THE STUDY OF URBAN POOR AND NON-POOR ACCESSIBILITY TO POTENTIAL JOB OPPORTUNITIES IN JAKARTA METROPOLITAN AREA-INDONESIA

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June, 2014

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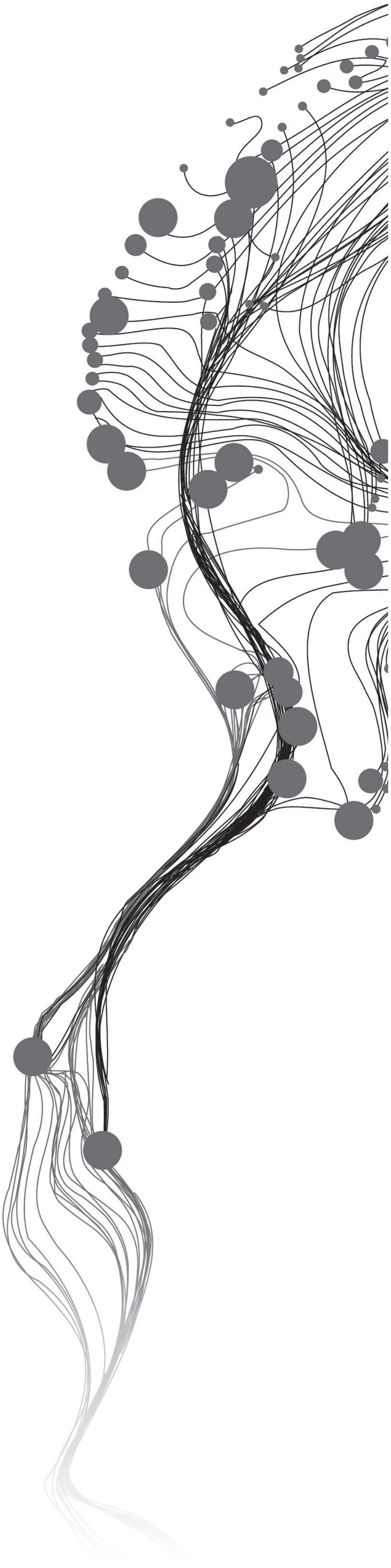

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ABSTRACT

Background: Understanding urban poor and non-poor mobility behaviour and their job accessibility in Jakarta Metropolitan Area (JMA)) is important for planner and policy makers in order to formulate appropriate urban mobility policy. However, lack of previous studies in JMA that were addressed to understand mobility and accessibility based on the combination socio-economic and spatial perspective.

Aim: To investigate the mobility behaviour of urban poor and non-poor and their accessibility to job opportunities in Jakarta Metropolitan Area (JMA)-Indonesia.

Methods: This research is started with literature review to provide theoretical framework. ArcGIS-based SQL and spatial SQL methods are used to extract database. Network analysis and accessibility model is used in order to develop potential accessibility model, cross-accessibility, and weighted accessibility for urban poor and non-poor.

Results: The urban poor and middle-income group primarily depend on the usage of moped instead of public transport and non-motorised transport whereas the high-income group overreliance on car usage. Although there is overdependence on moped for urban poor and middle-income, the potential accessibility analyses show that the potential job opportunities are more efficiently reached if there is a significant improvement in public transport. Therefore, it is important to make public transport to become more attractive so that there can be a shift from moped to public transport. The high-income group is overdependence on car usage but the potential accessibility analyses show that both car and moped provide high accessibility to potential job opportunities for the high-income group.

Whereas potential accessibility measure provides the information with regard to the ease to reach potential job opportunities from spatial perspective the cross-accessibility shows the condition for urban poor if they are able to reach potential job opportunities for middle income group. These two analyses shows that the improvement of public transport is necessary since this provides highly benefit to improve job accessibility and to reduce overdependence on motorised transport modes. The weighted accessibility provides the information related to the priority locations for proposing the policy intervention to improve accessibility. These three accessibility measures are complementary to each other so that it could be useful to be applied for deriving appropriate transport policy in JMA. This research suggests that improvement in public transport is a crucial aspect to improve accessibility in JMA. The improvement of public transport should be prioritised in the periphery areas to be able to release prevent urban poor from the spatial exclusion. Another intervention that follows the result of this research is the integration between motorised and non-motorised transport throughout transit oriented development concept. This intervention is advised to be implemented in the inner city area (CBD and its surrounding area) where the job density is high.

Keywords

Accessibility, Jakarta Metropolitan Area, Job, Urban Poor, Urban Non-Poor

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> Do the difficult things while they are easy and do the great things while they are small. A journey of a thousand miles must begin with a single step.
>
> Lao Tzu

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Chapter 1

Introduction

This chapter discusses the context of this research based on practical situation in Jakarta Metropolitan Area. The main focus in this research is to investigate the urban poor job accessibility in Jakarta Metropolitan Area. As comparison, the job accessibility of non-poor is also discussed in order to obtain a comprehensive information about accessibility to job opportunities in JMA. This issue is important to support the formulation of mobility policy in Jakarta Metropolitan Area

1.1 BACKGROUND AND JUSTIFICATION

Jakarta Metropolitan Area (JMA) is the largest metropolitan region in Indonesia with the number of population almost reaches 10 million inhabitants and the average population density by 15.4 thousand people per square kilometre (Central Bureau Statistics, 2010). JMA becomes the primary Indonesian economic centre development that contributes to approximately 16.40% of Indonesian GDP. Moreover, the trend of economic growth in JMA was stable between 6 and 6.6% during the period of 2004 to 2011. The economic growth is higher than the National growth that was between 5 and 6%.

In spite of its prodigious economic growth, JMA experiences serious problem for urban mobility. Suburbanisation rises and the satellite cities grow due to the extensive socio-economic activities as well as the substantial increase of the land value. As consequent, JMA is burdened by the great number of commuting activities due to the spatial mismatch problem. Spatial mismatch is the condition in which the location between the settlement and workplace are separated by reasonably long distance. Hence, people mobility is inefficient since people need to travel in longer distance and time travel.

The pattern of urban development in JMA inclines to grow towards sprawl development. Urbanised areas grow as corresponds to the construction of new road development. This circumstance stimulates people to become overdependence on private vehicles (car and motorcycle). Moreover, the quality and quantity of public transport service is insufficient in order to satisfy the mobility demand. In 2010, there are 1.1 million of daily commuting trips that are dominated by motorcycle (48.7%) and private car (13.5%) whereas trip by public transport/bus only accounts 12.9% (Coordinating Ministry of Economic Affairs, 2012a).

The primary sufferer of the deficiency of public transport service is the low-income social group (urban poor). 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 relation to mobility, urban poor primarily utilises non-motorised transport (NMT) mode such as walking and cycling (Kumar et al., 2013). Although

NMT is the most affordable mode for the poor, it has limitation to access distant employment opportunities. In contrast to the middle- and high-income social group, urban poor is more difficult to have access to motorised transport mode to access distant job opportunities. 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.

In the Indonesian context, Aminah (2009) remarks that urban poor transport expenditure reaches approximately 20-40% of total income. This fact shows that current transport service provision is inefficient and less-approachable for urban poor. In Jakarta case, the average monthly living cost is approximately IDR 7.5 million (USD 682). CBS defines urban poor is defined as the social group that has monthly income less than IDR 600 thousand (USD 55). If the transport cost is 20% of total income, urban poor has only IDR 480 thousand (USD 43.6) remain to cover living expenses. There is a significant gap between urban poor revenue and monthly living cost. This fact shows that the improvement of public transport service is necessary to reduce transport cost as well as to exempt the poor from social exclusion.

1.2 RESEARCH PROBLEM

Understanding urban poor accessibility to workplace is important in order to support the formulation of pro-poor urban mobility policy. The threat in formulating the appropriate pro-poor mobility policy is the lack of the comprehensive understanding of the poor mobility and their job accessibility. Urban poor mobility is a problematic issue that involves multidimensional perspectives. It needs to consider not only transport but also socio-economic and spatial aspects. Planners and policy makers are often experience the difficulty in structuring urban poor mobility issues due to lack of extensive information about the urban mobility characteristics and their accessibility to job.

In Indonesian case, understanding of urban poor is primarily approached from the socio-economic perspective rather than from the spatial perspectives. The poor is categorised based on the threshold of certain socio-economic indicators. For example, a household is categorised as the poor household if the income of household head is less than IDR 600,000 (USD 54.5). However, indicating the poor by only considering the socio-economic characteristics is insufficient to obtain the information about the mobility aspect of the poor. Further investigations are needed by incorporating spatial aspect to provide explanation of the urban poor mobility behaviour.

First, poor people have limited amount of income to spend for the public transport service because they experience the difficult trade-off between household and transport expenditures. In Indonesian large cities such as Jakarta, the standard living cost is extremely high by approximately IDR 7.5 million (USD 682) per month. There is a large gap between the poor income and living cost. This situation affects mobility behaviour of the poor people to their workplace. Roberto (2008) argues that urban poor encounters trade-off between housing and job location. Affordable house for the poor is generally located far from the job location. Consequently, the poor needs to spend very expensive transportation cost. In contrast, deciding to reside in the location that is close to job location has very expensive price that makes the poor is not able to cover their living cost. If the poor cannot afford to compensate the access to public transport and private vehicle, NMT (walking and cycling) becomes the only option.

Second, a paper by Hamzah (2012) argues that the effectiveness of the poverty alleviation policy is obstructed by the lack of comprehensive understanding with regard to the actual problems that are experienced by the poor. If this situation is reflected to the urban poor mobility policy, it is clear that understanding urban poor mobility characteristics is important. Ideally, the aim of pro-poor mobility policy is to improve the accessibility of the poor to their relevant job opportunities. It is important to know the mobility behaviour of the poor from the socio-economic and spatial perspective. For example, if the poor depends heavily on NMT, it is important to provide well-designed NMT transport facilities such as pedestrian and bike lanes at the location where urban poor is densely concentrated. If the policy makers aim at expanding the access of poor people to their job opportunities through public transport improvement, spatial distribution between urban poor settlement and their potential job locations are important aspect to evaluate where is the best location for public transport spoke and hub locations as well as the number of potential jobs that can be reached through the improvement of public transport system.

In JMA context, these two concerns are not widely discussed in the previous studies related to urban poor mobility. Certain research opportunities that can be undertaken to fulfil the gap of information between urban poor socio-economic and mobility characteristics.

- CBS defines the criteria of poor people based on the socio-economic indicators. Coordinating Ministry of Economic Affairs (2012a) observed the mobility behaviour of the commuters in JMA that incorporates socio-economic and spatial dimensions through Jakarta Urban Transport Policy Integration Project (JUTPIP). By combining the information of poor characteristics from CBS and mobility characteristics from Ministry of Economic Affairs, it is possible to obtain the characteristics of urban poor mobility behaviour in JMA. However, the method to extract and to combine socio-economic and spatial information from the JUTPIP database is not yet developed.

- The mobility behaviour and its implication to accessibility for both urban poor and non-poor for the context of JMA are rarely discussed in the previous studies. In this research, there are three components of mobility behaviour that are investigated: modal split, travel distance, and travel time. These three components are used to derive accessibility measure of the poor to their potential job opportunities. However, there is a challenging issue in deriving accessibility measures to potential job opportunities in deriving the suitable decay function. The previous studies in JMA are rarely addressed to model the decay function for measuring accessibility. The suitable decay function to develop accessibility for Jakarta case is unknown. However, JUTPIP database provides the opportunity to develop the decay function for different transport modes in order to deal with the gap of information about suitable decay function.

- It is important to compare accessibility of the urban poor with the different income groups (middle-, and high-income groups). This aspect provides comprehensive picture with related to urban poor accessibility and its related policy implications. For example, if urban poor lives in the location with high accessibility not only to job for the poor but also for the middle-, and high-income groups, they settle in spatially better location so that they have the opportunity to access better transport infrastructure. Therefore, the investment in the public transport in that area is beneficial. Otherwise, low-income people who live in spatially excluded area are likely to depend on NMT modes. An example of policy implication to response this situation is to provide a reliable NMT infrastructure to support urban poor mobility. The comparison of accessibility for different income group and transport mode is barely discussed in mobility-related studies in JMA.

1.3 AIM AND OBJECTIVES

The aim of this research is to investigate mobility behaviour of the urban poor and their accessibility to job opportunities in Jakarta Metropolitan Area. The objectives of this research are:

1. To define the urban poor in the context of Jakarta Metropolitan Area.
2. To examine mobility characteristics of urban poor and non-poor in the context of Jakarta Metropolitan Area
3. To develop suitable accessibility measure for urban poor and non-poor in Jakarta Metropolitan Area
4. To explore accessibility to job opportunity characteristics of urban poor and non-poor in Jakarta Metropolitan Area

1.4 RESEARCH QUESTIONS

Objective 1: To define the urban poor in the context of Jakarta Metropolitan Area.

1. What are the definitions of urban poor based on the global and Indonesian context?
2. How to define urban poor for the context of JMA?

Objective 2: To examine mobility characteristics of between urban poor and non-poor in the context of Jakarta Metropolitan Area

1. What are transport modes that are used by the poor to travel from home to work location?
2. What are transport modes that are used by non-poor to travel from home to work location?
3. How does the variation in the travel time distribution of urban poor group?
4. How does the variation in the travel time distribution of non-poor group?

Objective 3: To develop suitable accessibility measure for urban poor and non-poor in Jakarta Metropolitan Area

1. What is the suitable decay function for measuring accessibility for urban poor mobility?
2. What is the suitable decay function for measuring accessibility for non-urban poor mobility?

Objective 4: To explore accessibility to job opportunity characteristics of urban poor and non-poor in Jakarta Metropolitan Area

1. How does the pattern of urban poor distribution in JMA?
2. How does the pattern of urban non-poor distribution JMA?
3. How does the pattern of job opportunities for the poor?
4. How does the pattern of job opportunities for the non-poor?
5. Does urban poor live in the area that has good accessibility to potential job opportunities?
6. Is there any discrepancy between the settlement and the job location for the poor and non-poor?

7. What are suitable policy implication that can be derived from the potential accessibility to job opportunities for the poor and non-poor?

1.5 CONCEPTUAL FRAMEWORK

Figure 1.1 shows the conceptual framework of this research. In general, this research consists of two main parts: (1) conceptual; and (2) technical. In the conceptual part, two main concepts are used. First, the concept of poverty is used in order to understand the poverty from global and Indonesian context. The concept of poverty is used to determine the criteria for selecting urban poor group from the database. Second, the concept of accessibility is reviewed from the literature. This concept becomes the basis for determining suitable decay function and developing the accessibility model.

In the technical part, the information is extracted from two databases: (1) JUTPIP questionnaire; and (2) JUTPIP GIS database. JUTPIP questionnaire is the commuting database survey that was undertaken in 2010. There are two primary information that are derived from the database: (1) daily commuting trip sample; and (2) household income. The daily commuting trip consists of home-to-work and home-to-school trips. However, this research only considers home-to-work trip. Income classification is based on the household head income. By considering the criteria of urban poor according to Indonesian standard, the trip data is categorised into three income level: urban poor, middle income, and high income group. The travel behaviour of these income groups is observed by analysing the modal split of these different income groups. The mobility behaviour of these groups is used to determine the decay function for different transport modes that are used to travel from home to workplace.

The JUTPIP dataset is used in order to obtain the spatial information related to potential job accessibility for both urban poor and non-poor. There are two important information that are derived from JUTPIP dataset: (1) zonal population; and (2) population distribution. First, Zonal population is used in order to obtain the information related to population distribution based on their income level. This information is derived from the JUTPIP database because the population distribution on the questionnaire is based on sample rather than census data. Since JUTPIP spatial database consists of population data that is derived from the census data from the Central Bureau Statistics, it provides better information for being interpreted to support the accessibility analysis. Second, the job opportunity data is used in order to build accessibility model. The job opportunity data is classified based on the characteristics of job for urban poor, middle-income group, and high-income group. Both for zonal and job opportunity have 2010 time period in which similar to JUTPIP questionnaire.

The accessibility model is developed for urban poor, middle-, and high-income group level. The accessibility model is based on the travel decay function that is derived from the mobility behaviour of urban poor, middle-, and high-income group. The accessibility model is visualised on the GIS environment in order to explore the spatial variation of accessibility level for urban poor, middle-, and high-income group. The potential accessibility for different income groups is modified. First, the potential job opportunity by urban poor is modified by assuming that urban poor is able to reach potential job opportunities for middle-income group. This modification is called the cross-accessibility model. Second, the potential job opportunity is modified by introducing the weighted factor. The weighted factor is based on the number of population. The method to derive potential accessibility, cross-accessibility, and weighted accessibility is specifically discussed in Chapter 3.

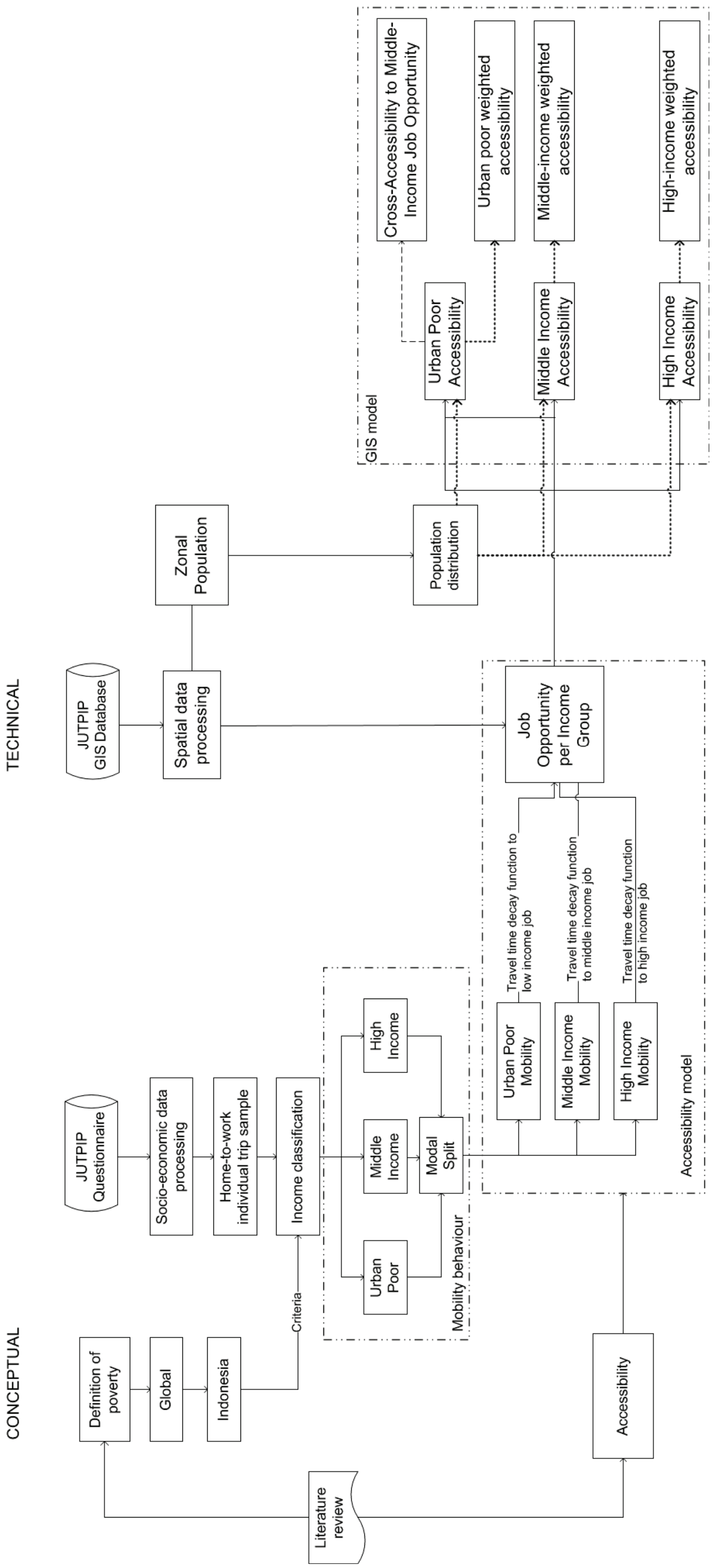


Figure 1.1: Conceptual framework

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 urban poor and accessibility measures. 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 are used in this research. Chapter 5 provides result and discussion in relation to the analysis to achieve the research objective. Chapter 6 provides the answer of the research question, general conclusion, and the recommendation for the future study.

