Development of Subsidized Housing Scheme with Sustainable Transportation: A Case Study of Housing in the Urban Fringe of Semarang and Kendal

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Abstract. The increase in the price of buying houses by 23.77% in the first quarter of 2019 has caused severe challenges. This made the Indonesian government create a subsidized housing program through the Regulation of the Minister of Public Works and Public Housing No. 21/PRT/M/2016. This is necessary because the existing subsidized housing is far from the city center and does not pay attention to integrated public transportation as well as the high use of private vehicles causing the value of the degree of saturation to reach 0.77 on housing access which makes the whole scheme environmentally unfriendly. Therefore, this research was conducted to analyze the factors influencing the community to select a subsidized housing program and determine the design of its integration with sustainable transportation using simulation methods. The findings showed the most influential factors were accessibility and choice of transportation modes while the ideal simulation reported the use of integrated transportation in the construction of subsidized housing, by making all private vehicle passengers shift to public transportation in Kendal District reduced the highest saturation level (DS) from 0.77 to 0.07 and CO₂ emissions by 47.71%. Therefore, the revision of government policies on integrated transportation in subsidized housing is recommended.

Keywords: Environmentally friendly, integrated transportation, policy, subsidized housing

1. Introduction

The Semarang city which is the center for economic, industrial, service and educational activities has experienced a significant increase in its population over the years. In accordance with the data recorded at the Semarang City Statistics Office in 2018 and Population and Civil Registry Office in 2019, the population growth rate and density were found to have increased by 1.77% from 2017 to December 2018 [1]. This was observed to be in line with the increasing number of basic needs such as clothing, food, and shelter. In 2018, Indonesian Real Estate (REI) Data reported the number of housing needs in Central Java Province reached around 400,000 units, and 50,000 of which are located in the Semarang City [2]. However, housing ownership for low-income people continues to be very difficult to be fulfilled due to high prices. In order to overcome this problem, the government launched the Million Houses Program through low-cost/subsidized housing for low-income people. Moreover, low-cost housing was defined according to the Regulation of the Minister of Public Works and Public Housing No. 25 of 2011 article 1 paragraph 4 to be a livable and affordable public house covering a floor area of 36 m² specifically provided for those with low income and purchased through loans/financing supported by housing finance liquidity facilities without down payment. The aim of the program is to ensure the residents of the community have a decent home with easy payment. These policies are not limited to...
Indonesia as different reports have shown its implementation in other countries. For example, the Housing Choice Voucher (HCV) and the Low-Income Housing Tax Credit (LIHTC) in the United States are established as rental and project-based assistance programs and have proven to be effective in offering decent housing to disadvantaged people [3].

The continuous increase in the price of land in Semarang has caused a lot of subsidized housing to be built on the outskirts and border of the city and this requires paying a very high transportation fee considering the distance of the houses to the city. However, there are presently no government regulations on the integration of housing development with public transportation facilities and this has led to the use of private vehicles for daily activities, causing traffic congestion and environmental pollution due to high fuel use. This is observed in a period where sustainable transportation is required to reduce traffic congestion, resolve urban pollution, and major environmental problems in different cities of the world as well as the shift from vehicle-oriented to the human-oriented system. Moreover, current studies and practices of these sustainable systems in China are only at an early stage while in-depth studies are being continuously conducted. However, these systems are expected to be developed in international cities in accordance with their characteristics and stages of development [4].

The human-oriented system founded on the basic principle of walking or cycling to nearby places and utilization of public transportation to distant places is known as the smart green transportation. The indicators of this system include availability of sidewalk networks and track infrastructure for safe and comfortable cycling as well as integrated public transportation facilities such as buses, trains, monorails, and others with the ability to fulfill the needs of the citizens [5]. According to Muellera et al. [6], residents need to be accustomed to walking or cycling in their daily activities and this means sidewalks and bicycle tracks are to be integrated with bus stops, stations, and terminals to schools, offices, markets, shopping centers, and parks.

It is necessary to socialize the use of sustainable transportation by replacing the use of private vehicles with integrated public transportation system to create a better environment. Ismiyati (2019) also described the development of Transit-Oriented Development (TOD) on the edge of the city had an impact on changing patterns of movement and reducing congestion [7]. Therefore, there is a need to integrate housing with sustainable transportation. The purpose of this research therefore was to analyze the factors with the most influence on the community’s interest to use subsidized housing programs and determine the design of subsidized housing integrated with sustainable transportation.

