra-urban transportation and open up more adjacent rural areas. This ultimately transforms the shape and structure of the city and its outskirts into a modern metropolitan area (Cohen & Paul, 2005).

A similar pattern of regional development is observed in Semarang City, as shown in Figure 1. The city's central activity zones (City Regions I, II, and III), which are the Central Business Districts (CBD) consisting of industries, commerce, and densely populated residential areas, have experienced significant reurbanization toward the surrounding suburban areas. This has led to land-use changes in the suburban regions around Semarang City.

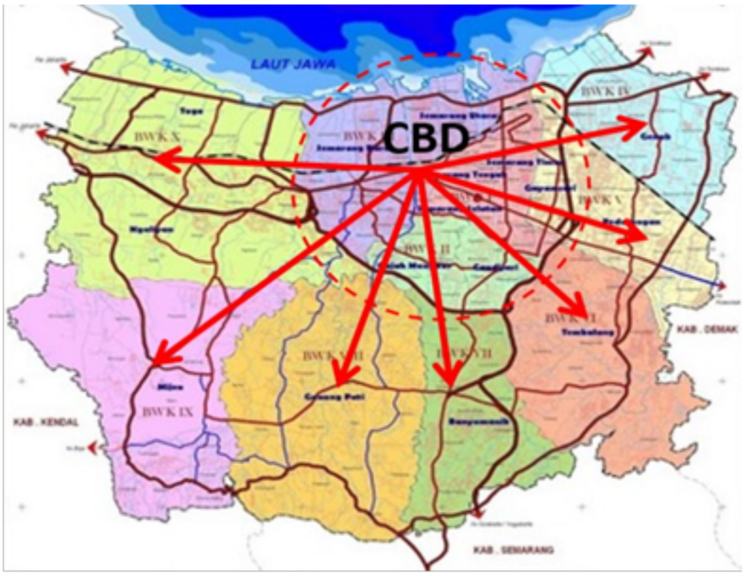

Figure 1: Map of reurbanization flows from the Central Business District (CBD) to suburban areas in Semarang City (Bappeda Kota Semarang, 2016).

According to data from the Semarang City Statistics Agency (2016), significant land-use changes have occurred in the suburban area of Mijen, particularly in agricultural, plantation, and forest land, which have been converted into residential and industrial areas.

The rate of land-use changes in Mijen Subdistrict from 2010 to 2015 is presented in the following table and map:

Table 1: Land Use Changes in Mijen Subdistrict between 2010 and 2015.

Landuse	**Area**				**Change**	
	2010 (Ha)	**%**	**2015 (Ha)**	**%**	**Area (Ha)**	**%**
Forest	1,541.04	28.65	1,496.65	7.83	-44.39	(0.83)
Industry	14.77	0.27	94.82	1.76	80.05	1.49
Landuse	**Area**				**Change**	
	2010 (Ha)	**%**	**2015 (Ha)**	**%**	**Area (Ha)**	**%**
Mixed Gardens	750.46	13.95	720.85	13.40	-29.61	(0.55)
Plantation	1,047.18	19.47	737.96	13.72	-309.22	(5.75)
Settlements	768.89	14.30	913.60	16.99	144.71	2.69
Farm	50.73	0.94	40.58	0.75	-10.15	(0.19)
Paddy	1,010.76	18.79	973.41	18.10	-37.34	(0.69)
Vacant Land	33.26	0.62	204.47	3.80	171.21	3.18
Tegalan	134.46	2.50	121.09	2.25	-13.37	(0.25)
TPA	26.77	0.50	26.77	0.50	0.00	-
Reservoirs		-	48.11	0.89	48.11	0.89
Amount	5,378.32		5,378.32			

Source: BPS Semarang City, 2016

Based on the table above, the land areas that experienced a reduction from 2010 to 2015 include forests by 44.39 Ha (0.83%), mixed gardens by 29.61 Ha (0.55%), plantations by 309.22 Ha (5.75%), livestock farming by 10.15 Ha (0.19%), rice fields by 37.34 Ha (0.69%), and dry fields by 13.37 Ha (0.25%). Meanwhile, land areas that increased include industrial land by 80.05 Ha (1.49%), residential land by 144.71 Ha (2.69%), vacant land by 171.21 Ha (3.18%), and reservoirs by 48.11 Ha (0.89%).

The land-use changes with the potential to increase mobility include industrial land, which grew from 14.77 Ha (0.27%) in 2010 to 94.82 Ha (1.76%) in 2015, a total increase of 80.05 Ha (1.49%). The establishment of industrial companies is expected to absorb a large workforce, leading to an increase in mobility in the Mijen suburban area.

Similarly, the expansion of residential areas, from 768.89 Ha (14.30%) in 2010 to 913.60 Ha (16.99%) in 2015, also has the potential to boost mobility, as more people move from the city center to suburban areas, increasing the demand for transportation.

