IDENTIFYING GAPS BETWEEN SERVICES AND TRAVEL NEEDS IN JAKARTA' BRT SYSTEM

BINGYUAN HUANG
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Thesis submitted to the Faculty of Geo-Information Science and Earth Observation of the University of Twente in partial fulfilment of the requirements for the degree of Master of Science in Geo-information Science and Earth Observation.
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ABSTRACT

Expanding the coverage area of BRT system in Jakarta Metropolitan Area (JMA) to increase the ridership is important for improving TransJakarta effectiveness and performance to solve mobility problem in JMA. However, a fundamental issue for expanding BRT system is to identify the potential travellers to find areas which have great potential travel demand but are not yet sufficiently covered by current BRT system. Based on that issue, the thesis aims to identify gaps between services and travel needs in Jakarta BRT system for commuting trips.

Travel need is identified through need index method about assembling transport need indicators for a series of spatial areas and defining a single need score for each areas. SQL and spatial SQL based on ArcGIS are used to extract data, correlation analysis is used to selected transport need indicators, and factor analysis and pairwise comparison method for decision making are used to obtain weights for each need indicators. Infrastructure based accessibility index is used to calculated supply level. Based on supply and needs, two scenarios are generated to compare the current need/supply gaps and the policy intervention gaps.

The results shows travel need primarily depends on socio-economic indicators, and is impacted mainly by three social groups: travelling groups, low income social state groups, and social groups with age disadvantage. Furthermore, high needs areas are aggregated around CBD (Central Business District) and industries areas. However, need index based on decision making is generally smaller than need index obtain from factor analysis. For supply level, low supply scores are distributed on the periphery of JMA and Central Jakarta areas. For need and supply gaps, high gap areas are aggregated on the periphery of JMA and CBD and industries areas. Finally, two scenarios of need/supply gaps shows decision making gaps are generally lower than gaps based on factor analysis, and the high gaps areas covered less areas.

The results indicate expansion of BRT is guided to periphery of JMA (low supply level) and CBD and industries areas (high need but low supply level), however, expansion based on gaps with policy intervention may cause social inequality due to policy intervention can benefit certain social group but also ignores other social groups at the same time. Furthermore, as socio-economic indicators mainly impact travel need, improvement of traffic mobility will not solely be achieved by expanding TransJakarta, but with measures aimed at reducing inequalities between areas.

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1. INTRODUCTION

1.1. Background and Justification

Jakarta Metropolitan Area (JMA) is the largest metropolitan region in Indonesia. It's the country's economic, cultural and political centre, and with a population of 10,135,030 as of January 2014(Jumlah Penduduk Provinsi DKI Jakarta, 2014).

However, JMA experiences serious problem about urban mobility. The extensive socio-economic activities and the substantial increase of the land value result in suburbanization rises and the satellite cities grow which cause great number of commuting activities. Hence, people mobility is inefficient since people need to travel in longer distance and time travel due to the location between the settlement and workplace are separated by reasonable distance (Hakim, 2009).

Furthermore, the city suffers a lack of urban public transport services due to prioritized development of road networks, which were mostly designed to accommodate private vehicles(Soehodho, Hyodo, Fujiwara, & Montalbo, 2005). This circumstance stimulates people to become over dependent on private vehicles (car and motorcycle). In 2010, the daily commuting trips reach 1.1 million. 48.7% and 13.5% trips are dominated by motorcycle and private car, whereas only 12.9% trips are public transport (Coordinating Ministry of Economic Affairs, 2012). It indicated the transportation policy has limited attention to support public transport and non-motorized transportation(NMT) modes, which causes congestion and harmed condition for NMT, and also causes air population in urban area which made Jakarta as the third most polluted mega city in the world(Mochtar & Hino, 2006) .

Therefore, to change the share of private transport use, improve mobility and promote the use of public transportation in JMA, Jakarta government planned bus rapid transit (BRT) system, which also called TransJakarta in the centre of the city which has already resulted in a shift of trips from private motor vehicles(GEF Project Brief, 2008). The TransJakarta system began operations on January 25, 2004. TransJakarta was designed to provide Jakarta citizens with a fast public transportation system to help reduce rush hour traffic. The buses run in dedicated lanes and ticket prices are subsidized by the regional government. Currently, the BRT system has a total of 12 corridors as of 2013, covering more than 241 km (75% exclusive lane), 670 buses and 213 stations. The system is still expanding and by 2015, 15 corridors will be in operation and over 400 new articulated buses will be added into the system(Adiwinarto, 2013).

The operation is considered moderately successful but estimations are that it is operating much below design capacity(Enhancing Jakarta's BRT System, 2012). Despite its vast network, the system has insufficiently effective and is still considered not optimum. One way to enhance the performance of the BRT system is to expand the coverage area of BRT system to increase the ridership on their lines and run efficient services, in particular commuters who make use of private transport (Enhancing Jakarta's BRT System, 2012).

In spite of all the measures to enhance the performance of TransJakarta BRT system, a fundamental issue is the expanding BRT system should be available and accessible to potential travellers. That's the effective way to attract ridership, because potential demand/need is generated by the desire to join in activities, trips will be generated if road network covers these demand area. In this thesis project, potential demand refers to the proportion of people who are likely to use BRT as primary transportation mode, once the public transit facility becomes available and accessible to these people. The areas which have great potential demand/need but are not yet sufficiently covered by current BRT system could be prioritized for the expansion of BRT network.

Due to the needs and benefits previously stated, this thesis project aims to examine potential demand and service level on the specific situation of Jakarta BRT system. If this objective succeeds it will be more ridership created by expanding BRT system based on potential travel demand/need, and it can be one proactive route design and route performance method and a potential impact on decisions made by transit planners.

1.2. Research Problem

Jakarta Metropolitan Area (JMA) builds bus rapid transit (BRT) system to solve the problem about urban mobility. The operation is considered moderately successful but estimations are that it is operating much below design capacity (Enhancing Jakarta's BRT System, 2012). One way to enhance the performance of the BRT system is to expand the coverage area of BRT system to increase the ridership on their lines and run efficient services, in particular commuters who make use of private transport (Enhancing Jakarta's BRT System, 2012). Based on literature review and the specific situation of Jakarta, the thesis chooses travel demand/need measure to analyse the potential demand (proportion of people who are likely to use BRT as primary transportation mode, once the public transit facility becomes available and accessible to these people) in Jakarta Metropolitan Area. In term of travel demand measures, Gahlot, Swami, Parida, and Kalla(2012) forecast travel demand based on traditional four-step travel demand modelling in GIS environment. But four-step model are costly, insensitive to land use, requires excessive auxiliary data, and often has low accuracy. So Cardozo et al.(2012) and Gutiérrez et al(2011) forecast ridership based on GIS and multiple regression analysis. However, the analysis is based on station level, which is improper for this thesis project focusing on potential travel demand/need beyond current transport network.

Instead of four-step modelling and station-level direct ridership forecasting model, Currie(2010), Jaramillo et al.(2012) and Yao(2007) analyse travel demand/needs based on need index which is a mathematical model computes a numeric measure for each spatial unit. The score of each spatial unit is defined based on the relative indicators. It's a suitable method to analyse travel demand in Jakarta, due to each spatial unit has its own need index, than the potential travel demand/need can be visualized in map trough GIS. Therefore, the need index map can be used to improve current BRT performance.

However, the Need Index models about Currie(2010) and Jaramillo et al.(2012) are based on social exclusion and social disadvantaged, like disabilities, old age, non-ownership of private vehicle, etc. . So the relative indicators impacting travel demand/need are focused on transport disadvantage which is irrelevant to the main objective of Jakarta situation. Yao(2007) analyses travel need for public transit for commuting trips, which has a similar aim as this thesis project. However, the indicators in Yao's model is about public transport which has a litter different as BRT system. Therefore, finding indicators impacting the demand about Jakarta BRT system is a main problem in this thesis.

What's more, Yao's Need Index brings the composite effects of all other contributing indicators that are innate to the spatial unit itself but nothing from the transit network. It means that Need Index will not change with the change of transit network. However, the demand analysis about Currie(2010) and Jaramillo et al.(2012) considers accessibility as an indicator in the transport Need Index, like street density and degree of accessibility to the Centre . So examining the relationship between accessibility and travel demand is a main problem in the thesis project.

Furthermore, Currie(2010) and Jaramillo et al.(2012) use accessibility measures as tool to analyse travel supply/provision, and compare travel demand with traffic supply/provision to identify need/supply gaps to bring about transport system improvement, which is better than giving advice just based on travel demand due to match public transport to social needs requires an objective and systematic approach to identify gaps between services and social needs(Currie, 2010). Therefore, finding suitable accessibility measure to represent traffic supply is also a main problem in the thesis project.

Last but not least, Jakarta is improving BRT operation through "Direct Service" system, which is to integrate other bus system (Non-BRT) with current BRT system to increase ridership and to expand coverage area of BRT system. The Non-BRT routes are selected based on peal hour frequency and percentage of route overlapped with BRT corridor. So if the Non-BRT line's frequency is more than 12 buses per hour and 40% of the Non-BRT line overlaps with BRT corridor, than the Non-BRT route is selected as direct service route(Adiwinarto, 2013). But whether selected direct system based on frequency and overlapping percentage solve the availability and accessibility to potential travellers? Comparing the direct service system with travel demand can give suggestion to urban planner to make direct service system more efficient and reasonable.

1.3. Objective

1.3.1. General Objective

Identifying gaps between services and travel needs in Jakarta BRT system for commuting trips.

1.3.2. Sub-Objectives

1) To build travel demand/need model to measure potential travel demand.
2) To represent the supply level of current BRT system and compare travel demand and transport supply to identify need/supply gaps.
3) To give suggestions to decision makers in Jakarta on how to expand BRT system based on the travel demand and supply gap map.

1.4. Research Question

Sub-Objectives 1

1) What indicators have been used in travel demand analysis? What are the suitable indicators for commuting travel demand analysis in the situation of Transjakarta?
2) What is the relation between accessibility and travel need?
3) What are the suitable accessibility measures that can be used for modelling travel demand based on commuting trips?
4) What are the suitable units to analyse potential demand?

Sub-Objectives 2

5) What are the indicators represent BRT supply quality? Is accessibility a big influence on supply? Which accessibility measures should be used to represent supply quality if accessibility is the main indicator to supply?
6) How to combine two measures to visualize need/supply gaps

Sub-Objectives 3

7) Which improvement could be made to improve the "Direct Service" system in order to expand coverage area of BRT system?

1.5. Conceptual framework

Figure 1.1 shows the conceptual framework of this research. The three elements commuters' socioeconomic characteristics, land-use characteristics, and transport are used to determine the travel demand/need and traffic supply about Transjakarta. The non-spatial elements of commuters like income and car ownership(Paulley et al., 2006),the spatial distribution of population, job density and the quality of transport network will impact travel demand, the accessibility about transport demonstrates the quality of transport system (Kalaanidhi & Gunasekaran, 2013) which reflect the traffic supply. The travel demands/need and traffic supply can be compared to identify need/supply shortfalls or spatial gaps to bring about transport system improvement. Finally, benefits of expanding BRT line in Jakarta will be evaluated in terms of comparing with current system.

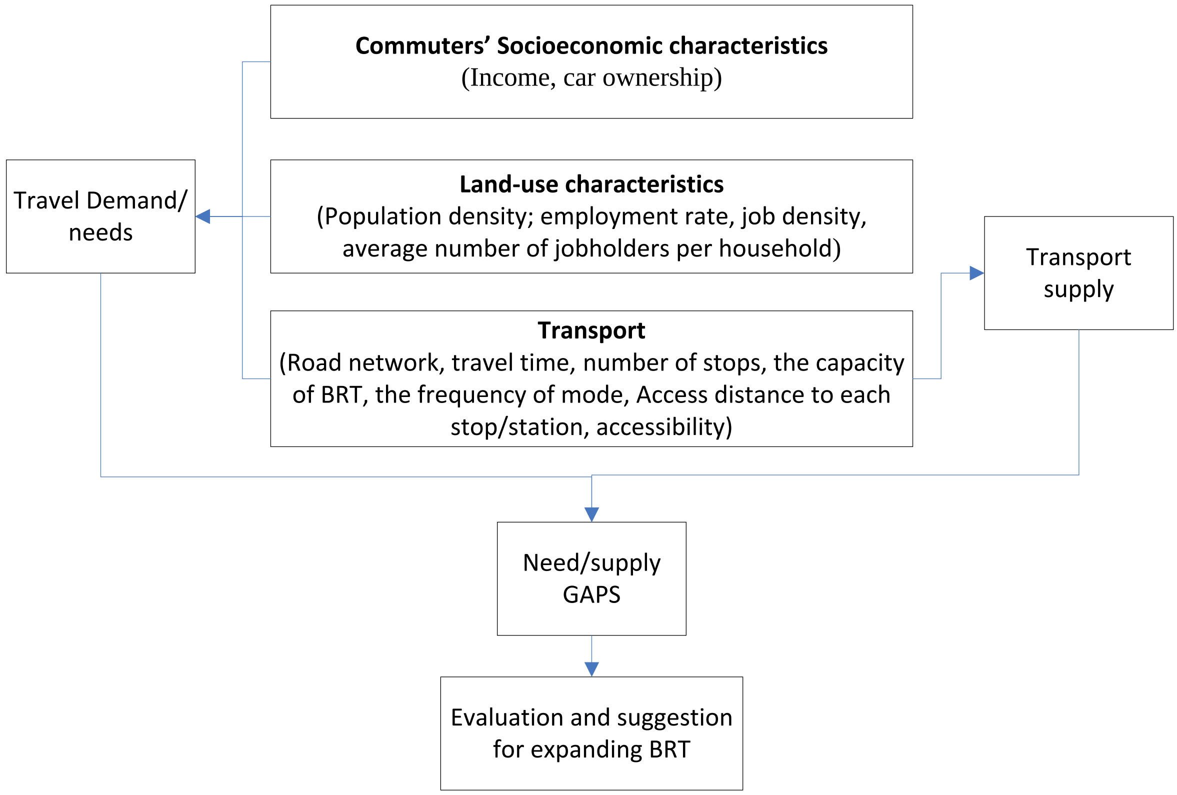


Figure 1.1 Conceptual framework

1.6. Thesis Structure

This thesis consists of six chapters. Chapter 1 is the introduction part in which introduces the contextual and research problems that are addressed in this thesis. Chapter 2 is the theoretical framework. This chapter provides the discussion with regard to travel demand model and transport supply. Chapter 3 is the introduction to case study area and dataset that are used in this research. Chapter 4 provides the discussion about the methodology that is used in this research. Chapter 5 provides result and discussion in relation to the analysis to achieve the research objective. Chapter 6 provides the general conclusion, and the recommendation for the future study.

2. THEORETICAL FRAMEWORK

2.1. Concept of BRT

TransJakarta is a form of Bus Rapid Transit (BRT), it is an integrated, flexible and high performance transit system which has dedicated lanes, design and services to effectively improve the congestion conditions in rush hours. BRT systems are being embraced worldwide as an increasingly popular public transport development option. A typical BRT system usually has most of the following elements:

- Specialized alignment in the center/edge of the road.
- Multiple doors vehicles.
- Bus priority at intersections
- Station platforms level with the bus floor
- Stations with off-board fare collection

Many benefits can be derived from the existence of the BRT system. The primary advantage of BRT is saving time for passengers comparing from the ordinary bus system because of relatively higher speeds. Multiple doors vehicles and bus priority at intersections help to reduce the boarding and alighting delay and avoid the intersection signal delay. Besides, the fare collection system is off-board, at the station, which means customers do not have to buy their ticket on board. This allows for faster stop times. Apart from time-saving property, the specialized designed station platform will make easy boarding possible and enhance accessibility of BRT, and provide a higher rate of comfort for passengers. Furthermore, the investment and operating costs of BRT are relatively low compared to urban rail transport such as LRT (Light Rail Transit) and MRT (Mass Rapid Transit). Generally, BRT system is a comprehensive transport system allowing higher speed, lower cost, improved capacity and better bus safety.

2.2. Research on Ridership in BRT System

Research on ridership of public transport system came from a variety of perspectives. According to classification, there are three main lines of researches. These lines are as following:

Firstly, many research focus on social, economic, land-use pattern, and built environment factors that affect the ridership of public transport system(Currie & Delbosc, 2011, Estupiñán & Rodríguez, 2008, Taylor, Miller, Iseki, & Fink, 2009, Zhao, Deng, Song, & Zhu, 2013,). For instance, Currie and Delbosc(2011) analyse the influence of employment and residential density, car ownership, vehicle trips, etc. on ridership of Australian BRT systems which is focused on route-level ridership. The objective of this kind of studies is just to find and explain factors affecting the ridership/patronage on present public route or stations of present traffic system. Besides, Cardozo, García-Palomares, & Gutiérrez(2012) and Gutiérrez, Cardozo, & García- Palomares(2011) forecast transit ridership on station-level. However, all these studies ignore the potential ridership refers to the proportion of people who are likely to use public transport as primary transportation mode, once the public transit facility becomes available and accessible to these people.

The second line of research concerns accessibility of public transport system itself, Kalaanidhi and Gunasekaran(2013) evaluates accessibility of urban transportation networks and assess its influence on the ridership of bus transit system. The ridership is about boarding and alighting which is on spatial unit for only one corridor. And Chandra et al(2013) analyses feeder transit through accessibility to solve the first/last mile transport connectivity problem to increase ridership, it evaluates the accessibility for feeder service, which focus on the feeder supply level.

The third kind of research looks at travel demand or travel needs, to increase ridership based on meet traffic demand. For example, Gahlot, Swami, Parida, and Kalla(2012) select high ridership oriented BRT corridor based on transit demand forecasting. They forecast travel demand based on traditional four stage travel demand modelling in GIS environment. Paulley et al(2006) report factors affecting the demand for public transport. Yao (2007) studies public transport from the potential demand for public transit, the study analysed potential demand for social-economic aspect and spatial aspect. Jaramillo, Lizárraga, and Grindlay(2012) examine the relationship between social exclusion and transport, and have a greater focus on the factors explaining the social need for transport to improve BRT services. Bocarejo S. and Oviedo H(2012) identify mobility needs based on accessibility. Currie(2010) measures public transport supply and needs to quantify spatial gaps. All these researches on ridership are listed table 2.1.

Table 2.1 Ridership literature matrix

Paper	Short description	Type	Level
(Currie & Delbosc, 2011)	Analysis of variables that increasing ridership on BRT routes.	Ridership impacted factors	Route level
(Estupiñán & Rodríguez, 2008)	Examination of the environment characteristics of station ridership.	Ridership impacted factors	Station level
(Taylor et al., 2009)	Analysis of the determinants of transit ridership across US urbanized areas.	Ridership impacted factors	Route level
(Zhao et al., 2013)	Study the impacts of factors on ridership within Metro station in China	Ridership impacted factors	Station level
(Gutiérrez et al., 2011)	Forecast boarding at the Madrid Metro station based on distance-decay weighted regression.	Forecasting ridership based on regression	Station level
(Cardozo et al., 2012)	Forecast boarding at the Madrid Metro station	Forecasting ridership based on regression	Station level
(Kalaanidhi & Gunasekaran, 2013)	Estimation of Bus Transport Ridership Accounting Accessibility	Forecasting ridership based on accessibility	Spatial unit
(Chandra et al., 2013)	Analysis of feeder transit through accessibility to solve the first/last mile transport connectivity problem to increase ridership	Improve connectivity and ridership based on accessibility	Feeder supply level
(Gahlot et al., 2012)	Selection high ridership oriented BRT corridor based on transit demand forecasting.	Selection new corridor	Demand level
(Paulley et al., 2006)	A collaborative study of factors affecting the demand for public transport.	Ridership impacted factors	Demand level
(Yao, 2007)	Analysis potential demand for social-economic aspect and spatial aspect.	Examination travel demand	Spatial unit
(Jaramillo et al., 2012)	Examination the relationship between social exclusion and transport, and have a greater focus on the factors explain the social need for transport to improve BRT services.	Spatial gaps between need and supply	Spatial unit
(Bocarejo S. & Oviedo H., 2012)	Identification social inequities and mobility needs based on accessibility.	Calculation of accessibility level	Spatial unit
(Currie, 2010)	Measurement about public transport supply and needs to quantify spatial gaps.	Spatial gaps between need and supply	Spatial unit

In the whole, many measures have been used for measuring ridership in public transport system. As mentioned above, the first and second lines of research focus on ridership along current public transport corridors or at station level. Through these researches, we can know what factors have big impact to ridership, so ridership can be improved by enhance different factors, like building feeder transit to improve accessibility to solve connectivity problem so as to increase ridership(Chandra et al., 2013). However, researches study ridership based on station level or route level are from the aspect of public transport supply level. It just focus on the ridership which may increase by the existing transport system, but ignores the potential ridership refers to the proportion of people who are likely to use public transport as primary transportation mode, once the public transit facility becomes available and accessible to these people. Furthermore, even they consider potential traffic needs/demands, spatial gaps between transport supply and needs are inevitable, which may lead social exclusion(Department for Transport, 2004). On this account, expanding current BRT system based on travel demand is a way to increase ridership, but also a way to improve transport disadvantage (the gap between supply and needs).

2.3. Travel Demand Measures

Travel demand or travel needs can be identified in many ways, for example, Gahlot, Swami, Parida, and Kalla(2012) forecast travel demand based on traditional four-step travel demand modelling in GIS environment. But four-step model are costly, insensitive to land use, require excessive auxiliary data, and often have low accuracy, and it can also slow down the response to the modelling results(Cardozo et al., 2012, Gutiérrez et al., 2011). So Cardozo et al.(2012) and Gutiérrez et al(2011) forecast ridership based on Geographic Information Systems and multiple regression analysis. But the analysis is based on station level, which is improper for this thesis project focusing on potential demand beyond current transport network.

In terms of Murray and Davis(2001), Currie(2010), Jaramillo et al.(2012) and Yao(2007), they analyse travel demand/needs based on need index. The Need Index is mathematically modelled which computes a score for each spatial unit. It's a suitable method, due to each spatial unit has its own need index (the score), than the potential demand can be visualized in map through GIS. In this way, each spatial unit has its own score, high score means high demand for transit system, low score means low demand for transit system. Therefore, the BRT system can expand its coverage through the high demand areas, so the need index map can be used to improve current BRT performance.

