Analysis on Transportation Infrastructure Availability to Achieve Environmental and Social Sustainability in Karawang

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Abstract. Sustainable infrastructure is the key to development success. At the same time, transportation infrastructure development will involve social and environmental conditions of the local surroundings. Assessment of the availability of such transport infrastructure is one of the solutions adapted from social and environmental impacts. By conducting a correlation test, the presence of transportation infrastructure and the social conditions of the environment can be identified. The results obtained show that the accessibility, the level of security, and the level of equality are correlated to social and environmental sustainability in Karawang. In terms of environment, the availability of transportation infrastructure is not directly related to the impact of environmental sustainability. The impact of the perceived environment also has no effect on the journey. Correlation results indicate that the length of travel time and congestion level do not make the perceived impact greater. The impact of the perceived environment is merely due to the high utilization of private vehicles in Karawang which subsequently leads to higher energy consumption.

1. Introduction

Development process will bring social impacts to the targeted community. These impacts have the potential to create social issues stemming from the direction of the relevant development policies, most likely because these policies were established by the government to focus its orientation on growth or physical development. In the meantime, the government is not giving adequate attention to existing social and cultural conditions. The government as the determinant of development policy often sets ideal images from its own perception, without inviting public contribution in shaping these images. The same thing applies in transportation infrastructure development which has not put into consideration the social needs in the targeted areas.

One of the said targeted areas for transportation infrastructure development is the Regency of Karawang, West Java Province, Indonesia. According to the Regency Planning and Development Board in 2016, Karawang is strategic because it is part of Pantura route, Jakarta – Bandung toll roads, and the intersection of 3 National Activity Center (Bodebek – Bandung – Cirebon). Such strategic location makes Karawang ideal for development projects, especially considering the plan to build Jakarta – Bandung fast train with Karawang as one of its transit stations. Therefore, existing transportation infrastructure must be well analyzed in order to ensure sustainability.

In addition to social sustainability, transportation infrastructure planning as well as any development policies must also have environmental sustainability. Consequently, this research is aimed at analyzing the current existing transportation infrastructure in Karawang for that purpose.

2. Literature review

Sustainable infrastructure transportation is a necessary approach in creating physical facilities to support both present and future economic, social and environmental objectives. For this purpose, the Indonesian National Planning and Development Agency established 9 indicators, namely movement activities, air pollution, road safety, economic productivity, accessibility, economic change, changes in land usage, asset ownership, and transportation policy and planning. These indicators are similar to those stated by Kumar, et al. [1], who grouped them into 3 categories: social, environmental and economic indicators.

According to Tumlin [2], land transportation consists of many aspects such as roads for bicycles, pedestrians, and other motor vehicles, and railways for trains, LRT, etc. Nonetheless, sustainable transportation indicators themselves cannot be defined directly due to different standards applied in each region with different stakeholders.

With regards to the environmental aspect, a few things must be controlled to ensure environmental sustainability: fuel consumption, pollution level, construction materials such as asphalt, and aggregates. This consideration also applies to pedestrian and bicycle facilities within public transportation system [3].

In terms of social aspect, a sustainable transportation system is needed to ensure every community is connected and their interests are promoted. It can also be seen from road accessibility and availability for pedestrians and bicycles, two things which also contribute to communication between communities. Their fuel consumption and resulting pollution will bring direct impacts to the surrounding environment.

3. Research methodology

The research methodology consists of research instruments in the form of questionnaires designed to assess social impacts which will be influenced by local accessibility and the ensuing infrastructure development. Data sampling was carried out in two stages: pilot survey and main survey. The pilot survey was conducted for ±4 days to test the questionnaires' readability. Afterwards, the main survey was conducted for 3 weeks in Karawang by taking respondent samples in a random manner from the streets and door-to-door. The areas covered were Teluk Jambe Timur, Karawang Barat, Kertasari, and Batujaya with a total of 344 respondents.

There are 5 variables related to social aspect, namely time, traffic congestion, transportation mode used, social welfare, and safety for road users. The variables related to the environmental aspect were land damage, air pollution, noise pollution and energy consumption.

These variables were the basis used to create the questionnaires in Likert scale, covering also origin and destination of respondents' daily activities to work/school, health centers, shopping centers, and worship centers. The questionnaire results correlated the Likert scale answers and the Origin-Destination answer. Spearman Test was selected to correlate the perceived conditions and the existing conditions, while Mann U Whitney and Scoring Tests were chosen to correlate other answers with the primary data. These test results both directly and indirectly described any existing relationships.

4. Results and Discussion

The respondents' demography consisted of 60% women and 40% men. In terms of age, the most respondents were within the age range of 17 – 25 years, with 42% of them students/college students and latest education at senior high or vocational school. Based on domiciles, the most respondents came from Teluk Jambe Timur since the survey was conducted mostly in urban areas.