Chapter 2

Theoretical Framework

This chapter discusses the theoretical foundation in relation to urban poor and accessibility measures. These theories are the basis for analysing potential accessibility to job opportunities for both urban poor and non-poor in Jakarta Metropolitan Area.

2.1 DEFINITION OF URBAN POOR

2.1.1 Absolute and relative poverty measure

Urban poverty can be measured by using either absolute of relative measure. These measures are primarily based on the income or consumption as its main indicator. Absolute measure adapts consistent quantitative indicators to characterise urban poverty. World Bank uses the daily purchasing power by USD 1.25 as the threshold for poverty line. Individual who purchases less than USD 1.25 is categorised as the poor. In contrast, relative measure is used to define the poverty by assessing the deprivation between the living situation of an individual and the actual living standard where the individual belong. Instead of using the daily indicator of USD 1.25, relative measure is more emphasised on the gap between individual/income with the normal live quality. For instance, in EU countries, if an individual earns income below 50% of median income, the individual is categorised at-risk-of poverty.

2.1.2 Social indicator poverty measure

In principal, poverty is characterised with the individuals exclusion from the necessitated of the basic needs for human well-being (Wratten, 1995). Therefore, it cannot be measured merely based on the level of income. Wratten (1995); Institute of Development Studies (1997) remark that there are two general perspectives regarding the discussion of urban poor: economic and anthropological.

Economic viewpoint is typically related to quantitative social indicators. This is commonly measured by using demographic (i.e. life expectancy, infant mortality), education (i.e. level of education, school enrolment), health (i.e. access to health facility, access to potable water), infrastructure and transportation, and asset (i.e. housing condition/quality) indicators. In contrast, anthropological viewpoint focuses on qualitative aspect such as individual independence, social security, social relationship, and opportunity to make decision, as well as the rights to legal protection and political aspiration.

2.2 CHARACTERISTICS OF THE POOR

2.2.1 Settlement

Baker (2008); World Bank (2009) remark two spatial characteristics of the urban poor settlement. First, urban poor is concentrated in the city centre area where close to the job location. Second, urban poor is located in the informal settlement in the periphery area. The settlement of the poor is separated from the settlement of the higher-income social group. In contrast to the middle- and high-income social group that live in the decent settlement area, the poor typically live in the socially-excluded and poor quality area (slum). The settlement of the poor is typically insufficient to access drinking water and improved sanitation, low tenure security, physically vulnerable housing, and overcrowding (World Bank, 2009).

2.2.2 Employment

Urban poor has limited number of job opportunities. Typically, urban poor depends on the availability of the unskilled job opportunities from the formal sector such as factory labour, clerks, security staff, and telemarketing. These types of jobs do not require high level of education but low level of job security. However, the number of unskilled job opportunity and the demand for the job is imbalance. Alternatively, urban poor seeks the opportunity for looking job at informal sector (International Labour Organization, 2004). Informal job is characterised as the job that is in the practice does not ensure fixed income, low job security, temporary work location, and illegitimate business unit. The job at informal sector is beneficial to support urban poor livelihood for the short term but it cannot assure the poor to have better wellbeing for the long term.

2.2.3 Mobility

The crucial problem in the mobility of the poor is that the poor spends large proportion of their income to obtain transport service. For example, a report from World Bank (2002) remarks that urban poor in African developing countries expends approximately 8-16% of their total income to cover transport cost. The implication of the expensive transport cost for the poor is that the poor is not able to continuously use public transport service. For instance, working urban poor at formal sector is able to use public transport but when the income is depleted, the non-motorised transport such as walking or cycling becomes the travel option.

The root of the overpriced transport cost is the trade-off between job and settlement location. GTZ (2002) remarks that urban poor typically lives in the informal settlements that are located in the inner-city or the urban peripheral area. In the extreme case, urban poor lives homeless (pavement dwellers). The trade-off between job and settlement location has the implication to the mobility behaviour of the poor.

First, urban poor encounters difficult situation in relation to the residential choice. The area that is close to employment opportunity with the good accessibility has the expensive land value that affects housing and property market. It is not possible for the poor to have access to the decent settlement that is close to their job location. Instead, urban poor lives in the slums and squatter districts or becomes pavement dweller. Although the poor lives in the settlement nearby the job location, the settlement of the poor is barely to have good accessibility by public transport. Moreover, income limitation causes the poor to do travel by non-motorised transport mode (i.e.

walking and cycling). This situation becomes problematic since many urban facilities are not accessible within walking distance or it is called accessibility poor (World Bank, 2002).

Second, the poor settlement is located in the urban peripheral area. The crucial problem is that urban poor needs to travel in the longer distance and time-consuming. Urban poor experiences the problem that is called âĂIJtime-poorâĂİ due to travelling by using slow transport mode (World Bank, 2002). Moreover, there are issues that are suffered by urban poor with regard to safety and physical condition. World Bank (2002) remarks that urban poor, in particular women, children, and the elderly group that uses pedestrian are susceptible to traffic accidents due to low-quality pedestrian facilities and street criminal (safety poor). In addition, the adverse effect of the long distance and time travel has consequence on reducing the poor productivity of the traveller due to exhaustion and wearied (energy poor). Furthermore, gender has implication to urban poor mobility.

World Bank (2002) remarks that female has more complex mobility behaviour in comparison to male. Female typically works in the specific type of occupation such as childcare, household management, and informal sector. However, female inclines to make more trips but in the shorter distance in comparison to the male traveller. Besides, female has tendency to make multipurpose trips in which becomes more expensive in term of out-of-pocket cost to cover public transport fare.

2.3 URBAN POOR IN THE INDONESIAN CONTEXT

Urban poor in Indonesian context is defined based on income and social indicators for satisfying the basic needs. Central Bureau Statistics stipulates 14 general indicators of poverty in Indonesian context (Ministry of Women Empowerment and Children Protection, 2013):

1. housing floor area is less than 8 m^2
2. housing floor is made from clay/bamboo wood/low-quality wood
3. housing wall is made from bamboo wood/sago palm/low-quality wood/uncovered wall
4. lack of private sanitation
5. lack of electricity
6. source for potable water comes originates from wells/unprotected fountain/river/rainfall
7. daily cooking fuel uses firewood/charcoal/kerosene
8. consuming meat/milk/chicken only once in a week
9. purchasing new clothes once in a year
10. consuming meal only one/two times every day
11. incapable of compensating healthcare service
12. the occupation of the household head comes from casual employment with the monthly income less than IDR 600 thousand (approx. USD 54.5).
13. low level of education head uneducated/unfinished primary education/primary education
14. lack of purchasable asset with the value equals to IDR 500 thousand (approx. USD 45.4)

A household is declared as the poor if minimum 9 out of 14 criteria are fulfilled. The poor household is eligible for the direct money subsidy from the government in order to support daily living cost.

2.4 MEASURING URBAN POVERTY

Baker and Schuler (2004) remarks five different approaches to analyse urban poverty: (1) income or consumption; (2) unsatisfied basic needs; (3) asset indicators; (4) vulnerability; and (5) participatory methods.

- Income or consumption measures urban poverty based on the affordability to fulfil basic needs such as food staple, house, and utilities. However, consumption is preferred to measure urban poverty rather than income since income tends to be fluctuated and the problem while reporting the actual income amount.
- Unsatisfied basic needs index is applied by defining minimum threshold to measure minimum access to basic needs. For example, some indicators that are used to measure unsatisfied basic needs are literacy index, school attendance, and overcrowding. A household that cannot satisfy the minimum threshold value is categorised as the unsatisfied basic needs household.
- Asset indicator is used to represent the household socio-economic characteristics. Certain examples of asset indicators are: vehicle ownership and dwelling characteristics (type of roof, flooring, and sanitation).
- Vulnerability is addressed to the risk that is possible to be experienced by a household or an individual. For example, a household or an individual may experience certain risks such as income or health poverty, crime, violence, and natural disasters. Certain indicators that are used to measure vulnerability are physical assets, human capital, networking, and access to credit. Vulnerability is measured by using time-series panel data in order to investigate the the household and individual exposure over time.
- Participatory method is emphasized on qualitative assessment in order to observe specific aspect with regard to urban poverty that cannot be exposed by using quantitative survey method. Participatory method is typically aimed at obtaining detailed information about certain issues that has implication to poverty issues. Certain tools that are used in participatory method are focus group discussion, case studies, and interview.

2.5 GENERAL CONCEPTION OF ACCESSIBILITY

Accessibility is a multi-dimensional concept (see Figure 2.1). It incorporates both of spatial (i.e geographic, land-use) and non-spatial dimensions (i.e. activity duration, individual benefit). In general, this research summarises accessibility concepts based on three major perspectives:

1. Accessibility is related to **spatial distribution** of socio-economic activities. This concept emphasizes on land use attractiveness as major component of accessibility.
2. Accessibility is defined as the **outcome of transport system performance**. This concept relies on the ability of transport system to diminish separation between individuals and spatial distribution of socio-economic activities.

3. Accessibility can be seen from **individuals perspectives** in relation to the **opportunity** to engage in certain activity and to decide different alternatives of mobility to overcome spatial separation.

In practice, these perspectives are often mixed. Hence, perceiving accessibility is context-specific. As consequent, stakeholders may have different insight about accessibility. Figure 2.1 shows a general conception for understanding accessibility that is categorised into three aspects: (1) land use-transport interaction; (2) individual opportunities relationship; and (3) user benefit.

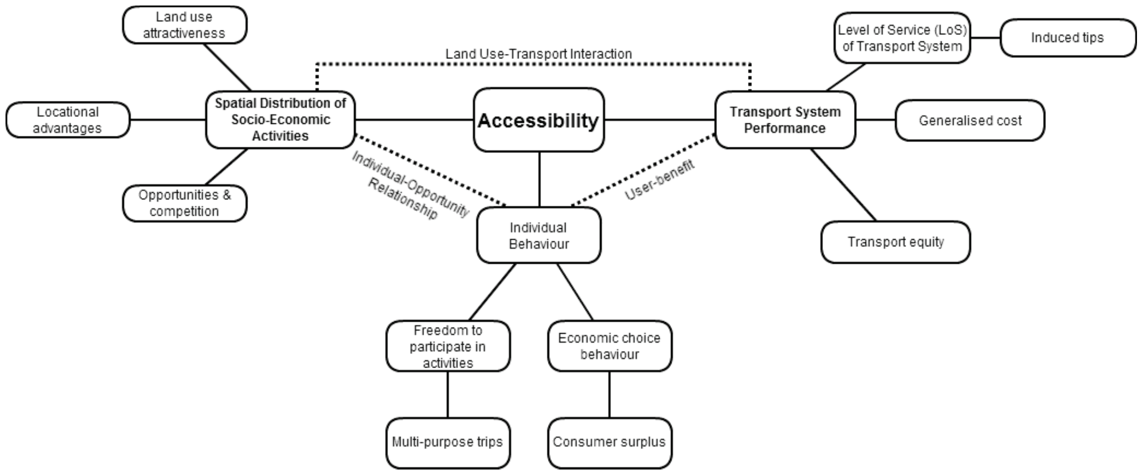


Figure 2.1: Hierarchical conception of accessibility

2.5.1 Land Use-Transport Interaction

The concept of land use-transport interaction is principally based on the idea of land use attractiveness. Land use attractiveness was initially studied by Hansen (1959), the research proposed the concept of accessibility as the ability and the inclination of people to overcome spatial separation of socio-economic opportunities.

The concept of land use and transport interaction as a measurement of accessibility is principally based on the capability of transport system to provide satisfied level of service to different socio-economic opportunities that are separated by distance (Burns and Golob, 1976). This concept is typically associated with the benefit of reaching particular locations as provided by certain transportation modes (Liu and Zhu, 2004; Litman, 2007).

Furthermore, from economic perspective, land use and transport interaction has implication to the presence of induced demand and discrepancy between opportunities and competition.

Purvis et al. (1996) argue that enhancing accessibility by improving transport system performance may satisfy induced trip demand. In practice, induced demand can be satisfied when improvement in transport system results in more efficient travel cost and more inclusive services (i.e. distance coverage, time flexibility).

Moreover, competition is principally an effect of locational attractiveness. For example, competition between two locations occurs when one location is more preferable rather than the other location because of the socio-economic attractiveness (i.e. employment, facilities) and transport services. This issue illustrates that accessibility in which is related to market mechanism of the opportunity distribution (Levinson, 1998). Thus, balancing accessibility may have implications towards competition effect and equity to access transport services.

2.5.2 Individual-Opportunities Attractiveness Relationships

The concept of individual-opportunity attractiveness relationship is principally quantification of the degree in which individual is able to reach spatially distribution of opportunities. In this concept, potential individual opportunity depends on the distance from individual at location i to the location j where the opportunity is available.

Therefore, the degree to which individual is able to reach the opportunity at location j from location i, A_{ij}, is shown by the equation,

$$A_{ij} = \sum_{j} O_j f(C_{ij}) \tag{2.1}$$

where O_j is the number of available opportunities at location j and $f(C_{ij})$ is the distance decay function. Moreover, the impedance function represents the inclination of trip making between two different locations that are separated by distance.

2.5.3 User Benefit

User benefit is a concept that emphasizes on the socio-economic advantages that are obtained by individuals that is provided by using particular transport alternatives. Individuals may conveniently decide from a set of alternatives that provides the highest utility to overcome spatial separation between two locations. Therefore, the better accessibility is indicated by the more efficient cost of travelling to overcome spatial separation.

2.6 MEASURING ACCESSIBILITY

2.6.1 Accessibility Component

A paper by Geurs and van Wee (2004) reviews four major components of accessibility: land use, transportation, temporal, and individual.

- Land use refers to spatial distribution of socio-economic activities. Furthermore, this component incorporates:
  - **Supply of socio-economic activities** at destination location (i.e. employment opportunity, urban facilities).
  - **Demand for socio-economic activities** at origin location (i.e. population density).
  - **Discrepancy** between supply and demand for socio-economic activities. Moreover, this may result in **competition** between supply and demand due to unbalanced ratio between supply and demand.

- Transportation refers to available transport infrastructure that encourages people to overcome spatial friction between two locations. Moreover, this component is often measured by transport performance indicator such as generalised transport cost (i.e. travel time, distance), transport benefit (i.e. reliability, level of comfort).
- Temporal refers to time dimension. This components can be related to either transport performance (i.e. public transport service frequency) or socio-economic activity (i.e. activity duration).
- Individual refers to personal socio-economic attributes (i.e. age, income, education, household profile) that influence individuals' access to different transport options to reach potential opportunities.

2.6.2 Accessibility Measurement

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

- **Infrastructure** measure emphasizes on analysing 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.
- **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).
- **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.
- **Utility** measure is based on **economic benefit** that **individuals gain** from available **transport alternatives** to reach spatially distributed opportunities.

2.6.3 Accessibility Indicators

Halden et al. (2005) remarks some basic typologies of accessibility indicator. In principal, the study distinguishes two indicators: **opportunity** and **time/cost/value** measures.

- Opportunity measures
  - Catchment/contour. This is based on **time travel** threshold to reach potential opportunities from origin location to destination.
  - Continuous deterrence function. This reflects the **spatial friction** of **geographically separated** socio-economic opportunities.
- Time/cost/value

- Opportunities within space-time boundaries. This indicator emphasizes on **available transport alternatives** to reach potential destinations by considering **time availability** of the transport options and (minimum) **duration** of particular activities at the destination.
- Utility based focuses on **value** and **benefit** to individual/group as the result of the improvement of accessibility.

2.7 SPATIAL ACCESSIBILITY MODEL

Spatial accessibility is based on two components: potential job opportunity and spatial friction. Potential job opportunity is based on the number of job that is available within a JUTPIP survey zone. Spatial friction is the resistance that separates between two or more locations. In principal, the spatial friction is based on travel distance or travel time from origin to destination locations. The spatial accessibility is represented by using accessibility index. The higher the index value of a location A, the easier to reach potential job opportunities that are dispersed in the vicinity. Figure 2.2 shows conceptual model of spatial accessibility.

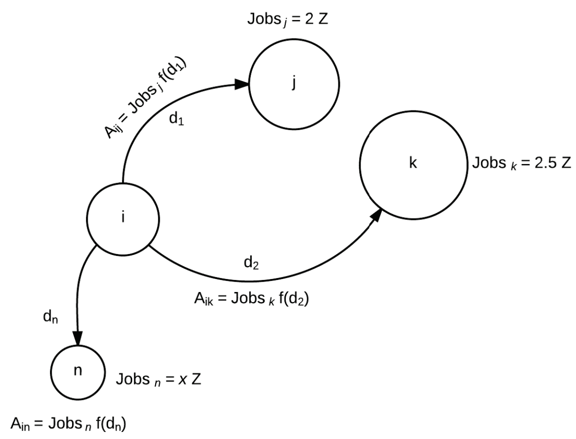


Figure 2.2: Conceptual model of spatial accessibility to potential job opportunity

A location is defined as the high accessibility area if it is able to reach the higher value potential opportunities within relatively short distance. According to Figure 2.2, accessibility from location i, A_i to reach potential job opportunities at location $j, k, \cdots, n$, is shown by the equation,

$$\text{Accessibility}_i = \sum_{j}^{n} \text{Jobs}_j f(\text{Distance}_{ij}) \tag{2.2}$$

The important aspect in the spatial accessibility analysis is the selection of the suitable decay (impedance) function. Reggiani et al. (2011) remarks that the impedance function represents the mobility behaviour pattern. The theory of spatial interaction emphasizes that the entities that are close to each other has the higher potential interaction in comparison to those that are distant. As the impedance (e.g. distance, travel time) that separates two or more entities becomes smaller, the higher potential interaction. Skov-Petersen (2001) remark different formulations to explore the potential interaction: (1) generalised distance decay function; (2) power distance decay function; and (3) exponential decay function.

2.7.1 Generalised decay function

This measurement of potential accessibility is undertaken by using certain threshold. For example, the threshold can be based on travel times. By assuming an ideal threshold for reaching a particular facility is 15 minutes. If the travel time from location i to location j is less than 15 minute, the potential interaction is high (in this case is equal to 1). Otherwise, the facility is inaccessible (in this case the potential interaction is 0). If accessibility to reach a facility in location j from location i, A_i, and the decay function from location i to j, C_{ij}, the potential accessibility is shown by equation,

$$A_{ij} = \sum_{n=1}^{j} f(C_{ij}) \cdot M_j \tag{2.3}$$

where $f(C_{ij})$ indicates the generalised decay function with the value is equal to 1 if the travel time is less than or equal to 15 minutes and it is equal to 0 if travel time more than 15 minutes. M_j is the attractiveness factor M that is available at location j.

2.7.2 Gravity-based decay function

The gravity-based decay function adapts the gravity model as described in the classical physics (Newtonian). In this case, the decay function is assumed to resemble the power function. If C_{ij} represents the travel cost between location i and j, the number of attractiveness in location j, M_j, and the distance between location i and j, d_{ij}, the potential accessibility in location i, A_i, is shown by equation,

$$A_i = \sum_{j=1}^{n} \frac{M_j}{C_{ij}^{\lambda}} \tag{2.4}$$

where λ is the parameter that represents the decay function.

