# Sustainable infrastructure transportation to improve society wellbeing in Karawang

**D T Winata[1] and A D Rarasati[1]**

[1]Civil Engineering Department, Faculty of Engineering, Center for Sustainable Infrastructure Development, Faculty of Engineering, Universitas Indonesia, Kampus UI Depok, Indonesia 16424

E-mail: ayomi@eng.ui.ac.id

**Abstract.** Transportation infrastructure design must follow sustainability concept that requires stability in economic, social and environment, then sustains in the future. Therefore, this research aims to identify time travel, fare level, percentage spending on transport, waiting time, and availability of alternatives mode as sustainable transportation indicators that could be applied in rural and urban area at Karawang Regency, as developing district correspond to society welfare as a social theme variable in sustainability development indicators. This research also identifies existing commutes characteristics and benchmark of the sustainable transportation indicators to improve society wellbeing. This research applies quantitative methods by conducting survey to collect data from respondents. The instruments to obtain data in Karawang Regency are questionnaire form, and then collaborated with structured-interview. Spearman's rank correlation is employed as the quantitative method in order to conduct non-directional and directional hypothesis test. In conclusion, time travel, spending on transport, and fare level variables representing mobility, equity, and affordability have significant influence to experience wellbeing, and then they have negative correlation to social welfare as well. For that reason, time travel and fare level must be reduced to improve society wellbeing.

## 1. Introduction

Infrastructures are structures and facilities that create system to support society daily activities especially social and economy sector in urban city. There are seven types of infrastructures related with society needs in a city that one of them is transportation infrastructures. Meanwhile human needs are getting complex from time to time, therefore infrastructure have to be developed in order to solve with new problems and fulfil society needs. On the other hand, infrastructure project development will have lot of constraints for example time limitation, budget constraint, and social impact.

Availability of infrastructure aim is to facilitate people with their daily activity to achieve efficiency and improve productivity. In order to achieve efficiency, infrastructure development and plan are needed in the future. The target of infrastructure improvement is to alter their existing and new infrastructure to more sustainable forms. Characteristics of sustainable infrastructure are eco-friendly, low budget construction and maintenance, influence social and culture in good way and durable.

Indonesia as a developing country still faces lots of problem and the most common problem is inequalities in between regions in social welfare and infrastructure development sector. According to

the Organisation for Economic Co-operation and Development (OECD) report in 2013, insufficient in quantity and inadequate in quality, transport infrastructure are serious problems in regional development. Most of regency and city roads that account for nearly 80% of the network, are in bad condition [1]. Inequalities produce different solution to solve problem depending on area development [2]. Therefore, development in a region must consider sustainable infrastructure solutions. It needs good analysis to pick the right solution adjusting with problems in society.

As a result, the researcher selected as Karawang Regency as research study case of developing region. Karawang Regency where the regency is located near Jakarta as the capital city of Indonesia, then Karawang becomes regency that supports Jakarta in logistic and agriculture stock [3]. Karawang Regency has the mixture of industrial area, agriculture area, and moreover, the transportation infrastructure development in Karawang is still growing. Therefore, the researcher wants to find the applicable sustainable transportation indicators that could be used to measure transportation condition in Karawang by correlating and assessing impact to society wellbeing as social development goals. Moreover, this research will determine how to improve society wellbeing using selected sustainable transportation indicators. In addition, the research also analyzes commutes characteristics in rural and urban area in Karawang according the selected sustainable transportation indicators.

## 2. Literature review
Happy Planet Index is one of multidimensional indicators of sustainability development for a country. Since it can be calculated based on experience of wellbeing, then it means improving experience wellbeing very important to represent achieve social goals of sustainable development [4]. Likewise HPI, sustainable transport infrastructures have their own specific indicators measuring impact to social sector, and then it has to bring good social impact especially social wellbeing. In order to develop transportation infrastructure, specific parameter must be determined in the beginning to accommodate society needs [5]. Moreover, the parameter must be measurable and bring good influence to society wellbeing in Karawang based on sustainable concept goals. Eventually, when all the goals are achieved, it will directly increase customer loyalty in order to get long-term financial performance and make a sustained investment [6].