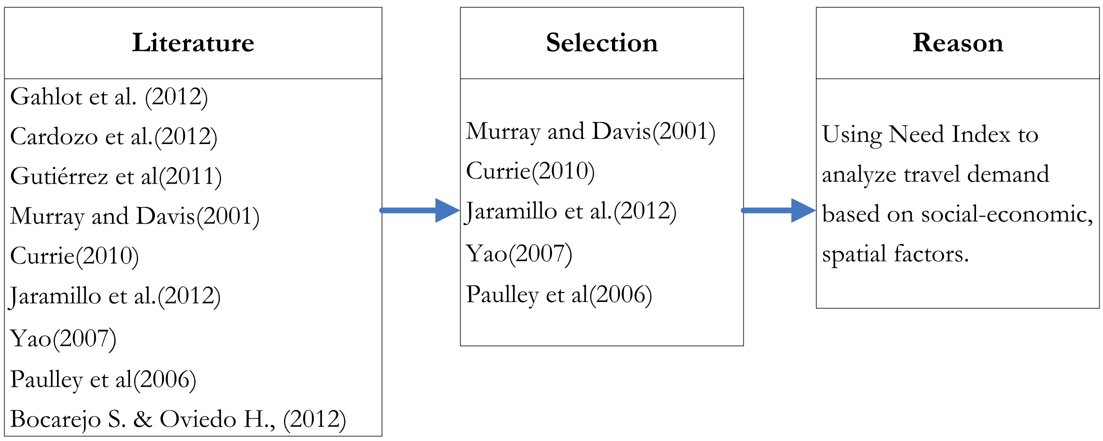


Figure 2.1 Travel demand measures selection matrix

Besides, Paulley et al(2006) report factors affecting the demand for public transport, the factors in the study can be used as reference to select factors in Jakarta BRT system. And Bocarejo S. & Oviedo

H.(2012) explains how accessibility level impact social exclusion and mobility need, which proves accessibility is an important factor to traffic demand.

Based on above discussion, the literatures that choose as related travel demand measurement is shown in figure 2.1.

2.4. Overview of Need Index Method

At present, statistics compiled for travel in urban areas give little information on unsatisfied demand or latent need, which makes it difficult to analyse the role of transport in social exclusion (McCray and Brais, 2007); the few studies about transport demand are described as below. For each study one essential work is to pay attention on specific details of derived indices(Murray & Davis, 2001).

Murray and Davis(2001) present a method to measure the potential travel need with a linearly weighted function of related indicators based on spatial units. The function index of is the following:

$$\Phi_i = \sum_j w_j R_{ij} \qquad 2\text{-}1$$

"Where *i* is the index of geographic areas; *j* is index of indicators or variables; w_j is importance weight of indicator *j*; R_{ij} is the derived value of indicator *j* in area *i*; Φ_i is the measure of relative need." (Murray and Davis,2001)

Adjusting weights by using raw indicator values is difficult, so Murray and Davis transforms each variable from the least needy to most needy for public transport into ordinal ranks. It's useful but involves significant subjective choices, and coarse measurement of index which limits the application of this method.

Currie(2010) uses need index to reflect social need associated with transport disadvantage for 5839 census collector districts (CCDs) of Melbourne's. The methodology involves assembling transport need indicators for spatial unit and defining a need score for each spatial unit based on the transport need indicator values.

The transport need indicators are selected through the Australian Bureau of Statistics Index of Relative Socio-Economic Advantage/Disadvantage (IRSAD). The chosen indicators are described as below:

- Adults without cars
- Persons aged over 60 years
- Accessibility
- Persons on a disability pension
- Low income households
- Unemployment
- Students
- Persons 5–9 years

The formula for calculating needs scores is as follows:

$$NS=\sum (SI1* WI) + (SI2 *W2) +\cdots+ (SI8 *W8) \qquad 2\text{-}2$$

Where, SI1- SI8 is the standardized indicators. WI1–WI8 is the weight for indicator I1–8. Weights were sourced from travel survey which analyses low trip making behaviour. Finally a single need score between 0 and 100 is generated from the indicators.

However, this Need Index is hard to realize in specific situation of Jakarta where no social-economic Advantage/Disadvantage index has been calculated. Besides, the weights were sourced from an analysis of low trip making behaviour from the Adelaide Household Travel Survey (Currie, 2004) which is also hard to analyse in specific situation of Jakarta

Jaramillo et al. (2012) propose a methodology which is similar as Currie (2010). But given the particularities shown for the study city of Santiago de Cali, they have modified the weightings from the point of build-in variables, more according to its socio-economic and urban condition, in order to demonstrate the importance of the factors. The Index of Transport Social Needs (ITSNs) has been calculated as follows:

$$ITSN_J = \sum_{i=1}^{n} TI_{ij} P_i \quad \text{2-3}$$

"Where $ITSN_j$ is the Index of Transport Social Needs for the district *j*; TI_{ij} the Standardized Indicator of Transport Disadvantage for factor *i* for the district *j*; and P_i is the Weighting of the Indicator of Transport Disadvantage for factor *i*. "(Jaramillo et al., 2012)

The method uses a high number of selected indicators. The chosen indicators are as below:

- Non-ownership of private vehicle
- Old age
- Disabilities
- Unemployment
- Academic study
- Socio-economic situation
- Children
- Illiteracy
- Degree of accessibility to the center
- Degree of accessibility to educational services
- Degree of accessibility to recreation and leisure
- Degree of accessibility to health services
- Socio-economic level of the district
- Degree of insecurity
- Degree of accessibility to economic activities

However, through weightings application of a multi-variant analysis (the Principal Components Analysis (PCA)), the selected indicators were reduced to another smaller group. This weightings method is very useful as it reduces the high number of selected indicators (Jolliffe, 2002) and explains high percentage of the total variance.

Yao (2007) examines potential need with multiple regressions to identify predictive variables for the share of public transportation for working commuting trips. The formula for Need Index (NI) is as follows:

$$\mathrm{NI} = \sum_{i=1}^{n} \beta_i x_i \quad \text{2-4}$$

"Where x_i is the land use and socioeconomic variables or any other contributing variables that are not related to the transit systems; β_i is the coefficient from a correlation analysis among these independent variables. " (Yao, 2007). The chosen indicators are as below:

1) Land-use characteristics:
   - Population density.
   - Employment rate.
   - Job density (total jobs in the TAZ divided by the area of the TAZ).
   - Average number of jobholders per household.
   - Percentage of home workers.
2) Socioeconomic characteristics:
   - Income: three different income levels.
   - Car ownership: Percentages of jobholders whose households have 0, 1, or 2+ vehicles, respectively.
3) Network structure: •
   - Density of public transit stops.

This method is efficient due to it ignores trips such as access to doctors, hospitals, chemists and other key activities so that the analysis is less cumbersome. It focuses on commuting trips, especially working trips, which is a big component of all the trips. But it ignores other kind of trips, like home to school trip, which also occupies a large proportion of public transport trips in Jaramillo et al.(2012)'s analysis. In Jaramillo's study, student population is a main indictor which impact public transport need. And as above Need Index (NI), it probes variables that are innate to the spatial unit, which means the NI ignores accessibility factors, which means transit accessibility will not impact public travel need. However, potential demand is generated by the desire to join in activities, trips will be generated if road network covers these demand area, so low accessibility means more travel need(Zuidgeest & Maarseveen, 2011). And Bocarejo S. & Oviedo H.(2012) explains how accessibility level impact social exclusion and mobility need, which proves accessibility is an important factor to traffic demand.

Through the above analysis, to find specific details of derived indices is the vital part of Need Index analysis. The common of above studies is they all select land use and socioeconomic factors, such as population density, employment rate, job density, average number of jobholders per household, income, car ownership, as travel demand analysis indicators. But for accessibility, they have different opinion. Jaramillo et al. (2012) and Currie (2010) choose Distance from CBD as the main indicator, but Yao (2007) does not use any accessibility indicator. As mentioned before, potential demand is generated by the desire to join in activities. So individuals who live far away from CBD have higher desire to use public transport than people live nearby CBD due to the need to join activities in CBD. Therefore, accessibility is chosen as an indicator in Jakarta BRT travel demand analysis. Due to most of the trips in Jakarta is home to work trips; accessibility to the labour market should be calculated to reflect travel demand.

2.5. Accerssibility

Conception

Accessibility shows a large range of measurements and applications embracing various issues and spatial scales. Recent reviews include those of (Handy & Niemeier, 1997)) and (Karst T. Geurs & van Wee, 2004). Three main clusters can be identified according to Wee, Hagoort, & Annema, (2001) for accessibility definitions and measures: infrastructure- related, activities-related and mixed approaches.

"The first approach focuses on characteristics of transport supply and demand; the activities approach is associated with land use and location, focusing on the number of activities accessible in a given range of travel time or distance. The last approach combines the preceding two, making a more complete analysis of accessibility; Generally, nearly all accessibility definitions and measures consider elements linked with generalized travel costs, demand characteristics such as number of households, job clusters, commercial activities, and origin–destination interaction and access." (Wee, Hagoort, & Annema, 2001)

Measuring Accessibility

Studies by Geurs & van Eck(2001)and Geurs and Wee (2004) remark four different perspectives for measuring accessibility: infrastructure, location, personal, and utility.

- "Infrastructure measure emphasizes on analyzing accessibility in accordance to transport system performance. This is based on certain indicators that are commonly used in transportation planning such as congestion level, travel speed over road network." (Geurs & van Eck, 2001)and (Geurs and Wee, 2004)
- "Location measure analyses accessibility based on the ability to reach distributed socio- economic activities. This approach is ordinarily undertaken at macro-level by quantifying the number of potential socio-economic opportunities that is possibly to be reached within particular constraint parameters (i.e. distance, time travel)." (Geurs & van Eck, 2001)and (Geurs and Wee, 2004)
- "Personal measure analyses accessibility at individual level. This perspective emphasizes on the flexibility of individuals to do particular kind of socio-economic activities as supported by transport services within certain temporal constraints. For instance, better accessibility is illustrated by the opportunity for individual to do different activities in the evening (i.e. shopping, leisure) because these activities are supported by 24-hour available transport service." (Geurs & van Eck, 2001)and (Geurs and Wee, 2004)
- "Utility measure is based on economic benefit that individuals gain from available transport alternatives to reach spatially distributed opportunities." (Geurs & van Eck, 2001)and (Geurs and Wee, 2004)

Accessibility selection

As mentioned in research question, accessibility measures are used to analyse travel demand and traffic supply. For public transport demand, as working trips is the main component of public commuting trips in Jakarta, analysing job accessibility is necessary to find the latent influence for travel demand. From above measuring accessibility, location based (gravity-based) accessibility is suitable for analyse job accessibility. As discussed in the previous section, gravity-based accessibility is the most commonly used method for measuring accessibility due to its' relatively low data requirements and technical demands. The most basic form of the gravity-based accessibility function consists of an opportunity term and an impedance function:

$$A_{\mathrm{ij}} = O_j f(D_{ij}) \qquad \text{2-5}$$

Where, A_{ij} = Accessibility from origin zone *i* to destination zone *j*

O_j = Opportunities in destination zone *j* (job opportunities in destination zone *j*)

D_{ij} = Generalized distance from origin zone i to destination zone *j*

$f(D_{ij})$= Impedance function

For supply level analysis, which mainly focuses on infrastructure, using the infrastructure based accessibility measuring is suitable for the special situation of Jakarta of congestion.

2.6. Overview of Supply Level

The supply measurement in Jakarta BRT system aimed to create a measure of transport supply for each spatial unit. But other methods for analysing service quality in public transportation are focus at service level, rather than spatial distribution. For example, Service level that is calculated by comparing different bus lines is useful for users to decides which bus lines to select for a specific journey. But it's not suitable for analyse spatial unit supply level. For the supply level in this research, infrastructure based supply is considered due to the aim of supple level analysis is to examine the coverage of current BRT system. Therefore, to measure BRT transport provision in each spatial unit, the following methodologies are mentioned.

Murray and Davis(2001) present an access analysis method for measuring public transport service provision. In fact, transport service provision could focus on service quality, such as regularity of service, travel time from origin to destination, and services may be reached. Though the level of access analysis for measuring public transport service provision is simple, "its simplicity and ease to understand is precisely the reason that it is relied on in planning and policy processes."(Murray & Davis, 2001)

Currie(2010) creates a combined measure of service frequency and access distance to measure transport supply for each census collector district (CCD). The approach explains the transport spatial coverage of each CCD based on walking catchments to public transport and relative service levels. The service level is accounts for the number of bus/tram/train vehicle arrivals per week. The approach is relatively simplistic but account for broad levels of supply(Currie, 2010).

Jaramillo et al. (2012) propose a methodology to present Index of Public Transport Provision by an index of infrastructure based topological accessibility(Rodrigue, Comtois, & Slack, 2006) (Geurs & Wee, 2004). The infrastructure topological accessibility is related to measure accessibility in a system a transportation network. It is assumed that accessibility is a measurable attribute significant only to specific elements of a transportation system, such as terminals (airports, ports or subway stations). Based on above theory, the supply index is calculated as the quotient of the total sum of the stops for the district by each service or mode available weighted by an indicator of capacity of the vehicles and another of the average frequency of service for each stop. It is an improved method than Currie's due to the consideration of more detail indicators, such as number of passengers of each stop, and the population of the district in relative term.

For the supply level analysis in Jakarta BRT system, infrastructure coverage and level of service available for each stop is the main considered characteristics. From above studies, Jaramillo et al. (2012) mythology is suitable for the situation of Jakarta system. But due to the high congestion and data limitation in Jakarta, supply index analysis can follow Jaramillo et al. (2012) but modified by Jakarta special situation.

3. STUDY AREA

This chapter provides a brief description of Jakarta Metropolitan Area, especially focus on the transportation of Jakarta Metropolitan Area. This chapter discusses overall socio-economic and mobility characteristics in the study area. In addition, the overview about the dataset that are used in this research (JUTPIP and GIS dataset) is generally explained.

3.1. Introduction to Study Area

Jakarta Metropolitan Area (JMA) is the study area in this research. JMA is the largest metropolitan area in the Southeast Asia, it consists of five cities: (1) Central Jakarta (Jakarta Pusat); (2) South Jakarta (Jakarta Selatan). (3) West Jakarta (Jakarta Barat); (4) East Jakarta (Jakarta Timur); (5) North Jakarta (Jakarta Utara). Moreover, in the surrounding areas of JMA, there are certain satellite cities in the vicinity that together with JMA called the Greater Jakarta. The depiction of JMA is shown on figure 3.1

1. Centre Jakarta

Central Jakarta (Jakarta Pusat) is the political and administrative centre. It has some part of CBD (central business district). The development in this area is very dense and characterized by high density. As political Centre, the facilities of this area are well developed which create good amenity for this area supported by green corridors, well planned parks.

2. South Jakarta

South Jakarta (Jakarta Selatan) is the main compactness area of CBD. The functional structuring of this area is commercial which has large amount of skyscrapers, large scale of shopping centres and elite apartment. This area fortifies its function as the compactness of CBD by novel designed skyscrapers and modern lifestyle of its inhabitant.

3. West Jakarta

West Jakarta (Jakarta Barat) is the compactness point for small scale industries. This area has 12 centres of small industries. (Analisis, 2012) The development in this area is still in horizontal level.

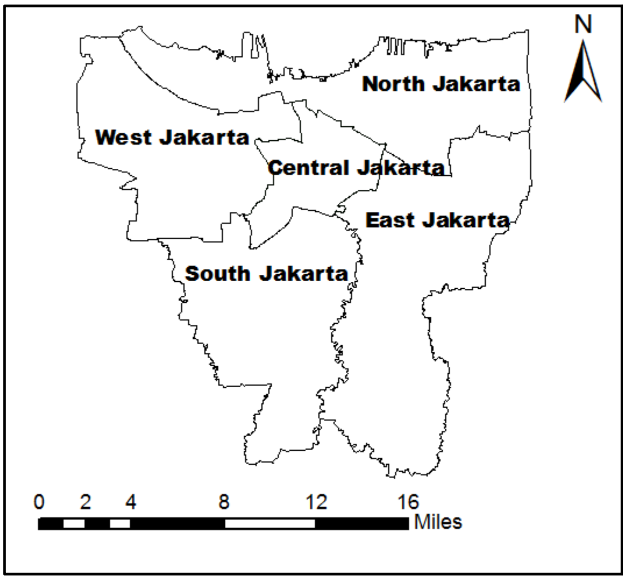
4. East Jakarta

East Jakarta (Jakarta Timur) is characterized by large number of middle and low class settlements and some of industries. Some of the settlements are informal which is called "*kampong*" due to high demand of housing from middle and low income class. It's a high dense area because 1 house normally inhabited by many people, sometimes even inhabited by two or three families. Many "*kampong*" are still in poor situation and do not have base infrastructure.(Frank, 2011).

5. North Jakarta

North Jakarta (Jakarta Utara) is the only area surrounded by the Java Sea in Jakarta. The main functions of North Jakarta are trade, industry and tourism. It has the most important export-import national port. And some well-known parks, such as Ancol Dreamland, the largest integrated tourism area in South East Asia, are regarded as the important parks for tourism.

Moreover, in the surrounding areas of JMA, there are eight satellite cities in the vicinity that together with JMA called the Greater Jakarta. They are: (1)Kabupaten Bekasi; (2)Kabupaten Bogor; (3)KabupatenTangerang; (4) Kota Bekasi; (5) Kota Bogor; (6) Kota Depok; (7) Kota Tangerang; and (8) Kota Tangerang Selatan. The depictions of greater Jakarta are shown on figure 3.2.



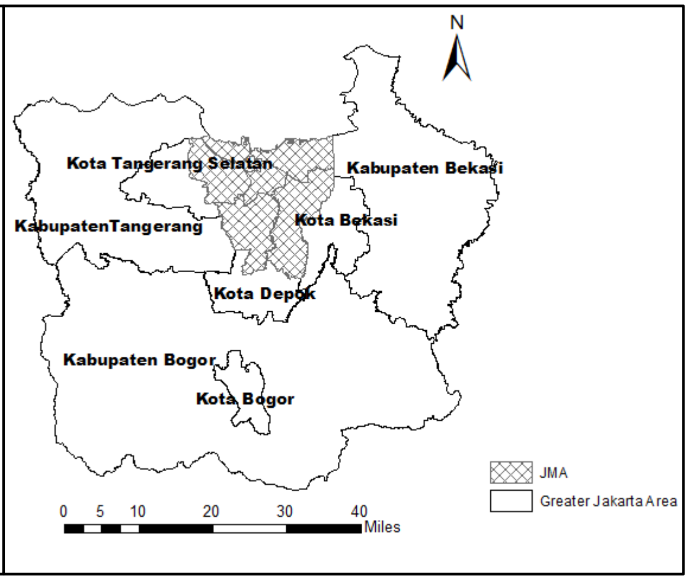


Figure 3.1Jakarta Metropolitan Areas

Figure 3.2 The Greater Jakarta Area

Issues in Jakarta Metropolitan Area

Jakarta Metropolitan Area (JMA) is a strong socio-economic activities center of national scale since some decades ago which absorbs new migrants from all over Indonesia and result in abrupt urbanization. This built-up area expanding system unavoidably causes spatial mismatch, like spilled-over development to areas surrounding Jakarta. And accelerates car oriented communities and creates poor mobility of public transportation(Sasono et al., 2001).

3.1.1. Demographic Overview and High Commuting

The total population size in JMA amount in 2011 to round 10 million people and the average population density is 15.4 thousand inhabitants/ km^2 (State Ministry of National Development Planning, 2013). Each municipality of JMA more than 1 million has population.

In The distribution of population and population density in the great Jakarta area is shown by following Figure.3.3 and 3.4.From the density maps, implication can be made that suburbanization has rapidly developed and population has spread out in satellite cities areas to seek better life quality.

The population movement toward suburban area has generated longer trips between residence and workplace and given much burden on existing transport infrastructure and mobility problem which result in high commuting trips.

Coordinating Ministry of Economic Affairs(2012) point that the amount of commuters in JMA has increased approximately 1.5 times between the period of 2002 and 2010, (Figure 3.5). The most significant increase of commuting trips is derived from Kabupaten and Kota Bekasi, which are 262 thousand to 423 thousand commuters. The amount of commuters in Kota Tangerang, Kota Tangerang Selatan, and Kabupaten Tangerang, and the number of commuters from Kota Depok, Kota Bogor, and Kab. Bogor all increased 1.4 times separately from 247 thousand to 344 thousand commuters and 234 thousand to 338 thousand commuters.

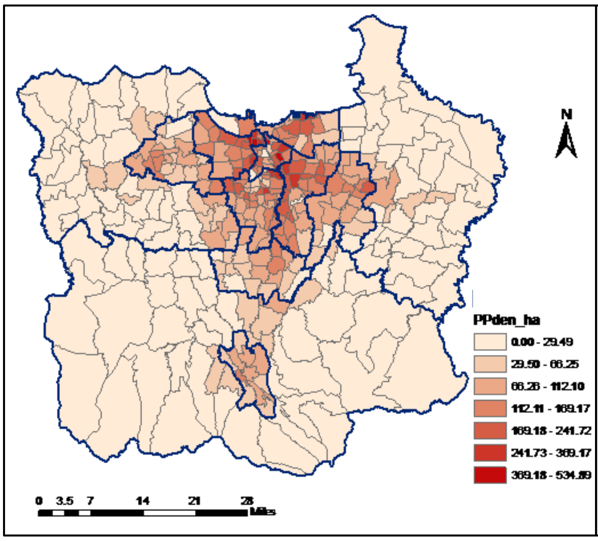


Figure 3.3 Density maps, 2004

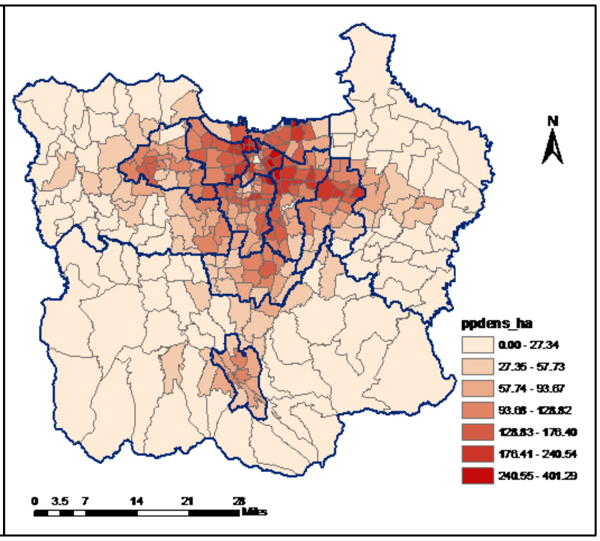


Figure 3.4 Density maps, 2010

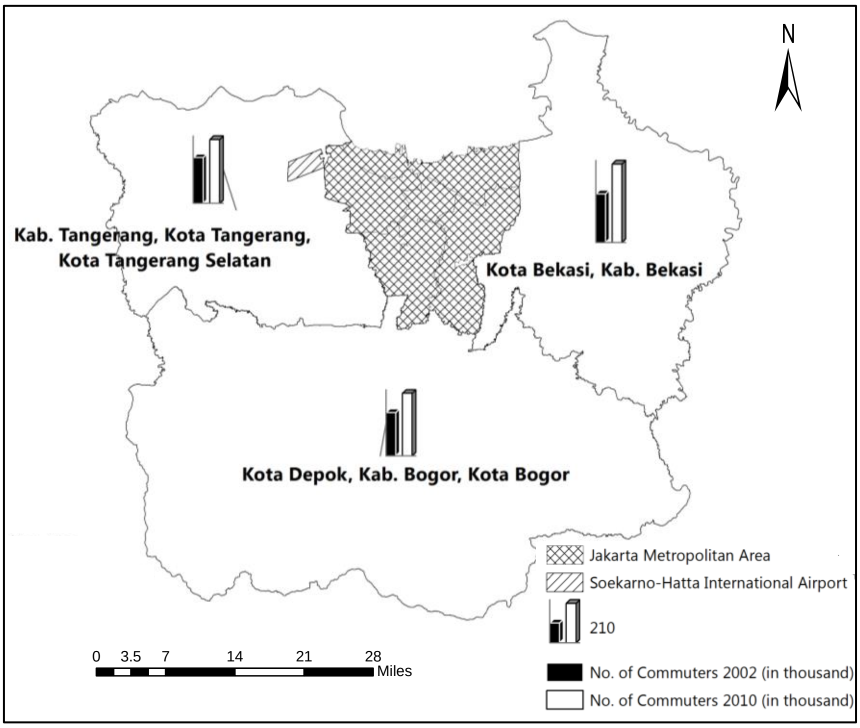


Figure 3.5 Change in the number of commuters in satellite cities in Jakarta Metropolitan Area between 2002 and 2010

3.1.2. Motorization and Traffic Congestion

The number of vehicle, especially motorcycles and passenger cars increase every year in Jakarta. The growth rate of car ownership is approximately 2.5% a year and the growth rate of motorcycle ownership is 14.5% a year (Analisis, 2012). The road network of Jakarta is predominated by personal vehicle. The number of each transportation modes in Jakarta is shown in figure 3.6.