According to (Muller, 1976), the development of suburban areas is greatly influenced by the availability of mobility infrastructure. Technological advancements in transportation, such as modern vehicles and well-maintained roads, have led to significant restructuring of urban space. Each stage of urban growth has been dominated by a particular mobility technology, with the expansion of transport networks shaping the spatial patterns of intra-urban groups. Improved transportation and accessibility attract people to invest in residential areas far from the city (Agus Budi Purwantoro, 2020), allowing them to commute daily between the suburbs and the city for work.

A similar trend is occurring in the Mijen suburban area, where land-use changes have been, and will continue to be, impacted by government transportation policies. The road network in the Mijen suburban area, consisting of secondary arterial roads, primary collectors, secondary collectors, and local roads, has been expanded and its quality improved (Hou & Chen, 2013). The condition of the roads in the Mijen suburban area is shown in Figure 2 below:

Figure 2: Road conditions in the Mijen suburban area in 2018

Table 2: Road Length and Types of Pavements in the Suburban Areas of Semarang City in 2018

No	Region	Road Lenght (Mtr)	Type of Pavement					
			Macadam (mtr)	% Paved	Paved (mtr)	% Paved	Hotmix (mtr)	%hotmix
1	Mijen	172.021	68.331	39,72%	48.582	28,24%	55.108	32,04%
2	Gunungpati	233.065	69.011	29,61%	147.264	63,19%	16.790	7,20%
3	Banyumanik	326.732	107.402	32,87%	161.052	49,29%	58.278	17,84%
4	Tembalang	274.948	143.105	52,05%	109.613	39,87%	22.230	8,09%
5	Pedurungan	224.107	146.387	65,32%	64.886	28,95%	12.834	5,73%
6	Genuk	163.110	117.301	71,92%	20.379	12,49%	25.430	15,59%
7	Monument	48.713	31.049	63,74%	8.266	16,97%	9.398	19,29%

Source: BPS Semarang City, 2019

From the seven suburban areas of Semarang City, the Mijen suburban area has the largest percentage of road length with the best quality (hotmix), which is 32%. This indicates significant regional development compared to other suburban areas.

Mobility Analysis in the Mijen Suburban Area

1. Variables Influencing Mobility

Mobility in the Mijen suburban area is influenced by several factors, including vehicle ownership (private car and motorcycle ownership), travel efficiency (travel time and public transport fares), travel comfort (comfort in public transport and ease of accessing public transport), public transport safety (driver behavior), and environmental friendliness (vehicle emissions that do not harm the environment). Survey results indicate an increase in trip generation or mobility from the period before the BRT (Bus Rapid Transit) service began, after its introduction in 2014, and following the introduction of online transportation services in 2016 (Tang & Lo, 2008).

One effort to achieve Smart Transportation conditions, as outlined in the transportation policy of Semarang City (Regional Regulation No. 14 of 2011 regarding the Spatial Plan for Semarang City 2011 – 2031), is to enhance public transport services that support the growth and development of urban service centers and to develop a mass transportation system. The program to improve public transport services in the Mijen suburban area began in 2014 with the introduction of BRT (Bus Rapid Transit), while the development of the mass transportation system is expected to materialize 10 years after the operation of BRT (by 2024). Therefore, it is also important to understand the transportation model in 2024 (Neirotti et al., 2014).

The mobility analysis aims to determine the frequency of daily mobility among the community, travel distribution, and mode selection levels. Based on survey data from interviews with 100 household heads (326 individuals), using variables that influence the frequency of mobility (Y) including car ownership (X1), motorcycle ownership (X2), public transport efficiency level (X3), public transport safety level (X4), public transport comfort level (X5), and environmental friendliness level (X6).

Table 3 shows the frequency of mobility, vehicle ownership, and public perception regarding the efficiency, safety, comfort, and environmental friendliness of public transport before the BRT service, after its introduction in 2014, and after the launch of online transportation services in 2016.

Table 3: Mobility Frequency Data Before the Operation of BRT (Bus Rapid Transit), After the Operation of BRT, and After the Operation of Online Transportation Services.

No.	Data Type	Before *BRT* (2012 - 2014)		After *BRT* (2014 - 2016) _		After there is online transportation *(*2016 - 2018)	
		Amount	Unit	Amount	Unit	Amount	Unit
1.	Number of Respondents	350	People	350	People	350	People
2.	Number of Travelers	171	People	186	People	218	People
3.	Travel Frequency a. With Private Vehicle b. With Public Transport	340 218 122	per day per day (64%) per day (36%)	396 180 216	per day per day (45%) per day (55%)	464 184 280	per day per day (40%) per day (60%)
4.	Number of Car Owners	3	Kent	14	Kent	13	Kent
5.	Number of Motorcycle Owners	61	Kent	64	Kent	67	Kent

Source: Analysis Results, 2019

The results of the interview survey on the mobility level in the Mijen suburban area can be found in Appendix 2.a, 2.b, and 2.c.