2. Research Location
The research was conducted in two locations, Palir Sejahtera Housing (PPS) in Semarang City and Delta Asri 6 (PDA) Housing in Kendal Regency, as shown in Figure 1. PPS is located on the outskirts of Semarang in Podorejo Village, Ngaliyan Sub-district while PDA is located on the border of Semarang City in Protomulyo Village, Kaliwungu Selatan Sub-district, Kendal Regency. The distance between the two locations is around 8.6 kilometers and can be reached by car in about 20 minutes via the Darupolo - Pandaan and Pangeran Djumilah roads/Boja - Kaliwungu roads with less traffic.

![Figure 1. Research Location.](Source: Google maps 2018: www.google.co.id)
3. Research Method

This research was conducted through the use of a mixed approach method. The qualitative aspect made use of structured and in-depth interviews to capture information on the characteristics of the population living in subsidized housing. Meanwhile, the quantitative aspect involved the application of field observation to obtain data on transportation activities, facilities, and infrastructure in the research location. The two methods were combined to explore social phenomena indescribable using only the quantitative approach.

Incidental sampling technique was used to select a total of 337 respondents willing to be used as samples for the survey while a purposive sampling technique was used to select all heads of the neighborhood and community units (RT/RW) to have a total sample of 30 respondents for interview. The research instrument used for data collection were questionnaires distributed to the residents of the subsidized housing after validity and reliability tests were conducted. The reliability was evaluated through the use of Cronbach Alpha (α) such that a variable is declared reliable/consistent if it has a value > 0.6 and unreliable/inconsistent if it is < 0.6 [8].

A simulation was conducted using public transportation procurement and increasing accessibility by calculating the degree of saturation (DS) on main roads with average daily traffic data, according to the 2014 Indonesian Highway Capacity Guidance (PKJI) [9] using Equations 1 and 2.

\[
C = C_0 \times FC_{LJ} \times FC_{PA} \times FC_{HS} \times FC_{UK}
\]

(1)

\[
DS = \frac{Q}{C}
\]

(2)

Where C is the capacity, Co is the basic capacity, FC_{LJ} is the capacity adjustment factor related to the width of the lane or traffic lane, FC_{PA} is the capacity adjustment factor related to the direction separator only on undivided roads, FC_{HS} is the capacity adjustment factor due to side barriers on road with shoulder and curb, FC_{UK} is the capacity adjustment factor related to city size, DS is the degree of saturation, and Q is the traffic flow. The amount of CO\textsubscript{2} pollutants generated by average daily traffic on the access road was calculated using the TIER II method [10] as shown in Equation 3.

\[
E = n \times EF \times K
\]

(3)

Where E is the number of emissions, n is the number of vehicles, EF is the emission factor, and K is the fuel consumption.

4. Analysis and Discussion

4.1. Respondent Characteristics

The results of the questionnaire for PPS and PDA showed 51% of the respondents were 35-50 years old, and 61% were 21-35 years old, respectively. In relation to gender, the majority were male while the largest amount of income earned by 77% in PPS was less than Rp. 3,000,000 per month and 30% in PDA earned between Rp. 4,000,000 and Rp. 5,000,000 per month. Moreover, 64% and 60% of the respondents in PPS and PDA, respectively showed transportation costs were below Rp. 500,000 per month. Most of the respondents were found to be private employees and the interview conducted reported majority work as factory employees in the industrial area on the border of Semarang City.

4.2. Transportation Activities

The morning rush hour is 06:00 AM- 07:00 AM while even and decline in traffic flow was recorded from 03:00 PM and above as shown in Figure 4. In PPS, 84% of the transportation mode choice was dominated by two-wheeled vehicles due to the lack of public transportation reaching the housing and this required using other means to cover 6-7 km. In PDA, 62% of the transportation mode choice was also dominated by two-wheeled vehicles due to the inaccessibility of public transportation services as.
shown in Figure 5. Moreover, the out-of-home trips for more than 60% of the population for both locations were to work as shown in Figure 2 while the average distance usually traveled was 10-20 km as observed with 59% and 53% for PPS and PDA residents respectively as presented in Figure 3.