As shown in the research of Mochtar and Hino (2006), vehicle increases approximately 10% whereas infrastructure only grows 1%, which means people is over dependent on private vehicles. Coordinating Ministry of Economic Affairs (2012a) points that, in 2010, the amount of working commuting trips in JMA reaching 1.1 million, which is predominated by private vehicles. Commuting trip by motorbike is about 48.7% and 13.5% by private car. Interestingly, non-motorized trip contributes to 22.6% to the total home-to-work trips. Trip by bus is about 12.9%, whereas other transport mode trips are equal to 5%.

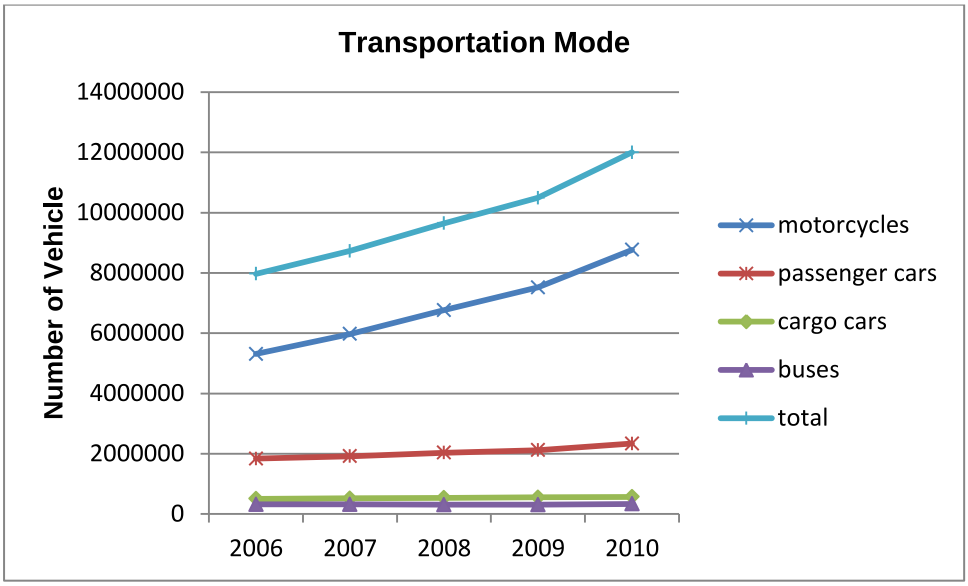


Figure 3.6 Transportation Modes in Jakarta (Source: Jakarta in Figure, 2012)

The high number of commuter trips and the high overdependence to private vehicle surely leads to traffic saturation. The decrease in the travel speed during the peak hour period can prove the congestion situation. During the peak hour period, the average travel speed decreases from approximately 20-30 km/h into 5-15 km/h.

3.1.3. Traffic problem for urban poor

The low-income social group (urban poor) primarily suffers from the deficiency of public transport service. Urban poor is defined as the social group that has various limitation to access employment opportunities and income, decent and secure shelter, health and education opportunities, and social protection (Baker, 2008). In terms of their mobility behavior, urban poor primarily utilizes non-motorized transport (NMT) mode such as walking and cycling (Kumar et al., 2013), and in Jakarta, the proportion of trips by NMT is approximately 41%(Wachyar, 2014). Although NMT is the most attractive mode for urban poor, it is limited to short trips (travel time less than 30 minutes). Except non-motorized mode, motorbike has the highest proportion (41%), but this mode is also limited for longer travel time. In general, the potential usage of NMT and motorbike is high when the travel time is relatively short whereas the usage of public transport is relatively stable at the longer travel time(Wachyar, 2014).

However, in terms of car trips, compared to the middle and high-income social group, urban poor is more difficult to access distant job opportunities by car, and urban poor relay on public transport for longer trips as mentioned above. Thus, the improvement of public transport service is essential in order to release the poor from the social exclusion as well as to improve their likelihood.

3.1.4. Public Transport

Coordinating Ministry of Economic Affairs(2012) states that transportation mode of commuting trips has significant changed from 2002 to 2010. The car and motorbike ownership has increased, whereas the bus users of commuters have decreased from approximately 40% in 2002 to 17% in 2010. The service provided by public transport is still based on demand-supply approach. Many of the busses are operated by private company, which are in poor, unclean and crowded conditions.

The government has already tried to solve public transportation problem by developing a Bus Rapid Transit project call TransJakarta since 2004 to improve public transport service to solve the mobility problem in JMA. TransJakarta was designed to provide Jakarta citizens with a fast public transportation system to help reduce rush hour traffic. The buses run in dedicated lanes and ticket prices are subsidized by the regional government. Currently, the BRT system has a total of 12 corridors as of 2013, covering more than 241 km (75% exclusive lane), 670 buses and 213 stations. The system is still expanding and by 2015, 15 corridors will be in operation and over 400 new articulated buses will be brought into the system(Adiwinarto, 2013).

3.1.5. BRT (TransJakarta Busway) system

Beside the poor public transport, the government has built TransJakarta Busway to reduce the traffic congestion by providing service for commuting trips, and to incite people shift from private car to public transport in order to reduce traffic congestion. The operation is considered moderately successful but estimations are that it is operating much below design capacity(Enhancing Jakarta's BRT System, 2012). Despite its vast network, the system has not been sufficiently effective and is still considered not optimum. As shown by Nobel, Yagi, & Kawaguchi (2013), the BRT system is not yet effective to shift from private vehicle user into public transport user. One way to enhance the performance of the BRT system is to expand the coverage area of BRT system to increase the ridership on their lines and run efficient services, in particular commuters who make use of private transport (Enhancing Jakarta's BRT System, 2012).

3.2. Introduction to the Dataset

There are two databases for this study: (1) Jabodetabek Urban Transport Policy Integration Project (JUTPIP); and (2) Geographic Information System (GIS) Database. JUTPIP is an interview survey on commuting trips for more than 180,000 households in 2010 the Jabodetabek(Greater Jakarta) area.it also includes travel characteristics. Coordinating Ministry of Economic Affairs of the Republic of Indonesia and the Japan International Cooperation Agency (JICA) cooperated the survey. Secondly, GIS database, which is called "Study on Integrated Transportation Master Plan for the Jabodetabek(SITRAMP) is a spatial database system that was developed for the project. State Ministry of National Development Planning and JICA also collaborated with this project.

For this these project, these two dataset are complimentary for each other. The spatial GIS dataset has attributes linking the attribute of JUTPIT survey data which contains the information about commuting trips; therefore the JUTPIP survey information can be spatially visualized. However, there is a drawback from linking these two data in term of spatial resolution. In general, JUTPIP dataset has smaller spatial resolution in comparison to the GIS dataset. In order to deal with this issue, the spatial processing in ArcGIS is undertaken (see Chapter 4)

3.2.1. JUTPIP Commuting Survey

The JUTPIP commuting survey is an interview survey on commuting trips based on households within the Greater Jakarta area. Three kinds of main information are contained in this survey: (1) household socio-economic characteristics; (2) household members' choice about traffic modal for commuting trips; and (3) household member individual trip record data. The survey consists of 178,953 household samples (household dataset), 657,165 household members (household member dataset), 186,819 individual samples for home-to-work trips, and 129,849 individual samples for home-to-school trips.

JUTPIP survey dataset consist mainly three kinds of dataset: (1) household dataset; (2) household member dataset; and (3) individual member person home-to-work and home-to-school trip dataset. The relational diagram among these three dataset is shown in figure 3.7. In principal, household dataset is commuting information dataset that include of household characteristics, such as such as origin-destination information, transportation mode, cost etc. Each household in commuting dataset has its own household members that are recorded in the household member dataset; the household member dataset has all members of each household, and household member dataset has the basic information such as age and gender. Moreover, there is a relationship between the household member dataset and the individual member trip data. Each household member has 0 or 2 trips that are recorded in the individual member trip dataset.

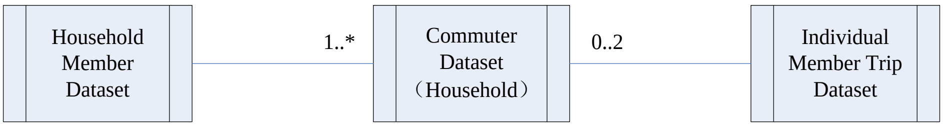


Figure 3.7 Relational diagram among household, household member, and individual member datasets in JUTPIP commuting survey

3.2.2. GIS Database

The GIS database of the SITRAMP project is a comprehensive dataset that consists of (1) infrastructure (transport and utility); (2) land use; (3) zoning system; and (4) geographic. Additionally, social economic dataset has income and population, employment, etc. information which can provide specific social-economic information combine with JUTPIP commuting survey. In this study, the important application of the GIS database is to link spatial information (i.e. road infrastructure, administrative boundary) and social-economic information with commuting and household characteristics information that is collected in JUTPIP commuting survey. In the GIS database, four main datasets are used: (1) infrastructure network (particularly road network); (2) administrative boundaries; and (3) social economic data and (4) land use dataset.

From above data description, the dataset that are used in this thesis project is shown as table 3.1. The two dataset are derived from Coordinating Ministry of Economic Affairs and JICA. These data are collected based on secondary data collection method in the form of soft files. This means that the researcher does not directly collect the data in the field. The data is collected by contacting the institution that has right to distribute the data.

Table 3.1 Description of dataset that are used in this research Dataset

Dataset	Sub Dataset	Year
JUPTIT commuting survey	Household	2010
	Household Member	2012
	Household Member Individual trips	2010
GIS dataset	Infrastructure network	2002
	Administrative boundaries	2002
	Social economic data	2010
	Land use dataset	2010

3.3. DELINEATION OF THE STUDY AREA

The study area is focus on JMA instead of analyzing the entire area of the Great Jakarta due to this study aimed at evaluating the BRT system, and BRT is concentrated in JMA. Therefore, JMA study area is chosen as with sufficient data. Moreover, comparing JMA with Great Jakarta area, JMA has the advantage of time and resource as the following practical reasons:

- Datasets for JMA are more complete and comprehensive rather than satellite cities around the JMA. The possibility of problems result from data incompleteness can be minimized by focusing on the JMA instead of Great Jakarta.
- Great Jakarta has a great quantity of datasets. Due to time availability and resources are limited for this research, limiting the scope of the study area to make this research more manageable is necessary.

3.3.1. General Approach

In this study, there are two major approaches for understanding spatial unit of the study area. Generally, the spatial unit can be based on administrative boundary or practical boundary.

• Administrative boundary (Figure 3.8) is based on bureaucratic level arrangement which is a geographical categorization.

• Practical boundary (Figure 3.9) is based on specific purpose which is a geographical categorization. Principally, the arrangement of practical boundary is based on:

- Postal coverage (GIS database).
- Survey data collection (i.e. demographic survey, transportation survey) which divides an area into several parts/zones. The JUTPIP commuting survey data is an example of practical boundary

A consistent delineation is used to confirm Administrative boundary. On the contrary, practical boundary is based on specific purpose which is more flexible. For example, JUTPIP project with detail field data collection are required at very detailed level.

Moreover, practical boundary is also used to delineate appropriate spatial unit in certain aspects. In terms of transport studies, Traffic Analysis Zone (TAZ) is an ideal analysis spatial unit. Commonly; criteria for defining TAZ are based on (1) land use homogeneity; and (2) number of residing population in certain zones (Ortúzar andWillumsen, 2011).

However, TAZ is often defined by practical approach. On one hand, to avoid significant error in analytical process the size of TAZ should not be oversize. On the other hand, the size of TAZ should be big enough to provide quite detail information. So it's usually much obstructed to define ideal TAZ based on data availability. In practice, attribute data for analyzing traffic related problems are available at such as administrative level, which is more rigid spatial unit. And data based on above spatial unit is quite difficult to disaggregate. Therefore, more practical and convenient zones such as postal code are used for defining TAZ for transport studies.

Furthermore, for this thesis project, the study area is disaggregated into more detailed spatial unit, the JUTPIP survey zone level. The aim of this project is to do appropriate traffic survey. The JUTPIP survey zone has specific predefined geographical zone attribute which can link with Administrative zone system.

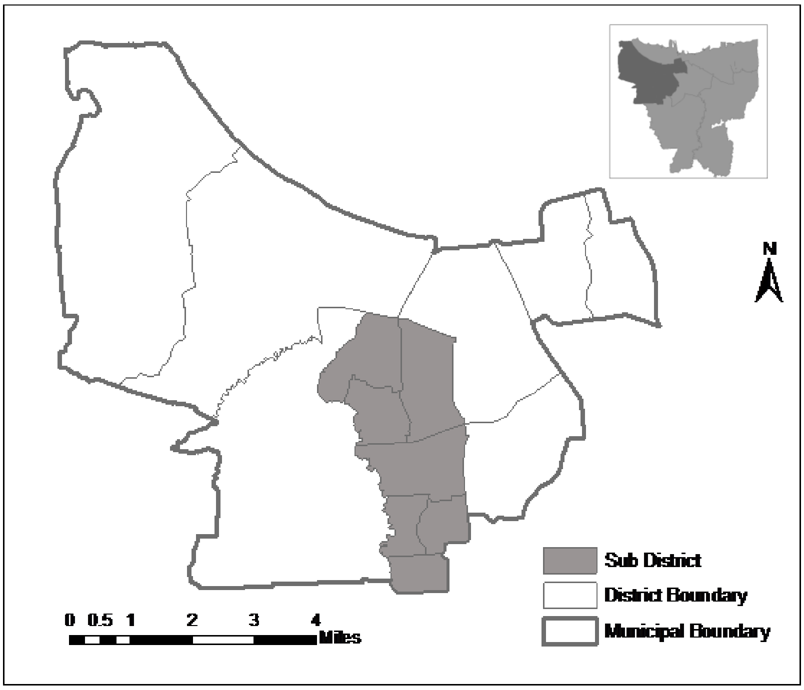


Figure 3.8 Administrative boundary (Sample: West Jakarta Municipality)

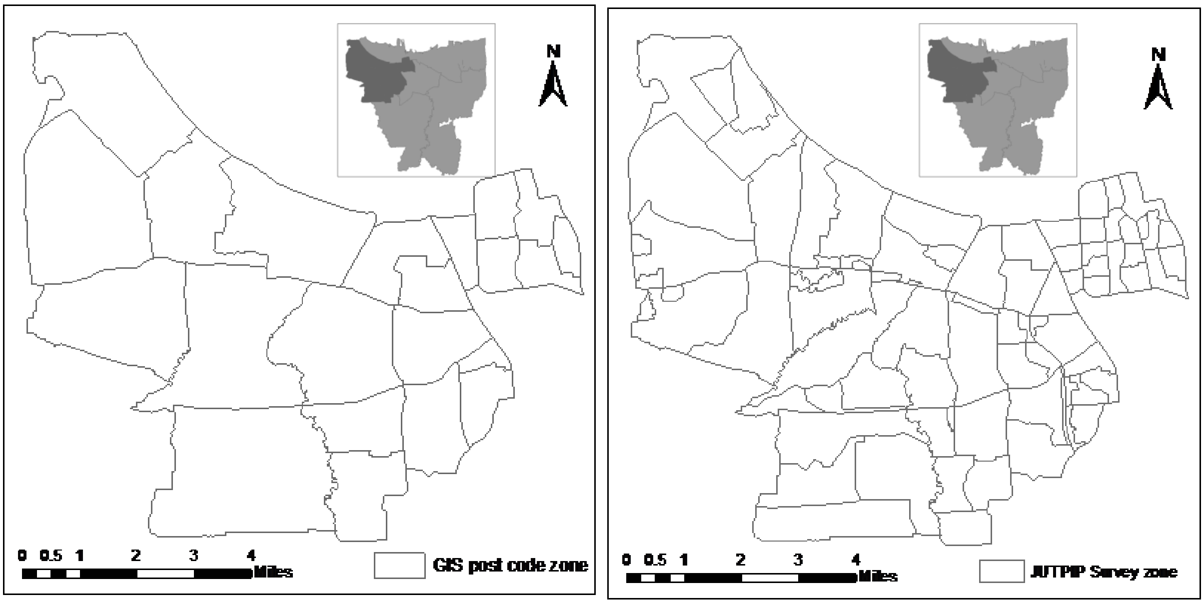


Figure 3.9 Practical boundary (Sample: West Jakarta Municipality)

3.3.2. Study Area Delineation

This research purpose is analysing transportation in Jakarta, so TAZ is used due to it is an ideal analysis spatial unit for transportation studies.TAZ is defined based on practical approach rather than ideal approach in this research due to ideal TAZ need specific information to elaborate, but in this study area, no official document has this information and this TAZ need to be able to integrated spatial attribute information from JUPTIP survey and GIS database which is hard to realize in ideal TAZ.

In the database, there are two practical boundaries which are based on post code level and survey zone level as shown in figure 3.9. However, this thesis prefers to use JUTPIP zone as the spatial unit to analysis travel demand and supply for the following specific reason:

- JUTPIP survey zone covers more detail information than post code. For travel demand analysis, indicators about commuting information need to be extracted. This information just contains in JUTPIP survey zone.
- And job accessibility is based on OD matrix, the weakness of this method as mention in following secton 4.2.7 is it doesn't discount opportunities over distance with each zone. So the smaller the zone the better. According to Figure 3.9, the size of survey zone is much smaller than GIS zone, which can low the weakness impact.

4. METHODOLOGY

This chapter is aimed at discussing the methodology to reach the research aim. The general methodology is shown as figure 4.1.

4.1. GENERAL DESCRIPTON OF TRAVEL DEMAND MODEL

Through literature review in chapter 2, the need index is chosen as method to analyse travel demand. An Index of each spatial unit can be calculated based on social-economic and spatial factors. For analysing travel demand in the Jakarta Metropolitan Area, two steps are required in the whole research process.

Firstly, determining the social-economic and spatial factors (DI) that impact travel demand in the situation of Jakarta public transportation based on preliminary indicators (PI) obtained from literature review of need index (NI) analysis. For this step, correlation analysis is used to choose DI. Correlation analysis deals with relationships among factors. In this thesis, correlation analysis compares Commuting Public Transport Trips (CPT) with other PI to check the association of PI with CPT. The PI which has high related with CPT means it is the latent indicator which may impact public transport demand, therefore chosen as the DI for further need index analysis.

Secondly, using determined indicators (DI) based on the first step, to measure the need index of each spatial zone. There are main two steps. First, the determined indicators (DI) of travel demand are standardized so that they take values between 0 and 1. Second, each DI is weighted by using a multi-variant analysis, the Principal Components Analysis (PCA). The need index (NI) is calculated as the weighted sum of the indicators within each survey zone.

4.1.1. General approach

This research applies a quantitative approach in order to achieve the research aim and objectives. The methods comprise literature review, SQL and spatial SQL, descriptive statistics, network analysis, and accessibility modelling.

- Literature review is used in order to provide basic indicators for this travel demand research and the method of weighting the indicator. Spatial SQL is used to extract preliminary indicators (PI) from both of JUTPIP database and GIS database.
- Network analysis is the ArcGIS vector analysis functionality that is used to analyze network-based problems. In this research, network analysis is applied in order to obtain indicators like distance from origin zone to destination zone and distance from each zone to CBD. This network distance is the basis for accessibility indicator analysis.
- An accessibility model is undertaken in order to obtain the indicator of job accessibility in Jakarta Metropolitan Area.
- Statistical methods are used to provide a description between both socio-economic and spatial characteristics with public transportation commuting trips in Jakarta Metropolitan Area to extract determined indicators from preliminary indicators and to calculate need index(NI) by weighting sum of the DI within each survey zone.

4.1.2. Literature review

Preliminary indicators (PI)

Literature review is used in order to derive appropriate indicators for developing a need index model. As can be concluded from the summary of related literatures from the above chapter, the following indicators are commonly used in need index analysis.