1. Validity and Reliability Test

Using SPSS software, the results of the validity and reliability tests for the dependent and independent mobility variables for each period are as follows:

a. Before the BRT Operation

The results of the validity and reliability tests for the dependent and independent mobility variables before the BRT operation, based on the survey data in Appendix 3.a, are as follows:

1) Validity Test

Details:

a) df = sample size – 2
b) = 171 – 2 = 169
c) The R table at a 95% confidence level is 0.151.
d) The calculated R value is 0.506, where R calculated > R table, meaning the tested data is categorized as valid.

2) Reliability Test

The reliability test results for 1 dependent variable (Y) and 6 independent variables (X1, X2, X3, X4, X5, and X6) can be seen in Table 4.

Table 4 Results of the validity and reliability tests for 1 dependent variable and 6 independent mobility variables before the BRT operation.

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
And	8.90	4.514	.072	.444
X1	10.92	4.676	-.119	.463
X2	10.57	3.918	.247	.387
X3	8.87	3.854	.065	.481
X4	8.48	2.286	.526	.136
X5	8.18	2.287	.459	.194
X6	9.70	4.481	-.020	.475

Source: Analysis results, 2019

From the table above, it is known that of the six free variables that have a significant correlation with the non-free variable (Y), only 4 variables are X2, X3, X4 and X5.

Furthermore, a feasibility test was carried out on 1 non-free variable (Y) and 4 independent variables (X2, X3, X4, and X5) with the results as shown in table 5.

Table 5 Results of validity and reliability tests on 1 variable not free and 4 variables free of mobility before the operation of BRT

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
And	7.65	4.406	.080	.533
X2	9.32	3.794	.263	.470
X3	7.62	3.661	.098	.564
X4	7.23	2.177	.542	.213
X5	6.92	2.224	.452	.302

Source: Analysis results, 2019

Based on Table 5 above, it is known that the alpha value for the five variables is greater than the R table value, which means that the data is categorized as reliable.

a. After the BRT Operation

The results of the validity and reliability tests for the dependent and independent mobility variables after the BRT operation, based on the survey data in Appendix 3.b, are as follows:

1) Validity Test

Details:

a) df = sample size – 2
   = 186 – 2 = 184
b) The R table at a 95% confidence level is 0.145.
c) The calculated R value is 0.749, where R calculated > R table, meaning the tested data is categorized as valid.

2) Reliability Test

The reliability test results for 1 dependent variable (Y) and 6 independent variables (X1, X2, X3, X4, X5, and X6) can be seen in Table 6.

Table 6 Results of the validity and reliability tests for 1 dependent variable and 6 independent mobility variables after the BRT operation.

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
And	10.59	6.287	.066	.681
X1	12.64	6.718	-.102	.689
X2	12.37	6.018	.172	.661
X3	9.83	3.473	.718	.461
X4	9.68	3.591	.770	.444
X5	9.72	3.565	.721	.462
X6	11.46	6.520	-.039	.701

Source: Analysis Results, 2019

From the table above, it is known that out of the six independent variables, only four variables (X2, X3, X4, and X5) have a significant correlation with the dependent variable (Y). Next, a reliability test was conducted on 1 dependent variable (Y) and 4 independent variables (X2, X3, X4, and X5) with the results shown in Table 7.

Table 7 Results of the validity and reliability tests for 1 dependent variable and 4 independent mobility variables after the BRT operation.

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
And	9.26	6.160	.094	.808
X2	11.04	5.868	.212	.785
X3	8.50	3.365	.743	.601
X4	8.35	3.527	.777	.589
X5	8.39	3.472	.740	.604

Source: Analysis results, 2019

Based on Table 7 above, it is known that the alpha value for the five variables is greater than the R table value, meaning the data is categorized as reliable.

a. After the Operation of Online Transportation

The results of the validity and reliability tests for the dependent and independent mobility variables after the operation of online transportation, based on the survey data in Appendix 3.c, are as follows:

1) Validity Test
   Details:
   a) df = sample size – 2
      = 218 – 2 = 216
   b) The R table at a 95% confidence level is 0.134.
   c) The calculated R value is 0.743, where R calculated > R table, meaning the tested data is categorized as valid.
2) Reliability Test
   The reliability test results for 1 dependent variable (Y) and 6 independent variables (X1, X2, X3, X4, X5, and X6) can be seen in Table 8.

Table 8 Results of the validity and reliability tests for 1 dependent variable and 6 independent mobility variables after the operation of online transportation.

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
And	10.29	5.663	.085	.680
X1	12.36	6.120	-.052	.681
X2	12.11	5.536	.168	.660
X3	9.56	3.188	.727	.453
X4	9.53	3.430	.730	.462
X5	9.49	3.366	.714	.466
X6	11.17	5.979	-.037	.701

Source: Analysis Results, 2019

From the table above, it is known that out of the six independent variables, only four variables (X2, X3, X4, and X5) have a significant correlation with the dependent variable (Y). Next, a reliability test was conducted on 1 dependent variable (Y) and 4 independent variables (X2, X3, X4, and X5) with the results shown in Table 9.