2.7.3 Exponential decay function

The exponential decay function is the alternative form to represent the decay function. If M_j represents the attractiveness factor in location j, the decay function between location i and j, $f(C_{ij})$, the potential accessibility in location i to reach potential job opportunity in location j, A_{ij}, is shown by equation,

$$A_i = \sum_{j=1}^{n} M_j.\exp(-\lambda.C_{ij} \tag{2.5}$$

where λ represents the parameter of the decay function.

One of the limitation in this study is lack of the information about the suitable form of decay function in Jakarta Metropolitan Area. Therefore, the decay function is analysed from the individual trips data according to the JUTPIP commuting survey.

Chapter 3

Overview of the Case Study

This chapter provides the overview of Jakarta Metropolitan Area as the study area of this research. 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

The study area in this research is Jakarta Metropolitan Area (JMA). JMA is the largest metropolitan area in the Southeast Asia. In 2011, JMA has the number of population more than 10 millions of inhabitants and average population density by 15.4 thousand inhabitants/ km^2 (State Ministry of National Development Planning, 2013). JMA consists of five cities: (1) Jakarta Barat (West Jakarta); (2) Jakarta Timur (East Jakarta); (3)Jakarta Pusat (Central Jakarta); (4) Jakarta Utara (North Jakarta); and (5) Jakarta Selatan (South Jakarta). The delineation of the study area is shown on the Figure 3.1.

3.1.1 Macroeconomic Overview

JMA is a province that has a specialised role as the capital region of the Republic of Indonesia. The economic and financial activities in JMA are the backbone of Indonesian economic development. According to Coordinating Ministry of Economic Affairs (2011), economic and financial activities in JMA influence to more than 85 % of the Indonesian financially-related decision making. Moreover, based on the data that are complied by State Ministry of National Development Planning (2013), the percentage of economic growth and GDP in JMA is higher than the national average. As shown on Figure 3.2a, from the period of 2004 to 2011, the percentage of economic growth in JMA remains stable between 6 to 6.6 % whereas national growth is between 5 to 6 %. However, due to the effect of global economic crisis in 2009, both of JMA and national economic growth decrease between the period of 2008 and 2009 by 5.02 % and 4.77 % respectively. As shown on Figure 3.2b, based on the GDP rate, both of GDP at JMA and national level have experienced double increase. However, GDP per capita in JMA is four times larger than the national GDP.

Moreover, State Ministry of National Development Planning (2013) remarks that in 2012, JMA has the Gross Domestic Regional Product (GDRP) by approximately 92 million US$ (including the revenue from oil and gas sector) and 91.5 million US$ (excluding the revenue from oil and gas sector). This contributes to 16.40% of National GDP. The economic structure are dominated by financial and services (27.58%); trade, hotel and restaurant (20.80%); and manufacturing (15.62%). In addition, manufacturing service and construction quite significant contribution to the macroeconomic by recording 12.63% and 11.47% respectively.

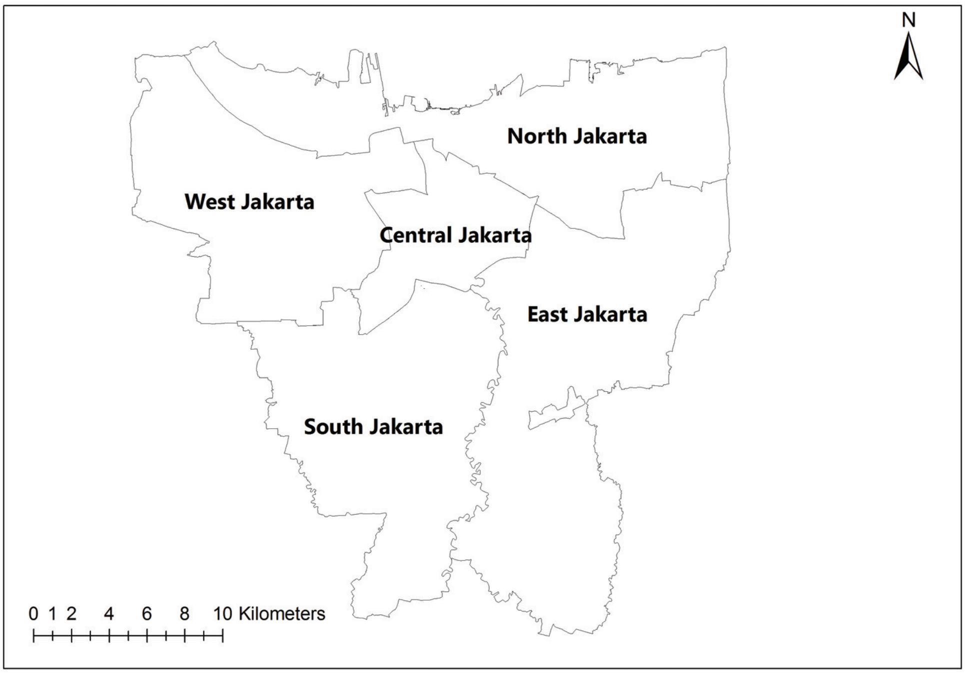


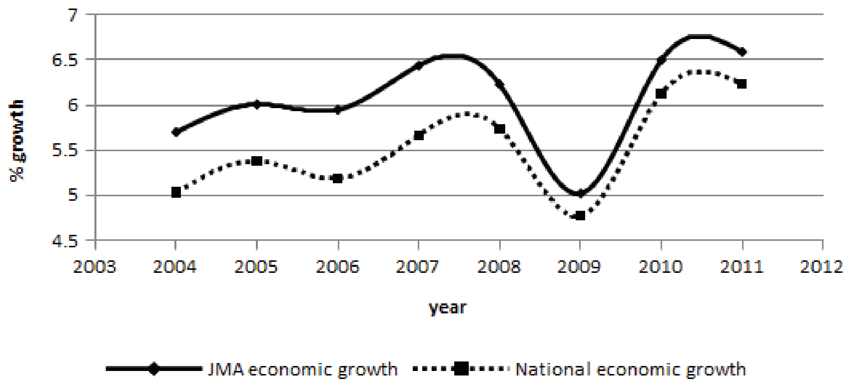
Figure 3.1: Jakarta Metropolitan Area

3.1.2 Demographic Overview

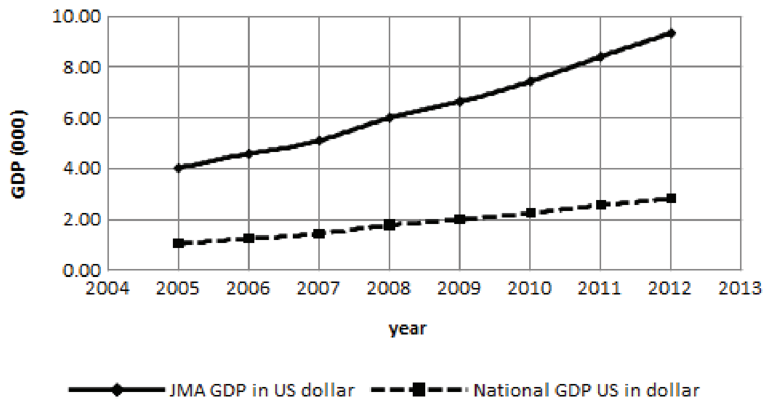
JMA is a gigantic metropolitan region. Each municipality within JMA has population more than 1 million inhabitants. Figure 3.3 shows the distribution of population and population density in each municipality in JMA. The distribution of inhabitants is primarily concentrated in East Jakarta and West Jakarta by approximately 2.9 and 2.2 millions inhabitants respectively. The number of population South Jakarta and North Jakarta is close to 2 million inhabitants. Central Jakarta has the smallest number of population by approximately 1.1 million inhabitants. However, based on the population density, Central Jakarta is the most densely municipality by approximately 23,000 inhabitants per km^2. The other four municipalities has population density less than 20,000 inhabitants per km^2 but more than 10,000 inhabitants per km^2.

Figure 3.4 and Table 3.1 shows the comparison of employed and unemployed inhabitants in Jakarta Metropolitan Area between 2008 and 2011. According to State Ministry of National Development Planning (2013), in terms of employment, from the period of 2008 to 2011, the number of employed people in JMA has increased. There are three municipalities that have shown a significant increase in terms of the number of employment: West Jakarta, North Jakarta, and Central Jakarta. Although there are increase in the number of employed inhabitants South Jakarta and East Jakarta, the increase of employed inhabitants is not substantial.

In contrast, the number of unemployed people has significant decrease in South Jakarta and East Jakarta. The number of unemployed people in these municipalities declines substantially. In North Jakarta, there is a slight decrease in the number of unemployed people. The contrary fact is shown in the West Jakarta and Central Jakarta in which the number of unemployed people has the slight increase.



(a) Comparison between JMA and National Economic Growth



(b) Comparison between JMA and National GDP per capita

Figure 3.2: Macro Economic Overview of Jakarta Metropolitan Area (State Ministry of National Development Planning, 2013)

Table 3.1 Employed and Unemployed Inhabitants in Jakarta Metropolitan Area between 2008 and 2011 in Thousand (State Ministry of National Development Planning, 2013)

	2008		2011	
Municipality	**Employed**	**Unemployed**	**Employed**	**Unemployed**
South Jakarta	979.45	133.07	1,020.34	100.46
East Jakarta	1,091.15	166.37	1,199.92	139.20
Central Jakarta	424.08	56.35	539.60	64.79
West Jakarta	1,013.16	114.21	1,146.57	117.66
North Jakarta	677.14	109.60	922.78	106.34

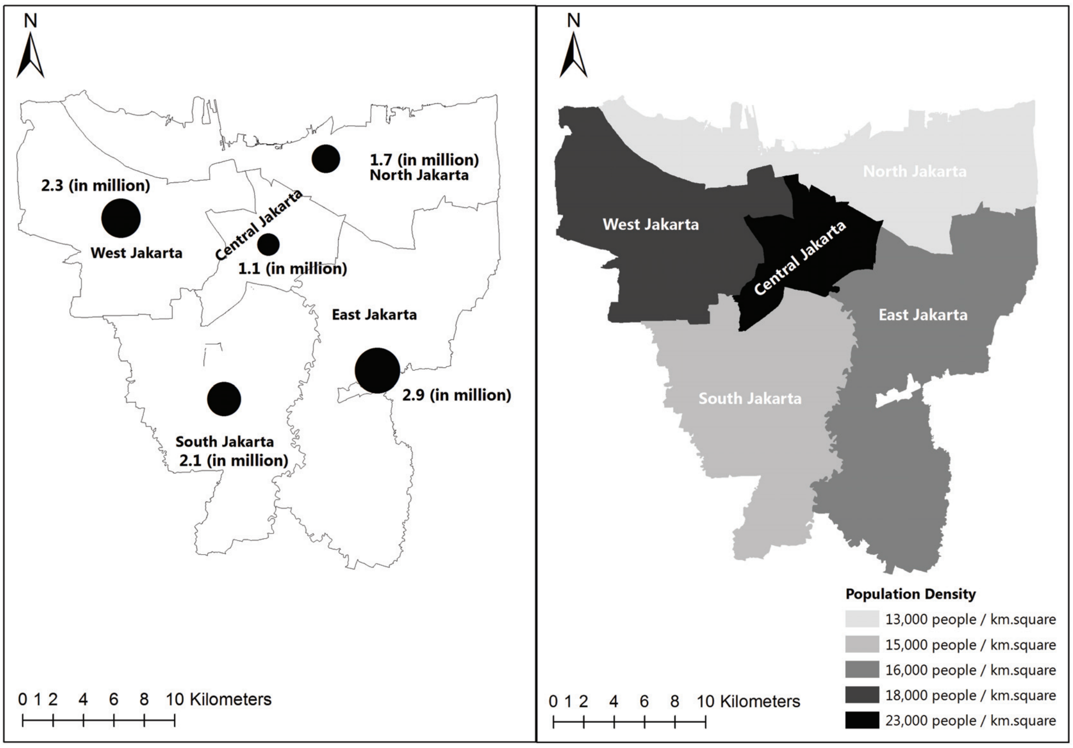


Figure 3.3: Population Distribution and Population Density in Jakarta Metropolitan Area

3.1.3 Issues in Jakarta Metropolitan Area

Urban Development

As the consequence of becoming the centre of Indonesian economic development, Cybriwsky and Ford (2001) remarks that JMA grows into two contrary directions. First, JMA has developed into a global economic centre where the economic and financial activities provide the opportunity for people to increase their prosperity. This circumstance implies to enormous urban development in which illustrated by the fast-growing high rises property and real estate development. Second, as the consequence of developing into global economic centre, JMA encounters challenging issues in relation to overpopulation and inadequate infrastructure services (in particular public transport, clean water, and proper settlement).

Moreover, in terms of spatial interaction, JMA has grown to form a conurbation together with certain satellite cities in the vicinity that is called the Greater Jakarta (Figure 3.5). The five cities within JMA are the urban core area of the Greater Jakarta in which employment opportunities are concentrated. In contrast, there are satellite cities in the vicinity is predominantly developed for human settlement due to the difficulty to obtain housing in the JMA. There are eight satellite cities in the surrounding of JMA: (1) Kabupaten Bekasi; (2) Kabupaten Bogor; (3) Kabupaten Tangerang; (4) Kota Bekasi; (5) Kota Bogor; (6) Kota Depok; (7) Kota Tangerang; and (8) Kota Tangerang Selatan.

In the period of 2002 and 2010, household income in the Greater Jakarta (JMA and its suburban area) has changed significantly. According to Coordinating Ministry of Economic Affairs (2012a),

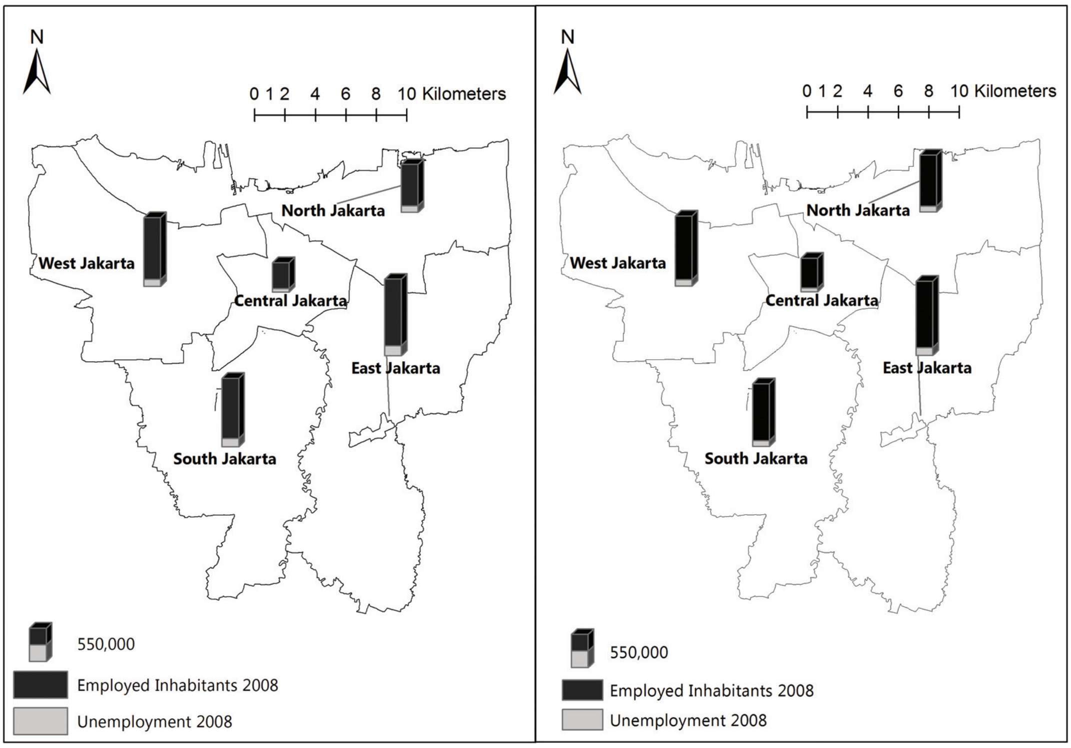


Figure 3.4: Map of Employed and Unemployed Inhabitants between 2008 and 2011 in Jakarta Metropolitan Area

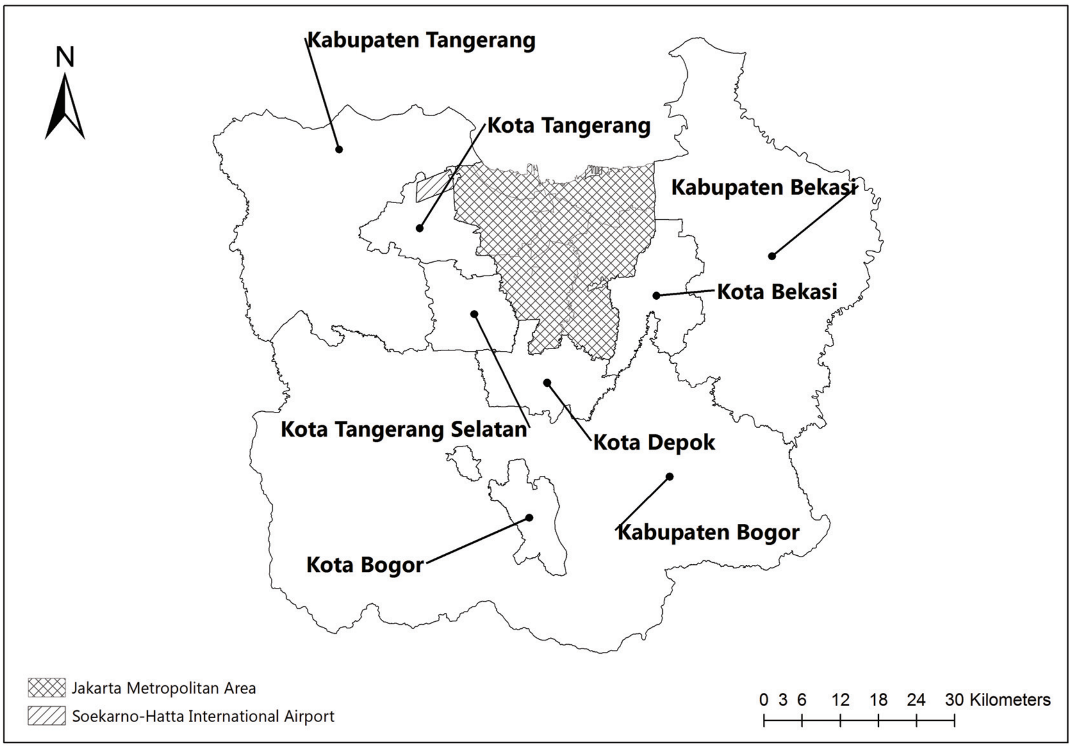


Figure 3.5: The Greater Jakarta Area

the proportion of population with monthly income less than IDR 1.5 million (approx. 136 US$) has decreased. In contrast, the proportion of people with monthly income from IDR 1.5 million to IDR 5.9 million (approx. 536 USD) becomes more dominant in 2010 whereas in 2008 most of the inhabitants has income between IDR 1 and 1.4 million (approx. 100 and 127 US$). Figure 3.6 shows the change in the income level for people in the Greater Jakarta.

Mobility

The discussion about mobility issues in JMA is started with the discussion about the spatial mismatch. Spatial mismatch is the condition in which the workers do not live nearby their workplace location. Moreover, this circumstance has led into urban sprawl and its negative effect such as low density development (leapfrog development) and overdependence to private vehicles. In the context of JMA, spatial mismatch occurs in which jobs are concentrated in the JMA where the workers reside in the satellite cities (Hakim, 2009).

The implication of spatial mismatch is the high demand for reliable public transport service. However, the infrastructure supply to satisfy the demand for mobility is insufficient. A study by Mochtar and Hino (2006) remarks that vehicle grows approximately 10% whereas infrastructure growth only 1%. Thus, people are overdependence to private vehicle. To illustrate, in the period between 2000 and 2006, the number of car ownership has a remarkable increase from 3.26 million to almost 8 million (Coordinating Ministry of Economic Affairs, 2012b).