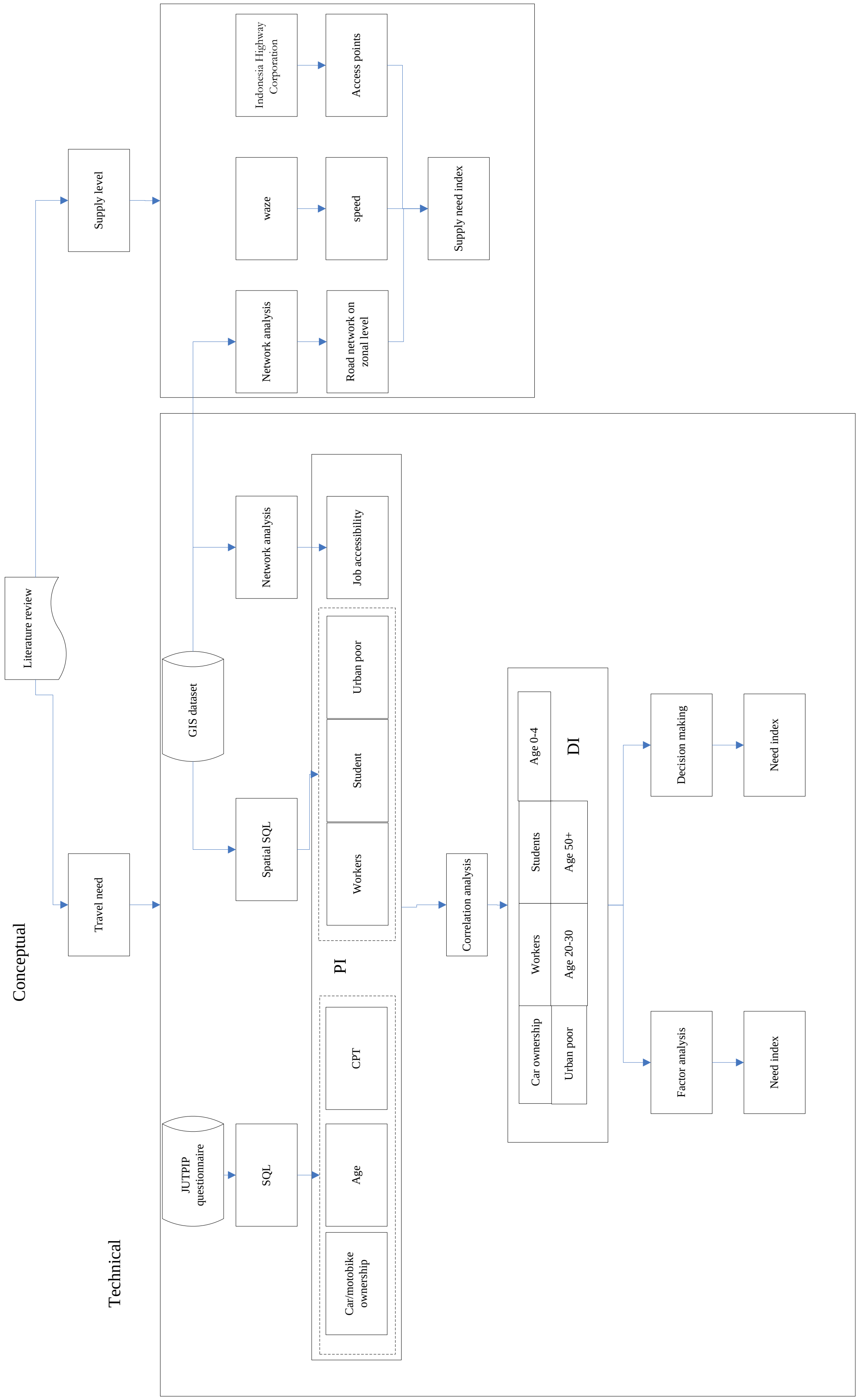


Figure 4.1 General methodology

- Socioeconomic characteristics
    - Population
    - Employment
    - Student
    - Income
    - Car ownership
    - Motorbike ownership
    - young age
- Network structure:
    - Distance to the CBD
    - Job accessibility

Table 4.1 Preliminary Indicators (PI) for need index analysis

PI	Description	Resource
Commuting Public Transport Trips(CPT)	Number of public transport trips per 1000 people of each survey zone	household member individual trip
Car ownership	Number of cars, buses, and freight vehicles per 1000 people of each survey zone	household information
Motorbike ownership	Number of motorbikes per 1000 people of each survey zone.	household information
Age	Percentage of people in different age groups of each survey zone.	household member individual trip
Workers	Percentage of individuals who has job of each survey zone	GIS database
Income	Percentage of population of different income level within each survey zone	GIS database
Student	Percentage of students of each survey zone	GIS database
Distance to CBD	The Euclidian distance from each zone centroid to CBD	GIS database
Accessibility	Accessibility to job opportunities	Combine with survey and GIS database

Above indicators are proposed from related literatures in chapter 2, which is preliminary indicators (PI) for need index analysis in Jakarta Metropolitan Area. These PI are obtained by analysing the general indictors used in literatures related to travel demand, but also combined the special situation of Jakarta, such as high motorbike ownership. However, to determine the indicators for Jakarta public transport demand, analysing preliminary indicators (PI) under situation of Jakarta is necessary to modify and construct composite indicators for Jakarta. All the preliminary indicators (PI), the description and resources they are extracted from are listed as below.

Weights **method-factor analysis**

As described above, the need index (NI) is calculated as the weighted sum of the indicators within each survey zone. So the weights for each indicator are an initial step. Comparing all the literatures in chapter 2, principle analysis is chosen as the method to obtain weights. As analysed above, Murray and Davis(2001) uses a linearly weighted function which included significant subjective intervention . Currie(2010) weighted indicators based on the sources of travel survey which is hard to achieve in Jakarta situation. Yao (2007) uses multiple regressions that assume there is a one-way causal effect from the indicators that may impact public transit, which is not suitable for need analysis due to obviously low income and vehicle both impact CPT from the study of Paulley et al.,(2006), but both of them impact the demand for public transport. So the method for weighting of indicators follows Jaramillo et al.(2012), which is Principal Components Analysis (PCA), and more specifically Factor Analysis(FA).

However, the thesis not entirely follow Jaramillo et al.(2012). For Jaramillo et al.(2012), the PCA/FA is used to reduce the high number of selected indicators to a small group and then weighted the indicators in that small group. But in this thesis, the DI are selected by correlation analysis from comparing PT with the data of CPT from JUTPIP survey. Selecting travel demand indicators based on comparing indicator with real public transport trips is more reliable. After selecting DI, PCA/FA is used to obtain weights, in which each indicator is weighted according to the contribution to the overall variance in the data. Due to the weight is gain based on revealing the internal structure of the indicators in a way that best explains the variance of the indicators, so it can represent the latent public travel demand based on the DI which has high correlation with CPT.

Weights method-decision making

DI is the indicator which will impact public transport travel demand. So from the view of TransJakarta, these indicators will impact the expansion of TransJakarta due to the high public transport travel demand areas imply more ridership for BRT system. Therefore, except above weighting method which starts with the internal structure of the indicators, the weights can gain from decision making aspect expanding BRT to benefit or encourage some group of people to use public transport system. In this step, weighting is based on multiple indicators(DI), so Multi-criteria evaluation(MCE) is a suitable method to apply because it explicitly considers multiple criteria in decision-making environments(Eastman, 1999).

Comparing MCE with the need index method (the detail is in 4.3.2), the phrases are similar: first, structuring criteria (selecting DI). Second, value analysis (standardization). Third, overall aggregation, which is weighted summation. The difference is the way to choose indicators and weight method. So MCE can use to gain weights from decision-making aspect assumed multiple criteria is selected by correlation analysis.

Three mainly weighting methods are applied in MCE(Malczewski, 1999), they are as following

- Ranking method: a. Expected value method. b. Rank sum method
- Rating method :
- Pairwise comparison(Saaty, 1980)

The ranking and rating methods are less precise than pairwise comparison. And from a holistic assessment of all the method, Pairwise comparison method is the best opinion and has been used by a number of studies(Ayalew & Yamagishi, 2005;Yahaya, Ahmad, & Abdalla, 2010)). Therefore, this method is adopted in this thesis.

4.2. DATA EXTRACTION

4.2.1. SQL

In order to acquire all the preliminary indicators (PI), extracting data from the JUTPIP dataset and GIS database is needed. In this research, JUTPIP questionnaire data and GIS database are examples of relational database management system. So the method of SQL can be used to extract PI from the above two databases. SQL is a programming language that is applied to extract and manage information that is stored in a Relational Data Base Management System (RDBMS).

The JUTPIP dataset consists of three main parts: (1) household information; (2) household member information; and (3) household member individual trip information, specifically classified into working and school trips. In this research the focus of the household member individual trip is the working trip and the school trip. The process of extracting data by using the SQL method is undertaken in ArcGIS by using its database management functionalities. The process of extracting the JUTPIP questionnaire is shown in Figure 4.2. In principle, the SQL is used in order to classify the household based on the income level, to calculate commuting public transport trips (CPT), to group the household based on different age groups, and to extract information of car ownership and motorbike ownership.

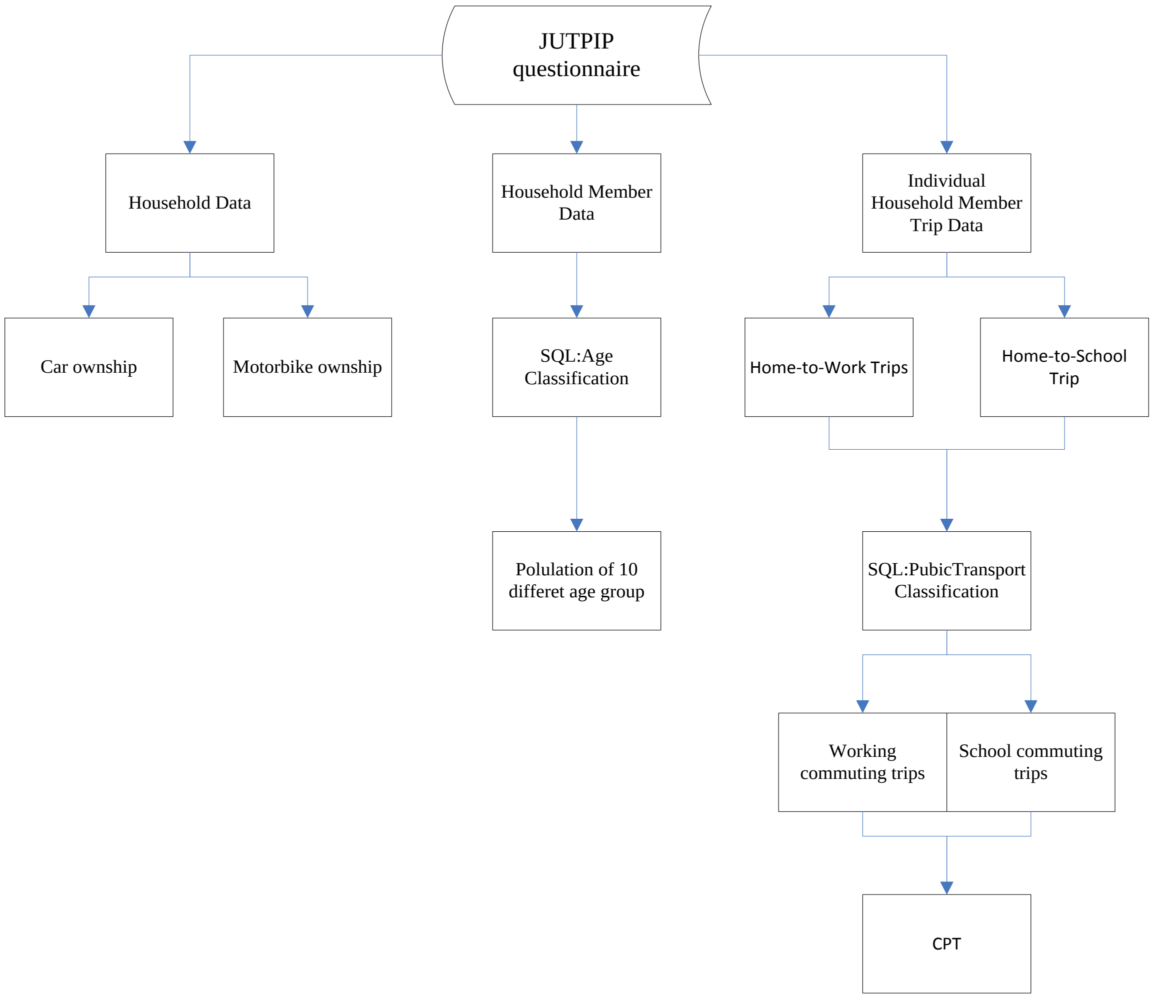


Figure 4.2 General data extraction of SQL method

4.2.2. SPATIAL SQL

Spatial SQL is the method that can be used to make inquiries related to spatially-referenced data as well as to be able to visually represent the spatial data (Egenhofer, 1994). In this research, there are two important roles of spatial SQL. First, spatial SQL is used to integrated data with different spatial resolutions. The primary challenges in the spatial data extraction is that the GIS data that contains the important information with regard the number of population for different income level, the job opportunities for different income groups and the population of students, which has a different spatial resolution then the JUTPIP survey zones. The JUTPIP survey zone is used as the appropriate spatial unit for obtaining a detailed travel need index since the data consists of commuting trips. However, the number of population, students, worker in residential zone, and employment in working zone for each income level is available in the GIS data. As a consequence, it is important to be able to transfer information from the GIS data into JUTPIP survey zones. Figure 4.3 illustrates the process of transferring population data from the GIS dataset into the JUTPIP zones. The process is principally undertaken in the ArcGIS environment.

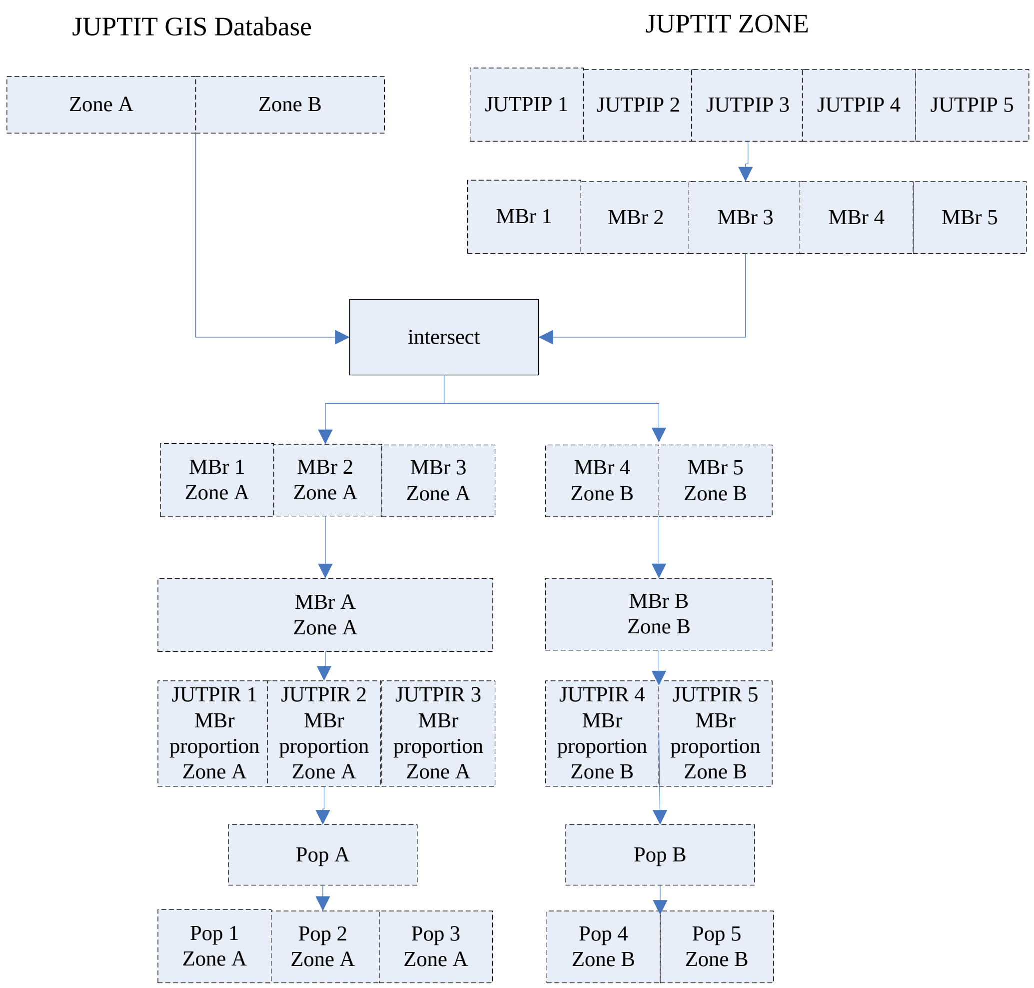


Figure 4.3 Illustration of spatial SQL method for combining two datasets in different spatial resolution

Where MBr is the total survey household members in each JUTPIT survey zone. From this step, the population of each JUTPIP zone can be obtained based on GIS dataset.

Second, spatial SQL is useful in order to generalize each PI extracted from questionnaire into JUPTIT zone level. The PI extracted from the questionnaire is based on Household Dataset, Household Member Dataset and Individual Household Member Trips Data. These datasets are questionnaire and extracted as Excel format. This information needs to be generalized into JUTPIP zone level so as to calculate scores of each zone to reflect travel need. Figure 4.4 illustrates the process of generalizing the PI into the JUTPIP zone level.

From this step, the PI can be visualized on JUTPIP zone level. And based on the different sample numbers of income level from Household dataset and number of students and workers from Household Member Dataset of each JUTPIP zone, the total population of different income level, the population of students and workers can scale up by comparing the population of each JUTPIP zone.

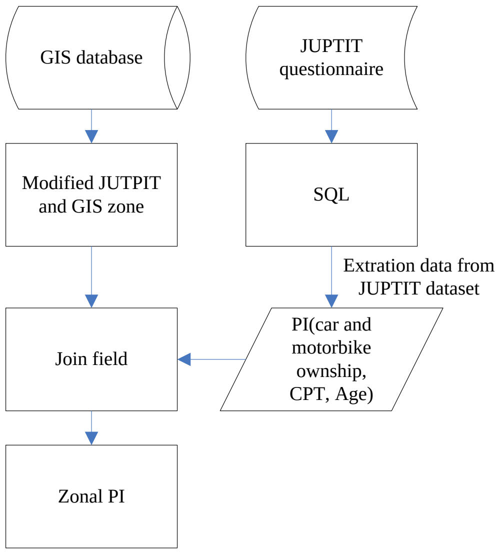
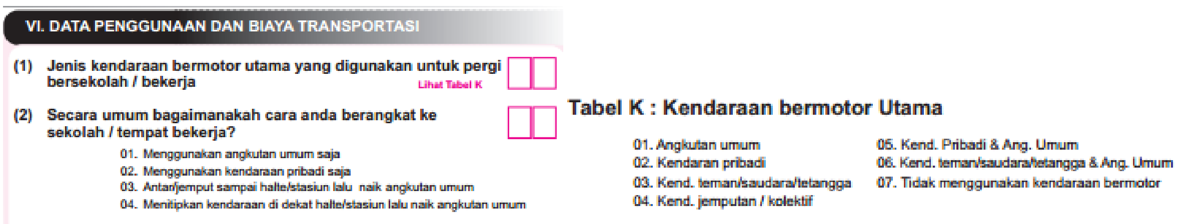


Figure 4.4 Illustration of spatial SQL method for generalizing PI into zone level

4.2.3. CPT calculation

In the JUTPIP dataset of household member's individual trips, the sixth question is about travel mode used by commuters. The questionnaires shown below give some detail of the travel mode survey. Because the questionnaire is about Jakarta urban transportation, it is written in Indonesian. The translation table is shown behind as table 4.2


VI. DATA PENGGUNAAN DAN BIAYA TRANSPORTASI

(1) Jenis kendaraan bermotor utama yang digunakan untuk pergi bersekolah / bekerja
Lihat Tabel K

(2) Secara umum bagaimanakah cara anda berangkat ke sekolah / tempat bekerja?
01. Menggunakan angkutan umum saja
02. Menggunakan kendaraan pribadi saja
03. Antar/jemput sampai halte/stasiun lalu naik angkutan umum
04. Menitipkan kendaraan di dekat halte/stasiun lalu naik angkutan umum

Tabel K : Kendaraan bermotor Utama
01. Angkutan umum
02. Kendaran pribadi
03. Kend. teman/saudara/tetangga
04. Kend. jemputan / kolektif
05. Kend. Pribadi & Ang. Umum
06. Kend. teman/saudara/tetangga & Ang. Umum
07. Tidak menggunakan kendaraan bermotor

Figure 4.5 Travel mode survey questionnaires

Table 4.2 Translation of travel mode of JUTPIP questionnaires

	Column 1	Column 2
	The main type of travel mode used to go school/work	In general, how do you set out to school / work?
1	Public transport	Only using public transportation
2	Personal vehicle	Only using private vehicles only
3	Vehicle of friends/relatives/neighbors	Delivery / pick-up stop / station and then take public transport
4	Vehicle of pickup/collective	entrust the vehicle near the bus stop / station and then take public transport
5	Vehicle of Pribadi & Ang. Umum	
6	Vehicle of friends/relatives/neighbors & Ang. Umum	
7	Do not use a motor vehicle	

Ang.Umum is abbreviation of Angkutan Umum, which means public transport in Indonesia. Jakarta has its special public transport like Pribadi & Ang. Umum, which is private vehicle but is used for public transportation.

As shown in the table, commuters who choose number 1, 4, 5, and 6 of the column 1, and commuters who choose 1, 3 and 4 of the column 2 are defined as commuting public transport trips (CPT).

The number of commuting public transport trips of each survey zone can be gained by using SQL based on Individual Member Trip Dataset. But to reflect the real CPT per 1000 people, the number of commuting public transport trips should be scaled up based on comparing sample survey data with overall population.

As shown in previous part of data description in chapter 3, JUTPIP commuting survey consists of three types of dataset: (1) household dataset; (2) household member dataset; and (3) individual member person trip dataset. Figure 3.7 shows relational diagram among these three dataset. In principal, commuting dataset is household dataset that consist of household socio-economic attribute data. Each household in commuting dataset has its own household member that is located in the household member dataset. Moreover, the household member dataset is related to individual member trip data. Each household member in the household member dataset may make 0 or 2 trips that are recorded in the individual member trip dataset.

So to scale up the number of commuting public transport trips of each survey zone obtained by Individual Member Trip Dataset to show the real absolute CPT and CPT per 1000 people, the sample dataset of Individual Member Trip Dataset need to compare with Household Member Dataset, and then scale up CPT based on Household Member Dataset with real population. So CPT per 1000 people of each survey can be gained as formula shown as below.

$$\text{R-CPT (per 1000 people)} = \frac{CPT}{MBr} * 1000 \qquad 4\text{-}1$$

Where, R- CPT is the relative commuting public transport trips in each JUTPIP survey zone, the number of commuting public transport trips per 1000 inhabitant within in each JUTPIP survey zone.
CPT is the commuting public transport trips in each JUTPIT zone based on of Individual Member Trip Dataset.
MBr is the total survey household members in each JUTPIT survey zone
POP is the total population of each JUTPIT survey zone.

4.2.4. Vehicle and motorbike ownership calculation

Vehicle and motorbike information is in the dataset of household, where vehicle consists of cars, buses, and freight vehicles. So the calculation of vehicle and motorbike is based on the unit of household. In the travel model analysis, vehicle and motorbike ownership need to be translated into an absolute number in each survey and the number of vehicle and motorbike per 1000 people of each survey zone. To scale up the number of vehicles and motorbikes in order to represent vehicle and motorbike ownership for the whole population, a calculation of vehicle and motorbike number based on household dataset need to refer to household member dataset, and then scale up with real population. The vehicle and motorbike per 1000 people of each survey can be gained as formula shown as below.

$$\text{R-Vehicle/Motorbike(per 1000 people)} = \frac{V/M_{household}}{\text{MBr}} \times 100 \qquad 4\text{-}2$$

Where, R-Vehicle/Motorbike is the relative number of vehicle and motorbike in each JUTPIP zone, the number of vehicle or motorbike per 1000 inhabitant within each JUTPIP zone;
$V/M_{household}$ is the number of vehicle and motorbike in each survey zone based on of Household Dataset;
MBr is the total number of survey household members in each survey zone;

4.2.5. Age calculation

In the Household Member Dataset, each household member has age information. In order to show how age impact travel mode, the initial step is to group age in different level. In this thesis, age is grouped in 10 different level: 0-4, 4-12, 0-12, 12-20, 20-30, 30-40, 40-50, 0-25, 25-50, and above 50 years old. The proportion of population based on these different age groups within each survey zone can be used as PI for further need index analysis,

$$\text{R-Age}_i = \frac{Age_i}{MBr} \times 100 \qquad 4\text{-}3$$

Where, R-Age$_i$ is the relative population in age group *i* in each JUTPIP zone, the proportion of population of age group i within each JUTPIP zone;
Age$_i$ is the number of age group *i* in each survey zone based on of Household Dataset;
MBr is the total number of survey household members in each JUTPIP survey zone;
POP is the total population of each JUTPIP survey zone.