Table 9 Results of the validity and reliability tests for 1 dependent variable and 4 independent variables after the operation of online transportation.

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
And	8.99	5.470	.112	.803
X2	10.81	5.327	.207	.779
X3	8.26	3.021	.758	.581
X4	8.22	3.327	.731	.599
X5	8.18	3.229	.730	.597

Source: Analysis Results, 2019

Based on Table 9 above, it is known that the alpha value for the five variables is greater than the R table value, meaning the data is categorized as reliable.

1. Mobility Model
   To develop a mobility model, a regression equation is sought based on the data on the number of trips, vehicle ownership, and public perception of efficiency, safety, comfort, and environmental friendliness

levels of public transportation, which has been tested for validity and reliability. The results of the linear regression analysis and the mobility model in the Mijen suburban area are as follows:

a. Before the BRT Operation

The results of the linear regression analysis on the dependent and independent mobility variables before the BRT operation can be seen in Table 10.

Table 10 Results of the linear regression analysis on the dependent and independent mobility variables before the BRT operation.

Coefficientsa

Model		Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	t	Mr.
1	(Constant)	1.957	.067		29.055	.000
	X2	-.017	.036	-.037	-.459	.647
	X3	.014	.022	.050	.632	.528
	X4	.009	.022	.038	.405	.686
	X5	.012	.020	.057	.608	.544

a. Dependent Variable: Y

From the table above, the mobility model before the operation of the BRT (Bus Rapid Transit) is obtained as follows:

Y = 1.957 – 0.017 X2 + 0.014 X3 + 0.009 X4 + 0.012 X5

a. After the BRT Operation

The results of the linear regression analysis on the dependent and independent mobility variables after the BRT operation can be seen in Table 11.

Table 11 Results of the linear regression analysis on the dependent and independent mobility variables after the BRT operation.

Coefficientsa

Model		Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	t	Mr.
1	(Constant)	1.927	.135		14.261	.000
	X2	-.084	.073	-.087	-1.141	.255
	X3	.028	.062	.054	.453	.651
	X4	.022	.073	.039	.296	.768
	X5	.028	.062	.053	.458	.648

Dependent Variable: Y

From the table above, the mobility model after the operation of the BRT (Bus Rapid Transit) is as follows:

Y' = 1.927 - 0.084 X2' + 0.28 X3' + 0.022 X4' + 0.028 X5'

a. After the Operation of Online Transportation

The results of the linear regression analysis on the dependent and independent mobility variables after the operation of online transportation can be seen in Table 12.

Table 12 Results of the linear regression analysis on the dependent and independent mobility variables after the operation of online transportation.

Coefficientsa

Model		Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	t	Mr.
1	(Constant)	1.860	.141		13.233	.000
	X2	-.094	.076	-.087	-1.239	.217
	X3	.038	.066	.064	.571	.569
	X4	.031	.071	.048	.438	.662
	X5	.034	.065	.054	.521	.603

From the table above, the mobility model after the operation of online transportation is as follows:

Y" = 1.860 - 0.094 X2" + 0.038 X3" + 0.031 X4" + 0.034 X5"

1. Mobility Frequency
   The mobility frequency (Y) in the Mijen suburban area is calculated based on the mobility model, with a multiplier factor for motorcycle ownership derived from vehicle ownership data in the Mijen area. The efficiency, safety, and comfort of public transportation are based on the number of people traveling per day in the Mijen area. The data components used to calculate frequency include motorcycle ownership and the number of travelers in the Mijen suburban area, as shown in Table 13.

Table 13 Population, number of travelers, and vehicle ownership in Mijen Subdistrict in 2012, 2014, and 2016.

No	Type of Data	Before *BRT* (2012)		After *BRT* (2014)		After the operation of online transportation (2016)	
		Amount	Unit	Amount	Unit	Amount	Unit
1.	Population	56.570		59.425		63.348	
2.	Number of motorcycles	6.398	Kent	6.938	Kent	7.994	Kent

Source: BPS Semarang City, 2019

Using the parameters in Table 4.10, the mobility frequency in the Mijen suburban area can be calculated for the three periods as follows:

- Before the BRT Operation:

Y = 1,957 – 0,017 X2 + 0,014 X3 + 0,009 X4 + 0,012 X5
= 1,957 - (0,017 x 6.398) + (0,014 x 56.570) + (0,009 x 56.570) + (0,012 x 56.570)
= 1.873 trips per day

- Period after the operation of the BRT (Bus Rapid Transit):

Y' = 1,927 - 0,084 X2' + 0,28 X3' + 0,022 X4' + 0,028 X5'.
. = 1,927 - (0,084 x 6.938) + (0,028 x 59.425) + (0,022 x 59.425) + (0,028 x 59.425)
= 4.054 trips per day

- Period after the operation of online transportation:

Y" = 1,860 - 0,094 X2" + 0,038 X3" + 0,031 X4" + 0,034 X5"
= 1,860 - (0,094 x 7.994) + (0,038 x 63.348) + (0,031 x 63.348) + (0,034 x 63.348)
= 5.775 trips per day