Morever, spatial mismatch has led into high burden for mobility. The most distinct effect is the

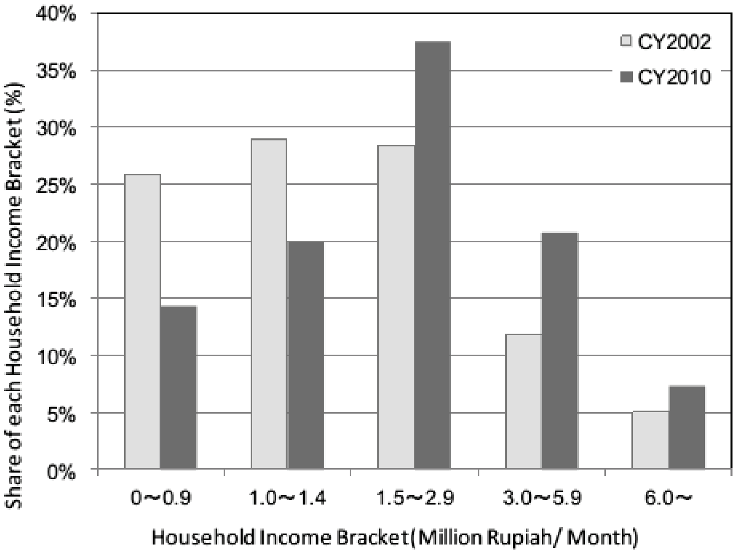


Figure 3.6: Change in the proportion of income in the Greater Jakarta between 2002 and 2010 (Coordinating Ministry of Economic Affairs, 2012a)

extensive number of commuting trips from the satellite cities into the Jakarta Metropolitan Area (JMA). Coordinating Ministry of Economic Affairs (2012a) remarks that between the period of 2002 and 2010, the number of commuters in JMA has increase approximately 1.5 times (Figure 3.7). The significant increase in commuting trips is originated from Kabupaten and Kota Bekasi from 262 thousand to 423 thousand commuters. The number of commuters in Kota Tangerang, Kota Tangerang Selatan, and Kabupaten Tangerang increases 1.4 times from 247 thousand to 344 thousand commuters. Likewise, the increase of commuter numbers in Kota Depok, Kota Bogor, and Kab. Bogor increases by 1.4 times from 234 thousand to 338 thousand commuters. The high number of commuter trips has implication to traffic congestion. This is indicated by the decrease in the travel speed during the peak hour period. The average travel speed decreases from approximately 20-30 km/h into 5-15 km/h during the peak hour period.

Some initiatives that have already been undertaken by the government to improve public transport service to support mobility in JMA throughout providing (1) Jakarta Bus Rapid Transport system (BRT); (2) Jakarta MRT project; and (3) monorail. First, Jakarta BRT system is known as *TransJakarta Busway* project is initiated in 2004. According to Coordinating Ministry of Economic Affairs (2012b); Nobel et al. (2013), currently there are twelve TransJakarta Busway corridors whose 520 unit that serve approximately 310 thousand passengers. The TransJakarta Busway system is designed with transit concept in which transit stations are located close to the office and commercial centres. Second, Jakarta MRT is still in the planning phase in 2014. This project is attempted to reduce the traffic congestion by providing service to support commuting trips as well as stimulating people to shift from private car user to public transport to reduce traffic congestion. Third, the monorail project in JMA has not yet to reach agreement in order to proceed to construction phase, at least in 2014. The project encounters problem in relation to financial sustainability (Dewi and Elyda, 2014).

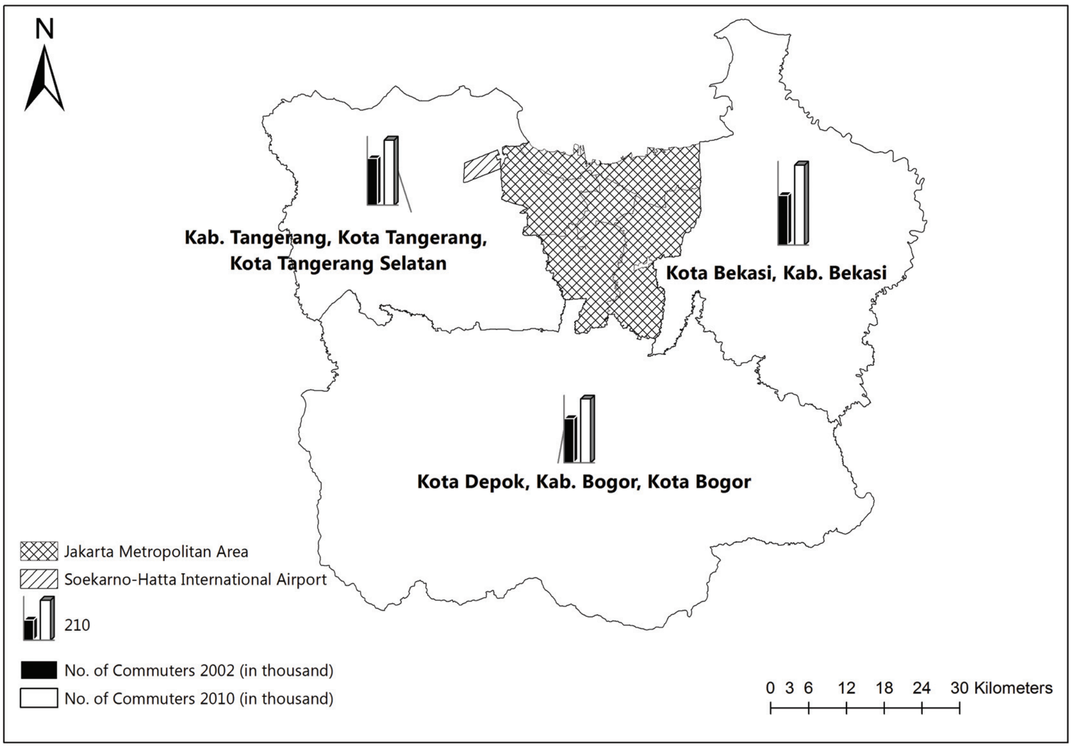


Figure 3.7: Change in the number of commuters in satellite cities in Jakarta Metropolitan Area between 2002 and 2010

Travel Behaviour

According to Nobel et al. (2013), people in the Greater Jakarta is overdependence to private vehicle. In the period of 2002 and 2010, both of private car and motorcycle ownership level has increased. In 2002, from approximately 5.7 million household, more than 1 million household own private car and almost 2 million people own motorcycle. In 2010, from approximately 7.3 million household, almost 2 million household own private car and almost 6 million household posses motorcycle.

Coordinating Ministry of Economic Affairs (2012a) remarks that the number of commuting trips to workplace in JMA approximately reaches 1.1 million trips in 2010 that is dominated by private vehicles. Commuting trip by motorcycle is about 48.7% and by private car is approximately 13.5%. Interestingly, there is also a quite significant number of non-motorised trip that contributes to 22.6% of the total home-to-work trip. Trip by bus records 12.9% whereas commuting trips by other transport mode is equal to 5% of the total trip.

A study by Nobel et al. (2013) remarks that the establishment of BRT System (TransJakarta) is not yet effective to shift from private vehicle (car, motorcycle) user into public transport user. Moreover, the study remarks that BRT system is typically used by travellers who are accustomed to use public transport. There is a limited number of travellers who use private vehicles that actually shift from private vehicle to BRT system. The primary reasons regarding the reluctance of traveller to shift from private vehicle to BRT system are due to flexibility, comfortability, travel time, and convenience aspects. Private vehicles (car, motorcycle) are more flexible in terms of coverage and able to provide more efficient travel time in comparison to BRT.

3.2 INTRODUCTION TO DATASET

This study utilises two database: (1) Jabodetabek Urban Transport Policy Integration Project (JUTPIP); and (2) Geographic Information System (GIS) Database. JUTPIP is a household commuter survey that was undertaken in 2010. The survey is a collaboration between Coordinating Ministry of Economic Affairs of the Republic of Indonesia and Japan International Cooperation Agency (JICA). Second, GIS database is a spatial database system that was developed for the project entitled "*Study on Integrated Transportation Master Plan for the Jabodetabek*" or abbreviated as "*SITRAMP*". This project is a collaboration between State Ministry of National Development Planning and JICA.

In this research, these two dataset are complimentary. JUTPIP survey data provides the recent information about commuting survey in which can be spatially visualised by linking attributes between JUTPIP survey and GIS dataset. 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 3).

3.2.1 JUTPIP Commuting Survey

JUTPIP commuting survey is a household based survey data within the Greater Jakarta. There are three major information that are captured in this survey: (1) household socio-economic characteristics; (2) household's opinion in accordance to modal choice; and (3) household member individual trip record data. The study consists of 178,953 household sample (commuting dataset), 657,165 household member (household member dataset), 186,819 individual sample for home-to-work trips, and 129,849 individual sample for home-to-school trips.

JUTPIP commuting survey consists of three types of dataset: (1) household dataset; (2) household member dataset; and (3) individual member person trip dataset. Figure 3.8 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 is recorded in the individual member trip dataset.

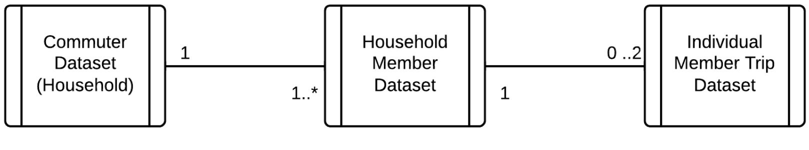


Figure 3.8: Relational diagram among commuting survey, household member, and individual member datasets in JUTPIP commuting survey

Household socio-economic characteristics

Household socio-economic characteristics encompass information about household income and expenditure, household size, household structures (household member, age), vehicle ownership. In addition, information about housing characteristics (type, ownership status, electricity) are provided in the household socio-economic characteristics.

Household opinion

Household opinion about modal choice is a qualitative enquiry to gather information related to the argumentation of the traveller for choosing particular transport mode. Moreover, households are also questioned about the possibility to purchase new vehicle or (at least) change old vehicle into new vehicle in the condition when household income increases 20% and 50%. In addition, household are asked about their opinion in relation to transport demand management for four different transport modes: bus, busway, rail, and private car.

Household member individual trip

Household member individual trip information is aimed at revealing travel behaviour for two types of trip: home-to-work; and home-to-school as well as travel information data.

In general, individual trip information consists of information about trip maker characteristics (age, gender, driving license), trip purpose (work or school), origin and destination location, transport mode, travel cost. For home-to-work trips, there are certain specific information: (1) education level; (2) occupation information (type of job, field, number of employer at workplace, office location). In addition, there are some enquiries about transport subsidy for employee and parking system. For home-to-school trip, specific information are: (1) school information (location, type of school, level of school, number of school day in a week).

Travel information data reveals information about the utilise of particular transport mode during the trip from home-to-work/school and work/school-to-home. In essence, the information consists of information for private vehicle and public transport. For private vehicle, information that are captured are travel time (departure and arrival), the number of passenger, and person who drive/ride. For public transport, the information that are captured are modal interchange, travel time in one mode, waiting time, and fare.

3.2.2 GIS Database

GIS database is a comprehensive dataset that consists of (1) infrastructure (transport and utility); (2) land use; (3) demographic; (4) geographic; and (5) remote sensing data. In addition, there is a dataset that has been designed with specific delineation for collecting data for JUTPIP commuting survey. In this study, the important application of GIS database is to link spatial information (i.e. road infrastructure, administrative boundary) with socio-economic information that is collected in JUTPIP commuting survey. In the GIS database, two datasets are used: (1) infrastructure network (particulary road network); (2) administrative boundary; and (3) delineation for collecting JUTPIP commuter survey data.

Table 3.2 shows the dataset that are used in this research. In general,both of JUTPIP commuting survey data and GIS dataset are used. The JUTPIP commuting survey data is primarily used for classifying the urban poor and non-poor and deriving the travel behaviour information. The GIS dataset are used in order to obtain information regarding population per income group and jobs. The source of these two dataset are from Coordinating Ministry of Economic Affairs and JICA. These data are collected in the form of soft files throughout secondary data collection method. This means that the researcher does not directly collect the data in the field contact the institution that has right to distribute the data.

Table 3.2 Description of dataset that are used in this research

Dataset	Feature	Year
JUTPIP commuting survey	Head of household income	2010
	Individual trips data	2010
	Modal split	2010
	OD pairs	2010
GIS dataset	JUTPIP delineation zone	2010
	Number of population	2010
	Number of jobs	2010
	Road network dataset	2002

3.3 DELINEATION OF STUDY AREA

Although in fact there is a spatial interaction between JMA and its satellite cities, the study area is limited to JMA (Figure 3.1) instead of analysing the entire area of the Greater Jakarta. This because this study aimed at evaluating the influence of accessibility in trip generation. Therefore, this study needs a manageable study area with the support of sufficient data. Moreover, choosing JMA as the case study is manageable from the perspective of time and resource for the following practical reasons:

- Available data for cities within JMA are more complete and comprehensive rather than cities that are outside the metropolitan region. By focussing on the context of Jakarta Metropolitan Area, the possibility to encounter problem due to data incompleteness can be minimised.
- The Greater Jakarta has very large datasets whereas time availability for this research and resources are limited. Hence, in order to make this research manageable, there is a need to limit the scope of the study area.

3.3.1 General Approach

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

- Administrative boundary is a geographical categorisation that is based on bureaucratic level arrangement. The following hierarchy is the typical administrative division in Indonesia.
  - Provincial (Provinsi) level
  - City/municipality (Kota/Kabupaten) level

  - District (Kecamatan) level
  - Sub District (Kelurahan) level

- Practical boundary is a geographical categorisation based on specific purpose. Typically, the arrangement of practical boundary (Figure 3.10) is based on:
  - Postal coverage
  - Purposive data collection (i.e demographic survey, transportation survey) that divides an area into several parts/zones. Delineation based on the JUTPIP commuting survey data collection is an example of practical boundary.

Administrative boundary provides a consistent delineation for being used to determine the study area. In contrast, practical boundary is more flexible because it is designed for specific purpose such as field data collection for JUTPIP project in which information are required at very detailed level.

Moreover, certain aspects are considered in order to delineate appropriate spatial unit. In transport studies, spatial unit of analysis is ideally based on Traffic Analysis Zone (TAZ). Commonly, criteria for defining TAZ are based on (1) land use homogeneity; and (2) number of residing population in certain zones (Ortúzar and Willumsen, 2011).

However, pragmatical approach is often undertaken to define TAZ. On one hand, the size of TAZ is ideally not oversize to avoid significant error in analytical process. On the other hand, it must be able to provide quite detail information. Delineating ideal TAZ is often obstructed by data availability. In practice, attribute data are available at more rigid spatial unit such as administrative level and it is quite difficult to disaggregate those kind of data. Therefore, TAZ area is delineated based on more practical and convenience approach such as postal code as alternative for deciding spatial unit in transport studies.

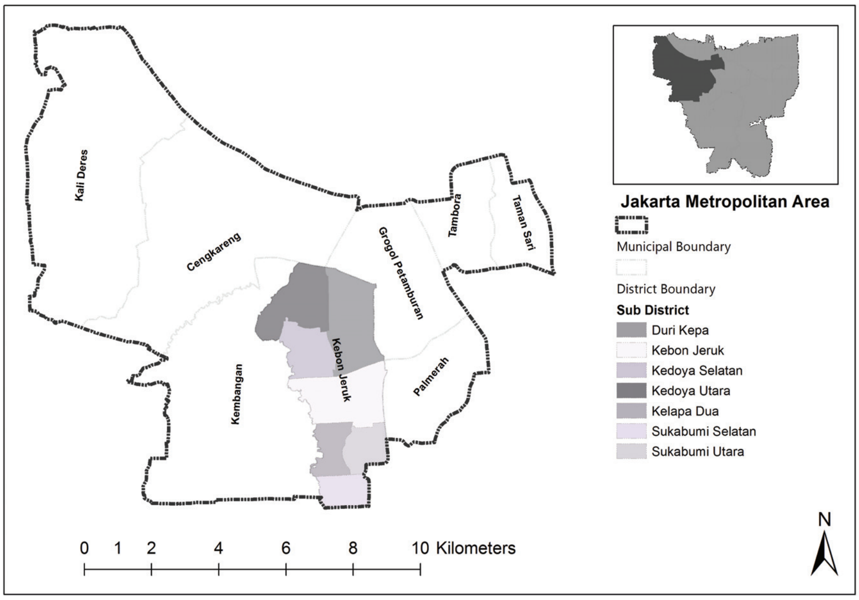


Figure 3.9: Example of administrative boundary at municipal, district, and sub district Level (Sample: West Jakarta Municipality)

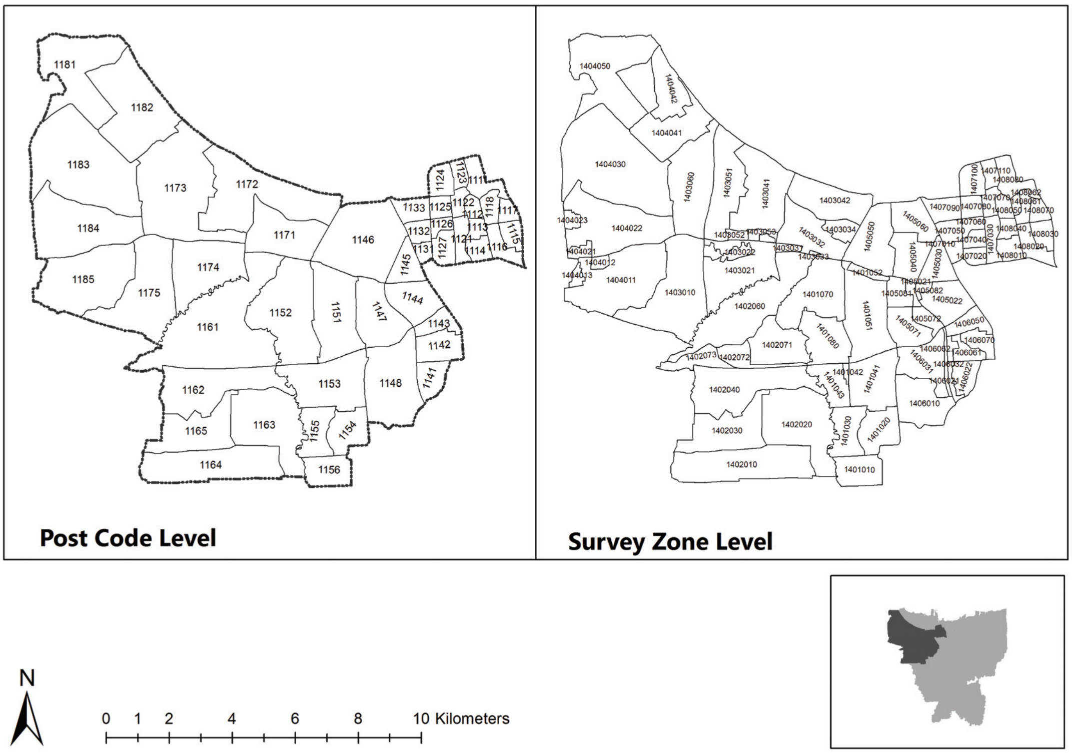


Figure 3.10: Practical boundary (Sample: West Jakarta Municipality)

Furthermore, the coverage of the study area is disaggregated into the most detailed spatial unit. The most detailed spatial unit in this research is the JUTPIP survey zone level. This process is undertaken in order to be able to do appropriate transport and accessibility modelling. Both of accessibility and transport models are derived from specific predefined geographical constellation that reflects particular locational attribute.