4.2.6. Income, student and worker calculation

In the GIS database, the attribute of population, employment and students are classified based on level of income. This classification from GIS database provides the detailed information about the spatial distribution of population, employment and students. However, the shortcoming is that the database needs spatial redistribution to be able to link with travel behaviour information in JUTPIP zone level. The GIS database and JUTPIP commuting survey data has different spatial resolution, where GIS database zone has larger spatial resolution compared with JUTPIP zone. Since the JUTPIP zone only covers the number of sample so that it is not possible to obtain a complete picture with regard to population distribution, the number of population in each zone from GIS database is transferred to JUTPIP zone. This process is done by implementing spatial join technique in ArcGIS as described in figure 4.3.

To calculate the population of different income, student and worker information in JUTPIP zone, sample information about income, student and worker calculated from JUTPIP questionnaire need to be scaled up compared with population in each JUTPIT zone.

$$\text{R-Income}_i = \frac{Income_i}{HMBr} \times 100 \qquad 4\text{-}4$$

$$\text{R- Stu/Worker} = \frac{\text{Stu/Worker}}{MBr} \times 100 \qquad 4\text{-}5$$

Where, R- Income$_i$ is the relative population in income group *i* in each JUTPIP zone, the proportion of population of income group i within each JUTPIP zone;
R-Stu/Worker is the relative population of students or workers *i* in each survey zone, the proportion of population of students or workers within each JUTPIP zone;
HMBr is the total number of survey households in each JUTPIP survey zone;
MBr is the total number of survey household members in each JUTPIP survey zone;

4.2.7. Road Network analysis

The network analysis holds an important role in this research. The network analysis is used to construct the road network to calculate the distance from each Origin to Destination from the working trips' point of view.

The basis for construction origin and destination matrix is the GIS Dataset. The process of constructing OD Matrix is entirely undertaken in ArcGIS by using Network Analysis tool. Figure 4.6 illustrates the process of constructing network analysis by using ArcGIS model builder.

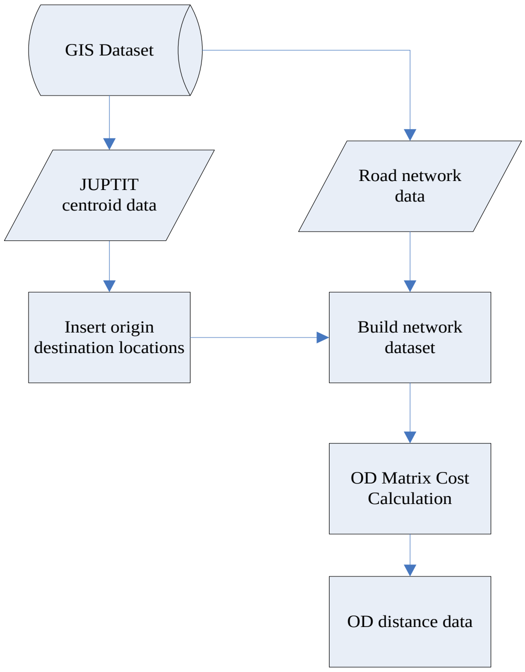


Figure 4.6 Illustration of network analysis in ArcGIS to construct OD matrix distance

The initial step that is undertaken is to establish network dataset. The network dataset is based on the road network data in Jakarta Metropolitan Area. The purpose of constructing OD cost matrix is to get the network distance based on OD matrix. The origin and destination locations are based on the centroid points from the JUTPIP zones spatial dataset. The process is undertaken in ArcGIS software by using model builder. But there is a weakness of this method, converting origin and destination on the centroid points does not discount opportunities over distance with each zone. One way to avoid is to divide the study as small as possible. But due to data limitation, the social economic and commuting data is based on JUTPIP survey zone, the method is chosen to analyse network distance.

4.2.8. Accessibility model

For analysing the job accessibility levels in Jakarta Metropolitan Area, one accessibility measure was applied in this research as analysed in above literature review chapter 2. The measure is the traditional gravity-based accessibility model due to we are mainly using aggregate data. For preliminary analysis; the formula for calculating accessibility is as follows:

$$A_i = \sum_J^{n} \frac{JOB_j}{D_{ij}} \qquad \text{4-6}$$

Where, A_i = Accessibility of origin zone *i;*

JOB_j =number of jobs in destination zone *j* (job opportunities in destination zone *j*);

D_{ij} = distance from origin zone *i* to destination zone *j;*

j=job location zone.

4.3. DESCRIPTIVE STATISTICS

4.3.1. Correlation analysis

From the literature review, and using SQL extracted data, PI are created. However, Jakarta has its local uniqueness. For example, motorbike ownership is really very high in comparison with other research cities in previous studies. From the above methods, all PIs are calculated at survey zone level. Therefore, to create the DI for travel demand in Jakarta, the correlation analysis is taken as a basis for analysing the relationships between PI with CPT within each survey zone. DI are selected PIs that can better explain CPT by excluding those PIs that show a low correlation, and a low ability to explain CPT.

4.3.2. Need index analysis

This is based on the previous 'needs-gap' approach (Currie 2010, Jaramillo et al. 2012). The Index of Needs (NI) has been calculated for the 386 JUTPIP survey zones of Jakarta Metropolitan area. The NI is calculated as the weighted sum of the indicators within survey zones, the formula for calculating needs scores is as follows:

$$NI_j = \sum_{i=1}^{n} TI_{ij} P_i \qquad 4\text{-}7$$

Where NI_j is the Index of Needs for the JUPTIT survey zones *j*; TI_{ij} the Standardized Indicator *i* for the survey zone *j*; and P_i is the Weighting of the Indicator *i*.

Each indicator of Jakarta travel demand is standardized so that they take values between 0 and 1, using following equation:

$$SI_{ij} = \frac{I_{ij} - I_i^{min}}{I_i^{max} - I_i^{min}} 100 \qquad \text{If benefit criterion} \qquad 4\text{-}8$$

$$SI_{ij} = 1 - \frac{I_{ij} - I_i^{min}}{I_i^{max} - I_i^{min}} 100 \qquad \text{If cost criterion} \qquad 4\text{-}9$$

Where, SI_{ij} is the Standardized Indicator of travel demand for indicator *i* for the survey zone *j*; I_{ij} is the value of indicator *i* for the survey zone *j*; I_i^{max} is the maximum value of *i* Indicator in whole survey zones; I_i^{min} is the minimum value of *I* Indicator in whole survey zones.

The standardization translates the performances of different DI into a value score so that offer an analytical description, and make each indicator comparable.

The benefit/cost criterion is decided by correlation analysis. If the correlation coefficient of PI with R-CPT is positive, then it's a benefit criterion, and vice versa.

Weights were sourced from a factor analysis as described in 4.3.3. Each standardized value is then weighted and added together and a finalized need index generated. The final need index is a standardized need scores between 0 and 1 for all survey zone in the analysis except zones without data. The index is a dimensionless score, a value of 1 indicates the highest travel need for public transport, and a value of 0 indicates the lowest need.

4.3.3. Factor analysis

The method for weighting of indicators follows Jaramillo et al.(2012), Principal Components Analysis(PCA), and more specifically Factor Analysis(FA), in which each indicator is weighted according to the contribution to the overall variance in the data.

As a statistical model, principal components analysis (PCA) or factor analysis (FA) could be used for group together individual indicators according to their degree of correlation. And all the individual indicators must have the same analysis unit. PCA/FA reveals each set of indicators which are strongest associated with different latent factor. In other words, the highest possible variance of all the indicators is explained by using the smallest possible number of factors under the method of PCA/FA. (OECD, 2008)

According to PCA/FA, weighting is based on the degree of correlation of each indicator. If there is no correlation between indicators, then estimation of weights makes little sense within this method.

There are four steps to give weights based on principal components analysis.

- First step is to check the correlation structure of the data. The indicators in the dataset have to be related to each other: if the correlations between indicators are weak, then they are barely share common factors.
- The second step is factor extraction. Each factor is defined as a set of coefficients (so called loadings), each coefficient measuring the correlation between the individual indicator and the latent factor. Principal components analysis is used to retain the subset of principal components.
    - Standard practice to choose factors is shown as below:
      (I) Factor that have associated eigenvalues larger than one;
      (ii) Factor that individually explaining overall variance by more than 10%;
      (iii) Factor that contributes cumulatively explaining the overall variance by more than 60%.
- The third step involves the rotation of factors extracted from step two. The rotation, in this paper using varimax rotation, is used to minimize the number of individual indicators that have a high loading on the same factor. In this way, it can transform the factorial axes to obtain a "simpler structure" of the factors.
- The last step copes with the weights construction based on the factor loadings matrix after rotation. The approach in this thesis project follows OECD(2008) and Nicoletti et al. , (2000) in consideration of the factor loadings square represents the proportion of the total unit variance of the indicator which is explained by the factor. And each factor is weighted by its contribution to the portion of the explained variance in the data set.

4.4. GENERAL DESCRIPTON OF SUPPLY MODEL

Through literature review in chapter 2, the supply measurement in Jakarta BRT system aimed to create a measure of transport supply for each spatial unit, and the supply index is chosen as method to analyse supply model. As described from Currie(2010) and Jaramillo et al. (2012), they choose infrastructure based supply measurement such as accessibility to public transport station and station density. But there is limited data about public transportation stations and bus road information except BRT system due to the special public transport situation of Jakarta, which most of the public traffic system is operated by private company in poor condition. So to visualize supply index of each survey zone of Jakarta, the index of infrastructure service level can be used to estimate public transport supply. It is calculated as the quotient of total road length in different grade for each survey zone weighted by an indicator of velocity of each road and the contribution of different road grades to public transport. In other words, the index is estimated as road network accessibility based on travel time and road grades. This methodology can be used to reflect public transport supply level for three reasons: first, travel time is one aspect of transport service quality. Second, different road grades has different influence to public transport, for example, in Jakarta, buses mainly run on major road, just some minibuses run on small road. Furthermore, Jakarta faces heavy traffic jam problem, and commuting trips primarily create in peak hours, so using peak hour real time speed data combine with road network density to represent transport supply level is suit to Jakarta transportation situation.

This thesis project chooses calculating supply index with road network accessibility based on travel time and road grades in each survey zone to present transport supply level. For analysing supply level in the Jakarta Metropolitan Area, the following approach is adopted.

1. Data of traffic speed and congestion information of all main roads in each survey zone. This can gain from "Waze" website, which is the world's largest community based traffic and navigation app. Drivers within Waze can share real time traffic and road info.
2. The road grade information comes from GIS database. There are four grades, Toll Road, Major Road, Secondary Road, and Other Road. And Toll road entrance information comes from Indonesia Highway Corporation.
3. Statistical methods to calculate supply index, which is based on Waze data and GIS database as table 4.3.

Table 4.3 Data and resource for supply model

Resource	Data
WAZE	Speed
Indonesia Highway Corporation	Toll road access point
GIS dataset	Road grade
	Length
	Study Area

4.4.1. Peak hour speed

The travel speed data is calculated from "Waze" website on weekdays evening peak hours (4pm-8pm), from Western Indonesian Time-seven hours in advance (UTC+7) of Greenwich Mean Time (GMT). And the average peak hours speed calculating is just for Toll Road and Major Road, excluding the Secondary road and other road, due to the huge amount of second road and other road.

The speed of Secondary Road and Other Road is obtained based on spot speeds observation of JMA and the average peak hour speed which is 10 km (6.2 miles) per hour or less according to the city's transportation agency. The station for calculating Secondary Road and Other Road is shown as figure 4.7.

4.4.2. Road network accessibility analysis

The supply index is estimated as road network accessibility based on travel time and road grades. In terms of road network accessibility, it is calculate as the quotient of total road length for each survey zone weighted by road grades. There are four road grades, Toll Road, Major Road, Secondary Road, and Other Road. But for Toll Road which is with controlled access, the accessibility cannot estimated by length but the number of access point for each zone. Because in each survey zone, Major, Secondary and Other road are connected with each other, the public transport can run on the roads if the roads are in the zone, but for the toll road, even if it goes through one zone, but there is no access in that zone, public transport in that zone cannot use the toll road from the zone itself. In this situation, the toll road has no impact to that zone. The toll road can just contribute the zone accessibility based on the access points in the zone. So the accessibility of each zone is calculated by length for Major, Secondary and Other Road and by access points for Toll Road. The access points come from the resource of Indonesia Highway Corporation, which is transferred into road network in the GIS Dataset.

Another problem about road network analysis for each zone is the actual impact of each road. The boundary of two survey zones sometimes are based on one major road which belongs to only one zone. But in the view of accessibility impact to these kinds of two zones, that major roads has the impact to both of zones. So this boundary major should count in both of the zones. The way to conclude the impact the boundary road to both survey zones is to extend the survey zone so the boundary road lays in both of zones. The process of boundary road analysis is undertaken in ArcGIS by using Proximity

Analysis tool-Buffer. And combine road network with survey zone is also undertaken in ArcGIS by using Overlay Analysis tool-Identity.

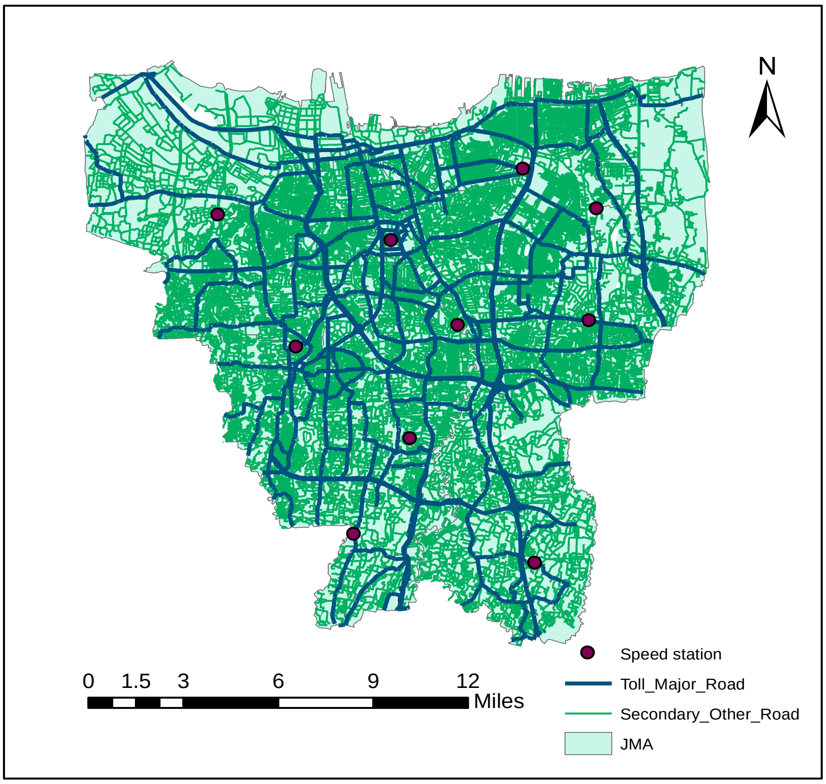


Figure 4.7 Road network and speed station distribution

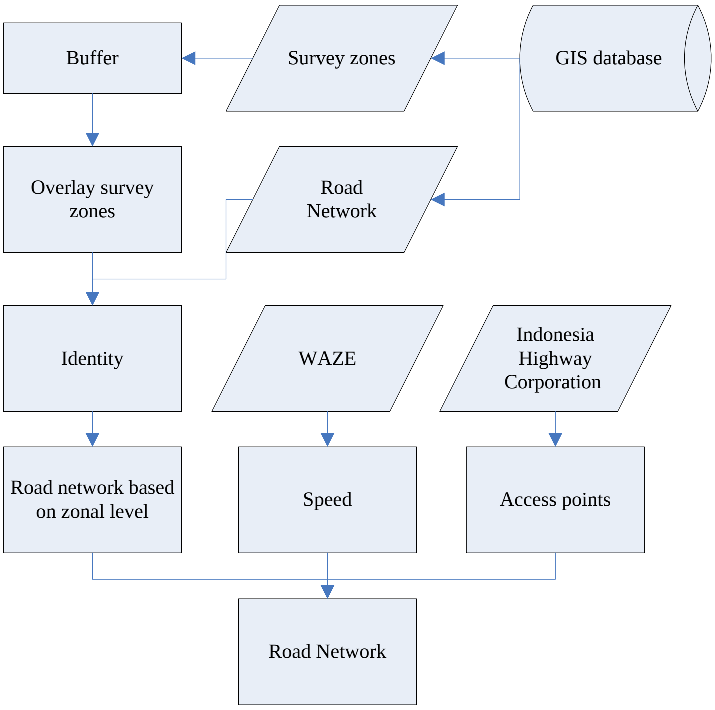


Figure 4.8 Illustrates the process of constructing network analysis by using ArcGIS model builder.

4.4.3. Supply index analysis

The supply index is calculated as the quotient of total road length (access points) for each survey zone weighted by an indicator of velocity of each road and the contribution of different road grades to public transport. So supply index is based on four different separate indicators of four different road grades. The first indicator is the accessibility of Toll Road weighted by velocity for each survey zone. The second indicator is the accessibility of Major Road weighted by velocity for each survey zone index in each zone. The third and fourth indicators are for Secondary and Other Road in the same way. The four indicators are shown as below expressions.

$$IT_j = \sum_{i=1}^{N_t} \frac{A_{ij}TV_i}{A_j} \quad 4\text{-}10$$

$$IM_j = \sum_{i=1}^{N_m} \frac{ML_{ij}MV_i}{A_j} \quad 4\text{-}11$$

$$IS_j = \sum_{i=1}^{N_s} \frac{SL_{ij}SV_i}{A_j} \quad 4\text{-}12$$

$$IO_j = \sum_{i=1}^{N_o} \frac{OL_{ij}OV_i}{A_j} \quad 4\text{-}13$$

Where IT_j is the Index of Toll Road supply in survey zones *j*; A_{ij} the access point of Toll road *i* for the survey zone *j*; and TV_i is the average speed of Toll road *i*; N_t is number of Toll roads access points in survey zone *j*; IM_j is the Index of Major Road supply in survey zones *j*; ML_{ij} the length of Major road *i* for the survey zone *j*; and MV_i is the average speed of Toll road *i*; N_m is number of Major roads in survey zone *j*; IS_j is the Index of Secondary Road supply in survey zones *j*; SL_{ij} the length of Secondary road *i* for the survey zone *j*; SV_i is the average speed of Secondary road *i*; N_s is number of Secondary roads in survey zone *j*; IO_j is the Index of Other Road supply in survey zones *j*; OL_{ij} the length of Other road *i* for the survey zone *j*; and OV_i is the average speed of Other road *i*; N_o is number of Other roads in survey zone *j*. A_j is the Area of survey zone.

The supply index is calculated based on above four indicators by weighted by the contribution for public transport system.

$$\text{IPTS}_j = w_1 SIT_j + w_2 SIM_j + w_3 SIS_j + w_4 SIO_j \quad 4\text{-}14$$

Where IPTS_j is the Index of public transport supply for the JUPTIT survey zones *j*; SIT_j, SIM_j, SIS_j and SIO_j are standardized indicators of IT_j, IM_j, IS_j, *and* IO_j; w_1, w_2, w_3 and w_4 are the weight for different grade of roads. The standardized indicators for each district were standardized as in the Eq. 4.8. Based on the road contribution to public transport, the weights is 0.2 for w_1, 0.5 for w_2, 0.2 for w_3, and 0.1 for w_4.

As in the previous index, areas with a low index score can be categorized as areas with relatively low public transport supply and areas with higher scores can be categorized as areas with relatively high transport supply.

4.5. Transport Need and Supply

The gap between public transport need and the public transport supply is defined as the index of Disparity between Needs and Supply.

$$\text{GAP} = \text{NI} - \text{IPTS} \quad 4\text{-}15$$

Where GAP is the Index of Disparity between Needs and Supply; NI is the Index of public transport needs; and IPTS is the Index of public transport supply. So the lower index scores the better situation which means less disparity.

The high gap areas which means high needs but low supply are the target areas to expand TransJakart(BRT) system so as to gain more ridership and solve the mobility problem as mentioned above in chapter 3. Because the Needs and Supply disparity is controlled by two factors. Just increasing transport supply alone will be inefficient to increase ridership of TransJakarta due to the change of indicator mentioned above (urban poor, employment, car ownership, etc.) will also impact the final gap.

5. RESULT AND DISCUSSIONS

5.1. CPT in JMA

CPT is analysed by mapping the commuting public transport trips in ArcGIS. The basis of calculating CPT is based on working commuting trips and school commuting trips. The basis data for CPT are derived from the JUTPIP dataset of household member individual trip. These data are transferred into the JUTPIP zone as described in the study area section.

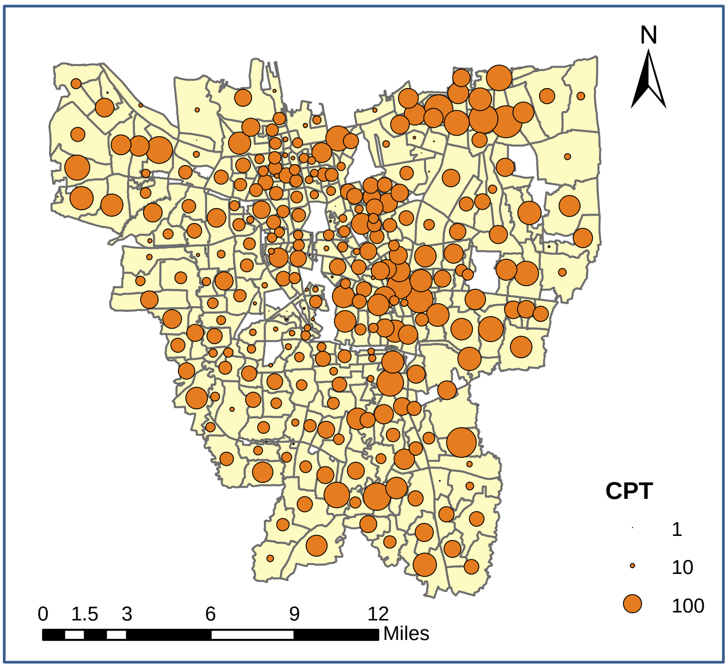


Figure 5.1 Commuting public trips distribution in Jakarta Metropolitan Area 2010

Figure 5.1 shows the maps of CPT distribution based on the JUTPIP commuting survey dataset. As shown as the no colour zones in the maps, 82 out of 386 zones have no commuting public transport trips. To find the reason of no CPT zone, Land use plan map from GIS database is used to analyse land use characters of no CPT zones. All these no CPT zones have the land use characters of industry, green area/park/open space, public sector, and residence low density. Due to CPT is defined as household trips from residential areas to work/school location, so zones have few residents, which results in few CPT. The resource of CPT data comes from JUTPIP dataset of household member individual trips, which is the survey data set. The CPT of sample JUTPIPT survey in each zone needs scale up to absolute number of CPT based on the total population. As the 82 no CPT zones in survey data, actually they has few CPT in reality .In this way, the non CPT zone can consider as no data due to the scale up methods.

5.2. Defining low income population and Vehicle Availability IN THE CONTEXT OF JMA

As described in chapter 3, the low-income social group (urban poor) primarily suffers from the deficiency of public transport service. So the necessary step of travel demand analysis is to define poverty so as to analysis the influence of poverty on travel demand.