Satisfaction with travel can be described by daily work commute activities. Ettema, et al. [7] and Olsson, et al. [8] argued that travelling satisfactory is important for experience wellbeing because it makes people possible to do various activities. According to Olsson, et al. that discussed about relationship between daily travel and subjective well-being in Sweden, characteristics of commutes could be described in travel time, number of travel modes, and transportation frequency time. Furthermore, subjective wellbeing may increase and having relationship to travel cost and spending transport in household. Due to Olsson, et al., defines commutes characteristics from 5 characteristics of commutes affecting travelling satisfactory and important for people's life satisfaction, and then the commutes characteristics is same with sustainable transportation indicators detail by Gundmundsson [9], Dobranskyte-Niskota [10], Friman & Fellesson [6], and Litman [11], therefore, the researcher selects sustainable transportation indicators that have similarities.

As a result, the researcher selects 5 transportation variables that represent commutes characteristics affecting travelling satisfactory and people's life satisfaction or subjective wellbeing. The variables are travel time or speed, number of alternatives travel modes, transportation frequency from waiting time, travel cost (fare level) and spending transport in household. Those variables also the same with sustainable transportation indicators, therefore it may represent sustainability of transportation infrastructure as well. The first following variable is travel time that same variables to measure mobility goals in sustainable transportation infrastructure [8]. The second is travel cost represents fare level as affordability variable. The third is transportation frequency time can be measured by waiting time in order to rate how efficient the transportation performance. Lastly, the travel cost is indicated by using fare level and spending on transport for passenger.

## 3. Research methods

The method during data processing and obtaining output data use quantitative methods. The aim of quantitative method is to count data in an attempt of observation. Then the data is in number forms and analyze by using statistical method. Data will be collected by cross-sectional survey. Questionnaire and structured interview were used as an instrument to collect data from respondents who use transport infrastructure frequently. The survey was conducted at Lamping Village in Pangkalan Sub-district, Tanjungpakis Village in Sub-district Pakis Jaya, Teluk Jambe Timur, and surrounding West Karawang Sub-district. The respondent's age is limited as productive age between 15 to 64 years old. The total respondents are 344 respondents, with 63 from rural area (Lamping Village and Tanjungpakis Village) and 281 from urban area (West-Karawang Sub-district and Teluk Jambe Timur).

The questionnaires are used to obtain general information about respondents relate with age, gender, home address, highest education level, monthly income respondent's household, details occupation and how often respondent do the traveling activities. After that, the questionnaire records destination (office or school) address, traveling duration time, daily transportation cost, many options of mode that people have and duration the respondents have to wait for public transport and traffic. Lastly, the questionnaire asks about individual wellbeing according to Gallup [12]. The wellbeing statements are related to supportive social, financial, community, physical, and motivation to achieve purpose of life. Then, the wellbeing will be scored in into 4 points scale base on Likert scale, ranging response from strongly disagree (1) to strongly agree (4).

From the questionnaire, it takes data processing to change to variables going to be applied. Firstly, travel time is same with average speed on trip, therefore it is produced from travelling duration divided by trip distance getting from measuring distance of home address to destination address. Travel time unit is minutes over kilometre. Fare level is how much money that spend on each kilometres travels. Secondly, fare level unit is price over distance where this research uses Rupiah as a currency price and kilometre as a distance unit. Amount of money spent on transport are gather from daily cost from each transportation mode that used in commute trip to destination. Afterwards, fare level is total cost divided by the distance. Thirdly, Percentage spending on transport from household income comes from cost proportion that every family spends on daily travel activity in a month. Transport cost is multiplied by two in order to assume commuting trip, thus it produces daily cost transport each respondent. Daily cost transport will be multiplied by how many days in a week that the respondent goes to work or school and it makes into a month by multiplying four. Final cost of transport is a total spend in a month. It will be divided by household monthly income and converted into percentage. Fourthly, waiting time is sum of total duration each respondent waits in exchange modes. Respondents who fills waiting time are considered as public transportation users. It happens because if the respondents use their own private vehicle, they do not have to wait.