3.3.2 TAZ Area Delineation

In this research, TAZ is delineated based on pragmatical approach rather than ideal approach due to the following considerations:

- There is not specific information from official documents (i.e. land use masterplan) that specify TAZ delineation in the study area.
- Spatial attribute that are provided in JUTPIP survey data and GIS database need to be able to be integrated in the TAZ.
- TAZ needs to be manageable for analysis and interpretation purposes.

Both of administrative and practical boundaries are used in defining TAZ area. In principal, the major consideration for combining these approaches is due to the needs to undertake specific analysis at quite detail level but the the interpretation must be able to be generalised at the higher level.

- Administrative boundary provides clear stratification regarding geographical situation that is useful for making generalisation and synchronising attribute data. Moreover, the most detail administrative boundary that is utilised in this research is at city/municipal level due to certain considerations:

  - City/municipal level is appropriate to undertake generalisation. This is because in transport and accessibility studies (for example Geurs and van Eck, 2001), generalisation about attractiveness is conducted commonly at city/municipal level.
  - Disaggregation towards more detail administrative boundary (i.e. district or sub district) may not result in meaningful generalisation in comparison to city/muncipal level.

- Practical boundary is useful for analytical and technical process. It has quite detail geographical coverage rather than administrative boundary so that it is appropriate for being used for analysis. In the database, two practical boundaries are available based on post code level and survey zone level. However, this study prefers to use survey zone as the spatial unit of analysis for the following specific reasons:
  - Survey zone coverage is more detail rather than post code. According to Figure 3.10, the size of geographical unit based on survey zone is smaller in comparison to post code so that this is useful for further technical purpose (i.e. least-cost path algorithm to measure accessibility).
  - In the database, certain post code areas have missing values. Consequently, it reduces the number of sample since missing values are omitted in analysis. This can be minimised if the analysis is undertaken according to JUTPIP survey zone level.

Chapter 4

Methodology

This chapter is aimed at discussing the methodology to reach the research aim. The methodologies that are discussed in this research are literature review, SQL and spatial SQL, descriptive statistics, network analysis, and accessibility model.

4.1 GENERAL APPROACH AND OVERVIEW METHODOLOGY

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

- Literature review is used in order to provide theoretical framework in this research. Spatial SQL is used to extract both of JUTPIP database and GIS database.
- SQL (structured query language) is the programming technique that is used to extract and to manage information in a Relational Data Base Management System (RDBMS). In this research, SQL is primarily used in order to extract data from the JUTPIP questionnaire dataset. The spatial SQL is the application of SQL with main purpose to extract and to manage spatial data from a relational spatial database system. In this research, both of SQL and spatial SQL are undertaken by combining ArcGIS functionalities (model builder and python scripting) and Microsoft Excel visual basic programming.
- Statistical methods are used to provide description for both socio-economic and spatial characteristics of different population group in Jakarta Metropolitan Area. In this research, statistics methods are combined with ArcGIS visualisation functionality in order to obtain spatial context with regards to the characteristics in the study area.
- Network analysis is the ArcGIS vector analysis functionality that is used to analyse network-based problems. Certain applications of ArcGIS network analysis are vehicle routing, closest facilities, service analysis, and location-allocation model. In this research, network analysis is applied in order to construct OD Cost Matrix as the basis for accessibility analysis. In this research, the network analysis is constructed by using ArcGIS network builder module.
- Accessibility model is undertaken in order to obtain the accessibility to the potential job opportunities for different income group in Jakarta Metropolitan Area. In accessibility model, three types of accessibility model are established. First, the potential accessibility model is developed by considering the number of potential job opportunities for specific income-level group that can be reached from a particular zone. Second, the cross-accessibility model for urban poor is developed by assuming that the urban poor are able to reach potential job

opportunities for the middle-income group. Third, the weighted accessibility model is developed by discounting the potential accessibility value with the weighted factor based on the number of population for specific income group. The development of accessibility model is undertaken by using MatLab scripting and it is visualised by using ArcGIS.

Figure 4.1 illustrates the general approach and overview methodologies that are undertaken to achieve the aim of this research. In principal, there are two parts: conceptual and technical parts. The conceptual part is aimed at reviewing fundamental concept to support this research. This part is mainly undertaken by using literature review. The technical part is undertaken in order to extract the pre-requisite data for model development as well as to visualise the data for interpreting the model.

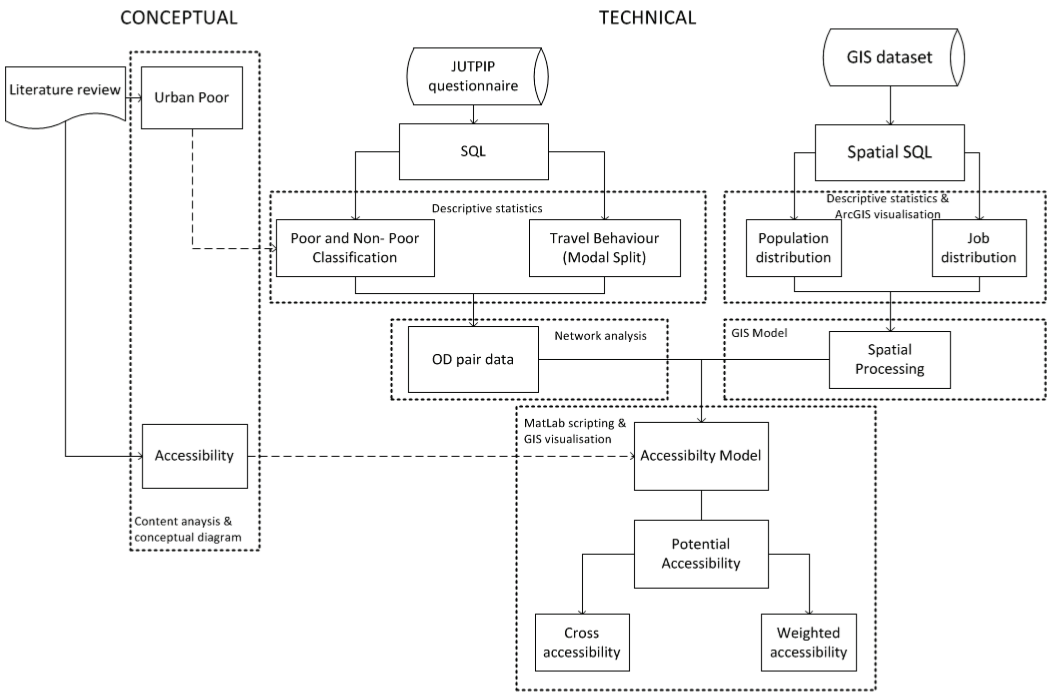


Figure 4.1: General Approach and Methodology

4.2 LITERATURE REVIEW

Literature review has two functions in this research. First, it is used in order to derive appropriate indicators for developing accessibility and trip generation model. Second, it is useful to provide theoretical foundation for evaluating the result of the analysis. Technically, literature review is undertaken by using content analysis and conceptual diagram. Content analysis is a method that is commonly used in order to construct a representative model of particular phenomenon by using conceptual form (Elo and Kyngäs, 2008). Conceptual diagram is a technique that is used to visualise interrelationship between different concepts that can be used for analytical purposes (Eppler, 2006). In this research, content analysis is applied for enquiring information from journals, text books, thesis, and electronic sources. Moreover, conceptual diagram summarises different concepts into graphical form before it is transformed into mathematical/statistical model for further analytical purpose.

4.3 DATA EXTRACTION

4.3.1 SQL

SQL is a programming language that is used to extract and to manage information that are stored in the Relational Data Base Management System (RDBMS). In this research, JUTPIP questionnaire data is an example of relational database management system. The JUTPIP dataset consists of three main parts: (1) household information; (2) household member information; and (3) household member individual trip that are specifically classified into working and school trips. In this research the focus of the household member individual trip is the working trips. The process of extracting data by using SQL method is undertaken in ArcGIS by using its database management functionalities. The process of extracting JUTPIP questionnaire is shown on Figure 4.2 . In principal, the SQL is undertaken in order to classify the household based on the income level and to extract the information of the mobility behaviour for different income groups.

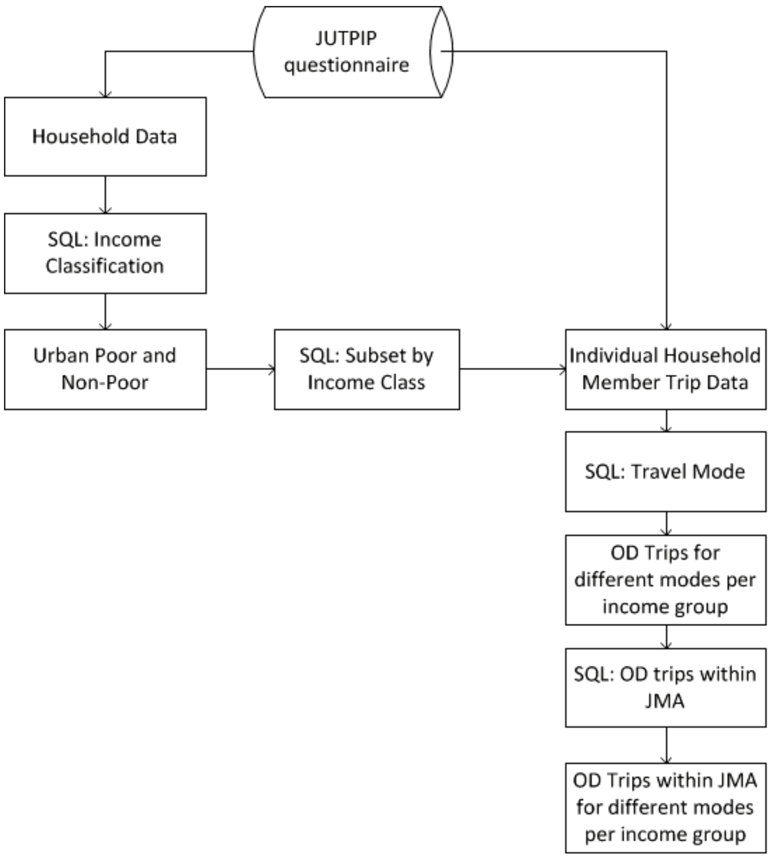


Figure 4.2: Illustration of SQL method

4.3.2 Spatial SQL

Spatial SQL is the method that is to make inquiries related to spatially-referenced data as well as to be able to visually represented the spatial data (Egenhofer, 1994). In this research, there are two important roles of spatial SQL method. First, the 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 consists the important information with regard the number of population for different income level and the job opportunities for different income group has different spatial resolution with JUTPIP zones. The JUTPIP zone is used as the basis for constructing accessibility model since the data consists of the pair of origin and destination locations. However, the number of population and job opportunities for each income level is available in GIS data. As a consequent, it is important to be able to transfer information from GIS data into JUTPIP zone. Figure 4.3 illustrates the process of transferring population and job data from GIS dataset into the JUTPIP zones. The process is principally undertaken in the ArcGIS environment.

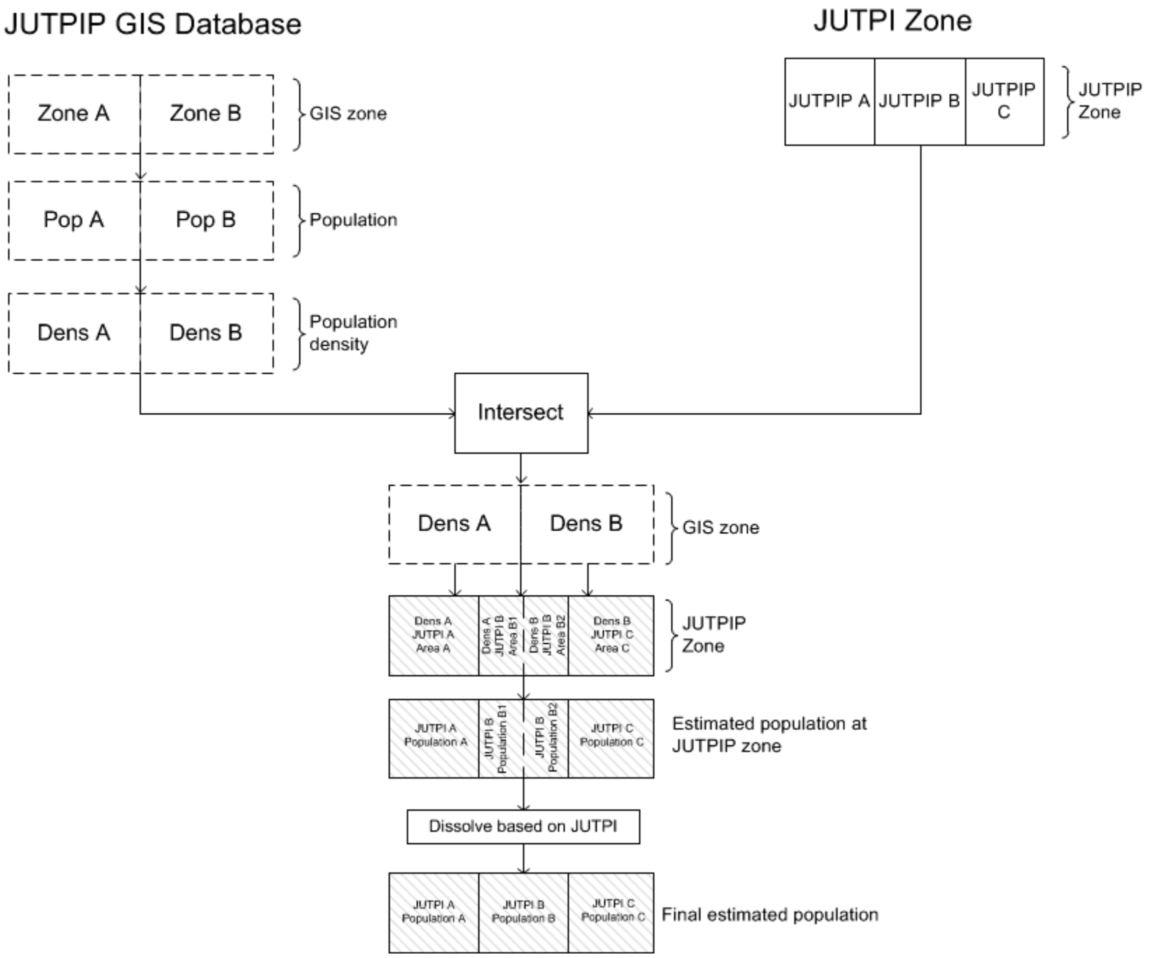


Figure 4.3: Illustration of spatial SQL method for combining two datasets in different spatial resolution

Second, spatial SQL is useful in order to generalise the potential accessibility measure from individual OD trips data into the zonal accessibility. The potential accessibility is based on the OD pair data from individual household member trips. This information needs to be generalised into the zonal level. In order to deal with this situation, the spatial SQL is applied by referencing OD pair data according to the origin zone. Figure 4.4 illustrates the process of generalising the potential accessibility measure into the zonal level. In principal, the method for generalising the individual OD matrix data is undertaken by using Microsoft Excel and ArcGIS.

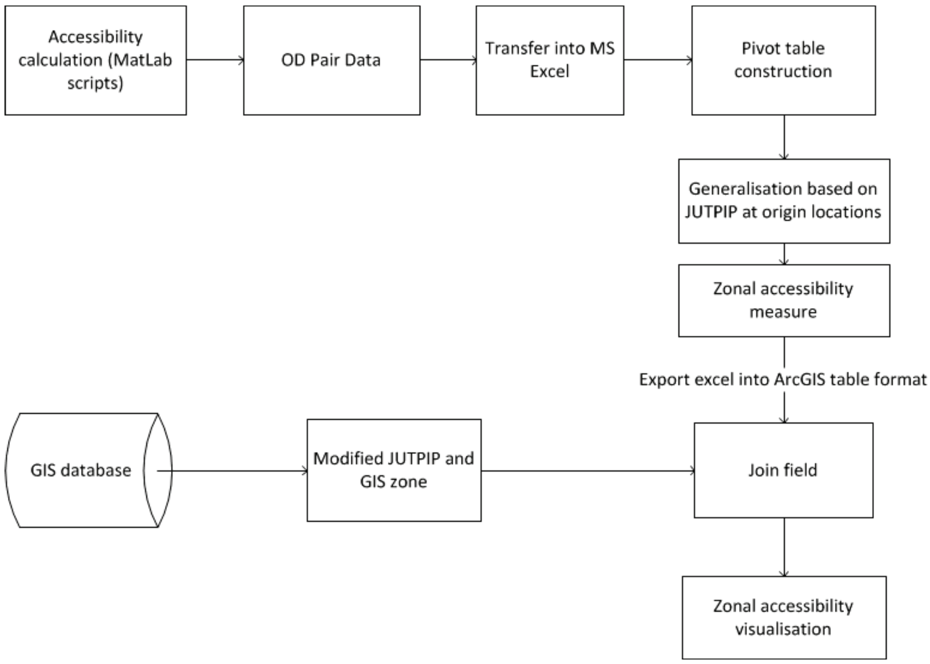


Figure 4.4: Illustration of spatial SQL method for generalising data from individual trips into zonal level

4.4 DESCRIPTIVE STATISTICS

Descriptive statistics is a technique that is used in order to summarise the data with regard to particular phenomena in the study area. The interpretation about the phenomena in the study area is based on the summary of the data. In this research, there are some important roles of the descriptive statistics.

First, the descriptive statistics is primarily used in order to summarise the modal split data. Modal split data consists of the information related to the transport modes that are used by different income groups in JMA.

Second, this technique is used to interpret the information with regard to time travel distribution in the study area. The travel time illustrates the average travel time distribution for different transport modes that are used in JMA. The travel time distribution is presented for different income group in JMA.

Third, the descriptive statistics is used to interpret the travel time decay function as the function to measure accessibility. The travel time decay function indicates the potential uses of certain type of transport modes with respect to travel time of particular transport modes. In essence, the travel time decay function indicates the mobility behaviour of travellers. For example, if the travel time is relatively longer, private vehicles (i.e. car or moped) are more attracted rather than non-motorised transport.

In this research, the descriptive statistics is analysed by using Microsoft Excel and ArcGIS. Microsoft Excel is used to summarise the data in the tabular format due to its functionalities in rows and columns manipulation (i.e. pivot table, filtering). ArcGIS is used to obtain the summary of the data with specific spatial visualisation. For example, the distribution of population and jobs are summarised by using ArcGIS spatial visualisation. For certain cases in this research, the descriptive statistics is undertaken in Microsoft Excel and it is visualised in ArcGIS. In order to support data extraction for descriptive statistics, Excel Visual Basic (VB) programming technique is applied to support the conversion process from Microsoft Excel to ArcGIS. For example, VB programming is used to export charts from Excel to ArcGIS.

4.5 NETWORK ANALYSIS: OD MATRIX CONSTRUCTION

The network analysis holds an important role in this research. The network analysis is used to construct the Origin-Destination Matrix. The basis for construction origin and destination matrix is the JUTPIP individual household member trip data. The process of constructing OD Matrix is entirely undertaken in ArcGIS by using model builder. In addition, two programming languages are used: (1) python; and (2) visual basic in order to undertake rows and columns modification. Figure 4.5 illustrates the process of constructing network analysis by using ArcGIS model builder.