The definition of urban poor is based on income level in this research due to the limitation in the data availability. And according to Wachyar (2014) who analyzed urban poor in Jakarta, the poor household is defined as the head of household has income level less than IDR 1 million (USD 90.9). Wachyar (2014) adjusted the poor criteria between CBS and JUTPIP questionnaire which is suitable for this thesis research.

Therefore, the classification of different income household follows the method of Wachyar (2014), which is shown in table 5.1.

From the JABODETABEK Urban Transportation Policy Integration Project in the Republic of Indonesia in 2010, Lower middle-income group occupied the biggest proportion of JMA families (74.57%) and then was followed by low income (15.79%), upper middle income (9.13%) and high income (0.52%) as shown on Table 5.1. More than a half of all groups owned more than one motorbike that owned mostly in lower middle income group and almost a half of lower middle income; more than half of low income group has no vehicle at all (see Table 5.2).

Table 5.1 Income Group in JMA 2010

Income Group	Total HH	Income Band(IDR.000)
Low(L)	15.79%	<1,000
Lower Middle(LM)	74.57%	1,000-3,900
Upper Middle(UM)	9.13%	3,900-12,400
High(H)	0.52%	>12,400

Table 5.2 Vehicle Available in JMA, 2010

Vehicle Availability	Income Group				Total
	L	LM	UM	H	
No vehicle available	65.65%	22.20%	4.25%	2.39%	27.36%
1 or more cars, no motorcycles	0.13%	0.78%	6.28%	14.46%	1.26%
1 or more motorcycles, no cars	33.93%	72.59%	48.72%	10.36%	63.84%
1 or more cars and motorcycles	0.29%	4.43%	40.74%	72.78%	7.53%

5.3. Correlation Analysis

5.3.1. Income, Employment and Number of Students

From above literature review, the hypothesis is that the more low income population, population of workers, and student population the more commuting public transport trips (CPT) per 1000 people in each JUPTIT zone. To test the hypothesis and to choose the determined indicators (DI) to analysis travel demand in Jakarta, correlation analysis between R-CPT with percentage of low income population (R-poor), percentage of working population (R-worker) and percentage of student population (R-stu) for each survey zone is applied.

The table below is a matrix result of Pearson's correlation between above indicators in 386 JUTPIP survey zones.

The correlation coefficients result of R-CPT with the proportion of low income population is above .158 which can weakly explain CPT per 1000 people. And the proportion of student population and working population has positive relation above.250, which generally can explain R-CPT per 1000 people. The results well verify hypothesis. And indicators of population of low income, student and worker can use as DI.

Table 5.3 Correlation analysis of R-CPT with urban poor, employment and student

		R-CPT	R-poor	R-worker	R-stu
R-CPT	Pearson Correlation	1	.158**	.293**	.283**
	Sig. (2-tailed)		.005	.000	.000
	N	319	310	310	310
R-poor	Pearson Correlation	.158**	1	-.197**	.150**
	Sig. (2-tailed)	.005		.000	.008
	N	310	310	310	310
R-worker	Pearson Correlation	.293**	-.197**	1	-.237**
	Sig. (2-tailed)	.000	.000		.000
	N	310	310	310	310
R-stu	Pearson Correlation	.283**	.150**	-.237**	1
	Sig. (2-tailed)	.000	.008	.000	
	N	310	310	310	310

**. Correlation is significant at the 0.01 level (2-tailed).

5.3.2. Vehicle and motorbike ownership

From above literature review in chapter 2, the hypothesis is that the more vehicles the more commuting public transport trips (CPT). But Jakarta has its special situation which has a high motorbike ownership. So analysis with vehicle and motorbike ownership with commuting public transport trips (CPT) is necessary to find the DI for analyzing travel demand in Jakarta Metropolitan Area.

Table 5.4 Correlation analysis of CPT with vehicle and motorbike ownership

		R-CPT	R-Vehicle	R-Motorbike
R-CPT	Pearson Correlation	1	-.234**	.041
	Sig. (2-tailed)		.000	.469
	N	319	310	310
R-Vehicle	Pearson Correlation	-.234**	1	.119*
	Sig. (2-tailed)	.000		.037
	N	310	310	310
R-Motorbike	Pearson Correlation	.041	.119*	1
	Sig. (2-tailed)	.469	.037	
	N	310	310	310

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

The result of correlation analysis of CPT per 1000 people (R-CPT) with the number of vehicle per 1000 people(R-vehicle) and number of motorbike per 1000 people(R-motorbike) is shown as table 5.4. The correlation coefficient of CPT with vehicle per 1000 people is negative -.234, but motorbike per 1000 people is below .050. So the hypothesis is verified. And also this result implies the motorbike has little impact to CPT. This is reasonable due to motorbike trip are less attractive to long travel time(Wachyar, 2014). Therefore, just vehicle indicators are chosen as DI.

5.3.3. Distance to CBD

From the studies of Currie(2010) and Jaramillo et al. (2012). Distance to city center is an indicator to analyse travel demand and it has a positive impact to public transportation trips. To test the hypothesis in the situation of Jakarta, correlation analysis between CPT per 1000 people (R-CPT) with distance to CBD is analysed.

The result of correlation analysis of R-CPT with Distance to CBD within JUTPIP zones is shown as table 5.5. The correlation coefficient is .073. So the indicator of distance to CBD can hardly explain CPT. The difference of Jakarta situation with previous studies may because Jakarta has multiple centers. Therefore, this indicator is rejected.

Table 5.5 Correlation analysis of CPT with distance to CBD

		R-CPT	near_dist
R-CPT	Pearson Correlation	1	.073
	Sig. (2-tailed)		.194
	N	319	319
near_dist	Pearson Correlation	.073	1
	Sig. (2-tailed)	.194	
	N	319	386

5.3.4. Age

Age information comes from Household Member Dataset. As described in 3.2.4, there are ten different age groups, they are 0-4, 4-12, 0-12, 12-20, 20-30, 30-40, 40-50, 0-25, 25-50, and above 50 years old. From above literature review in chapter 2, generally, young age population and old age population have positive impact to public transportation trips. As to test that hypothesis, correlation analysis between CPT per 1000 people (R-CPT) with proportion of each age group population within JUTPIP zone is calculated.

The result of correlation analysis of CPT with the proportion of different age group is shown as table 5.6. The correlation coefficients of age group 0-4 and 20-30 are all above 0.20; age group above 50 years old has the correlation of -.168. Other correlation coefficients are below 0.15. However, the young(0-4) and old(>50) age population has negative impact to CPT, which means the high proportion of young and old age population, the less CPT per 1000 people. The result is different as the hypothesis due to Currie(2010) and Jaramillo et al. (2012) analysed age indicator based on social disparity and for all public transportation trips, but this thesis project just choose commuting trip data to analyse public transport due to data limitation.

Table 5.6 Correlation analysis of CPT with different age group

		R-CPT	R_Age0_4	R_Age20_30	R_Age50
R-CPT	Pearson Correlation	1	-.204**	.283**	-.168**
	Sig. (2-tailed)		.000	.000	.003
	N	319	310	310	310
R_Age0_4	Pearson Correlation	-.204**	1	-.078	-.351**
	Sig. (2-tailed)	.000		.172	.000
	N	310	310	310	310
R_Age20_30	Pearson Correlation	.283**	-.078	1	-.199**
	Sig. (2-tailed)	.000	.172		.000
	N	310	310	310	310
R_Age50	Pearson Correlation	-.168**	-.351**	-.199**	1
	Sig. (2-tailed)	.003	.000	.000	
	N	310	310	310	310

**. Correlation is significant at the 0.01 level (2-tailed).

So proportion of age group 0-4, above 50 and 20-30 can account for CPT. Therefore, all three indicators are selected.

5.3.5. Accessibility

As discussed in the previous section, job accessibility is calculated by gravity-based accessibility method. Job accessibility in origin zone is calculated by opportunity of jobs (number of jobs) in all destination zones divide by distance from origin to destination zone. As working trips is the main component of public commuting trips, so to analysis job accessibility with CPT is a necessary way to find the latent influence factor for travel demand. As job accessibility measures how easy it is for people to reach job opportunities. Therefore, the assumption is the more easily, the less CPT, which means the higher accessibility value the less CPT.

The result of Pearson's correlation between CPT per 1000 people with job accessibility is shown as below. The correlation coefficient is .025. So the indicator of job accessibility can hardly explain CPT. The result can support the studies of Currie(2010) and Jaramillo et al. (2012), which all took out of accessibility factors. Therefore, this indicator is rejected.

Table 5.7 Correlation analysis of CPT with job accessibility

		R-CPT	Accessibility
R-CPT	Pearson Correlation	1	.025
	Sig. (2-tailed)		.654
	N	319	319
Accessibility	Pearson Correlation	.025	1
	Sig. (2-tailed)	.654	
	N	319	386

5.4. Factor analysis

The above correlation analysis, which is to create the determined indicators (DI) for travel demand based on correlation analysis with CPT with all PI within survey zone level, gives the DI and its cost or benefit value function as shown below.

Table 5.8 Determined Indicator for travel demand analysis

Determined Indicator	Cost/benefit
Proportion of urban poor population	+
Proportion of workers	+
Proportion of students	+
Number of cars per 1000 inhabitant	-
Proportion of population between 0-4 years	-
Proportion of population between 20-30 years	+
Proportion of population age over 50 years	-

Seven indicators from are selected from 9 PI as DI. But three of them have negative impact to travel demand, which means areas with high car ownership, high proportion of 0-4 and above 50 years population have less public transport demand.

After selecting DI, each DI is standardized based on equation 4.8. Then PCA/FA is used to obtain weights, in which each indicator is weighted according to the contribution to the overall variance in the data. Due to the weight is gain based on revealing the internal structure of the indicators in a way that best explains the variance of the indicators, so it can represent the latent public travel demand based on the DI which has high correlation with CPT.

5.4.1. Factor extraction

To make the DI comparable, Interval standardization (as described in 4.3.2) is used to transform the value of DI into 0-1based on cost and benefit. And factor extraction is preceded through factor analysis based on SI (standardized indicator). The result of Initial Eigenvalues is shown in table 5.9 and figure 5.2.

The first three are factors with eigenvalues close to unity based on the standard practice described in section 4.3.4. Individually they explain more than 10% of the total variance and overall about 64% of variance.

Table 5.9 Eigenvalues of SI

Component	Initial Eigenvalues		
	Total	% of Variance	Cumulative %
1	1.712	24.459	24.459
2	1.472	21.022	45.481
3	1.317	18.810	64.291
4	.983	14.038	78.329
5	.808	11.545	89.874
6	.392	5.599	95.473
7	.317	4.527	100.000

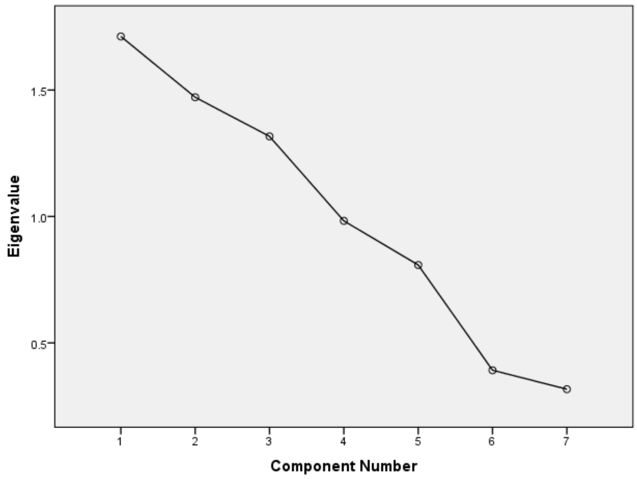


Figure 5.2 Scree plot of Eigenvalues

5.4.2. Rotation of factors

The estimation of the factor rotation loading contributes to aggregate the detailed indicator into factor-specific scores (Table 5.10).

Table 5.10 Factor loadings of SI based on principal components

	Factor loading			Squared factor loading (scaled to unity sum)		
	Factor 1	Factor 2	Factor 3	Factor 1	Factor 2	Factor 3
stand_R_poor	-.089	.636	-.079	0.00	**0.28**	0.00
stand_R_workers	.803	-.264	-.079	**0.39**	0.05	0.00
stand_R_students	-.310	.630	.151	0.06	**0.27**	0.02
stand_R_vehicle	.255	.711	-.006	0.04	**0.35**	0.00
stand_R_age0_4	.230	.159	-.803	0.03	0.02	**0.47**
stand_R_age20_30	.866	.135	.082	**0.45**	0.01	0.00
stand_R_age50	.243	.168	.830	0.04	0.02	**0.50**
Expl.Var	1.676	1.448	1.377			
Expl./Tot	.372	.322	.306			

Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 5 iterations.

The factor 1 has salient loadings on the indicators of worker and population between 20-30 years. It may be interpreted as representing majority component of traveling population.

The factor 2 has salient loadings on indicators of urban poor, students and vehicle ownership and may be interpreted as the social state with low income.

The factor 3 has salient loadings on indicators of population between 0-4 years and population above 50 years. It may be interpreted as representing the social disadvantage with age problem.

5.4.3. Construction of the weights

Weights construction is calculated based on squaring and normalizing the squared factor loadings due to the squared factor loading explain the proportion of the total unit variance (standardization indicator) of the indicator which is explained by the factor. The thesis follows the approach of Nicoletti et al.(2000) and OECD (2008), who construct weights by grouping the original indicators which have the highest squared factors loading into intermediate composite indicators.

With the DI data set, there are three intermediate composites (Table 5.10). The first includes workers (with a weight of 0.39) and population between 20-30 years (weight 0.45). Likewise the second intermediate is formed by poor, students and vehicle ownership (worth 0.28, 0.27 and 0.35 respectively), the third is composited by of population between 0-4 years (0.47) and population above 50 years (0.50).

The three intermediate composites indicators are aggregated by assigning a weight to each one of them equal to the proportion of the explained variance in the data set: 0.372 for the first (0.372 = 1.676/(1.676+1.448+1.377)), 0.322 for the second, and 0.306 for the third. To preserve comparability, the final weights are rescaled to sum up to one (Table 5.11).

Table 5.11 Weights for the TAI indicators

stand_R_poor	0.100138
stand_R_workers	0.159928
stand_R_students	0.098261
stand_R_vehicle	0.125253
stand_R_age0_4	0.159819
stand_R_age20_30	0.185736
stand_R_age50	0.170866

From table 5.11 we can see, all indicators have a general equal contribution to latent public transport demand. But the factor 1 which includes indicators of worker and population between 20-30 years has a higher impact on travel need. In other words, the majority component of traveling population has a higher demand for public transport need.

Indicators of population between 0-4 years and above 50 years have higher contribution (33.06%) to whole variables. Due to these two indicators are costs indicators, so it implies population under age social disadvantage have a lower demand for public transport.

From transport problem analysis in chapter 3, urban poor has a demand for public transport for longer trips. But comparing to population under age social disadvantage and commuting trips, demand of urban poor is less.

Furthermore, in this case, the majority of the variables (87.47%) are explained by socio-economic indicators, only one mobility-related variable (car ownership) is relative high in explaining travel demand. For this reason, the improvement of traffic mobility will not solely be achieved by improving infrastructure (expanding TransJakarta) or investing public transport, but with measures aimed at reducing inequalities between zones.

5.4.4. Weights based on decision making

The PCA/FA method for weighting is according to the contribution of each indicator to the overall variance in the data. The need index based on this weights demonstrate the current travel demand of each zone. However, to benefit or encourage some group of people to use public transport system, the weights can be given based on the mission and plan of the TransJakarta system.

From chapter 3, the Jakarta government develops TransJakarta Busway to solve problem of transport problem from main two views, first is to reduce the traffic congestion by providing service for commuting trips, second is to incite people shift from private car to public transport, third is to solve traffic problem for urban poor.

Simultaneously, there are three factors extracted from all the indicators which impact travel demand of Jakarta public transportation system based on above factor analysis. The three intermediate composite factors which represent different aspect of influence on travel demand are shown in table 5.12.

Table 5.12 Three intermediate composite factors and the explained indicators

	Interpretation	Indicators
Factor 1	Majority component of commuting population	worker population between 20-30 years
Factor 2	Social state based on low income	urban poor students vehicle ownership
Factor 3	Social disadvantage with age problem	population between 0-4 years and population above 50 years

The first factor reflects the main commuting population, and the second factor represents the low income based issues, like car ownerships and urban poor, due to in the analysis of section 5.2, urban poor in a situation of low vehicle availability.

These two factors fit closely to the composition of TransJakarta mission which is commuting trips, and traffic problem with urban poor. In this case, factor 1,2 and 3 are choose as three criteria in decision making process, indicators under each factor are sub criteria.

As mentioned in section 4.1.2, Pairwise Comparison Method is used in determining the weights for three factors and the indicators under each factor. This method compares indicators and allows the comparison of two indicators at a time. Saaty (1980) developed this method for decision making process known as Analytical Hierarchy Process (AHP). Based on the relative weights from Pairwise Comparison matrix, the AHP which is a mathematical method, translates this matrix into a vector of relative weights for the indicators(Yahaya et al., 2010).

Comparison of the factors and determine weight

From table 5.13, a matrix is constructed, where each criterion is compared with the other criteria, relative to its importance, on a scale from 1 to 9. After getting Pairwise Comparison matrix, priority vector is calculated from normalized principal Eigen vector. To normalize the values, the thesis use the cell value divided by its column total.

Table 5.13 Pairwise Comparison matrix and weight determination

	Factor 1	Factor 2	Factor 3	Priority vector
Factor 1	1	3	7	0.64
Factor 2	1/3	1	5	0.29
Factor 3	1/7	0.2	1	0.07
	1.48	4.2	13	

So given the first two factors and the explained indicators more weights can help to build travel need index which in the profit of TransJakarta plan.

The rule that a CR less than or equal to 0.1 indicates an acceptable reciprocal matrix, a ratio over 0.1 indicates that the matrix should be revised.

Calculation of Consistency Ratio (CR)

CR= CI/RI

Where CI = λmax-n/n-1

RI = Random consistency index

N = Number of criteria.

λmax is priority vector multiplied by each column total.

Table 5.14 Random Indices for matrices of various sizes.

n	1	2	3	4	5	6	7	8
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.45

CR = 0.08 < 0.10 (Acceptable)

Based on the same method, the weights of indicators under each factor are calculated in the same way, the Pairwise comparison matrix and weight for each indicator under three different factors are shown in table 5.15. The final weights for factors and indicators are shown in table 5.16.

Table 5.15 Pairwise Comparison matrix and weight determination for each indicator

Factor 1	worker	Age20--30	Priority vector
worker	2	1	0.65
Age20--30	1/2	1	0.35
	2.5	2	

Factor 2	Urban poor	students	vehicle	Priority vector
Urban poor	1	2	3	0.54
students	1/2	1	2	0.30
vehicle	1/3	1/2	1	0.16
	1.83	3.50	6.00	

Factor 3	Age0--4	Age50+	Priority vector
Age0--4	1	1	0.5
Age0--4	1	1	0.5

Table 5.16 weights for indicators based on TransJakarta

Factor weight		Indicator weight	Indicators	Final weight
0.64	Factor 1	0.65	worker	0.416
		0.35	population between 20-30 years	0.224
0.29	Factor 2	0.54	urban poor	0.1566
		0.30	students	0.087
		0.16	vehicle ownership	0.0464
0.07	Factor 3	0.50	population between 0-4 years	0.035
		0.50	and population above 50 years	0.035

Comparing table 5.16 and table 5.10 we can see the difference of weighting to each factor. The PCA/FA give a general equal weight to each indicators based on revealing the internal structure of the indicators in a way that best explains the variance of the indicators, so it can represent the latent public travel demand. The result implies population of age disadvantaged has a big negative impact to public travel demand, but the majority component of traveling population (workers and population between 20-30 years) has a higher demand for public transport need. And the indicators belong to social state with low income also have high weight but just lower than traveling population indicators.

However, using decision making method, the decision makers are supposed to benefit or encourage some groups of people to use public transport system, so the weights have wide difference. In this thesis case, traveling population indicators have high weight, and indicators for population of age disadvantaged have lowest weight. By this decision the need index can help to benefit people of commuting groups.

5.5. Indices of Transport Social Needs

Figure 5.3 and 5.4 illustrate the spatial distribution of need index divided into seven need score groups based on two different weighting methods. These intervals are identified by the natural break point method.

The need index results of figure 5.3 which is based on factor analysis demonstrating the current travel demand illustrate that:

- There is trend that the very high and high traffic needs scores are located mainly in Central Jakarta. But it's not entirely the case; some survey zones in the South Jakarta around outer Toll road have high level of public transport need.
  As mentioned in chapter 3, Central Jakarta has the vital CBD, and South Jakarta is the main concentration area of CBD. It is reasonable these areas have the highest need for public transport.
- The middle high traffic need scores are aggregated full of Central Jakarta, outer part of East Jakarta and North Jakarta, and middle part of South Jakarta and West Jakarta.
  For Central Jakarta and South Jakarta, CBD attracts a higher traffic need. Similarly, as shown in figure 5.3, the areas around industries have higher traffic need in West, North and East Jakarta.
- The low need scores are mainly found on the periphery of whole JMA, except some zones close to CBD. These areas are well organized or with few inhabitant from Google satellite maps.

Compared need index results derived from the view of decision making with above need index, the need index results based on TransJakarta mission can lead need scores in the benefit of public transport plan. The result of Figure 5.4 illustrates that:

- The result of need index based on TransJakarta plan is generally smaller than above need index, which is shown in figure 5.5, the scores are obtained by using need index of factor analysis minus need index from decision making. The reason of significant gaps between two methods is need index based on factor analysis demonstrates the real travel demand, it's the optimal situation. But decision making tends to certain social group, such as commuting group. In that case, for factor analysis, indicators of workers and population of 20-30 years explain almost the same as other indicators, which will not contribute too much to travel demand, but decision making give a higher weight to commuting group indicators so as to using this need index combined with supply index to expand TransJakarta to benefit commuters. The decision making in this case is a tool to improve TransJakarta to solve certain mobility problem, but it distorts the real travel need, therefor, the expansion Jakarta based on this may benefit certain social groups but may also cause social inequality.
- The very high and high travel needs scores based on decision making are mainly located in the areas have high proportion of workers.

5.6. Indices of Transport Supply

Figure 5.6 shows the findings of public transport supply index. The spatial distribution of supply index is divided into seven intervals from smallest to largest value. This indicates the following:

- The very high and high level of supply scores are located along the Toll Road areas. Generally, the scores above average supply level are aggregated in the middle ring areas of JMA.
- The very low supply scores are distributed on the periphery of JMA and the CBD areas. As well as the low and medium low supply scores.
- As the studies from of Currie(2010) and Jaramillo et al. (2012), the high supply scores areas basically lie in the CBD area. But the supply result from JMA shows the CBD areas have low supply scores which result from the high congestion situation of CBD areas.

5.7. Needs-gap analysis

In Figure 5.7 and 5.8, the results of gap between public transport need and the public transport supply are shown in the map of JMA divided by survey zone based on two different weighting methods of need index. The break points of two maps are different but all have seven intervals to identify the high gap scores of each map in generally. Because the gaps map just shows a general discrepancy of travel need and traffic supply, provides relative high and low gaps scores to give a macro transport improvement leading. Certainly, as described in section 5.4, the gaps scores of factor analysis is higher than decision scores in this case based on same indicators but different weights.