The following step is checking the obtained transport variables samples either well distributed or not, with a purpose determine parametric or non-parametric test. The data distribution is checked by using skewness and graph frequency distribution. The conclusion of travel time or speed, number of alternatives travel modes, transportation frequency from waiting time, travel cost (fare level) and spending transport variables are not distributed well and use non-parametric test. The tests are Mann-Whitney U test and Spearman's Rank Correlation Test. Mann-Whitney U test is used to test either any different in between urban and rural respondent's characteristics. Spearman's Rank wants to identify correlation and benchmark the selected sustainable transport indicators to society wellbeing. Lastly, the researcher does generalization of commutes characteristics using mean, median and inter-quartile range (IQR) as statistical descriptive.

## 4. Results

Firstly, the researcher assess questionnaire with validity using Product-Moment Correlation and reliability test using Cronbach's Alpha. The validity test result shows the lowest computed r-xy is 0.57 and it is bigger than r-critical with 0.0903 for significance level 0.05 (5%) or the confidence level 95%

with one-tail degree of freedom (df) is 342. Therefore, the questionnaire passed validity test and collect variables accurately with valid answers. The reliability test using Cronbach's Alpha, the result of internal consistency reliability ($\alpha$) is 0.7015. The reliability of the five statements that going to measure society wellbeing could be accepted because the alpha ($\alpha$) is bigger than 0.7 categorized in acceptable criteria.

Secondly, the researcher finds that the variables in not well distributed data or not because the lowest skewness value is not zero with skewness value of 0.8904 for alternatives mode. For that reason, the researcher conducted a Mann-Whitney U Test to check whether there are any difference characteristics in urban and rural area in Karawang. The Mann-Whitney U calculation results are presented in table 1.

**Table 1.** Mann-Whitney test characteristic urban and rural area.

|  | Urban (281) | Rural (63) | Conclusion |
|---|---|---|---|
| **Time Travel** |  |  |  |
| U-value | 2668.5 | 3183.5 |  |
| z-value | 0.684 |  | Not different |
| p-value | 0.248 |  | Not significant |
| **Spending on Transport** |  |  |  |
| U-value | 8097.5 | 9605.5 |  |
| z-value | 1.052 |  | Not different |
| p-value | 0.144 |  | Not significant |
| **Fare Level** |  |  |  |
| U-value | 1513 | 4333 |  |
| z-value | 3.74 |  | Different |
| p-value | 0.000 9 |  | Significant |
| **Waiting Time** |  |  |  |
| U-value | 3839.5 | 13863.5 |  |
| z-val ue | 7.024 |  | Different |
| p-value | 0.0001 |  | Significant |
| **Alternatives Mode** |  |  |  |
| U-value | 262.5 | 1507.5 |  |
| z-value | 8.752 |  | Different |
| p-value | 0.00001 |  | Significant |
| **Wellbeing Score** |  |  |  |
| U-value | 8330.5 |  |  |
| z-value | 0.729 |  | Not Different |
| p-value | 0.252 |  | Not significant |

Based on table 1, it shows some different commutes characteristic in urban and rural area in Karawang. The conclusion of different will be obtained if the z-value is higher than z-critical with 1.65 and the p-value do not pass 0.05. Eventually, there are differences in fare level, waiting time, and alternative mode they had between urban and rural people in Karawang. The following step is assessing correlation to society wellbeing, and if the characteristic is not different, the computation results do not need to split up. The result of spearman's rank correlation as non-parametric test is presented in table 2.