4.1. Analysis on the Connection between Transportation Infrastructure Availability and Social Sustainability

This research assesses respondents' mobilization towards locations that can support social sustainability of the community such as education, work, health centers, shopping centers and worship facilities. Over 50% of these respondents used motor vehicles to reach said locations, except worship centers. For worship purposes, 74% of these respondents preferred to walk due to the near proximity of the worship centers.

Safety level is the only variable that highly influenced community's mobilization towards these locations, even though the correlation remains the same positive value, low to medium, in describing the correlations between travel time, congestion level, and the expenses for each journey towards those locations.

Community participation is a prerequisite in achieving social sustainability, as seen in rural and urban areas that are exposed to technology and outside influence from different communities. Karawang's participation level (with regards to safety facilities, reprimand against violations, assistance for the disable) is very high, with only a difference in that rural communities have more urge to assist the disable is using transportation facilities.

4.2. Analysis on the Connection between Transportation Infrastructure Availability and Environmental Sustainability

Further tests were performed to learn about the environmental sustainability in Karawang, as divided into 2 areas: rural and urban. This division was meant to identify the perceived environmental impacts on different levels of advancement in the transportation infrastructure as well as the population density in both areas.

Basically, all respondents perceived negative impacts due to transportation, with air pollution as the most perceived impact (75%). No correlation was found between the perceived impacts and the travel time and level of congestion. This showed that even though the travel time and congestion level are low, the respondents still perceived significant environmental impacts.

4.3. Accessibility and Mobility in Karawang

The minimum service standards on transportation infrastructure can be seen in the performance index, which depends on, among others, the accessibility to a certain area. This, in turn, depends on the length of existing roads. According Bappenas in 2012, the accessibility index is obtained by dividing the total length of roads with the width of the area in km^2. Data in 2016 showed that Karawang is 1,753.27 km^2 wide with a total road of 2,682.06 km in length [4]. Therefore, Karawang's accessibility index can be calculated as below:

$$\text{Accessibility Index: } \frac{\text{Length of Roads (km)}}{\text{Width (km}^2\text{)}}$$

$$\text{Accessibility Index : } \frac{2{,}682.06\ \text{km}}{1{,}753.27\ \text{km}^2} = 1.53\ \text{km/km}^2$$

According to The Ministry of Public Works Regulation No. 534/KPTS/M/2001, the accessibility index depends on population density. Different densities in different regions will have different needs for road networks. The higher the accessibility index of a region, the more effective its road networks are in servicing its community. Population density can be obtained by comparing the number of population to the area width. In 2016, Karawang had a population density of 1,094 people/km^2, a number which is considered high. However, its accessibility index was 1.53km/km^2, higher than the required minimum standard of 1.5 km/km^2.

In addition to the accessibility index, road performance can also be measured from the region's mobility level by calculating the total length of existing roads (km) per 1000 population. In 2016, Karawang had 2,273,579 populations and therefore its mobility can be calculated as below:

$$\text{Mobility Index} = \frac{\text{Length of Roads (km)}}{1000\ \text{Population (people)}}$$

$$\text{Mobility Index} = \frac{2{,}682.06\ \text{km}}{2{,}273\ \text{people}} = 1.17\ \text{km/person}$$

The two road performance factors showed that Karawang has fulfilled the required length of roads; however, the quality of these roads tends to be poor as observed by the researchers and can be seen in Figure 1.

The 2016 BPS data on Karawang [4] stated that 39.37% of its regency and village roads were categorized as poor while 26.25% were categorized as satisfactory. Hence, to meet the minimum road standards, the regional administration should improve the quality of Karawang's roads.

Figure 1. Road condition in Karawang Regency

4.4. The Connection between Transportation Infrastructure Availability and Social Sustainability

Transportation infrastructure availability is used as a benchmark to achieve social and environmental sustainability since it is expected to support community's mobility. Therefore, this research is aimed at learning how the availability of transportation infrastructure influences the respondents' desire to travel. Social sustainability is achieved when community can fulfill its basic needs such as adequate education, health service, and income. Transportation infrastructure supports the community's needs to reach the locations of these basic needs.

The first significance level is in the mobility towards work areas. Basically, all social-based sustainable transportation variables influence community's mobility. The scoring test on safety, travel time and congestion level variables showed that these had the highest assessment weight. Duration and congestion level variables had higher correlation values compared to cost variable due to varieties in the cost required by workers to mobilize them to work. Everyone's standard is different so the amount spent for transportation to work has different significance between one worker and another. An example is by comparing farmers and office workers, where the same amount of transportation expenses might have higher significance to farmers' mobilization than that of office workers. Therefore, although transportation cost can influence mobilization, there is only little correlation between the amount and its significance. In addition, the travel time between one profession and another is different: even a little time is valuable for office workers since they do not wish to be late, whereas farmers and some other professions have a little more freedom in this regard. The average duration was 26.26 minutes with 15.1 minutes of congestion. In conclusion, duration has medium significance in influencing respondents' mobility.