Figure 5.7indicates that:

- The gap scores of low and very low level are all located along the inner and outer Toll rings.
- There is trend that high gap scores are aggregated on the periphery of JMA and central area of Central Jakarta. Nevertheless, some zones in the middle of West and South Jakarta have high gap scores level due to the industries in West and main CBD in South Jakarta attract more trips but have congestion which cause high gaps score.

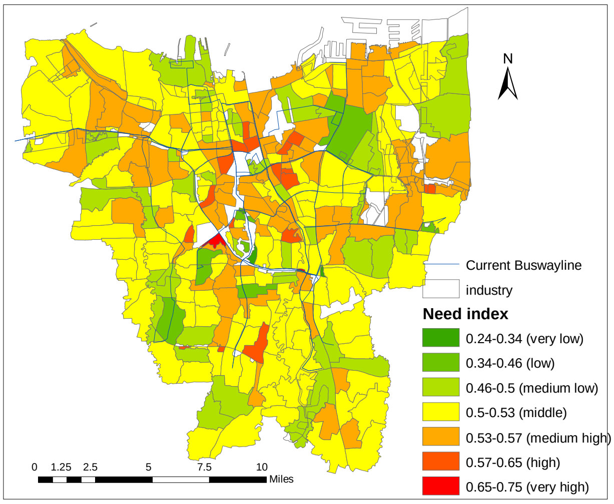


Figure 5.3 Need index based on factor analysis

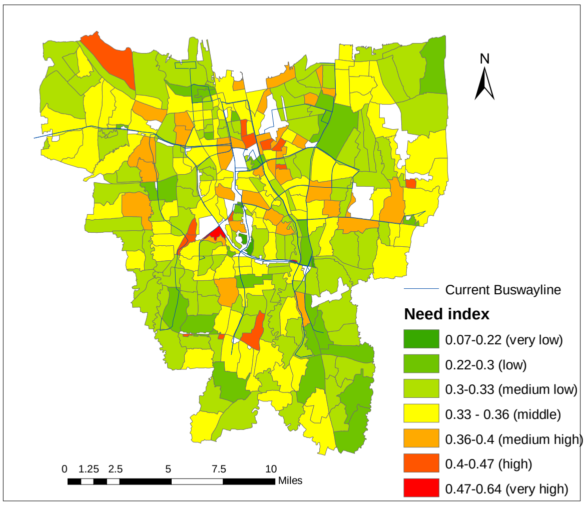


Figure 5.4 Need index based on decision making

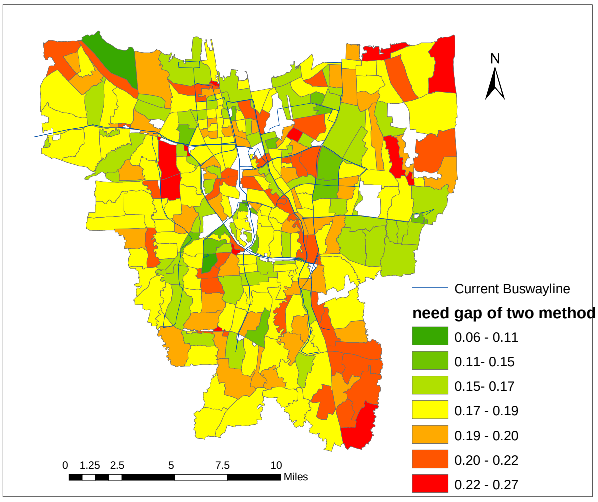


Figure 5.5 Need gaps based on two methods

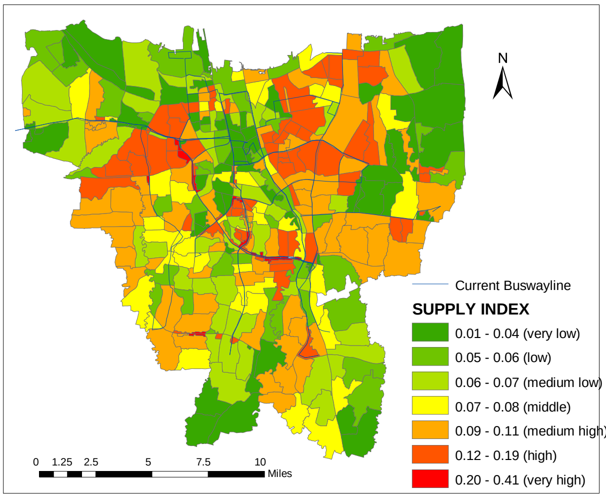


Figure 5.6 Distributions of supply measure scores

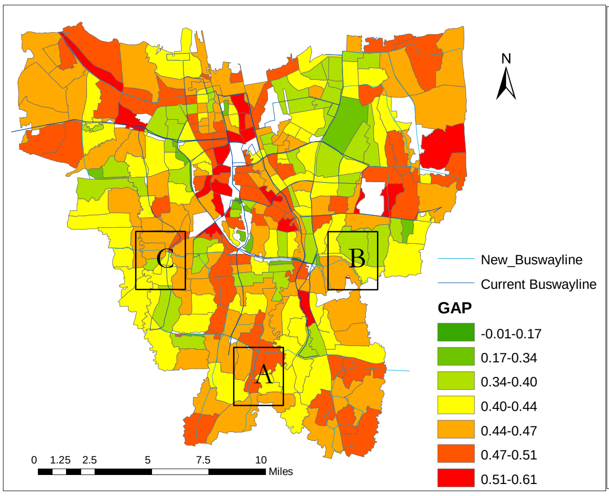


Figure 5.7 Need/supply-gap and Expansion of current TransJakarta system based on FA

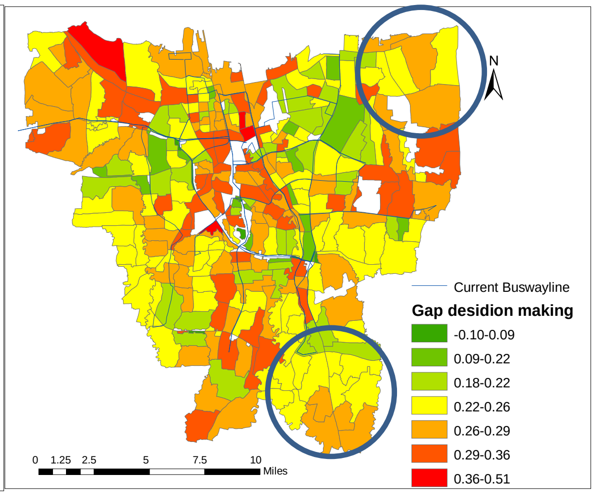


Figure 5.8 Need/supply-gap based on decision making

The result by comparing Gap Index result of figure 5.8 with above need index illustrates that:

- The result of Gap index based on decision making is lower than as above Gap index, the same problem happens in need index of two methods.
- But ignoring the discrepancy between two gaps based on different methods, and breaking the decision making need/supply gaps into seven groups, the high and low moving tendency are similar between two methods.
- Compared with figure 5.7, from the relative high and low point of view, the high gap level areas are more tend to West Jakarta due to more workers in this industrial area. And less concentrated in bottom of East Jakarta and eastern concern of North Jakarta.
- Different weight made by decision maker about need index can solve different mobility problem based on the final gap index map. For instance, more weight to urban poor can lead zones with more urban poor higher gap. So the gap index map can lead transport to these areas which can enhance social exclusion.

Expansion of TransJakarta

As mentioned above, need/supply gaps based on factor analysis represents the real travel demand, it's the optimal situation, so the example of expanding TransJakarta system is analysed on the current real Gap without any policy intervention.

The high gap areas which mean high needs but low supply are the target areas to expand TransJakarta (BRT) system so as to gain more ridership and solve the mobility problem. On the map of seven interval groups, the high and very high areas are the target areas. The expansion TransJakarta system is shown as figure 5.7.

As the way to reduce expenditures, the expansion BRT system is based on the current major roads. And denser BRT network can build around CBD.

To further test the validity of the need and supply gap method, the expansion results are compared with the real transit expansions. Corridors A, B and C based on Gap Index maps are also corridors 13, 14, and 15 under planned, which means this method can give guiding for expanding current system.

If using the same guide method to expand BRT on decision making gaps map, the BRT system will not expand to bottom of East Jakarta and eastern concern of North Jakarta, as shown in the circles in figure 5.8, which may cause social inequality.

6. CONCLUSIONS AND RECOMMENDATION

6.1. Conclusion

The main objective of this research is identifying gaps between Jakarta public transport services and travellers' travel need to expand TransJakarta Busway system. Literatures on travel need measures and traffic supply measures are reviewed. The need index method is about assembling transport need indicators for a series of spatial areas and defining a single need score for each area based on the relative indicator values, and the supply index method is about combing travel speed and road network density of each spatial areas and defining a single supply score for each area. The gap is defined as the index of Disparity between Needs and Supply.

In terms of need index method, correlation analysis is used to extract transport need indicators, factor analysis and pairwise comparison method are used to obtain weights for each indicators. Based on correlation and factor analysis, seven indicators are selected for Jakarta transport need analysis. However, 87.5% of variables are explained by socio-economic indicators, only one mobility-related variable (car ownership) is relative high in explaining travel demand based on factor analysis. For this reason, the improvement of traffic mobility will not solely be achieved by improving infrastructure (expanding TransJakarta) or investing public transport, but with measures aimed at reducing inequalities between areas. Furthermore, seven indicators are aggregated into three main factors, which are travelling groups, social groups with low income social state, and social groups with age disadvantage. Travel need is impacted by these three social groups, and disparity of need between different areas can be solved from this three aspects. What's more, the need index map shows the high travel need areas are aggregated around CBD and industries areas which implies travelling groups, social groups with low income social state lives around these areas.

Considered the need index result based on decision making which weights indicators on the aim to expand TransJakarta to benefit or encourage some group of people to use public transport system. The need scores of each zone is generally smaller than need index obtain from factor analysis. Because need index based on factor analysis demonstrates the real travel demand, it's the optimal situation. But decision making tends to benefit certain social group but ignores other social groups which is beneficial for certain police plan but may also cause social inequality. Furthermore, in the case to benefit working groups, the high need scores areas are located mainly in the areas have high proportion of workers.

In term of supply index method, the result map shows the low supply scores are distributed on the periphery of JMA and Central Jakarta areas due to the road network is denser in inner JMA. However, the low scores areas which lied in high density Central Jakarta is due to the special congestion situation in CBD.

Compared need and supply index, high gap scores are aggregated on the periphery of JMA (low supply level) and central area of Central Jakarta (high need but low supply level). Nevertheless, some zones in the middle of West and South Jakarta have high gap scores level due to the industries in West and main CBD in South Jakarta attract more trips but have congestion which cause high gaps score. Furthermore, the expansion of TransJakarta is led to peripheral areas of JMA based on gaps map.

Furthermore, compared gaps index of decision making with factor analysis, the relative high and low gaps moving tendency are similar between two methods, however, expansion guide for TransJakarta on decision making gaps map neglect bottom of East Jakarta and eastern concern of North Jakarta which may cause social inequality.

6.2. Recommendation

One limitation of this research is that the JUTPIP survey zone is used as the appropriate spatial unit for obtaining a detailed travel need index since the data consists of commuting trips. However, the number of population, students, worker in residential zone, and employment in working zone for each income level is available in the GIS data which has different resolution with JUTPIP survey zone. As a consequence, it is important to be able to transfer information from the GIS data into JUTPIP survey zones. For example, one way to gain population in JUTPIP zone is by comparing the samples in each JUTPIP zone belongs to one GIS zone with real population in this GIS zone, it's shown in figure 4.2. Due to some JUTPIP zones don't have enough detail survey data about urban poor or age information, which cause some zones have on need scores. Therefore, this research recommends getting more detail social-economic dataset from census dataset on lower zone lever.

For public transport demand, as working trips is the main component of public commuting trips in Jakarta, analysing job accessibility is necessary to find the latent influence for travel demand. Job accessibility measure in this thesis uses location based (gravity-based) accessibility. It calculated the number of jobs in destination zone that is possibly to be reached with distance constraint parameters. The distances from each Origin to Destination from the working trips' point of view are calculated based on OD matrix based on the centroid points from the JUTPIP zones. However, the weakness of this method is that it doesn't discount opportunities over distance with each zone. One way to avoid the weakness is to use commuting dataset which contains commuters' travel mode and travel time. By this method, different travel modes need to be calculated separately which is time-consuming for this thesis project. Therefore, this method is recommended for further study.

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APPENDIX A

JUTPIP Questionnaire Data

KEMENTERIAN KOORDINATOR BIDANG PEREKONOMIAN REPUBLIK INDONESIA

SURVEY WAWANCARA RUMAH TANGGA (COMMUTER SURVEY)

JABODETABEK URBAN TRANSPORTATION POLICY INTEGRATION PROJECT

MARET - MEI 2010

JAPAN INTERNATIONAL COOPERATION AGENCY

RAHASIA

FORM 1, Halaman 1

NO. SURVEYOR ☐☐☐☐ **KODE ZONA** ☐☐☐☐☐☐☐ **NO. BATCH** ☐☐☐☐☐ **NO. SAMPEL** ☐☐☐☐☐

NAMA SURVEYOR ____________ **TGL. SURVEY** ☐☐ / ☐☐ /2010

I. DATA RUMAH TANGGA

(1) Nama Kepala Keluarga : ____________

(2) Nomor Telepon ☐☐☐☐ ☐☐☐☐☐☐☐☐

(3) Nomor Handphone ☐☐☐☐ ☐☐☐☐☐☐☐☐

(4) Alamat Jln. ____________

Rt. ☐☐☐ Rw. ☐☐☐ Kel./Desa : ____________

Kecamatan: ____________ Kode Pos ☐☐☐☐☐

Kab. / Kota: ____________ Kode Zona ☐☐☐☐☐☐☐

(5) Jenis rumah / bangunan tempat tinggal : ☐☐

01. Permanen A
02. Permanen B
03. Permanen C
04. Permanen D
05. Semi Permanen
06. Rumah Susun
07. Apartemen
08. Asrama
09. Rumah Toko (Ruko)
10. Lainnya (__________)

(6) Daya Listrik di rumah : ☐☐

01. Tidak ada Listrik
02. 0 - 450 W
03. 900 W
04. 1.300 W
05. 2.200 W
06. 3.500 W
07. 4.400 W
08. 6.600 W atau lebih

(7) Status kepemilikan rumah : ☐☐

01. Milik Sendiri
02. Milik Keluarga
03. Rumah Dinas
04. Sewa / Kontrak
05. Lainnya (__________)

(8) Total Pendapatan Perbulan Rumah Tangga : ☐☐

(9) Total Pengeluaran Perbulan Rumah Tangga : ☐☐

(10) Total Pengeluaran untuk Transportasi per bulan : ☐☐

01. di bawah Rp.1.000.000,-
02. Rp. 1.000.000,- s/d Rp. 1.499.999,-
03. Rp. 1.500.000,- s/d Rp. 1.999.999,-
04. Rp. 2.000.000,- s/d Rp. 2.999.999,-
05. Rp. 3.000.000,- s/d Rp. 3.999.999,-
06. Rp. 4.000.000,- s/d Rp. 4.999.999,-
07. Rp. 5.000.000,- s/d Rp. 5.999.999,-
08. Rp. 6.000.000,- s/d Rp. 7.999.999,-
09. Rp. 8.000.000,- s/d Rp. 9.999.999,-
10. Rp.10.000.000,- s/d Rp.12.499.999,-
11. Rp.12.500.000,- s/d Rp.14.999.999,-
12. Rp.15.000.000,- s/d Rp.17.499.999,-
13. Rp.17.500.000,- s/d Rp.19.999.999,-
14. Rp.20.000.000,- s/d Rp.22.499.999,-
15. Rp.22.500.000,- s/d Rp.24.999.999,-
16. Rp.25.000.000,- ke atas

(11) Lama tinggal di rumah yang sekarang : ☐☐,☐ thn

(12) Tempat tinggal terakhir sebelum tempat tinggal saat ini :

Alamat Jln. ____________

Rt. ☐☐☐ Rw. ☐☐☐ Kel./Desa : ____________

Kecamatan: ____________ Kode Pos ☐☐☐☐☐

Kab. / Kota: ____________ Kode Zona ☐☐☐☐☐☐☐

(13) Jumlah kendaraan dalam keluarga :

(termasuk kendaraan pribadi / digunakan untuk keperluan pribadi, kendaraan dinas / operasional, kendaraan yang anda sewa, kendaraan yang digunakan sendiri untuk usaha)
(terkecuali kendaraan yang anda sewakan / dioperasikan orang lain, seperti: angkutan umum, taksi, dsb)

1. Sedan, Kijang, Minibus, dll ☐☐ unit
2. Pick-up, Box, Truck, dll ☐☐ unit
3. Sepeda Motor ☐☐ unit
4. Sepeda ☐☐ unit
5. Lainnya ( ) ☐☐ unit

(14) Jumlah kendaraan yang dimiliki untuk usaha :

(termasuk kendaraan yang disewakan / dioperasikan oleh orang lain, seperti: angkot, taksi, kopaja, dsb atau kendaraan yang anda kelola sendiri / orang lain untuk disewakan)

1. Taksi, Angkot, Sedan, Kijang, Minibus, dll ☐☐ unit
2. Pick-up, Box, Truck, dll ☐☐ unit
3. Bus kecil / besar ☐☐ unit
4. Bajaj, bemo ☐☐ unit
5. Sepeda Motor ☐☐ unit
6. Sepeda ☐☐ unit
7. Lainnya ( ) ☐☐ unit

(15) Data Anggota Keluarga :

Ada berapa orang yang tinggal di rumah anda ?
Termasuk saudara , orang tua, anak, pembantu rumah tangga, supir, dll yang tinggal dalam rumah anda.
Mohon berikan keterangan apakah termasuk di dalam kartu keluarga anda atau memiliki kartu keluarga sendiri.

Nomor Anggota Keluarga	Usia (tahun)	Jenis Kelamin (1. Laki-laki 2. Perempuan)	Hubungan dgn Kepala Keluarga (Lihat Tabel A)	Hubungan dgn K.K Utama (Lihat Tabel B)	Status Sosial / Kegiatan Utama (Lihat Tabel C)	Kondisi Gangguan Tubuh
01.	☐☐	☐	☐☐	☐☐	☐☐	☐☐
02.	☐☐	☐	☐☐	☐☐	☐☐	☐☐
03.	☐☐	☐	☐☐	☐☐	☐☐	☐☐
04.	☐☐	☐	☐☐	☐☐	☐☐	☐☐
05.	☐☐	☐	☐☐	☐☐	☐☐	☐☐
06.	☐☐	☐	☐☐	☐☐	☐☐	☐☐
07.	☐☐	☐	☐☐	☐☐	☐☐	☐☐
08.	☐☐	☐	☐☐	☐☐	☐☐	☐☐
09.	☐☐	☐	☐☐	☐☐	☐☐	☐☐
10.	☐☐	☐	☐☐	☐☐	☐☐	☐☐
11.	☐☐	☐	☐☐	☐☐	☐☐	☐☐

Tabel Kondisi Gangguan Tubuh :

01. Tidak ada gangguan
02. Gangguan penglihatan
03. Gangguan pendengaran
04. Gangguan berbicara
05. Gangguan pendengaran dan berbicara
06. Gangguan penggunaan lengan dan jari
07. Gangguan penggunaan kaki
08. Gangguan penggunaan kaki, lengan dan jari
09. Gangguan kelainan bentuk tubuh
10. Gangguan mental retardasi
11. Gangguan eks penyakit jiwa / eks psikotik
12. Gangguan penggunaan lengan dan jari dan penglihatan
13. Gangguan pengunaan lengan dan jari dan berbicara
14. Gangguan penggunaan kaki dan pendengaran
15. Gangguan penggunaan kaki dan berbicara

FORM 1, Halaman 2 **RAHASIA**

II. JEJAK PENDAPAT

(1) Nomor anggota keluarga yang menjawab pertanyaan jejak pendapat [ ][ ]

PILIH SATU JAWABAN DARI PERTANYAAN BERIKUT INI

(2) Apa sarana transportasi utama (paling sering digunakan) yang sehari-hari anda gunakan? [ ][ ]

(4) Apakah ada alternatif sarana transportasi lain yang tersedia, tetapi tidak dipilih sebagai transportasi utama? [ ][ ]

01. Kereta	09. Taksi
02. Transjakarta Busway	10. Bajaj / bemo
03. Trans-Pakuan	11. Ojek
04. Patas AC / sejenis	12. Becak / Kereta kuda
05. Bis besar non-AC	13. Bus Jemputan
06. Bis sedang	14. Mobil pribadi
07. Angkot/Angpedes	15. Sepeda motor pribadi
08. Omprengan	16. Sepeda

(3) Tingkat Kepuasan

1. Tidak memuaskan
2. Kurang memuaskan
3. Biasa saja
4. Memuaskan
5. Sangat memuaskan

a. Kecepatan	1	2	3	4	5
b. Kemudahan	1	2	3	4	5
c. Biaya	1	2	3	4	5
d. Kenyamanan	1	2	3	4	5
e. Keamanan	1	2	3	4	5

a b c d e [ ][ ][ ][ ][ ]

(5) Penilaian

1. Tidak memuaskan
2. Kurang memuaskan
3. Biasa saja
4. Memuaskan
5. Sangat memuaskan

a. Kecepatan	1	2	3	4	5
b. Kemudahan	1	2	3	4	5
c. Biaya	1	2	3	4	5
d. Kenyamanan	1	2	3	4	5
e. Keamanan	1	2	3	4	5

a b c d e [ ][ ][ ][ ][ ]

Untuk pertanyaan 6 ABCD, anda dapat memilih maksimal 3 pendapat mengenai penggunaan sarana transportasi yang ada saat ini

Untuk anda yang menjawab "01. Kereta" pada pertanyaan nomor (2), silahkan langsung ke pertanyaan (6 B)

(6 A) Mengapa saat ini anda tidak menggunakan kereta ? [ ][ ] [ ][ ] [ ][ ] [ ][ ]

01 Stasiun terdekat sulit untuk dicapai dengan berjalan kaki
02 Stasiun terdekat sulit dicapai dengan kendaraan pribadi, (jalan akses ke stasiun kecil, tidak ada fasilitas parkir "park and ride")
03 Stasiun terdekat sulit dicapai dengan kendaraan umum, (sedikit rute bis/angkot menuju stasiun)
04 Jarak waktu keberangkatan kereta sangat lama.
05 Total waktu perjalanan dengan kereta ke tempat tujuan lebih lama dari pada menggunakan kendaraan lain.
06 Operasional kereta yang tidak tepat waktu
07 Keamanan di dalam gerbong dan di stasiun tidak aman.
08 Gerbong kereta yang ada tidak nyaman (gerbong kotor dan sangat penuh penumpang)
09 Gerbong kereta yang ada tidak nyaman (banyak pengamen, pengemis dan pedagang)
10 Saya tidak pernah menggunakan kereta
11 Moda transportasi yang digunakan saat ini masih lebih baik dari kereta.