Based on table 2, the correlated sustainable transportation variables to society wellbeing are time travel, fare level and spending on transport. It can be categorized as correlated variables if the absolute r-value is bigger than 0.1147 as the r-critical. Moreover, if the r-value is lower than 0 or it is in negative form, it shows that the behaviour of variable is negative correlation. Negative correlation means when the time travel, fare level and spending on transport decrease, and then the society wellbeing is improved. It also similar with the meaning of time travel, fare level and spending on transport is inversely proportional to society wellbeing.

**Table 2.** Correlation to society wellbeing.

|  | **Urban Area** | **Rural Area** |
|---|---|---|
| **Fare Level** | | |
| R-value | -0.173 | -0.3216 |
| P-value | 0.0045 | 0.19 |
| Conclusion correlation to wellbeing | Significant correlated (negative) | No Correlation |
| **Waiting Time** | | |
| R-value | -0.00726 | 0.1825 |
| P-value | 0.222 | 0.1521 |
| Conclusion correlation to wellbeing | No Correlation | No Correlation |
| **Alternatives Mode** | | |
| R-value | -0.0726 | 0.1905 |
| P-value | 0.118 | 0.134 |
| Conclusion correlation to wellbeing | No Correlation | No Correlation |
| **Time Travel** | | |
| R-value | -0.1848 | |
| P-value | 0.00163 | |
| Conclusion correlation to wellbeing | Significant correlated (negative) | |
| **Spending on transport** | | |
| R-value | -0.184 | |
| P-value | 0.0016 | |
| Conclusion correlation to wellbeing | Significant correlated (negative) | |

After conducting correlation test, in order to examine existing condition of commutes characteristics refers to time travel, spending on transport, fare level, waiting time, and alternatives mode, the researcher conducted statistical analysis. The researcher figures the existing condition by analyzing through average, median and inter-quartile range (IQR). The description about commutes characteristics in urban and rural area in Karawang is presented in table 3.

**Table 3.** Commutes characteristics urban and rural in Karawang.

| **Time Travel (min/km or km/hr)** | | |
|---|---|---|
| Average | 4.67 minutes/km (12.85 km/h) | |
| Median | 2.92 minutes/km (20.58 km/h) | |
| IQR | 1.74 - 5.82 minutes/km (10.31-34.48 km/h) | |
|  | **Urban** | **Rural** |
| **Spending on Transport (%)** | | |
| Average | 11.02% | |
| Median | 8% | |
| IQR | 2%-16% | |
| **Fare Level (Rp/km)** | | |
| Average | Rp 1.575,- | Rp 465,- |
| Median | Rp 850,- | Rp 293,- |
| IQR | Rp 365 – Rp 1700 | Rp 0 – Rp 650 |
| **Waiting Time (Minutes)** | | |
| Average | 13 | 3 |
| Median | 10 | 0 |
| IQR | 0-20 | 0 |
| **Alternatives Mode (Quantity)** | | |
| Average | 2 | 0 |
| Median | 1 | 0 |
| IQR | 1-2 | 0 |

## 5. Discussion

Before discussing correlation experience wellbeing to each sustainable transport variables, characteristic society of welfare in Karawang will be analyzed generally a bit. From five statements relating with supportive social, financial, community, physical and motivation to reach life goals, the respondents was asked to rate 1 to 4 for each statement. As a result, the score for social welfare will be in range 5 to 20 for the total score. Then the result for total score affecting individual welfare is 15 for median and the inter-quartile range is 14 to 16. If the total score from 5 to 20 is equalized to rate 1 to 10, then the median is 6.67 and the IQR range is within 6 to 7,33. According to Happy Planet Index Report 2016, the experience wellbeing of Indonesia has score 5.4 over 10. Higher score society wellbeing in Karawang Regency than overall in Indonesia also shows that higher GDP sometimes also increase society wellbeing in a region. Based on Karawang Regency Government report in 2016 [3], Karawang Regency Gross Domestic Product per capita in 2014 is Rp 41.986.072, then Gross Domestic Product per capita in Indosnesia is about Rp. 41.8 million.