From the calculations above, the mobility trend in the suburban area of Mijen can be seen as follows in the graph:

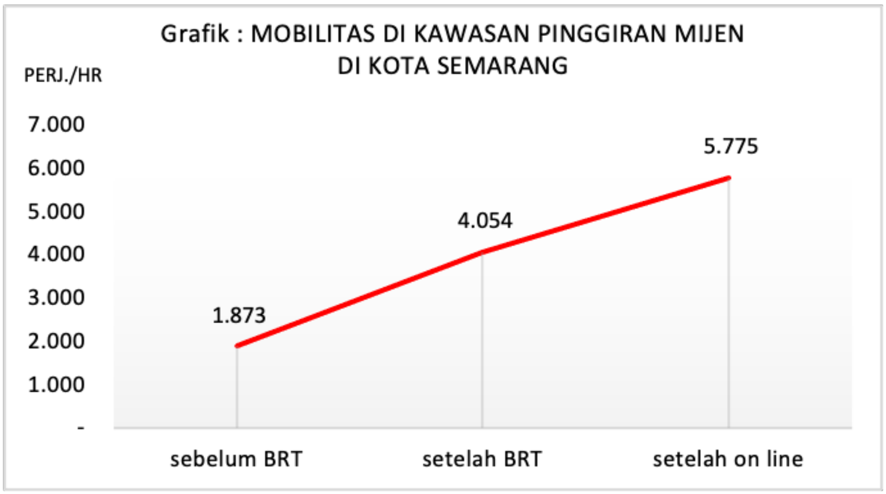

Figure 3: Graph of Mobility Growth in the Mijen Suburban Area

There was a 116.44% increase in mobility (from 1,873 people per day to 4,054 people per day) from the period before the BRT operation to the period after the BRT operation. Meanwhile, from the period after the BRT operation to the period after the operation of online transportation, there was a 42.45% increase in mobility (from 4,054 people per day to 5,775 people per day).

Discussion

The success parameters of programs or policies in the transportation sector are as follows:

1. Sustainable Mobility: An increase in mobility growth in the area to maintain ongoing mobility (sustainable mobility).
2. Equilibrium of Demand and Supply: The availability of transportation facilities that meet the mobility needs of the community, thus achieving a balance between the demand and supply of transportation facilities.
3. Smart Transportation: An improvement in transportation services aimed at increasing the proportion of public transport users, contributing to the achievement of smart transportation programs.

The Impact of Transportation Policies on Mobility Growth

The success parameters of transportation policies in increasing population mobility can be measured through simulation methods, which estimate the growth in mobility. The simulation methods used are as follows:

1. Simulation 1: Do Nothing (No Change in Transportation Policy)
   In this scenario, transportation policy from 2012 to 2018 assumes that the government applies conventional transportation services without any improvement in services.
   In Simulation 1, the calculation of mobility over time uses the same model, Y = 1.957 – 0.017 X2 + 0.014 X3 + 0.009 X4 + 0.012 X5, with vehicle ownership and population data adjusted for the target year.

The calculation results of mobility values and mobility growth using Simulation 1 can be seen in Table 14.
Table 14 Mobility and mobility growth using Simulation 1 for the years 2012, 2014, 2016, and 2018.

Parameter	Year			
	2012	2014	2016	2018
Population	56.570	59.425	63.348	73.479
Motorcycle Ownership	6.398	6.938	7.994	8.936
Mobility Rate	1.873	1.964	2.083	2.422
Percentage of Increase		5,8%	6,1%	16,3%
Average Growth	4,4%			

Source: Analysis Results, 2019

Table 14 shows that the mobility rate increased by 4.8% during the period 2012-2014, increased by 6.1% during the period 2014-2016, and increased by 16.3% during the period 2016-2018. The average mobility growth achieved was 4.4% per year.

1. Simulation 2: Do Something 1 (Improvement of 1 Transportation Service)

   In this scenario, the transportation policy from 2012-2014 involved conventional transportation services, and from 2014-2018 involved both conventional transportation services and BRT (Bus Rapid Transit) services.

   In Simulation 2, the mobility calculation for the period 2012-2014 used the model Y = 1.957 – 0.017 X2 + 0.014 X3 + 0.009 X4 + 0.012 X5, and for the period 2014-2018 used the model Y' = 1.927 - 0.084 X2' + 0.28 X3' + 0.022 X4' + 0.028 X5', with vehicle ownership and population data adjusted for the target year.

The results of the mobility value and mobility growth calculations using Simulation 2 can be seen in Table 15.

Table 15 Mobility and mobility growth using Simulation 2 for the years 2012, 2014, 2016, and 2018.

Parameter	Year			
	2012	2014	2016	2018
Population	56.570	59.425	63.348	73.479
Motorcycle Ownership	6.398	6.938	7.994	8.936
Number of Mobilities	1.873	4.054	4.272	4.983
Percentage of Increase		116,4%	5,4%	16,6%
Average Growth	17,7%			

Table 15 shows that mobility increased by 116.4% during the period 2012-2014, by 5.4% during the period 2014-2016, and by 16.6% during the period 2016-2018. The average annual mobility growth achieved was 17.7%.