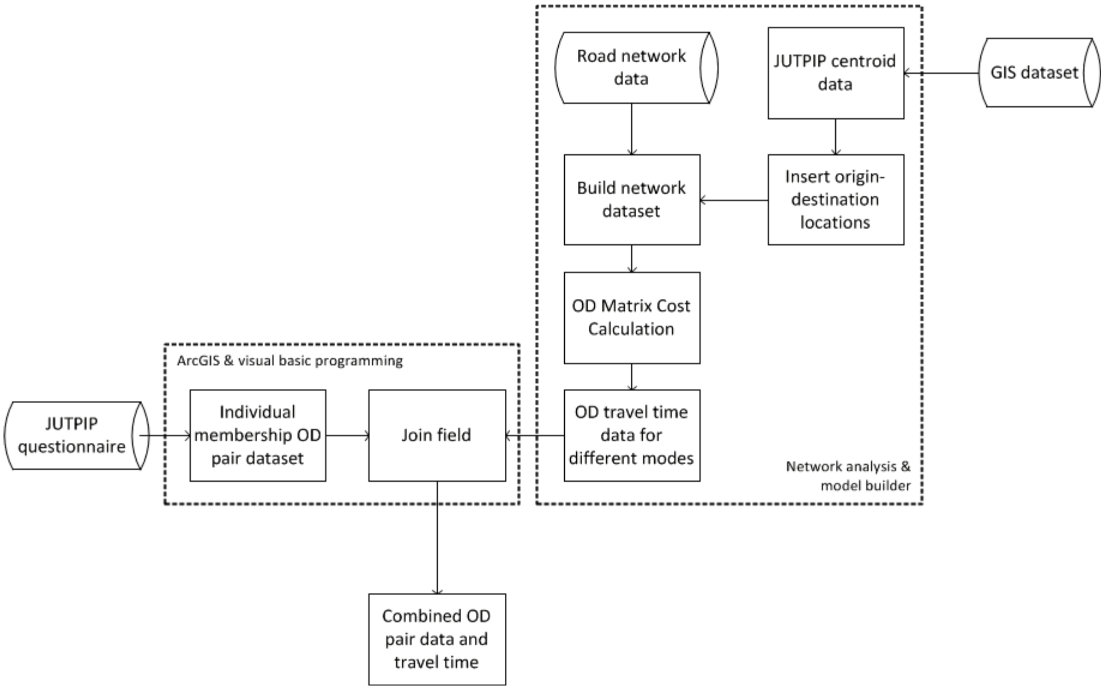


Figure 4.5: Illustration of network analysis in ArcGIS to construct OD matrix cost

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. There are certain assumptions that are considered while constructing network dataset:

- The network analysis only considers unimodal transport. This means that traveller constantly use a single mode while producing home-to-workplace trips.
- The time impedance is based on the travel duration from origin to destination points without considering any other penalty such as waiting time (for public transport) and time travel from parking location to the destination. This is due to the limitation in the data availability for waiting time and time travel.

- Certain restrictions are applied within the construction of network datasets. Walking and cycling modes are able to transverse in road network with the assumption that walking is in the pedestrian while cycling is in side of road network or bike lane. These transport modes are not able to enter toll road network. Public transport refers to bus except for the Trans Jakarta Bus Transit System. The public transport is not allowed to enter toll road. Private car is able to enter the toll road and the common road network system.

- For public transport and private car, the time travel is based on the congested network condition. This is because JMA is a heavily congested region so that vehicles cannot travel in the appropriate speed. For walking and cycling, it is assumed that these modes are not affected by congestion since these use pedestrian and the side of road network or bike lane.

- Specific speed values are assigned for different transport modes. These speed values are adjusted as close as possible to the actual situation in JMA. The speed value is based on the previous studies in JMA.
  - Walking speed is assigned by 3.2 km per hour (Wicaksono et al., 2012)
  - Cycling speed is assigned by 8 km per hour (Wicaksono et al., 2012)
  - The speed for public transport (bus), moped and car are based on assumption due to lack of official data that measure speed of these modes during the congestion. However, there is an online newspaper source that remarks that the speed of vehicles during congestion period in Jakarta is between 10 and 20 km per hour (Akib, 2012). It is assumed that during the congestion, moped is fastest transport modes whereas public transport (bus) is the slowest. The speed value for these modes are 14 km per hour (moped), 10 km per hour (bus), and 12 km per hour (car).

These assumptions are translated into the network builder parameter. In principal, there are two paramaters: (1) the travel time from origin node to destination node; (2) the restriction. First, the travel time is calculated by multiplying the speed and the distance. If v_k is the speed of mode k, and d_{ij} is the distance from location i to j. The travel time from location i to j, t_{ij}, is shown by the equation,

$$t_{ij} = \frac{d_{ij}}{(v_k).60} \tag{4.1}$$

The unit of the speed is defined in km per hour, therefore in order to obtain the time travel unit in minute the denominator is multiplied by 60. The travel time is calculated for five different transport modes: walking, cycling, public transport (bus), moped, and car.

Second, the restriction parameter limits the route that can be travelled by particular modes. The network dataset in JMA consists of hierarchal network: (1) toll road; (2) major road; (3) secondary road; and (4) other road. It is not possible to non-motorised transport (walking and cycling) and moped to used toll road. The restriction parameter is applied by prohibiting these modes to enter toll road. The technique to apply restriction is undertaken in ArcCatalog by specifying a new field that indicates the restriction. The binary values (0 and 1) are used to express the restriction parameter in the road network. The value of 0 indicates that the road section is not the toll road whereas 1 indicates that the road section is the toll road. In ArcCatalog, the restriction parameters is applied by using the default value avoid:high. This restriction means that the algorithm will highly avoid the toll road whereas it attempts to calculate the shortest travel time route between origin and destination locations. In practice, the OD cost matrix applies this restriction for calculating travel time by non-motorised transport and moped.

Upon completion to establish the network dataset, the following process is to construct OD cost matrix based on the travel time. The origin and destination locations are based on the centroid points from the JUTPIP zones spatial dataset. The OD cost matrix is calculated for different transport modes. The process is undertaken in ArcGIS software by using model builder. The result of OD cost matrix calculation is integrated with the OD pair data (location) based on the individual household member trips. This process is undertaken in ArcGIS by using database management functionalities with the modification by using Visual Basic programming. The main issue is that the OD cost matrix has the primary key the name of OD pair (example: 1500001-1560002) whereas the JUTPIP questionnaire separates the origin and destination ID on the different fields. Therefore, VB programming is applied to modify origin and destination IDs so that it can be placed together in one field. This technique is applied by using concatenation function in VB. This process is undertaken in ArcGIS by using field calculation function. The subsequent process is to join the OD travel time cost and JUTPIP database by using the OD pair name as the primary key. This becomes the basis for calculating the accessibility model.

4.6 ACCESSIBILITY MODELING

In this research, the calculation of accessibility model are categorised into three types: (1) potential accessibility; (2) cross-accessibility; and (3) weighted accessibility. First, the potential accessibility analyses the number of potential job opportunities that can be reached from certain zones. The potential job accessibility is analysed for different income category: urban poor, middle-, and high-income group. Second, the cross-accessibility is the modification of potential accessibility model. The potential accessibility is modified by assuming that urban poor is possible to reach job opportunities for the middle-income group. Third, the weighted accessibility model is modification of potential accessibility model by multiplying potential accessibility with the population-based weighting factor. Figure 4.6 illustrates the process of developing accessibility model.

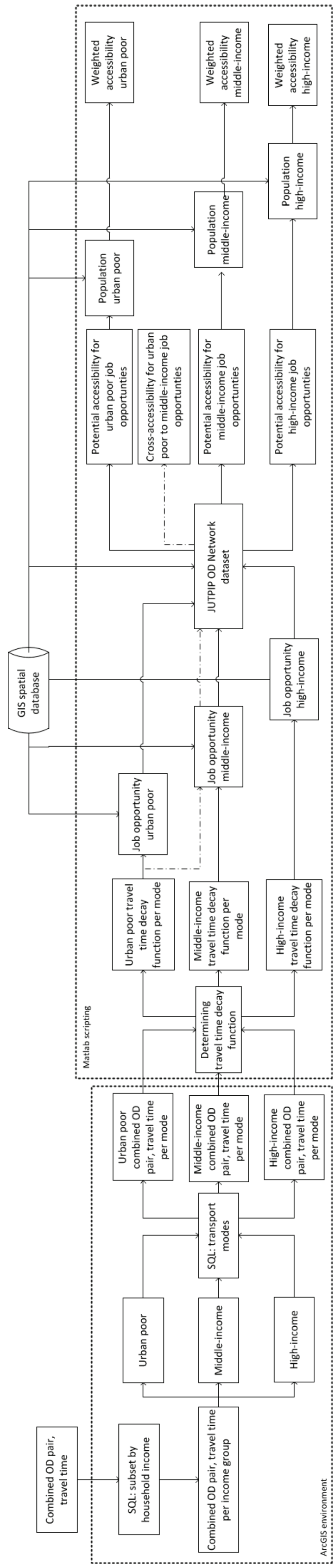


Figure 4.6: Illustration of the construction of accessibility model

4.6.1 Travel time decay function development

The first phase to develop accessibility mode is to determine the distance decay function. Initially, the combined OD pair data and travel time needs to be extracted based on the household income. This results in the OD pair data per income group (urban poor, middle-, and high-income group). For each income group, the OD pair dataset is extracted per transport mode (walking, cycling, public transport, moped, and car). This process is results in the dataset that consists of the OD pair and travel time for each transport mode for three different income groups. This process is undertaken in ArcGIS environment by using data management funcitons. The travel time is categorised in order to construct the travel time distribution. In this research, the categorisation of travel time are: : (1) less than 15 min; (2) 15-30 min; (3) 30-45 min; (4) 45-60 min; (5) 60-75 min; (6) 75-90 min; (7) 90-105 min; (8) 105-120 min; and (9) more than 120 min. The selection of these cut-off value follows the cut-off value as described by Skov-Petersen (2001). The number of OD pair trips is categorised according to the cut-off value. The method of presenting travel time distribution follows the descriptive statistics for grouped data. Table 4.1 illustrates the presentation of the travel time distribution.

Table 4.1 Illustration of grouped data for classifying travel time

Category	Lower boundary	Upper Boundary	Middle Value	No. Trips
<15 min	0	15	7.5	f_1
15-30 min	15	30	22.5	f_2
30-45 min	30	45	37.5	f_3
45-60 min	45	60	52.5	f_4
60-75 min	60	75	67.5	f_5
75-90 min	75	90	82.5	f_6
90-105 min	90	105	97.5	f_7
105-120 min	105	120	112.5	f_8
>120	120	150	127.5	f_9

Based on the travel time distribution, the cumulative value is calculated. In order to obtain the cumulative value, the number of trips in each cut-off value is transformed into the proportion. This is obtained by dividing the number of trips at each cut-off value with the total number of trips.

For example, for the proportion for trip category for < 15 min is shown by the equation,

$$p_n = \frac{f_n}{\sum_{n=1}^{9} f_n} \tag{4.2}$$

When the proportion of trip in each income class is obtained, the cumulative proportion is calculated by accumulating the proportion of trips in each travel time cut-off value.

The cumulative value, P_n, for the travel time at category n^{th} is shown by the equation,

$$P_n = \sum_{n=1}^{n} p_n \tag{4.3}$$

Since we are interested in analysing the distance decay, the inverse cumulative is calculated by subtracting the total proportion (the value is equal to 1) with the cumulative proportion of trip in each travel time cut-off value. If cumulative proportiion trip at the n-th category, P_n, the cumulative inverse at n-th category is shown by the equation,

$$I_n = 1 - P_n \tag{4.4}$$

The inverse cumulative value is the basis for calculating travel time decay function. The travel time decay function is calculated by plotting the inverse cumulative value (in y-axis) and the middle value of each travel time class (in x-axis). This process is undertaken in MatLab by using curve fitting functionality. The sample of the plotting is shown on Figure 4.7.

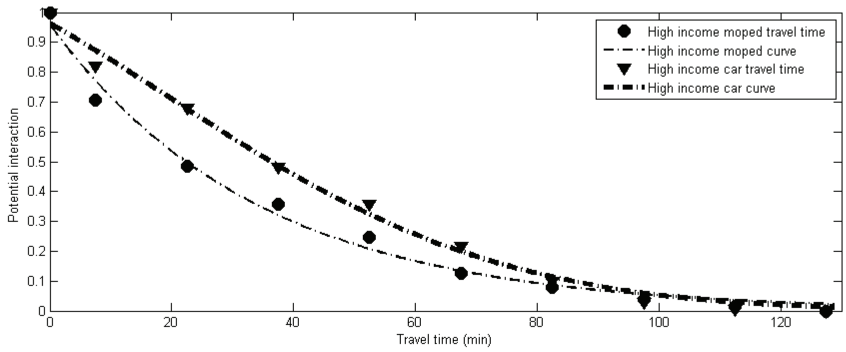


Figure 4.7: Example of plotting the decay function

4.6.2 Potential accessibility calculation

The calculation of potential accessibility is undertaken by using the travel time decay function that is multiplied by the number of jobs. The potential accessibility is calculated for each income group. If the potential accessibility at location i by using mode k for income group m is indicated by A^m_{ik}, the travel time cost between location i and j by using mode k, C^k_{ij}. Then, the accessibility is shown by the equation,

$$A^m_{ik} = f(C_{ijk}) \cdot \sum \text{Jobs}^m_j \tag{4.5}$$

Where jobs^m_j is the number of job opportunities at location j for the income group m. However, since the potential accessibility is calculated with the basis of OD pair data. The generalisation into spatial level is undertaken. The generalisation of potential accessibility in zone i is calculated by accumulating the potential accessibility to job opportunities that are available in zone $j_1, j_2, \cdots, j_n$ from zone i. This process is undertaken by using MatLab and Microsoft Excel Pivot Table functionalities.

4.6.3 Cross accessibility calculation

The cross accessibility calculation is undertaken by calculating potential accessibility for urban poor with respect to potential job opportunities for middle-income group. If cross accessibility in location i for urban poor by using mode k is indicated by $\text{CA}^{\text{poor}}_{ik}$, the job opportunity for middle-income, $\text{Jobs}^{\text{mid}}_j$, is shown by the equation,

$$\text{CA}^{\text{poor}}_{ik} = f(C_{ijk}) \cdot \sum \text{Jobs}^{\text{mid}}_j \tag{4.6}$$

where $f(C_{ijk})$ is the travel time cost from location i to j by using mode k.

4.6.4 The weighted accessibility calculation

The weighted accessibility calculation is the potential accessibility to job opportunities that is discounted by the proportion of population at particular income group. The assumption of the weighted accessibility calculation is that the potential accessibility calculation does not take into account the number of people at particular income level who lives within a zone. The weighted accessibility calculation is useful for deriving the suitable policy implications at the priority locations with the high number of population at particular level of income. If the potential accessibility at location i by mode k for income class m is indicated by A_{ik}^m. The weighted accessibility at location i by using mode k for income group m, WA_{ik}^m, is shown by the equation,

$$\mathrm{WA}_{ik}^m = \frac{x_i^m}{\sum x^m} \cdot A_{ik}^m \tag{4.7}$$

where x_i^m is the number of population for income class m and $\sum x^m$ is the total population of income class m. The weighted accessibility is calculated for different income class by using MatLab and it is visualised by using ArcGIS.

Chapter 5

Results and Discussions

This chapter provides the outcome of the analysis and the discussion of the analysis. There are five major parts of this chapter. First, this chapter starts with discussing the process of defining urban poor criteria based on the criteria of urban poor for in the Indonesian context. Second, the spatial distribution of urban poor and non-poor (middle-, and high-income) and their corresponding job opportunities is discussed. Third, the variation of mobility behaviour of home-to-work trips for different income level category is analysed. Fourth, the travel time decay function is constructed based on the individual household member trips data. Fifth, the potential accessibility model for different income group is constructed. The potential accessibility to job opportunities are modified for constructing the cross-accessibility model (if urban poor is able to access job opportunities for middle-income group) and weighted accessibility model.

5.1 DEFINING URBAN POOR IN THE CONTEXT OF JMA

The initial phase in this research is to adjust the normative definition of poverty in the Indonesian context with the commuting JUTPIP questionnaire data and JUTPIP GIS data as the basis for examining mobility characteristics and accessibility to potential job opportunities. As discussed in Chapter 2, the classification of urban poor is based on certain socio-economic indicators as determined by CBS. Due to the limitation in the data availability, the classification of urban poor in this research is based on the income level. According to the criteria from CBS, a household is categorised as the poor household if the income of the head of household is approximately less than IDR 600,000 (USD 54.5). In this research, the convention for converting currency from is 1 USD is equal to IDR 11,000. Adapting the criteria of the urban poor based on CBS into JUTPIP questionnaire and JUTPIP GIS database cannot be undertaken straightforwardly. The main problem is due to the differences in the classification of the income category at both JUTPIP questionnaire and GIS dataset. Whereas CBS defines the poor household as the level of income of the household head is less than IDR 600,000 (USD 54.5), the lowest income level categorisation for the household head in the JUTPIP questionnaire dataset is less than IDR 1 million (USD 90.9). Therefore, this research defines the poor household as a household in which the head of household has income level less than IDR 1 million (USD 90.9). This definition is the adjustment of the poor criteria between CBS and JUTPIP questionnaire. The assumption is that by defining urban poor as the household with the income of household head less than IDR 1 million, the criteria of poor people by CBS is already covered.

In the JUTPIP GIS database the attribute of population and jobs are classified according to its corresponding level of income. For example, population distribution is categorised as low-, middle-, and high-income population. This classification provides the advantages for developing accessibility model and complete information about the spatial distribution of population and jobs. The shortcoming of this database is that the database needs spatial adjustment to be able to link the zonal information (population and jobs) with the socio-economic data and travel behaviour in the JUTPIP commuting survey data. The fundamental problem is because the spatial resolution of JUTPIP GIS database and JUTPIP commuting survey data is different. In general, JUTPIP GIS database zone has larger spatial resolution in comparison to 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 (described in Chapter 4).

5.2 POPULATION AND JOB DISTRIBUTION IN JMA

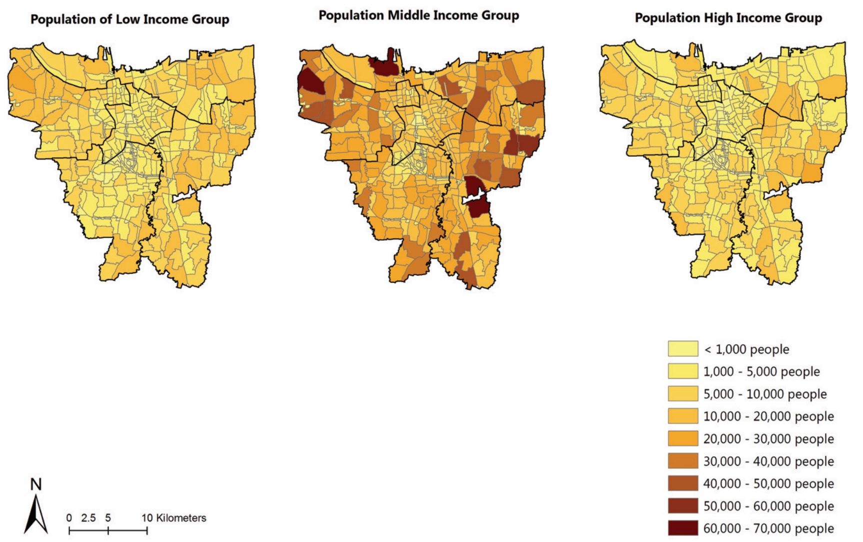
The population and job distribution are analysed by mapping the population and job distribution in ArcGIS. The basis of analysing the population and job distribution is based on the population and job density. The basis data for the number of population and jobs are derived from the GIS dataset. These data are transferred into the JUTPIP zone as described in the previous section. In order to obtain the density maps, the number of population and job are normalised by dividing either population or job with the total area of a particular JUTPIP zone (in km square).

Figure 5.1 and 5.2 show the maps of population and job distribution as well as the population and job density. In general, the population and job distribution in JMA is dominated by middle-income class. Job distribution for low-income group is relatively smaller in comparison to middle- and high-income group. The job for low-income/urban poor group may be undercounted due to the nature of urban poor job. For example, the job for urban poor in the informal sector such as trader or street vendors may not be officially registered by the government or statistical office. This situation may cause the number of jobs for urban poor is smaller than the job for non-poor. Unlike the urban poor, job for non-poor is relatively easier to be registered since the non-poor is rarely to work in the informal sector.