Untuk anda yang menjawab "02. Transjakarta Busway dan 03. Trans-Pakuan" pada pertanyaan nomor (2), silahkan langsung ke pertanyaan (6 C)

(6 B) Mengapa saat ini anda tidak menggunakan Busway/Trans-Pakuan ? [ ][ ] [ ][ ] [ ][ ] [ ][ ]

01 Halte terdekat sulit dicapai dengan berjalan kaki
02 Halte terdekat sulit dicapai dengan kendaraan pribadi, (jalan akses ke halte kecil, tidak ada fasilitas parkir "park and ride")
03 Halte terdekat sulit dicapai dengan kendaraan umum, (sedikit rute bis/angkot menuju halte busway)
04 Tidak tersedia kendaraan umum / feeder yang menjangkau ke rumah saya
05 Antrian panjang dan lama untuk naik Busway (armada kurang, bis yang ada sudah penuh)
06 Menunggu lama untuk transfer ke koridor lainnya
07 Halte dan terminal yang tidak nyaman (tidak ada AC, kotor dan sempit)
08 Total waktu tempuh menggunakan Busway lebih lama dari mobil pribadi
09 Total waktu tempuh menggunakan Busway lebih lama dari sepeda motor
10 Tidak tersedia fasilitas pejalan kaki yang nyaman dari dan menuju halte busway
11 Saya tidak pernah menggunakan busway
12 Moda transportasi yang digunakan saat ini masih lebih baik dari busway

Untuk anda yang menjawab "no.04 s/d no.07" pada pertanyaan nomor (2), silahkan langsung ke pertanyaan (6 D)

(6 C) Mengapa saat ini anda tidak menggunakan bis/angkot : [ ][ ] [ ][ ] [ ][ ] [ ][ ]

01 Halte terdekat sulit dicapai dengan berjalan kaki
02 Halte terdekat sulit dicapai dengan kendaraan pribadi, (jalan akses ke halte/terminal sangat kecil, tidak ada fasilitas parkir "park and ride")
03 Rute yang ada sulit digunakan untuk ke tempat tujuan (lebih dari 3 kali berganti bis/angkot)
04 Jarak waktu keberangkatan bis/angkot yang sangat lama
05 Total waktu perjalanan dengan bis/angkot ke tempat tujuan lebih lama dari pada menggunakan kereta
06 Total waktu perjalanan dengan bis/angkot ke tempat tujuan lebih lama dari pada menggunakan mobil pribadi
07 Operasional bis/angkot yang tidak tepat waktu
08 Total biaya menggunakan bis/angkot lebih mahal
09 Keamanan di dalam bis/angkot dan di halte / terminal tidak terjamin
10 Kendaraan bis/angkot tidak nyaman (sangat padat, kotor, banyak asap)
11 Saya tidak pernah menggunakan bis/angkot.
12 Moda transportasi yang digunakan saat ini masih lebih baik dari bis/angkot.

Untuk anda yang menjawab "kendaraan pribadi" pada pertanyaan nomor (2), silahkan langsung ke pertanyaan (7)

(6 D) Untuk semua responden: Seandainya saya memiliki kendaraan pribadi.
Saya akan menggunakan kendaraan pribadi, apabila: [ ][ ] [ ][ ] [ ][ ]

01 Menggunakan kendaraan pribadi lebih mudah dan nyaman untuk pergi ketempat kerja / sekolah.
02 Biaya operasional kendaraan, tol, parkir dan lainnya masih terjangkau.
03 Pelayanan angkutan umum (bis dan angkot) masih buruk
04 Pelayanan angkutan kereta masih buruk.
05 Tarif angkutan umum (bis/angkot) dan kereta dinaikkan.
06 Tersedia lokasi parkir yang mudah, aman dan murah.
07 Jalan yang dilewati tidak macet.
08 Tidak ada peraturan yang membatasi penggunaankendaraan pribadi.

Ket.:
Park and Ride : Fasilitas parkir kendaraan yang disediakan bagi pengguna angkutan umum pada halte/stasiun tertentu. Anda dapat menggunakan kendaraan pribadi mobil/motor dan memarkirkannya pada fasilitas ini kemudian melanjutkan perjalanan dengan menggunakan angkutan umum seperti Busway, Kereta, atau MRT.

(7) Apabila pendapatan rumah tangga 20% lebih tinggi dari saat ini, apakah anda akan mengganti kendaraan yang anda miliki atau menambah dengan membeli yang baru? [ ][ ]

01. Tidak akan membeli kendaraan baru dan menggunakan pendapatan tambahan untuk keperluan lainnya.
02. Ya, membeli sepeda motor / mobil (mengganti/menambah).

a. Jika mengganti, Mobil [ ][ ] Sepeda Motor [ ][ ]
b. Jika menambah, Mobil [ ][ ] Sepeda Motor [ ][ ]

(8) Apabila pendapatan rumah tangga 50% lebih tinggi dari saat ini, apakah anda akan mengganti kendaraan yang anda miliki atau menambah dengan membeli yang baru? [ ][ ]

01. Tidak akan membeli kendaraan baru dan menggunakan pendapatan tambahan untuk keperluan lainnya.
02. Ya, membeli sepeda motor / mobil (mengganti/menambah).

a. Jika mengganti, Mobil [ ][ ] Sepeda Motor [ ][ ]
b. Jika menambah, Mobil [ ][ ] Sepeda Motor [ ][ ]

(9) Berikan tanda silang untuk pendapat anda mengenai pernyataan berikut ini

Bis Umum	a. Pengawasan terhadap tingkat pelayanan bis harus dilakukan oleh pihak berwenang	1	2	3
Busway	b. Perlu dilakukan penindakan terhadap mobil dan motor yang menggunakan lajur khusus Busway	1	2	3
	c. Diperlukan penambahan jumlah armada busway karena halte sangat padat dan waktu menunggu lebih lama.	1	2	3
Kereta	d. Perlu penambahan operasi kereta ber-AC	1	2	3
Mobil pribadi	e. Diperlukan manajemen lalu lintas yang lebih baik dari yang diterapkan saat ini.	1	2	3

Pendapat anda:
1. Ya, saya setuju
2. Tidak, saya tidak setuju
3. Saya tidak tahu

a b c d e [ ][ ][ ][ ][ ]

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JAPAN INTERNATIONAL COOPERATION AGENCY

FORM 2A (KHUSUS RESPONDEN YANG BEKERJA ATAU BERSEKOLAH) **RAHASIA**

NAMA SURVEYOR ________ NO. SURVEYOR ☐☐☐☐☐ KODE ZONA ☐☐☐☐☐☐☐ NO. BATCH ☐☐☐☐☐ NO. SAMPEL ☐☐☐☐☐ NO. ANGGOTA KELUARGA ☐☐

III. DATA ANGGOTA RUMAH TANGGA YANG BEKERJA ATAU BERSEKOLAH/KULIAH

(1) Umur ☐☐ tahun (2) Jenis Kelamin 01. Laki-laki 02. Perempuan ☐☐

(3) Jenis Surat Izin Mengemudi (SIM) yang dimiliki Lihat Tabel D ☐☐

(4) Dari mana anda berangkat kerja/sekolah/kuliah setiap harinya? Lihat Tabel E ☐☐

(5) Status responden ☐☐ 01. Sekolah / Kuliah → IV; 02. Bekerja → V

Untuk responden yang menjawab (02. Tempat Kos) dari pertanyaan III.(4)

Alamat Kost Jln. ________

Kel./Desa : ________

Kecamatan: ________ Kode Pos ☐☐☐☐☐

Kab. / Kota: ________ Kode Zona ☐☐☐☐☐☐☐

IV. KHUSUS UNTUK RESPONDEN YANG BERSEKOLAH

(1) Jumlah hari sekolah dalam 1 minggu ☐ hari

(2) Jenis Sekolah 01. Sekolah Negeri 02. Sekolah Swasta ☐☐

(3) Tingkat Sekolah Lihat Tabel F ☐☐

Nama Sekolah ________

Alamat: Jln. ________

Kel./Desa : ________

Kecamatan: ________ Kode Pos ☐☐☐☐☐

Kab. / Kota: ________ Kode Zona ☐☐☐☐☐☐☐

V. KHUSUS UNTUK RESPONDEN YANG BEKERJA

(1) Pendidikan Terakhir Lihat Tabel G ☐☐

(2) Apakah anda bekerja dirumah? 01. Ya 02. Tidak ☐☐

(3) Jenis Pekerjaan Lihat Tabel H ☐☐

(4) Jenis Tempat Pekerjaan Lihat Tabel I ☐☐

(5) Bidang Industri Pekerjaan Lihat Tabel J ☐☐

(6) Jumlah jam kerja dalam 1 minggu (ditempat kerja utama) ☐☐

(7) Jumlah karyawan ditempat anda bekerja ________ orang

(8) Status Kantor 01. Kantor Pusat 02. Kantor Cabang ☐☐

Nama Perusahaan: ________

Nama Gedung: ________

Alamat: Jln. ________

____

Kel./Desa : ________

Kecamatan: ________ Kode Pos ☐☐☐☐☐

Kab. / Kota: ________ Kode Zona ☐☐☐☐☐☐☐

TUNJANGAN TRANSPORTASI (KHUSUS untuk yang Bekerja)

(21) Apakah tempat anda bekerja memberikan tunjangan Transportasi (misalnya: biaya angkutan umum / BBM / Tol / Biaya fasilitas parkir, dan sebagainya)? 01. Ya 02. Tidak ☐☐

(22) Apakah tempat anda bekerja menanggung semua biaya transportasi dari dan ke tempat kerja (PP) ? 01. Ya 02. Tidak ☐☐

(23) Bila biaya transportasi tidak seluruhnya (hanya sebagian) ditanggung oleh perusahaan, berapa besar tunjangan transportasi diberikan?

(23 A) Tunjangan diberikan langsung tanpa perincian (lumpsum)

Sejumlah : Rp ☐.☐☐☐.☐00

(23 B) Tunjangan diberikan langsung berdasarkan jenis / penggunaannya

Bahan bakar Rp ☐.☐☐☐.☐00

Tol Rp ☐.☐☐☐.☐00

Parkir Rp ☐.☐☐☐.☐00

(24) Bagaimanakah sistem parkir di lokasi/gedung tempat anda bekerja? 01. Parkir milik perusahaan 02. Parkir sewa / dikelola gedung ☐☐

VI. DATA PENGGUNAAN DAN BIAYA TRANSPORTASI

(1) Jenis kendaraan bermotor utama yang digunakan untuk pergi bersekolah / bekerja Lihat Tabel K ☐☐

(2) Secara umum bagaimanakah cara anda berangkat ke sekolah / tempat bekerja? ☐☐

01. Menggunakan angkutan umum saja
02. Menggunakan kendaraan pribadi saja
03. Antar/jemput sampai halte/stasiun lalu naik angkutan umum
04. Menitipkan kendaraan di dekat halte/stasiun lalu naik angkutan umum

(2 A) Untuk pengguna angkutan umum, jemputan/kolektif dan kendaraan teman/saudara/tetangga. Berapa biaya Transportasi per Bulan yang biasa dikeluarkan?

Rp ☐.☐☐☐.☐00

(2 B) Khusus Pengguna Kendaraan Pribadi (anggota keluarga yang tidak membayar langsung tidak perlu mengisi). Berapa biaya transportasi per bulan yang biasa dikeluarkan untuk bekerja / sekolah?

Bahan bakar Rp ☐.☐☐☐.☐00

Tol Rp ☐.☐☐☐.☐00

Parkir Rp ☐.☐☐☐.☐00

(2 B1) Bila anda tidak tahu biaya bahan bakar perbulan untuk bekerja/sekolah, berapa jarak dari rumah ke kantor/sekolah? ☐☐ Km

(2 C) Untuk pengguna angkutan umum, dan menitipkan kendaraan. Berapa biaya Transportasi per Bulan yang biasa dikeluarkan?

Angkutan Umum Rp ☐.☐☐☐.☐00

Bahan bakar Rp ☐.☐☐☐.☐00

Tol Rp ☐.☐☐☐.☐00

Parkir/Titip Kendaraan Rp ☐.☐☐☐.☐00

(2 C1) Bila anda tidak tahu biaya bahan bakar perbulan untuk ketempat penitipan kendaraan, berapa jarak dari rumah ke tempat penitipan kendaraan? ☐☐ Km

(3) Apabila anda menggunakan angkutan umum (kecuali taksi) dari tempat tinggal anda, berapa kali anda harus naik angkutan untuk sampai ke sekolah / tempat kerja? Lihat Tabel L ☐☐

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FORM 2B (KHUSUS RESPONDEN YANG BEKERJA ATAU BERSEKOLAH)

RAHASIA

DATA PERJALANAN ANGGOTA RUMAH TANGGA YANG BEKERJA ATAU BERSEKOLAH/KULIAH

VII. Data Perjalanan pergi ke Tempat Kerja / Sekolah

(1) Waktu berangkat dari Rumah __ __ : __ __ WIB

(2) Waktu tiba di sekolah / kantor __ __ : __ __ WIB

Pengguna Kendaraan Pribadi

(3) Siapakah yang mengemudikan kendaraan ? Lihat Tabel M __

(4) Berapakah jumlah penumpang termasuk anda ? __ __ orang

(5) Total Biaya Tol Rp __ . __ __ __ . __ 0 0

(6) Total Biaya Rp __ . __ __ __ . __ 0 0

CATATAN MODA dan DETAIL PERJALANAN

Lama menunggu angkutan umum		Lihat Tabel N	Lama Perjalanan	Biaya (yg dikeluarkan sendiri)	Nama / Nomor Ang. Umum	Lokasi Transfer / Halte	Kode Zona Lokasi Transfer / Halte
	Moda 1		menit	Rp . . 0 0			
menit	Moda 2		menit	Rp . . 0 0			
menit	Moda 3		menit	Rp . . 0 0			
menit	Moda 4		menit	Rp . . 0 0			
menit	Moda 5		menit	Rp . . 0 0			
menit	Moda 6		menit	Rp . . 0 0			
menit	Moda 7		menit	Rp . . 0 0			
menit	Moda 8		menit	Rp . . 0 0			
menit	Moda 9		menit	Rp . . 0 0			

VIII. Data Perjalanan pulang ke Rumah

(1) Waktu berangkat dari sekolah/kantor __ __ : __ __ WIB

(2) Waktu tiba di Rumah __ __ : __ __ WIB

Pengguna Kendaraan Pribadi

(3) Siapakah yang mengemudikan kendaraan ? Lihat Tabel M __

(4) Berapakah jumlah penumpang termasuk anda ? __ __ orang

(5) Total Biaya Tol Rp __ . __ __ __ . __ 0 0

(6) Total Biaya Rp __ . __ __ __ . __ 0 0

CATATAN MODA dan DETAIL PERJALANAN

Lama menunggu angkutan umum		Lihat Tabel N	Lama Perjalanan	Biaya (yg dikeluarkan sendiri)	Nama / Nomor Ang. Umum	Lokasi Transfer / Halte	Kode Zona Lokasi Transfer / Halte
	Moda 1		menit	Rp . . 0 0			
menit	Moda 2		menit	Rp . . 0 0			
menit	Moda 3		menit	Rp . . 0 0			
menit	Moda 4		menit	Rp . . 0 0			
menit	Moda 5		menit	Rp . . 0 0			
menit	Moda 6		menit	Rp . . 0 0			
menit	Moda 7		menit	Rp . . 0 0			
menit	Moda 8		menit	Rp . . 0 0			
menit	Moda 9		menit	Rp . . 0 0			

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DAFTAR KODE PILIHAN JAWABAN

Tabel A : Hubungan dengan Kepala Keluarga

01. Kepala Keluarga
02. Istri / Suami
03. Anak
04. Menantu
05. Cucu
06. Orang Tua / Mertua
07. Kakek / Nenek / Paman / Bibi
08. Saudara/Sepupu/Keponakan
09. Saudara yang tinggal sementara / baru datang
10. Baby sitter / P.R.T / Sopir / Security / Tk. Kebun
11. Penyewa kamar kost

Tabel B : Hubungan dengan Kartu Keluarga Utama (Kartu Keluarga dalam daftar Sample)

01. Termasuk di dalam daftar K.K Utama
02. Anak / Orang tua dengan K.K terpisah/sendiri (sebelumnya dalam K.K yang sama dgn K.K Utama)
03. Bekerja di rumah ini / Saudara / Kost dgn KTP & K.K di Kecamatan & Kab./Kota yang sama dgn responden.
04. Bekerja di rumah ini / Saudara / Kost dgn KTP & K.K di Kecamatan berbeda dalam Kab./Kota yang sama dgn responden.
05. Bekerja di rumah ini / Saudara / Kost dgn KTP & K.K di Kab./Kota yang berbeda dgn responden.

Tabel C : Status Sosial / Kegiatan Utama

01. Bekerja (Full time, Peg.Tetap, Pemerintah)
02. Bekerja (Full time, Peg.Kontrak/Honorer, Pemerintah)
03. Bekerja (Full time, Peg.Tetap, Swasta)
04. Bekerja (Full time, Peg.Kontrak/Honorer, Swasta)
05. Bekerja (Part time, Peg.Tetap, Pemerintah)
06. Bekerja (Part time, Peg.Kontrak/Honorer, Pemerintah)
07. Bekerja (Part time, Peg.Tetap, Swasta)
08. Bekerja (Part time, Peg.Kontrak/Honorer, Swasta)
09. Wiraswasta
10. Pelajar (TK)
11. Pelajar (SD / MI)
12. Pelajar (SMP / MTs)
13. Pelajar (SMA / SMK / MA)
14. Pelajar (Akademi / Kejuruan)
15. Pelajar (Universitas / Perguruan Tinggi)
16. Ibu Rumah Tangga
17. Pensiunan
18. Pengangguran
19. Lainnya (______________________________)

Tabel D : Surat Izin Mengemudi yang dimiliki

01. SIM C
02. SIM A
03. SIM B
04. SIM C & SIM A
05. SIM C & SIM B
06. Tidak memiliki SIM

Tabel E : Tempat berangkat sekolah/ kuliah /kerja

01. Rumah (alamat sama dengan data keluarga)
02. Tempat kost / kontrakan (digunakan selama hari kerja)

Tabel F : Tingkat sekolah saat ini (Untuk responden bersekolah)

01. T.K
02. SD / MI
03. SMP / MTs
04. SMA / SMK / MA
05. Akademi
06. Univ. / Perguruan Tinggi
07. Pasca Sarjana

Tabel G : Pendidikan Terakhir (untuk responden bekerja)

01. Tidak Bersekolah
02. Tidak/Belum tamat SD
03. SD / (sederajat)
04. SMP / (sederajat)
05. SMA Umum / (sederajat)
06. SMA Kejuruan / (sederajat)
07. Diploma (DI/II)
08. Akademi (DIII)
09. Universitas (S1 / D4)
10. Pasca Sarjana (S2/S3)

Tabel H : Jenis Pekerjaan

01. Professor, manager, direktur, dsb
02. Pemilik industri / usaha
03. Tenaga Ahli (Teknik, Fisika, Kimia dsb), Dosen, Guru, Pengajar
04. Dokter, Insinyur, Akuntan, Pilot
05. TNI/POLRI
06. Staf administrasi
07. Teknisi
08. Pelayan, Bartender,
09. Sales, Pedagang
10. Tukang/ahli (perhiasan, kayu...)
11. Tenaga konstruksi, stasiun, pelabuhan, gudang, dsb
12. Pekerja pabrik, Buruh
13. Supir angkutan umum
14. Supir pribadi
15. P.R.T, office boy, tukang kebun
16. Petani, nelayan
17. Petugas keamanan
18. lainnya.......

Tabel I : Jenis Tempat Pekerjaan

01. Rumah atau asrama
02. Kantor Pemerintah / Fasilitas umum
03. Perusahaan / Kantor swasta
04. Lembaga pendidikan (TK,SD,SMP, dsb)
05. Tempat ibadah (Mesjid, Gereja, Vihara, dsb
06. Rumah sakit, klinik, puskesmas
07. Hotel, penginapan, Tempat hiburan
08. Rumah makan
09. Toko eceran, pasar, mini market
10. Supermarket,
11. Pusat perbelanjaan, plaza, mall, toserba
12. Pasar grosir / Induk
13. Pabrik, bengkel
14. Gudang, tempat penyimpanan
15. Stasiun, pelabuhan, terminal, bandara
16. Tempat instalasi (gas, air, listik)
17. Fasilitas rekreasi, olahraga
18. Taman-taman, cagar alam
19. Tempat pertanian, kehutanan, perikanan
20. Tempat konstruksi, pekerjaan bangunan
21. Lainnya (____________________)

Tabel J : Bidang Industri Pekerjaan

01. Pertanian/Kehutanan/Perikanan
02. Pertambangan/Penggalian/Pengeboran
03. Industri/Pabrik
04. Proyek Bangunan/Konstruksi
05. Transportasi & Komunikasi
06. Bank, Lembaga Keuangan
07. Perdagangan Besar & Eceran
08. Listrik, Gas & Air Minum
09. Pemerintah Pusat
10. Pemerintah Daerah
11. TNI/POLRI
12. Usaha Sewa-Menyewa
13. Jasa-Jasa (Hotel, hiburan, penelitian, iklan, dokter, konsultan, rohani, dsb)
14. Lain-lain (____________________)

Tabel K : Kendaraan bermotor Utama

01. Angkutan umum
02. Kendaran pribadi
03. Kend. teman/saudara/tetangga
04. Kend. jemputan / kolektif
05. Kend. Pribadi & Ang. Umum
06. Kend. teman/saudara/tetangga & Ang. Umum
07. Tidak menggunakan kendaraan bermotor

Tabel L : Berapa kali naik angkutan umum

01. 1 kali naik angkutan umum
02. 2 kali naik angkutan umum
03. 3 kali naik angkutan umum
04. 4 kali naik angkutan umum
05. 5 kali naik angkutan umum
06. lebih dari 5 kali naik angkutan umum
07. tidak tahu

Tabel M : Pengemudi kendaraan

01. Saya sendiri
02. Anggota keluarga
03. Saudara/teman/tetangga
04. Supir

Tabel N : Moda / Sarana Transportasi dan Alat angkut

01. Hanya jalan kaki sampai tujuan
02. Jalan kaki dari/ke angkutan umum

Kendaraan Pribadi

03. Sepeda
04. Sepeda Motor
05. Sedan, Jeep (5-6 pen.)
06. Kijang, L300 (7-8 pen.)
07. Elf, Travello (8-12 pen)
08. Pick-Up / Box kecil
09. Truck

Angkutan Umum

10. Kereta Eksekutif / Ekspres
11. Kereta Ekonomi AC
12. Kereta Ekonomi
13. Transjakarta Busway
14. Trans-Pakuan
15. Bis Besar (AC / patas AC)
16. Feeder Busway / Shuttle Bus
17. Bis Besar (Patas)
18. Bis Besar (Reguler, dsb)
19. Bis Sedang (Elf, Metromini, dsb)
20. Bis Kecil (Angkot, Angpedes, dsb)
21. Taksi
22. Bajaj
23. Ojek
24. Becak / Kereta kuda
25. Omprengan

Lain-lain

26. Bis Karyawan / Bis Sekolah
27. Bis Komunitas
28. Bis Sewa / Carter / Wisata
29. Kendaraan lain

APPENDIX B

Indonesia Highway Corporation Toll road access point