![Figure 2. Type of Trip.](image)

![Figure 3. Distance of Trip.](image)

4.3. Factors influencing community interest in utilizing subsidized housing programs

Factors influencing the selection of housing locations include price, income, accessibility, comfort, and transportation costs [11]. In the case of the subsidized housing scheme, accessibility, income, and transportation costs are the focus as well as the distance and time to work and the choice of transportation mode. The validity test conducted on 23 statement items showed a sig value <0.05 for 21 and > 0.05 for the remaining 2. Therefore, the statements were found to be valid. Moreover, the Cronbach Alpha value was recorded to be 0.656 > 0.60 for PPS and 0.648 > 0.6 for PDA and this means the questions were reliable as shown in Tables 1 and 2.

| Table 1. Reliability from PPS. | Table 2. Reliability from PDA. |
|--------------------------------|-------------------------------|
| Reliability Statistics        | Reliability Statistics        |
| Cronbach’s Alpha              | Cronbach’s Alpha              |
| N of Items                     | N of Items                     |
| .656                           | .648                          |
| 23                             | 23                            |

The value of each variable studied was determined using the correlation and percentage of the description. The qualitative approach was used to strengthen, expand, and deepen the quantitative results obtained such that interviews were conducted on trusted informants after field observations through the process of data collection, reduction, display, and verification have been performed. The quantitative and qualitative data for each of the variables were compared as shown in Table 3.

The correlation analysis showed the most significant influence was the time and distance to work variable with 0.529 and this was consistent with the descriptive results showing 88.66% needed high transportation costs because they use private vehicles. It is also important to note that the high use of private vehicles as observed with the 84% recorded has caused environmentally unfriendly housing conditions as shown in Figure 5. This is in line with the findings of Ismiyati, I and Ferry Hermawan, 2018 [12] that in developing countries such as Indonesia, there is usually a high rate of private vehicles due to changes in lifestyle and this further leads to congestion and air pollution. Moreover, accessibility and choice of transportation modes were very influential in the trip to work as shown in Table 3. These
two influential factors were subsequently used to design subsidized housing integrated with sustainable transportation.

**Table 3. The relationship between quantitative and qualitative data variables.**

| Item Instrument/categories | Quantitative data | Qualitative Data | Result |
|---------------------------|-------------------|------------------|--------|
|                           | Correlation       | Description      |        |
| Accessibility with community interest in utilizing subsidized housing programs | 0.508 | 71.34% | Accessibility affects housing development and the roads to the housing were observed to be poor because they are narrow, physically damaged, and lack of drainage. Road condition is the most influential factor in the accessibility and development of integrated housing due to the reciprocal/interactive relationship found between the variables. |
| Distance and time to work with community interest in utilizing subsidized housing programs | 0.529 | 54.93% | On the overall, the distance and time to work are not considered by the community in choosing a subsidized housing program. Most of the respondents work within 10-20 km and prepare their travel time by leaving 1 hour before work, but choose the fastest route with a closer distance at the risk of traffic jams. |
| The choice of transportation mode with community interest in utilizing subsidized housing programs | 0.334 | 86.73% | The choice of integrated, fast, cheap, safe, and comfortable public transportation modes is an important factor to shift from private to mass public transportation. This indicates a reciprocal/interactive relationship between the variables. |
| Income with community interest in utilizing subsidized housing programs | 0.446 | 58.93% | Income greatly influences community interest to use the subsidized housing program. Since the minimum wage is IDR 2.5 million/month, subsidized housing is the best way to have a decent house but many people obtain it as an investment rather than for shelter. |
| Transportation costs with community interest in utilizing subsidized housing programs | 0.328 | 88.66% | To use public transportation, PPS citizens need at least 2 transits, the first involves a motorcycle taxi/online at a cost of IDR. 15,000 per trip and BRT IDR. 32,500 which means a round-trip requires a total of IDR. 37,000 per day or IDR. 888,000 per month. For PDA citizens, the transit to Semarang requires 3 times with a tariff of IDR. 30,000 per day or IDR. 720,000 per month. Therefore, housing residents choose to use two-wheeled vehicles at costs less than IDR. 500,000 per month. |
| Other factors influencing the interest to utilize subsidized housing programs | | | Expands quantitative data |

Expands and deepens quantitative data |
4.4. The design of subsidized housing integrated with a sustainable transportation

To determine the design of subsidized housing integrated with sustainable transportation, the following steps were conducted.