For alternatives mode, the average and median in urban area is 2 for average and 1 for median, on the other hand the rural area has no option for alternatives modes. Refers to analysis of obtained data in Karawang Region, available alternatives mode is very limited. No modes answers show there are some respondents prefer to go by walking (25% go to work and 10% go to school) than using vehicle especially in rural area. Moreover, most of respondents select motorcycle as main mode that is often used vehicle. Particularly in rural or villages in Karawang Region, public transportations such as minibus or "angkot" do not reach them. Even though the public transportations reach them, they cross rarely and the number of vehicles is small. The public transportations are only available every 1 to 2 hours. Eventually, people who live in villages depend on their private vehicle or motorcycle. Moreover, due to limited public transportations problems common in every suburb area in Karawang Region, most of people already understand and do not bother their society welfare as long as fuel price for their private vehicle not increasing.

Waiting or delaying time during operational transport also do not cause serious influence to society wellbeing likewise the number of alternatives mode. Since most of people rely upon motorcycle as private vehicle, the waiting time for public transport in city is relatively short. The urban area specifically in West Karawang sub-district, the waiting time average is 13 minutes or in range 0 to 20 minutes, in contrary for rural area, the society only have to spend less time or almost no delaying time in doing travelling. No delaying time in rural area or villages is caused by none use public transport due to no public transportation operated and the traffic very low.   In addition, based on researcher observation during survey, the overall traffic in Karawang Region specifically at the city is moderate or the traffic only takes about 5 minutes. Owing to short range waiting time in society, the waiting time cannot be correlated and not significant enough with society wellbeing as well

Time travel in Karawang in general same and no difference, then correlation using statistical analysis presents that time travel transportation significantly influences society wellbeing. The research gets the median of travel time 2.92minutes/km (20.58 km/h) and the inter-quartile range (IQR) is 1.74 - 5.82 minutes/km (10.31-34.48 km/h).  The average of time travel in Karawang is 4.67 min/km (12.85 km/h). Furthermore, benchmark in order to improve society wellbeing is negative correlation as well. Negative correlation means the faster people could reach the destination, the more welfare they are as well. Logically, if people go anywhere faster, they could save time to do other activities and achieving their life goals. In addition, faster time will save people energy to do their job or study as student. From the behaviour most of people Karawang's village, they would rather buy gasoline at near station to save time even though it is more expensive than normal price, it could be concluded that faster time is the most important matter in a trip.

Percentage spending on transport expenditure is one of variables to measure equity and fairness in social dimension. The median for percentage spending on transport expenditure is 8%, average is 11.02% and the IQR is 2% to 16% from the income. Almost 50% of samples spend percentage 2% to 16% of income to pay daily transportation cost. Through observations, researcher finds equity and fairness in transportation will seriously alter economy and social welfare in society. It is very

influencing for rural and urban society welfare because spending on transport significantly correlated to society wellbeing. The correlation has negative correlation, therefore the benchmark in order to improve society wellbeing, percentage of spending on transport must be decreased. The reason monthly expend that have to spend for transportation must be decreased is in order to fulfil other financial needs.

Fare level measures how much money (Rupiah) people have to pay for certain distance and in this research is a kilometre. Through characteristic analysis, the fare level in rural versus urban and student versus non-student show significant difference. From the correlation test shows fare level brings significant impact only to urban society welfare. Based on descriptive statistical, the researcher calculates the median of fare level in urban area is Rp.850,-/km, then the IQR is Rp.365,-/km to Rp.1700,-/km. The average fare level is Rp.1574,-/km. This much higher than fare level in rural area because in people activities in urban area rely on the transportation mode, while in urban area the people go by walking and not spend much money. Likewise the preliminary researcher assumption, using direction correlation hypothesis test, it supports with the negative correlation assumption. Low fare level is also a substantial variable in transportation infrastructure rising up social welfare. This fact is also supported by result of other research showing price is the most crucial factors that encourage society to use public transportation. They demand for cheaper fare in order to boost up the users.