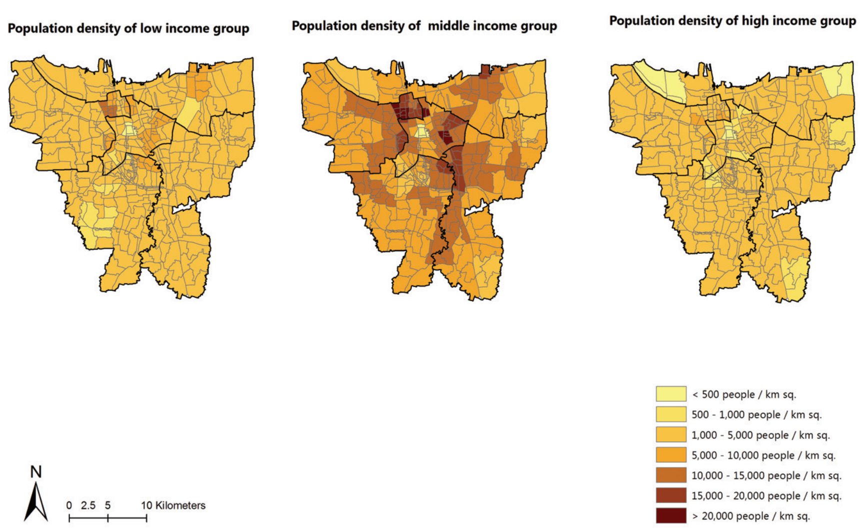
5.2.1 Distribution of urban poor and their jobs in JMA

The urban poor settlements are primarily settled in the periphery area of JMA and in the inner-city area that is close to Central Business District (CBD). The number of urban poor is sparsely distributed in the western, eastern, and northern part of the JMA. From the regional economic perspective, the concentration of urban poor in the periphery area can be associated with the development of industrial activities in the periphery of JMA. A paper by Viantari (2012) argues that the industrial activities grow intensely in the northern, western, and eastern part of JMA. The massive industrial development in the periphery area provides opportunity for urban poor to enter job market. Viantari (2012) remarks that in the northern, western, and eastern part of JMA, the number of industrial activities reaches approximately 736, 536, and 317 industries with total employment more than 300,000 employment (including the non-poor employment).

The concentration of urban poor in the inner city area (close to CBD) is closely associated with the availability of job opportunity for low-income group in the services sectors. The inner city zone of JMA is the concentration of business, commercial, and political activities at both national and international scale. In general, the business and commercial activities in the inner city zone is agglomerated in five locations: Sudirman Central Business District (SCBD), Kuningan, and Rasuna Epicentrum. This agglomeration is not only requires the demand for highly skilled labour (i.e.

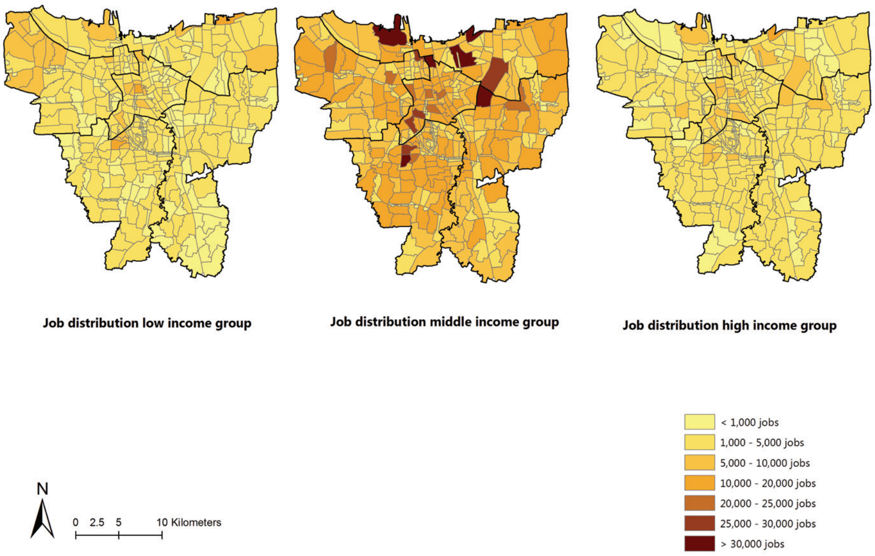


(a) Population distribution in Jakarta Metropolitan Area 2010

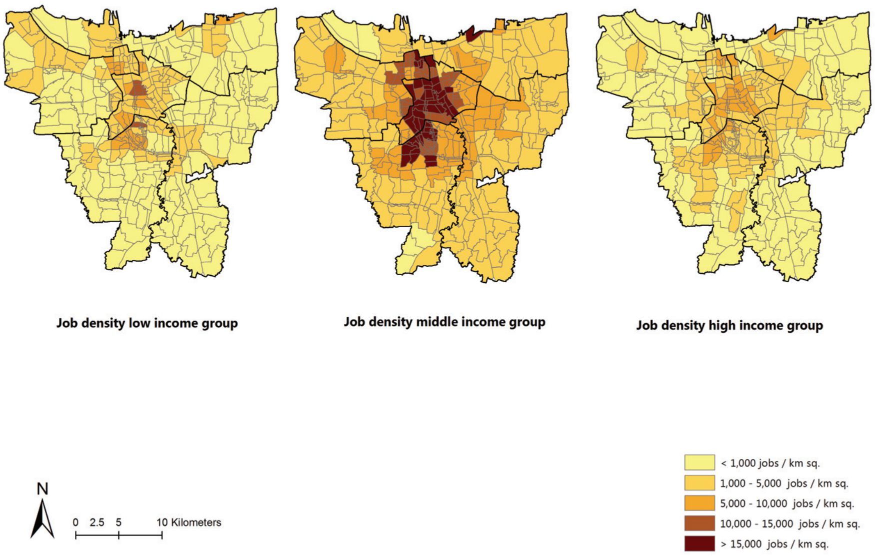


(b) Population density in Jakarta Metropolitan Area 2010

Figure 5.1: Population information based on GIS dataset in Jakarta Metropolitan Area



(a) Job distribution in Jakarta Metropolitan Area 2010



(b) Job density in Jakarta Metropolitan Area 2010

Figure 5.2: Job information based on GIS dataset in Jakarta Metropolitan Area

engineer, lawyer, accountant) but also the demand for low-skilled labour (i.e. security, cleaning service). This agglomeration becomes the major driving force to attract low-skilled labour to find job opportunity in the inner city area. Figure 5.3a illustrates the location of the agglomeration of jobs for urban poor by using Google image.

In addition, as commonly experienced in the developing countries, the inner city area is the potential location for the informal economic activities (i.e. street vendor, informal services). Since the land use pattern of the inner city area is dominated by office and commercial activities, this situation attracts high number of employment. The high number of employment is the potential demand for the informal economic activities. For example, there is the emergence of street vendor to provide foods and beverages at relatively inexpensive price in the surrounding office buildings. The informal economic activities are the job for urban poor who are not able to enter labour market. People who work in informal economic sector are usually live close to their work location in certain part surrounding the inner city area. This factor contributes to explain the concentration of low-income people in the inner city area.

5.2.2 Distribution of urban non-poor in JMA

Middle-income group

The middle-income group is highly concentrated at inner city zone, northern, and southern part of the city. In the inner city zones, the concentration of middle income group can be associated with the agglomeration of job for middle-income group in the CBD. Since the land use pattern in the CBD area is dominated by office and commercial activities, the job opportunity for middle income group is associated with service-related occupation such as consultant, lawyer, and civil servant.

In the northern part of JMA, the shipping-related activities in Tanjung Priok port becomes the primary job opportunity for middle-income group. Since 1897, the port of Tanjung Priok has become the important hub for both international and national shipping activities. The loading-unloading activities in this port reach approximately 70% of the cumulative cargo services in Indonesia. Shipping activities stimulates to the growth of supporting activities such as logistics (transhipments), warehousing, and trading. These activities that are potentially create high demand of labour market for middle-income groups. Typically, the job market for port-related economic activities requires specific qualifications (i.e. port engineers, accountants) so that these types of job provide high remuneration.

In the southern part of JMA, there are the agglomeration of offices and commercial activities. Certain potential job opportunities that attract the high number of employments in the southern part of JMA are government office complex (i.e. ministry of public works), private office high rise buildings, university, and shopping centres. Figure 5.3b illustrates the agglomeration of job opportunities for middle-income group by using Google image.

High-income group

The high-income group has no significant clustering pattern across the JMA. The highest concentration of high-income group settlement is in the inner city area where the high class residential complexes are located. The potential job opportunities for high-income group are primarily located in the CBD and southern part of JMA. Typically, the large international and national companies have their head office or branch office located in the primary office estate in the CBD area such as Sudirman Central Business District (SCBD) and Rasuna Epicentrum. In addition, the surrounding CBD area is the agglomeration of government complex (i.e. governor office, ministry of transportation, ministry of tourism), financial centre (the central bank of Republic of Indonesia), and large-scale commercial and entertainment centres (i.e. shopping mall).

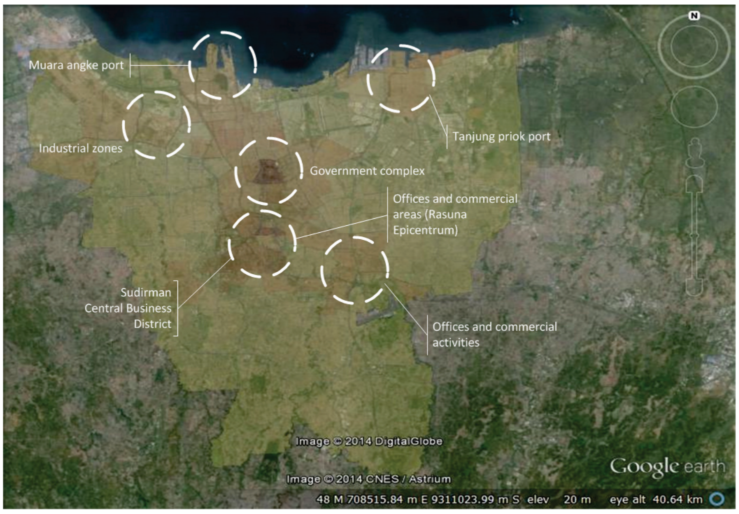
In the southern part of the city, the job opportunities for high income group are predominately government (i.e. ministry of public works, national land agency) and private sector office complex (i.e. national electricity company). The southern part of JMA is the potential location to attract middle- and high-income group employment. This because the property demand for office location in the southern part of the city is high so that it is expected that the more jobs are potentially created in the southern part of JMA. Figure 5.3c illustrates the agglomeration of job opportunities for high-income groups by using Google image.

5.3 JOB CATEGORY

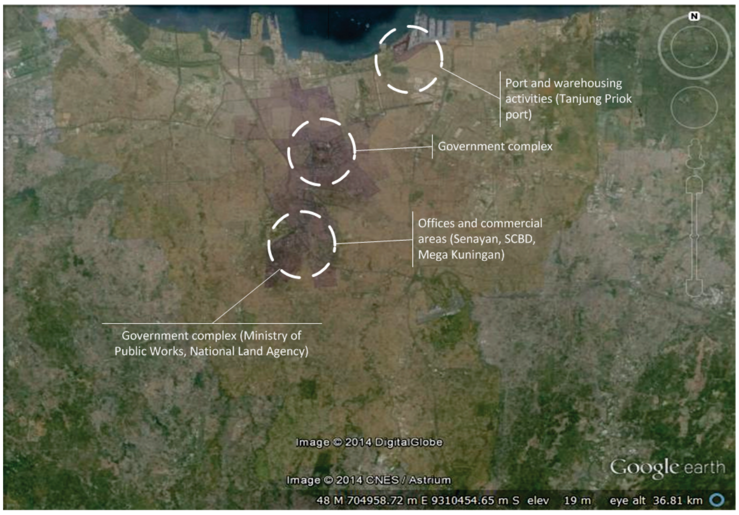
The jobs are classified according to the type of job that is asked in the JUTPIP commuting survey questionnaire. This research categorises the job based on the requirement to obtain the job. The job for urban poor is typically the low-skilled job that does not need specific education level (i.e. university graduates) or specialised training (i.e. computer training). In contrast, the job for urban non-poor is the high-skilled job that needs specific level of education and/or specialised training to obtain the position.

In general, there are 18 types of job in the JUTPIP commuting survey questionnaire (see Appendix C, Table C.3). However, these types of jobs are not explicitly classified based on the level of income. In order to classify the job for the poor, the SQL procedure based on the household income level is undertaken in ArcGIS. First, the household is categorised based on its income level (urban poor, middle-income, high-income). Second, in each household category, the occupation of each working member in the household is observed. The descriptive statistics technique is used in order to obtain the overall job classification for different income level.

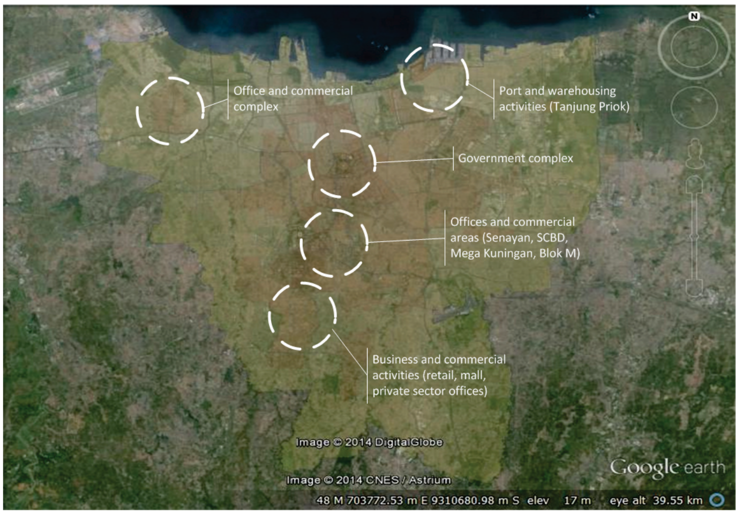
Figure 5.4 illustrate job type for different income level in JMA. The job that is presented in these figures are selected based on the most frequent type according to JUTPIP commuting survey. For urban poor, sales and trader are the most common occupation by approximately 29%. This is followed by factory labour, security, clerk and bartender by 21%, 15%, and 12% respectively. The middle-income group job types are divided into two categories: (1) middle-lower; and (2) middle-upper income job types. For middle-lower income group, the typical jobs are sales/trader (24%), factory labour (19%), company employees (17%). For middle-upper income group, the typical jobs are company employees (36%), sales/trader (18%), business owner and high skilled labour (i.e. engineer, lecturer) by 15%. For the high income group, the typical jobs are business owner (36%), high-level professional such as professor, manager, director (20%), and company employee (17%).



(a) Agglomeration of job opportunities for urban poor

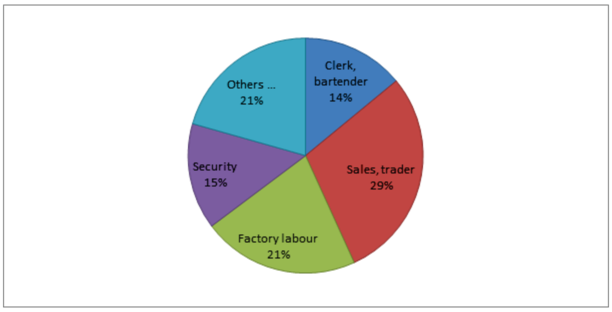


(b) Agglomeration of job opportunities for middle-income group

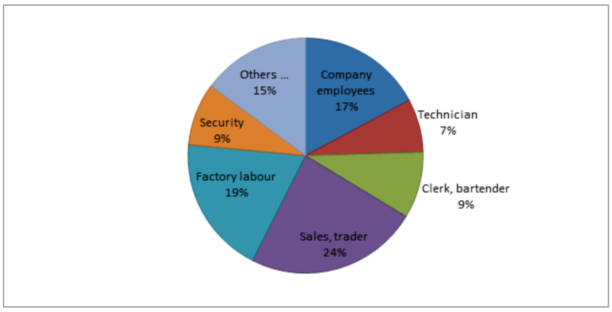


(c) Agglomeration of job opportunities for high-income group

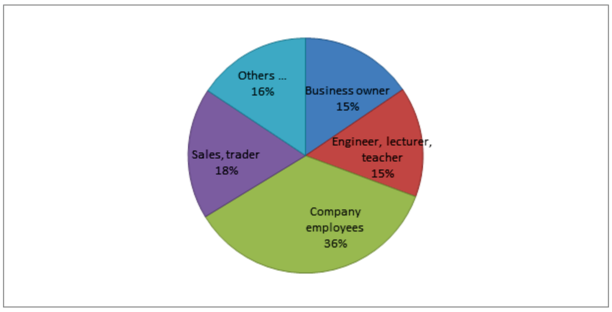
Figure 5.3: Job distribution for different income group in Jakarta Metropolitan Area



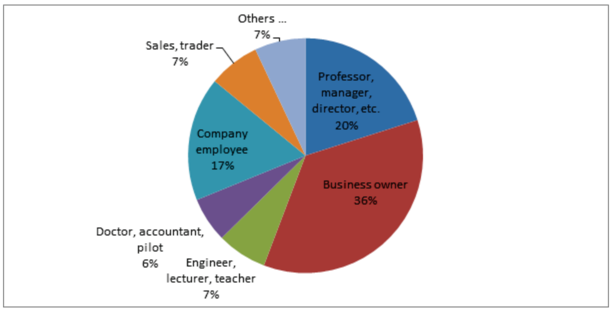
(a) Proportion of job opportunities for urban poor



(b) Proportion of job opportunities for middle-low income group



(c) Proportion of job opportunities for middle-upper income group



(d) Proportion of job opportunities for high-income group

Figure 5.4: Proportion of job opportunities for different income group in Jakarta Metropolitan Area

5.4 MOBILITY BEHAVIOUR ANALYSIS

5.4.1 Modal split

In principal, the mobility behaviour for both urban poor and non-poor is analysed according to the household income category in which an individual belong. For low-income group, the first step that is undertaken is to select the household member who generates journey to work trip from the low-income household. The classification of low-income household is derived from JUTPIP commuting survey data by setting the threshold value for low-income household based on the income level of the head of household. A poor household is defined if the income of the household head is less than IDR 1 million (USD 90.9).

For the non-poor household, the level of income is classified into middle-, and high-income group. The middle-income household is categorised into two groups. First is the middle-low income that is defined as the household with the income level of head of household between IDR 1 million (USD 90.9) and IDR 3.9 million (USD 354.54). Second is the middle-upper income with the range between IDR 3.9 million (USD 354.54) and IDR 12.4 million (USD 1,136.27). Although the middle-income level is divided into two income groups, these two groups are combined while analysing their mobility behaviour.

The high-income household is defined as the household with the income level of the household head more than IDR 12.4 million (USD 1,136.27). While the categorisation of low-income group adapts the criteria from CBS, the categorisation of middle-, and high-income level are undertaken by selecting the interval based on the available data. This is because no official convention for defining middle-, and high-income group.

Upon the classification of individual trip makers according to the household category, the subsequent categorisation is made by classifying individual trip makers by the transport modes. In general, the transport modes that are analysed are walking, cycling, public transport/bus, moped, and car. The trip distribution is analysed by developing the Origin-Destination (OD) matrix. The basis data for establishing the OD matrix is the home-to-work trips data that are originated from JUTPIP commuting survey data. The JUTPIP commuting survey data contains the information related to the pair of origin (home) and destination (workplace) locations by using particular transport mode.

In addition to these OD pair data, the travel impedance data are analysed by calculating travel time that is needed to travel from origin to destination locations. The travel impedance is analysed by using ArcGIS Network Analysis. Network analysis is undertaken by building network dataset that is based on the road network in JMA.