1. Simulation 3: Do Something 2 (Improvement of 2 Transportation Services)

   In this scenario, the transportation policy from 2012-2014 involved conventional transportation services, from 2014-2016 included conventional transportation services and BRT (Bus Rapid Transit), and from 2016-2018 included conventional transportation services, BRT, and online transportation services.

   In Simulation 3, the mobility calculation for the period 2012-2014 used the model Y = 1.957 – 0.017 X2 + 0.014 X3 + 0.009 X4 + 0.012 X5, for the period 2014-2018 used the model Y' = 1.927 - 0.084 X2' + 0.28 X3' + 0.022 X4' + 0.028 X5', and for the period 2016-2018 used the model Y'' = 1.860 - 0.094 X2'' + 0.038 X3'' + 0.031 X4'' + 0.034 X5'', with vehicle ownership and population data adjusted for the target year. The results of the mobility value and mobility growth calculations using Simulation 3 can be seen in Table 16.

Table 16 Mobility and mobility growth using Simulation 3 for the years 2012, 2014, 2016, and 2018.

Parameter	Year			
	2012	2014	2016	2018
Population	56.570	59.425	63.348	73.479
Motorcycle Ownership	6.398	6.938	7.994	8.936
Number of Mobilities	1.873	4.054	5.775	6.730
Percentage of Increase		116,4%	42,4%	16,5%
Average Growth	23,8%			

Source: 2019 Analysis Results

Table 16 shows that mobility increased by 116.4% during the period of 2012-2014, by 42.4% during the period of 2014-2016, and by 16.5% during the period of 2016-2018. The average annual mobility growth achieved was 23.8%.

Based on the calculation of total mobility and the average annual mobility growth in the suburban area of Mijen, the results are summarized in Table 16.

Table 17: Total Mobility and Annual Mobility Growth Based on Simulation 1, Simulation 2, and Simulation 3 for the Years 2012, 2014, 2016, and 2018.

Simulation	Year				Growth per Year
	2012	2014	2016	2018	
Simulation 1	1.873	1.964	2.083	2.422	4,4%
Simulation 2	1.873	4.054	4.272	4.983	17,7%
Simulation 3	1.873	4.054	5.775	6.730	23,8%

Source: 2019 Analysis Results

Table 17 shows that the most optimal transportation policy simulation implemented is Simulation 3, with the highest mobility growth factor of 23.8%. The trend of mobility growth from 2012 to 2018 using the three simulations can be seen in the graph in Figure 4.

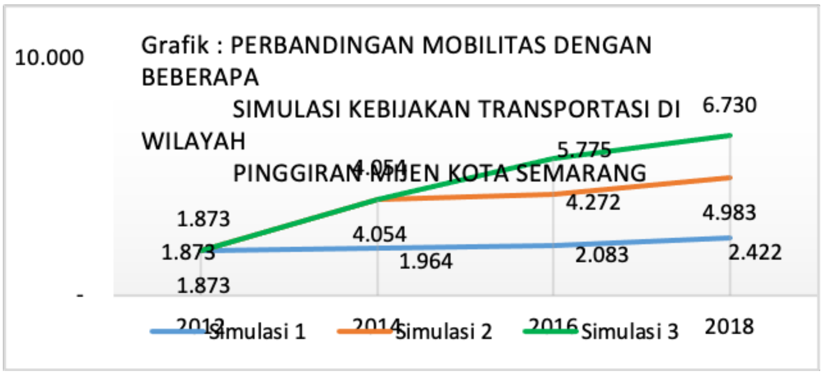

Figure 4: Graph of Mobility Comparison with Various Transportation Policy Simulations in the Suburban Area of Mijen, Semarang City

Based on the graph above, it can be observed that the most optimal transportation policy is the one using simulation 3, where in 2018, it achieved the highest mobility rate of 6,730 trips per day.

The Impact of Transportation Policies on the Balance between Transportation Demand and Supply

One of the impacts of the implemented transportation policies on the mobility conditions of the community is the balance between the availability of transportation facilities (supply) and the demand for transportation services (demand). The transportation policies implemented by the government to anticipate the mobility needs in the suburban area of Mijen are outlined in Table 18.

Table 18: Number of Mobility Needs and Availability of Transportation Facilities in the Suburban Area of Mijen in 2012, 2014, 2016, and 2018.