4.4.1. Simulation of the choice of transportation mode. The simulation was conducted by replacing private vehicles with integrated public transportation by 30%, 70%, and 100% as shown in Table 4. Moreover, the survey results showed 53% of PPS residents needed a small bus while the same percentage of those in PDA needed Bus Rapid Transit (BRT) on a routine trip to work as shown in Table 4. The number of public transport passengers was in accordance with the Decree of the Director-General of Land Transportation number SK.687/AJ.206/DRJD/2002.

Table 4. Public transportation needs.

| Type of Public Transportation | Total Passenger | Total Private Transport | Vehicle Reduction Simulation 30% | Vehicle Reduction Simulation 70% | Vehicle Reduction Simulation 100% | Public Transportation Needs 30% | Public Transportation Needs 70% | Public Transportation Needs 100% |
|-------------------------------|-----------------|-------------------------|----------------------------------|----------------------------------|----------------------------------|--------------------------------|--------------------------------|--------------------------------|
| PPS Small Bus (Metro Mini)    | 19              | 437                     | 131.05                           | 305.78                           | 437                              | 14                             | 32                             | 46                             |
| PDA Medium Bus (BRT)          | 30              | 1,103                   | 330.84                           | 771.96                           | 1,103                            | 22                             | 51                             | 74                             |

Table 5 shows the calculated degree of saturation with the initial value being 0.28 and 0.77 for PPS and PDA respectively while the reduction and replacement of private vehicles by public transportation led to 0.05 and 0.07 for PPS and PDA, respectively.

Table 5. Calculation of degree of saturation values.

| Simulation                      | Traffic Volume (Q) | Degree of Saturation (Q/C) | Simulation                      | Traffic Volume (Q) | Degree of Saturation (Q/C) |
|--------------------------------|--------------------|-----------------------------|--------------------------------|--------------------|-----------------------------|
| Palir-Kaliancar Road, Semarang City | 439                | 0.28                        | Boja-Kaliwungu Road, Kendal District | 1,189               | 0.77                        |
| Reality 30% reduction in private vehicles replaced with 33 units of public transport cars | 361                | 0.23                        | Reality 30% reduction in private vehicles replaced with 22 units of bus rapid transit | 887                | 0.57                        |
| 70% reduction in private vehicles replaced with 76 units of public transport cars | 166                | 0.11                        | 70% reduction in private vehicles replaced with 51 units of bus rapid transit | 483                | 0.31                        |
| 100% reduction in private vehicles replaced with 109 units of public transport cars | 111                | 0.07                        | 100% reduction in private vehicles replaced with 74 units of bus rapid transit | 189                | 0.12                        |
Subsequently, CO₂ emissions were calculated to determine the environmental friendliness of the mode of transportation selected. Based on the simulation performed to replace private vehicles with small buses and BRT, the value of CO₂ emissions was found to have decreased, and the results obtained are shown in Table 6.

**Table 6. Calculation of CO₂ emission simulation.**

| Description | Average CO₂ Emissions (kg/hour.km) | Percentage (%) | Result |
|-------------|------------------------------------|----------------|--------|
| **Palir - kaliancar road, semarang city** | | | |
| Reality | 1,869.50 | 0.00% | Reality |
| Simulation of 30% reduction in private vehicles replaced with 14 units of the small bus | 1,817.58 | -2.78% | Down |
| Simulation of 70% reduction in private vehicles replaced with 32 units of the small bus | 1,720.04 | -7.99% | Down |
| **Boja - Kaliwungu Road, Kendal District** | | | |
| Reality | 7,274.88 | 0.00% | Reality |
| Simulation of 30% reduction in private vehicles replaced with 22 units of bus rapid transit | 6,226.43 | -14.41% | Down |
| Simulation of 70% reduction in private vehicles replaced with 51 units of bus rapid transit | 4,816.41 | -33.79% | Down |
| Simulation of 100% reduction in private vehicles replaced with 74 units of bus rapid transit | 3,804.25 | -47.71% | Down |

The highest CO₂ emission reduction was 10.62% in PPS and 47.71% in PDA. The ideal simulation for subsidized housing integrated with sustainable transportation was to replace 100% of the private vehicles by public transportation. For PPS, 46 units of small buses with a capacity for 19 people were used as feeders to the existing BRT and for the PDA, 74 units of BRT with a capacity for 30 people were used.