Judging from the mapping, the respondents were mainly local farmers as well as workers in industrial areas in the regency capital city. The mobilization of workers towards the capital city and its surrounding areas was mostly due their employment in these industrial areas, especially in *Karawang*

International Industrial City (KIIC). This mobilization data is also supported by BPS, who stated that Karawang's workers mostly work in industry sector, even though some people domiciled farther away from the capital city chose to become local farmers. The ability of industry to absorb labor and the possible income it offers are attractive, therefore enticing people to work in the capital city and its surrounding regions. The influence of travel time and cost to mobility caused many workers to move and live closer to the capital city in order to save time and minimize transportation expense to work. In turn, this would increase the population in the capital city and its surrounding areas. To avoid this, it is therefore necessary to accommodate the workers' needs for shorter travel time and minimum transportation cost. At the same time, the development of effective and inexpensive transportation infrastructure must be accompanied by improvement in facilities for farmers, such as work loan. This would help towards avoiding the decrease in the number of farmers who might be tempted to leave farming in favor of industrial work. Therefore, the number of industrial workers and farmers would remain balanced.

In addition to employment, education quality also plays an important role to achieve social sustainability. Therefore, transportation infrastructure that supports the community to reach their education centers must be prioritized in details. The average travel time required to reach education centers is 27.79 minutes with 10 minutes' congestion. In general, students perceived travel time, congestion level and cost as having similar significance. All three influences their mobility to schools but the correlation tends to be weak.

Similar to workers, many Karawang students traveled towards the capital of Karawang and its surrounding areas, including those further away from the capital. This tendency is understandable since universities are located in these areas such as Universitas Singaperbangsa, the only state university which is located near the capital in Teluk Jambe Timur. The need for decent education is a basic right for the people of Karawang and the need to mobilize towards education centers must be fulfilled with effective transportation infrastructure. This improved connection between areas inside Karawang must also be accompanied with quality education infrastructure especially in its remote areas for the sake of education equality among these areas.

In addition to the needs to mobilize towards education centers and business centers, social sustainability is also achieved when community can fulfill their basic needs for food, health and worship. These three aspects similarly require transportation infrastructure to connect community to the desired locations for these purposes. Correlation and significance tests showed that in general all transportation factors namely accessibility, safety, and modes influence mobility although they may have weak correlation.

4.5. Connection between Transportation Infrastructure Availability and Environmental Sustainability

The impacts perceived by the community showed that some factors were not correlated to the environmental impacts they felt. The correlation test showed that the length of travel time and congestion level was not related to the impacts. All respondents feel that transportation brought negative impacts to Karawang's environment in the form of damage, air pollution and noise pollution. The use of private vehicles especially motorbikes was one of the main contributor to this. Table 1 shows the minimum number of people using public transportation.

The high percentage of private vehicles usage especially motorbike means higher fuel consumption for transportation in Karawang. According to 2015 data from the Directorate General of Land Transportation in, each motorbike consumed 1500 KJ of energy, higher than that of public transportation. This level of energy consumption presents one transportation problem for Karawang to achieve environmental sustainability.

Table 1. Transportation Modes Used to Reach Locations

Transportation Mode	Work	School	Market	Health Center	Worship Center
Motorbike	**54%**	**73%**	**80%**	**80%**	19%
Private car	18%	5%	9%	11%	3%
Public car	1%	3%	3%	2%	1%
On foot	25%	10%	5%	6%	**76%**
Rented Motorbike	1%	6%	4%	1%	1%
Bicycle	1%	1%	0%	0%	1%
Train	0%	1%	0%	0%	0%
Total	100%	100%	100%	100%	100%

5. Conclusion

Karawang has adequate quantity of road infrastructure for decent accessibility and mobility; however, 26.25% of these roads are categorized are poor quality. This research showed that there is a correlation between transportation infrastructure and social sustainability as seen from the community's mobility in fulfilling its basic needs. This mobility is highly influenced by the levels of accessibility and safety, two factors with the most significance.

With regards to environmental sustainability, Karawang has rather high energy consumption, environmental damage and pollution level. However, the perceived environmental impacts are not correlated with the perceived travel factors even though the environmental impacts stemmed from the high percentage of private vehicle usage, especially motorbike, and high fuel consumption. The high percentage of private vehicle usage itself is due to lack of decent public transportation options.

Transportation indicators such as accessibility, mobility, safety and equality in Karawang need to be considered in accordance with the community condition in order to achieve sustainability. In addition, environmental sustainability is low when environmental damage, air pollution and noise pollution is high and affecting community. Transportation infrastructure in Karawang can still achieve social and environmental sustainability but it is lacking in integrated public transportation modes and decent road condition.

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