Time

Time	*Demand*	*Supply*								Total Carrying Capacity	*Load Factor (%)*
		Conventional Bus		*BRT*		*Ojek On Line*		*Mobil On Line*			
		Smear	ALSO	Smear	ALSO	Smear	ALSO	Smear	ALSO		
Before BRT	1.873	14	2.688							2.688	69,7%
After BRT	4.054	14	2.688	25	4.800					7.488	54,1%
After Online	5.775	14	2.688	25	4.800	45	675	22	528	8.016	72,0%
Th. 2018	6.730	14	2.688	25	4.800	45	675	22	528	8.016	84,0%

Source: 2019 Analysis Results

Based on Table 18, the following can be described:

1. Before the BRT (Bus Rapid Transit) service

   Before the BRT service, the transportation policy to accommodate the mobility of 1,873 people per day (demand) in the suburban area of Mijen was to provide public transportation in the form of 14 conventional buses, each with a capacity of 24 passengers. With 8 trips per day, the number of people that could be served was 2,688 per day (supply). Thus, the load factor obtained was 69.7%.

2. After the introduction of the BRT (Bus Rapid Transit) service in 2014

   After the introduction of the BRT service, the transportation policy to accommodate the mobility of 4,054 people per day (demand) in the suburban area of Mijen was:

   a. Providing 14 conventional buses, each with a capacity of 24 passengers. With 8 trips per day, the number of people that could be served was 2,688 per day.

   b. Providing 25 BRT buses, each with a capacity of 24 passengers. With 8 trips per day, the number of people that could be served was 4,800 per day.

   Combining both types of transportation services, the capacity available to accommodate mobility (supply) was 7,488 people per day. Thus, the load factor obtained was 54.1%.

3. After the introduction of online transportation services in 2016

   After the introduction of online transportation services, the transportation policy to accommodate the mobility of 5,775 people per day (demand) in the suburban area of Mijen was:

   a. Providing 14 conventional buses, each with a capacity of 24 passengers. With 8 trips per day, the number of people that could be served was 2,688 per day.

   b. Providing 25 BRT buses, each with a capacity of 24 passengers. With 8 trips per day, the number of people that could be served was 4,800 per day.

   c. Accommodating online transportation services:

      1) Online motorcycle taxis (ojol): 45 vehicles, each with a capacity of 1 passenger. With an average of 15 trips per day, the number of people that could be served was 675 per day.

      2) Online car services: 22 vehicles, each with a capacity of 4 passengers. With an average of 6 trips per day, the number of people that could be served was 528 per day.

   Combining all three types of transportation services, the available capacity to accommodate mobility (supply) was 8,016 people per day. Thus, the load factor obtained was 72.0%.

4. After the introduction of online transportation services in 2018

   In 2018, after the introduction of online transportation services, the transportation policy to accommodate the mobility of 6,730 people per day (demand) in the suburban area of Mijen was:

   a. Providing 14 conventional buses, each with a capacity of 24 passengers. With 8 trips per day, the number of people that could be served was 2,688 per day.

   b. Providing 25 BRT buses, each with a capacity of 24 passengers. With 8 trips per day, the number of people that could be served was 4,800 per day.

   c. Accommodating online transportation services:

      1) Online motorcycle taxis (ojol): 45 vehicles, each with a capacity of 1 passenger. With an average of 15 trips per day, the number of people that could be served was 675 per day.

      2) Online car services: 22 vehicles, each with a capacity of 4 passengers. With an average of 6 trips per day, the number of people that could be served was 528 per day.

Combining all three types of transportation services, the available capacity to accommodate mobility (supply) was 8,016 people per day. Thus, the load factor obtained was 84.0%.

The comparison between the mobility demand and transportation capacity (supply) for the period from 2012 to 2018 can be seen in the graph in Figure 4.

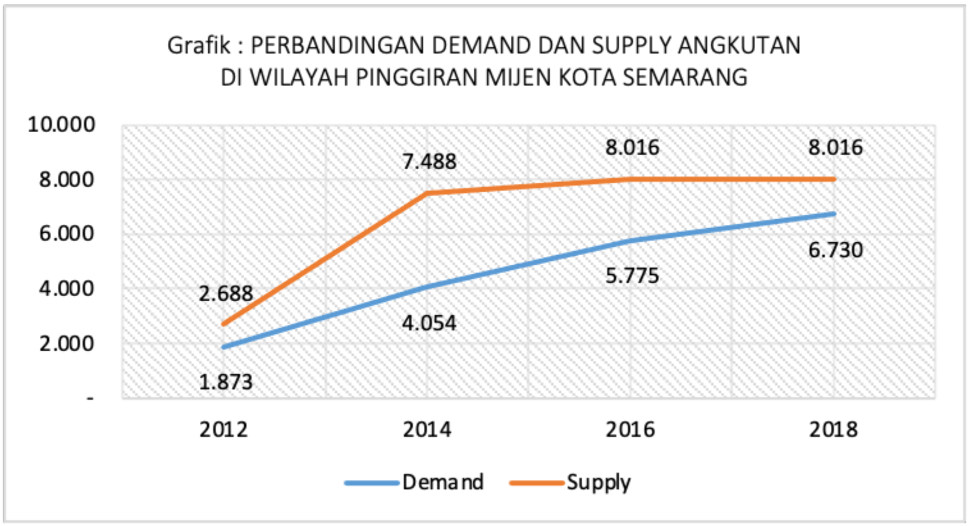

Figure 4: Comparison Graph of Transportation Demand and Supply in the Suburban Area of Mijen, Semarang City

Figure 4 shows the comparison between demand and supply in the suburban area of Mijen, Semarang City. Mobility demand has increased year by year. Before the BRT service in 2012, the mobility demand was 1,873 people per day, while the available transportation capacity was 2,688 people per day. After the introduction of BRT in 2014, the mobility demand increased to 4,054 people per day, with transportation capacity rising to 7,488 people per day.