**4.4.2. Design of subsidized housing with the accessibility improved.** The simulation results showed the appropriate sustainable transportation method suitable for subsidized housing in PPS is the direct integration of small buses into the existing BRT system while the best method for the PDA is to integrate
feeder transportation through small buses into the cross-regional buses in the form of the BRT. Moreover, the survey conducted showed 40% of the population generally strongly agreed while 55% and 57% in PPS and PDAs respectively agreed to switch to using integrated public transportation. Furthermore, 68% and 64% agreed while 19% and 17% strongly agree to walk or bike to the nearest shelter for PPS and PDA respectively.

The subsidized housing was designed by improving access roads to the housing and its environment. Table 7 shows the road data and requirements in accordance with Government Regulation PP No. 34/2006 as well as the technical planning of pedestrian facilities in accordance with the Minister of Public Works Circular PUPR no. 02/SE/M/2018. However, there are no specific regulations requiring the integration of public transportation into subsidized housing. Therefore, the existing regulations were simulated to implement this integration with the design and minimum provisions presented in Table 7 to provide the models illustrated in Figures 6, 7 (a) and 7 (b).

Table 7. Road data at research location.

| Name of Road                  | Classification | Avenue Data | PP RI No: 34 / 2006 | SE Mentri PUPR No:02/SE/M/2018 |
|------------------------------|----------------|-------------|---------------------|-------------------------------|
|                              | Government Administration | Road Function | Width (m) | Min Width (m) | Street Space (m) | Bicycle Lane (m) | Width of Green Land (m) | Distance Shelter (m) | Drainage (m) |
| Palir-Kaliancar Road (PPS)   | City Street | Primary Local | 4.5 | 1 | 7.5 | 11 | 1.25 | 1.5 | 300 | 0.5 |
| Boja-Kaliwungu Road (PDA)    | Provincial Road | Primary Collector | 5 | 1.5 | 9 | 15 | 1.25 | 1.5 | 300 | 0.5 |

Figure 6 shows the design of the subsidized housing integrated with public transportation with the availability of shelters within 300 m from the environment and parking facilities for bicycles and private vehicles. A special lane with a width of 1.25 meters was created for cycling while sidewalk with a width of 1.5 meters equipped with greening along the road was provided for pedestrians to walk comfortably to the shelter. Figure 7 (a) and Figure 7 (b) show the cross-section of the access and main roads respectively and the main which was previously 4.5 meters wide was widened to 9 meters and those within the residential area were at least 8 meters wide.

Figure 6. Simulation of Integrated Subsidized Housing Layout.
5. Conclusion
The most influential factors to ensure a successful integration of subsidized housing at the border of Semarang City and Kendal Regency were accessibility and choice of transportation mode and the ideal simulation was to replace 100% of the private vehicles with public transportation. Moreover, the mode of transportation in PPS was small buses used as feeder transport for the BRT and it reduced the DS value from 0.28 to 0.02 and CO$_2$ emissions by 10.62% while the PDA preferred BRT which reduced DS value from 0.77 to 0.12 and CO$_2$ emissions by 47.71% to ensure the realization of sustainable transportation. Furthermore, the design showed the improvement in accessibility by increased the minimum environmental road width to 8 meters and access road width to 9 meters and through the provision of public transport shelters at a distance of 300 m from the residential environment, bicycle/private vehicle parking facilities, a special lane for cycling, and sidewalks for pedestrians with greening for comfortable walk to the shelter.

6. Suggestion
The policy by the central government on subsidized housing with the exclusion of integrated transportation as well as the spatial policy of Semarang City and Kendal Regency need to be revised to ensure proper transportation facilities for the residents. In addition, there is need for sensitization on sustainable transportation by the governments starting from the village to the neighborhood and community levels in order to raise public awareness about its importance for the safety of the surrounding environment, individual health, and to maintain the survival of future generations.

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