## 6. Conclusion

According to finding and result of research conducted in Karawang Region, from 5 selected variables that are by time travel, fare level, percentage spending on transport, waiting time, and availability of alternatives mode representing of mobility, equity, affordability, efficiency and accessibility, only 3 variables has significant impact to society welfare. The most substantial transportation variables for society wellbeing in Karawang are mobility represented by time travel, and then the time travel characteristics is same at urban or rural area in Karawang. Moreover, equity and affordability measured by spending on transport and fare level also influence significantly society wellbeing especially in urban area. In conclusion, time travel, spending on transport and fare level can be used to assess efficiency on transportation for sustainability in economic and social perspective in Karawang.

Sustainability of transportation according to time travel, spending on transport and fare level bring significant impact to society wellbeing. It has been proved using hypothesis test in chapter 4, and then it also supported by direction hypothesis. The directional hypothesis describes that they have negative correlation or monotonic decreasing to social welfare. Negative correlation shows if time travel, spending on transportation and fare level get lower, then society wellbeing will tend to increase symbolizing the social welfare gets better. As a result, in order to improve society wellbeing in Karawang, the benchmarks for time travel, spending on transport and fare are the lesser time travel, spending on transport and fare are better.

In addition, this survey may represent existing commutes characteristics based on selected sustainable transport indicator in Karawang. Due to the data is not well-distributed and the researcher check whether any differences between student versus non-student and urban versus rural area, the researcher will split the description if there is significant difference. The commutes characteristic will explain using average median and IQR range to generalize the performance.

## 7. Acknowledgement

## 8. References

[1] The Organisation for Economic Co-operation and Development 2013 *Structural Policy Country Notes Indonesia*

[2] Asian Development Bank 2012 *Transport Sector Assessment, Strategy, and Road Map.* Manila

[3] Karawang Regency. 2016. *Rencana Pembangunan Jangka Menengah Daerah.* Karawang. Retrieved from http://karawangkab.go.id/sites/default/files/pdf/Perda Nomor 8 Tahun 2016.pdf

[4] Paul D, Tessa P, Andy D, Melanie K, David P, Aki T and Mat W 2006 *Research on The Relationship Between Well-Being and Sustainable Development* 1–52

[5] Yannis T and Constantinos A 2008 Public transit user satisfaction: Variability and policy implications *Transp. Policy* **15** 260–272

[6] Margareta F and Markus F 2009 Service supply and customer satisfaction in public transportation: The Quality Paradox *Journal of Public Transportation* **12** 57–69

[7] Dick E, Tommy G, Lars E O, Margareta F and Sjef M 2013 The road to happiness: Measuring Dutch car drivers' satisfaction with travel *Transp. Policy* **27** 171–178

[8] Lars E O, Tommy G, Dick E, Margareta F and Satoshi F 2013 Happiness and satisfaction with work commute *Social Indicators Research* **111** 255–63

[9] Henrik G 2001 Indicators and performance measures for Transportation, Environment and Sustainability in North America *Research Notes from NERI* **148**

[10] Agne D-A, A Perujo, J Jesinghaus and P Jensen 2007 Indicators to assess sustainability of transport activities *JRC Scientific and Technical Reports* **54971**

[11] Todd L 2007 Developing indicators for comprehensive and sustainable transport planning *Transportation Research Record: Journal of the Transportation Research Board* **2017** 10–15.

[12] Gallup-Heathways Global Well-Being Index 2014 *2014 Country Well-Being Rankings Report* Retrieved from http://www.well-beingindex.com/2014-global-report