After the introduction of online transportation in 2016, the mobility demand reached 5,775 people per day, while the transportation capacity was 8,016 people per day. In 2018, after the introduction of online transportation, the mobility demand reached 6,730 people per day, with the transportation capacity remaining at 8,016 people per day. Thus, the available transportation capacity (supply) during each period was able to accommodate the mobility needs (demand) of the population.

The Impact of Transportation Policies on Increasing the Proportion of Public Transport Use

The proportion of transportation mode usage for mobility in the suburban area of Mijen, Semarang City, divided into private vehicle users and public transport users, can be seen in Table 19 and Figure 25.

Table 19: Number of Private Vehicle Users and Public Transport Users in the Suburban Area of Mijen, Semarang City in 2012, 2014, and 2016

Mobility	Before BRT		After BRT		After Online Transportation	
	Amount	Percentage	Amount	Percentage	Amount	Percentage
Total Mobility	1.873	100%	4.054	100%	5.775	100%
Private Vehicle Users	1.201	64%	1.843	45%	2.290	40%
Public Transportation Users	672	36%	2.211	55%	3.485	60%

Source: 2019 Analysis Results

Based on Table 10.14, it is known that the proportion of private vehicle users has decreased over time. Prior to the Bus Rapid Transit (BRT) service, the proportion stood at 64%, dropping to 45% after the introduction of the BRT service, and further declining to 40% after the introduction of online transportation services. Meanwhile, the proportion of public transport users has increased over time. Before the BRT service, the proportion was 36%, rising to 55% after the introduction of BRT, and reaching 60% following the introduction of online transportation services.

The trend of private vehicle usage and public transport use in the suburban area of Mijen, Semarang City, is illustrated in the graph in Figure 5.

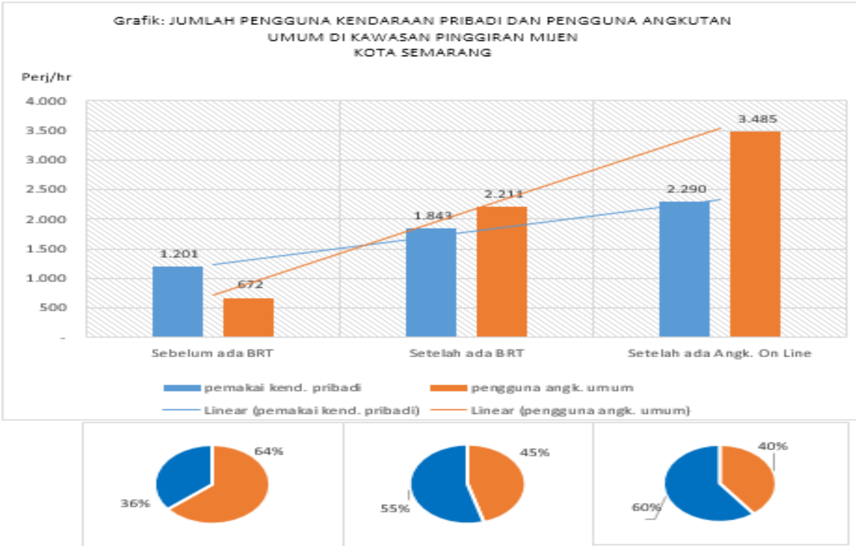

Figure 5. Graph of Private Vehicle and Public Transport Users in the Suburban Area of Mijen

The blue line represents the trend of private vehicle users from before the BRT service to after the introduction of online transportation, increasing from 1,201 trips per day to 2,290 trips per day, with an annual growth rate of 17.51%. The brown line represents the trend of public transport users from before the BRT service to after the introduction of online transportation, increasing from 672 trips per day to 3,485 trips per day, with an annual growth rate of 50.90%.

CONCLUSION

The study on the impact of transportation policies on mobility in the suburban area of Mijen, Semarang City, shows significant changes in land use and transportation systems. Industrial and residential land areas increased between 2010 and 2015, along with a 32% improvement in road quality. Transportation policies that shifted the conventional system to BRT in 2014 and online transportation in 2016 led to a rise in daily mobility, from 1,873 people in 2012 to 6,730 people in 2018, with a mobility growth rate of 23.8% per year. Additionally, there was a balance between the demand and availability of transportation facilities, as well as an increase in the proportion of public transport users from 36% in 2012 to 60% in 2016. This increase in mobility and public transport usage reflects the initial success of transportation policies towards an intelligent transportation system.

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