5.4.2 OD Matrix construction

The OD cost matrix is built based on the pair of OD and time travel value for different transport modes in ArcGIS environment. The travel time to reach the origin and destination locations are categorised in order to develop time travel distribution. The cut-off value for categorising travel time are These cut-off values are the basis for analysing travel time decay function. Travel time decay function is the curve that shows the propensity of using certain type of transport mode with regard to time travel impedance. Conceptually, the smaller travel time impedance, the higher propensity of using a particular type of transport mode.

Since the cut-off value that is applied to develop time travel distribution is based on the categorised data, the middle value in each categorised data is used to plot travel time. For example, the lowest time travel category is less than 15 min. This category has the minimum value is 0 and the maximum value is 15 min. The middle value for this category is resulted from adding minimum and maximum value and then dividing the results by 2. This results in the middle value by 7.5 min. The similar process is replicated until the middle value of each category is obtained.

Travel time decay is visually depicted by using Cartesian coordinate in which x-axis indicates the travel time (in minutes) and y-axis indicates the potential interaction. The travel time decay curve is constructed by using cumulative inverse approach. This is because the cumulative inverse is suitable to illustrate the fall-off of the interaction between two different locations as the time travel between these locations increase. First, the number of trips by working individual is accumulated in its corresponding travel time category. The data for the number of trip is derived from JUTPIP commuting survey database. For instance, if the travel time from location i to j is equal to 10 minutes, it is categorised into less than 15 min travel time. The categorisation of trips based on its corresponding travel time is undertaken for different transport mode. This process results in the travel time distribution for various type of transport mode.

Second, once the trip distribution based on travel time is established, the next step is to plot the trip distribution to observe the mobility behaviour. Initially, the number of trip for each travel time category is transformed into the individual trip proportion. This is obtained by dividing the number of trips in each category with total number of trips. For example, if 20 out of 100 trips fall into the category less than 15 min, the proportion of trip in this category is 0.2. The calculation of trip number proportion is repeated until the proportion of all travel time category is obtained.

Third, cumulative value is obtained by aggregating the proportion of trip in each travel time category. This aggregation results in the accumulative proportion of the trip number that is equal to 1. Since we are interested in observing travel time decay, cumulative inverse is used in plotting the travel time decay function. The cumulative inverse value is obtained by subtracting the total cumulative value (the value is equal to 1) with the cumulative number of trips in each category. Once the inverse cumulative value for each travel time category is obtained, the next step is to plot the inverse cumulative value in the Cartesian coordinate. The x-axis indicates travel time in minute that is represented by the middle value in each travel time category. The y-axis indicates the potential interaction that is represented by the inverse cumulative value.

5.4.3 Urban poor mobility behaviour

The urban poor income group primarily depend on the moped (41%), and walking (35%) as their major transport mode. The proportion of trip by public transport is approximately 10% whereas cycling is approximately 6%. These percentages illustrate that private vehicle is preferred by urban poor for working trips (Figure 5.6). Table 5.1 to 5.4 show cumulative inverse of the travel time for different type of transport modes that are used by the urban poor. In general, the potential usage of non-motorised transport (walking and cycling) is high when the time travel is relatively short whereas the usage of public transport is relatively stable at the longer travel time. The critical travel time is after 30 minutes travel time. When the travel time is longer than 30 minutes, non-motorised transport is no longer attractive for urban poor. An interesting point is the travel time decay curve for the moped. Although moped has the highest proportion in the modal split, the potential use of moped is quite limited for longer travel time. The potential use of moped declines significantly when the travel time longer than 45 minutes. In contrast, the public transport that contributes only 10% on the modal split has the larger potential uses, particularly for longer travel time (45-75 minutes).

Table 5.1 Cumulative inverse for urban poor mobility by walking

Category	Total	Mid Value	Proportion	Cumulative	Inverse
0 min	0	0.0	0	0	1.00
<15 min	399	7.5	0.84	0.84	0.16
15-30 min	20	15.0	0.04	0.88	0.12
30-45 min	26	22.5	0.05	0.93	0.07
45-60 min	9	30.0	0.02	0.95	0.05
60-75 min	0	37.5	0.00	0.95	0.05
75-90 min	5	45.0	0.01	0.96	0.04
90-105 min	4	52.5	0.01	0.97	0.03
105-120 min	2	60.0	0.00	0.98	0.02
>120	11	67.5	0.02	1.00	0.00

Table 5.2 Cumulative inverse for urban poor mobility by cycling

Category	Total	Mid Value	Proportion	Cumulative	Inverse
0 min	0	0.0	0	0	1.00
<15 min	399	7.5	0.84	0.84	0.16
15-30 min	20	15.0	0.04	0.88	0.12
30-45 min	26	22.5	0.05	0.93	0.07
45-60 min	9	30.0	0.02	0.95	0.05
60-75 min	0	37.5	0.00	0.95	0.05
75-90 min	5	45.0	0.01	0.96	0.04
90-105 min	4	52.5	0.01	0.97	0.03
105-120 min	2	60.0	0.00	0.98	0.02
>120	11	67.5	0.02	1.00	0.00

Table 5.5 shows the average travel time for four different transport modes that are available for urban poor. In general, the non-motorised transport has relatively short average travel time, less than 20 minutes. This situation indicates that the non-motorised transport is preferred by urban poor for relatively short travel time. The average travel time for bus is approximately half hour whereas by moped is approximately 21.67 minutes. These figures indicate that motorised transport mode is preferred for longer travel time.

Table 5.3 Cumulative inverse for urban poor mobility by public transport (bus)

Category	Total	Mid Value	Proportion	Cumulative	Inverse
0 min	0	0.0	0.000	0	1.00
<15 min	43	7.5	0.336	0.34	0.66
15-30 min	27	15.0	0.211	0.55	0.45
30-45 min	23	22.5	0.180	0.73	0.27
45-60 min	15	30.0	0.117	0.84	0.16
60-75 min	7	37.5	0.055	0.90	0.10
75-90 min	6	45.0	0.047	0.95	0.05
90-105 min	3	52.5	0.023	0.97	0.03
105-120 min	0	60.0	0.000	0.97	0.03
>120	4	67.5	0.031	1.00	0.00
Grand Total	128				

Table 5.4 Cumulative inverse for urban poor mobility by moped

Category	Total	Mid Value	Proportion	Cumulative	Inverse
0 min	0	0.0	0.000	0.000	1.00
<15 min	344	7.5	0.520	0.52	0.48
15-30 min	134	15.0	0.202	0.72	0.28
30-45 min	83	22.5	0.125	0.85	0.15
45-60 min	53	30.0	0.080	0.93	0.07
60-75 min	31	37.5	0.047	0.97	0.03
75-90 min	11	45.0	0.017	0.99	0.01
90-105 min	1	52.5	0.002	0.99	0.01
105-120 min	5	60.0	0.008	1.00	0.00
>120	0	67.5	0.000	1.00	0.00
Grand Total	662				

Table 5.5 Average travel time of transport modes for urban poor

Category	Mid Value (x)	f Walking	$f.x$ Walking	f Cycling	$f.x$ Cycling	f Bus	$f.x$ Bus	f Moped	$f.x$ Moped
0 min	0.0	0	0.00	0	0.00	0.00	0.00	0	0.00
<15 min	7.5	399	2992.50	55	412.50	43.00	322.50	401	3007.50
15-30 min	22.5	20	450.00	10	225.00	27.00	607.50	134	3015.00
30-45 min	37.5	26	975.00	9	337.50	23.00	862.50	83	3112.50
45-60 min	52.5	9	472.50	4	210.00	15.00	787.50	53	2782.50
60-75 min	67.5	0	0.00	2	135.00	7.00	472.50	31	2092.50
75-90 min	82.5	5	412.50	1	82.50	6.00	495.00	11	907.50
90-105 min	97.5	4	390.00	0	0.00	3.00	292.50	1	97.50
105-120 min	112.5	2	225.00	2	225.00	0.00	0.00	5	562.50
>120 min	127.5	11	1402.50	0	0.00	4.00	510.00	0	0.00
TOTAL		476	7320	83	1627.5	128	4350	719	15577.5
		Mean	15.38	Mean	19.61	Mean	33.98	Mean	21.67

5.4.4 Middle-income group mobility behaviour

The middle-income group is highly dependence on private vehicle uses rather than public transport and non-motorised transport. This is shown by the proportion of modal split for the middle-income group in which moped and car uses reach approximately 69% and 16%. The usage of public transport and walking reach 7% and 6% whereas cycling is the least preferred mode by approximately 2% of total modal split (Figure 5.8).

Table 5.6 to 5.10 show the cumulative inverse of the travel time function for middle-income group. The potential usage of non-motorised transport (walking and cycling) is limited to relatively short time travel. The critical point for non-motorised transport is 45 minutes. If the travel time is longer than 45 minutes, the non-motorised transport is no longer attractive for middle-income group. Car, public transport, and moped are potential transport mode to travel in the longer travel time. The critical travel time for public transport and moped is 60 minutes. If travel time is longer than 60 minutes, both of public transport and moped are less attractive. Car has the critical travel time 105 minutes. This can be interpreted that car is quite attractive for the longer travel time.

Table 5.6 Cumulative inverse for middle-income group by walking

Category	Total	Mid Value	Proportion	Cumulative	Inverse
0 min	0	0.0	0.00	0.00	1.00
<15 min	4854	7.5	0.79	0.79	0.21
15-30 min	265	15.0	0.04	0.83	0.17
30-45 min	369	22.5	0.06	0.89	0.11
45-60 min	205	30.0	0.03	0.93	0.07
60-75 min	117	37.5	0.02	0.95	0.05
75-90 min	79	45.0	0.01	0.94	0.06
90-105 min	38	52.5	0.01	0.95	0.05
105-120 min	33	60.0	0.01	0.95	0.05
>120 min	182	67.5	0.03	0.98	0.02

Table 5.7 Cumulative inverse for middle-income group mobility by cycling

Category	Total	Mid Value	Proportion	Cumulative	Inverse
0 min	0	0.0	0	0	1.00
<15 min	357	7.5	0.610256	0.61	0.39
15-30 min	108	15.0	0.184615	0.79	0.21
30-45 min	45	22.5	0.076923	0.87	0.13
45-60 min	42	30.0	0.071795	0.94	0.06
60-75 min	21	37.5	0.035897	0.98	0.02
75-90 min	8	45.0	0.013675	0.99	0.01
90-105 min	2	52.5	0.003419	1.00	0.00
105-120 min	1	60.0	0.001709	1.00	0.00
>120 min	1	67.5	0.001709	1.00	0.00

Table 5.11 shows the average travel time by using different available transport modes for middle-income group. It is clear that the non-motorised transport modes (walking and cycling) are preferred for relatively short travel time less than 20 minutes. For longer travel time, the motorised

Table 5.8 Cumulative inverse for middle-income group mobility by public transport (bus)

Category	Total	Mid Value	Proportion	Cumulative	Inverse
0 min	0	0.0	0.000	0.000	1.00
<15 min	865	7.5	0.326	0.33	0.67
15-30 min	530	15.0	0.200	0.53	0.47
30-45 min	432	22.5	0.163	0.69	0.31
45-60 min	272	30.0	0.103	0.79	0.21
60-75 min	223	37.5	0.084	0.88	0.12
75-90 min	108	45.0	0.041	0.92	0.08
90-105 min	79	52.5	0.030	0.95	0.05
105-120 min	76	60.0	0.029	0.98	0.02
>120 min	65	67.5	0.025	1.00	0.00

Table 5.9 Cumulative inverse for middle-income group mobility by moped

Category	Total	Mid Value	Proportion	Cumulative	Inverse
0 min	0	0.0	0.00	0	1.00
<15 min	10993	7.5	0.41	0.41	0.59
15-30 min	5267	15.0	0.20	0.61	0.39
30-45 min	4026	22.5	0.15	0.76	0.24
45-60 min	2698	30.0	0.10	0.87	0.13
60-75 min	1726	37.5	0.07	0.93	0.07
75-90 min	1035	45.0	0.04	0.97	0.03
90-105 min	484	52.5	0.02	0.99	0.01
105-120 min	189	60.0	0.01	1.00	0.00
>120 min	130	67.5	0.00	1.00	0.00

Table 5.10 Cumulative inverse for middle-income group mobility by car

Category	Total	Mid Value	Proportion	Cumulative	Inverse
0 min	0	0.0	0.00	0.00	1.00
<15 min	540	7.5	0.23	0.23	0.77
15-30 min	345	15.0	0.15	0.38	0.62
30-45 min	357	22.5	0.15	0.53	0.47
45-60 min	350	30.0	0.15	0.68	0.32
60-75 min	288	37.5	0.12	0.81	0.19
75-90 min	203	45.0	0.09	0.89	0.11
90-105 min	118	52.5	0.05	0.95	0.05
105-120 min	74	60.0	0.03	0.98	0.02
>120 min	53	67.5	0.02	1.00	0.00

transport modes are preferred. The average travel time for mopped is almost reaches half hour. The average travel time by using bus is 36.75. There are slight differences between the average travel time for moped and bus. This situation indicates the competition between these two modes. The average travel time by car is 45.68 minutes. This indicates that car is preferred for longer travel time.

Table 5.11 Average travel time of transport modes for middle-income group

Category	Mid Value (x)	f Walking	$f.x$ Walking	f Cycling	$f.x$ Cycling	f Bus	$f.x$ Bus	f Moped	$f.x$ Moped	f Car	$f.x$ Car
0	0.0	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
<15 min	7.5	4854	36405.00	357	2677.50	865	6487.50	10993	82447.50	540	4050.00
15-30 min	22.5	265	5962.50	108	2430.00	530	11925.00	5267	118507.50	345	7762.50
30-45 min	37.5	369	13837.50	45	1687.50	432	16200.00	4026	150975.00	357	13387.50
45-60 min	52.5	205	10762.50	42	2205.00	272	14280.00	2698	141645.00	350	18375.00
60-75 min	67.5	117	7897.50	21	1417.50	223	15052.50	1726	116505.00	288	19440.00
75-90 min	82.5	79	6517.50	8	660.00	108	8910.00	1035	85387.50	203	16747.50
90-105 min	97.5	38	3705.00	2	195.00	79	7702.50	484	47190.00	118	11505.00
105-120 min	112.5	33	3712.50	1	112.50	76	8550.00	189	21262.50	74	8325.00
>120 min	127.5	182	23205.00	1	127.50	65	8287.50	130	16575.00	53	6757.50
TOTAL		6142	112005	585	11512.5	2650	97395	26548	780495	2328	106350
		Mean	18.24	Mean	19.68	Mean	36.75	Mean	29.40	Mean	45.68

5.4.5 High-income group mobility behaviour

The middle-income group is highly dependence on private vehicle uses rather than public transport and non-motorised transport. This is shown by the proportion of modal split for the middle-income group in which moped and car uses reach approximately 69% and 16%. The usage of public transport and walking reach 7% and 6% whereas cycling is the least preferred mode by approximately 2% of total modal split (Figure 5.10).

Table 5.12 and 5.13 show the cumulative inverse of the travel time function for middle-income group. The potential usage of non-motorised transport (walking and cycling) is limited to relatively short time travel. The critical point for non-motorised transport is 45 minutes. If the travel time is longer than 45 minutes, the non-motorised transport is no longer attractive for middle-income group. Car, public transport, and moped are potential transport mode to travel in the longer travel time. The critical travel time for public transport and moped is 60 minutes. If travel time is longer than 60 minutes, both of public transport and moped are less attractive. Car has the critical travel time 105 minutes. This can be interpreted that car is quite attractive for the longer travel time.

Table 5.12 Cumulative inverse for high-income group mobility by moped

Category	Total	Mid Value	Proportion	Cumulative	Inverse
0 min	0	0.0	0.00	0.00	1.00
<15 min	37	7.5	0.29	0.29	0.71
15-30 min	28	15.0	0.22	0.52	0.48
30-45 min	16	22.5	0.13	0.64	0.36
45-60 min	14	30.0	0.11	0.75	0.25
60-75 min	15	37.5	0.12	0.87	0.13
75-90 min	6	45.0	0.05	0.92	0.08
90-105 min	5	52.5	0.04	0.96	0.04
105-120 min	3	60.0	0.02	0.98	0.02
>120 min	2	67.5	0.02	1.00	0.00

Table 5.13 Cumulative inverse fo high-income group mobility by car

Category	Total	Mid Value	Proportion	Cumulative	Inverse
0 min	0	0.0	0.00	0	1.00
<15 min	72	7.5	0.18	0.18	0.82
15-30 min	56	15.0	0.14	0.32	0.68
30-45 min	80	22.5	0.20	0.52	0.48
45-60 min	49	30.0	0.12	0.64	0.36
60-75 min	57	37.5	0.14	0.79	0.22
75-90 min	46	45.0	0.12	0.90	0.10
90-105 min	29	52.5	0.07	0.97	0.03
105-120 min	9	60.0	0.02	1.00	0.01
>120 min	2	67.5	0.01	1.00	0.00

Table 5.14 shows the average travel time by using different available transport modes for middle-income group. It is clear that the non-motorised transport modes (walking and cycling) are preferred for relatively short travel time less than 20 minutes. For longer travel time, the motorised

transport modes are preferred. The average travel time for mopped is almost reaches half hour. The average travel time by using bus is 36.75. There are slight differences between the average travel time for moped and bus. This situation indicates the competition between these two modes. The average travel time by car is 45.68 minutes. This indicates that car is preferred for longer travel time.

Table 5.14 Average travel time of transport modes for high-income group

Category	Mid Value (x)	f Moped	$f.x$ Moped	f Car	$f.x$ Car
0	0.0	0	0.00	0	0.00
<15 min	7.5	37	277.50	72	540.00
15-30 min	22.5	28	630.00	56	1260.00
30-45 min	37.5	16	600.00	80	3000.00
45-60 min	52.5	14	735.00	49	2572.50
60-75 min	67.5	15	1012.50	57	3847.50
75-90 min	82.5	6	495.00	46	3795.00
90-105 min	97.5	5	487.50	29	2827.50
105-120 min	112.5	3	337.50	9	1012.50
>120	127.5	2	255.00	2	255.00
	TOTAL	126	4830	400	19110
	Mean		38.33		47.78

5.5 ACCESSIBILITY TO POTENTIAL JOB OPPOTUNITIES

5.5.1 The calculation of potential accessibility measure

The potential job accessibility measure is calculated by multiplying travel time decay function with the potential job opportunity that can be reached from a particular JUTPIP zone. The time travel decay function is derived based on the plot of inverse cumulative value. This process is undertaken in MatLab software to determine the appropriate decay function. The time travel decay function is used to calculate potential accessibility measure to reach job opportunities. Since mobility behaviour is analysed for different income and transport mode, the time travel decay function have different forms.

The potential accessibility to job opportunities is calculated by multiplying the travel time distance decay function with the travel time to reach potential job opportunities from the origin to destination locations. This process is undertaken in MatLab and the results are visualised in ArcGIS.

5.5.2 Travel time decay function for urban poor

In general, the travel time decay function for urban poor travel behaviour follows the negative exponential function. Since the actual travel behaviour differs from one mode to the other mode, the coefficient values are varied from one mode to the other mode. Table 5.15 and Figure 5.5 show the travel time decay function for each transport mode that is available for the poor. In general, the travel time decay function by using negative exponential function is suitable for representing actual travel behaviour of the urban poor.

Table 5.15 Travel time decay function for urban poor potential job accessibility

Transport mode	Formula	RMSE
Walking	$0.99.\exp(-0.23.time)$	0.05
Cycling	$0.97.\exp(-0.1055.time)$	0.07
Public transport (bus)	$0.96.\exp(-0.03487.time)$	0.03
Moped	$0.95.\exp(-0.06169.time)$	0.05

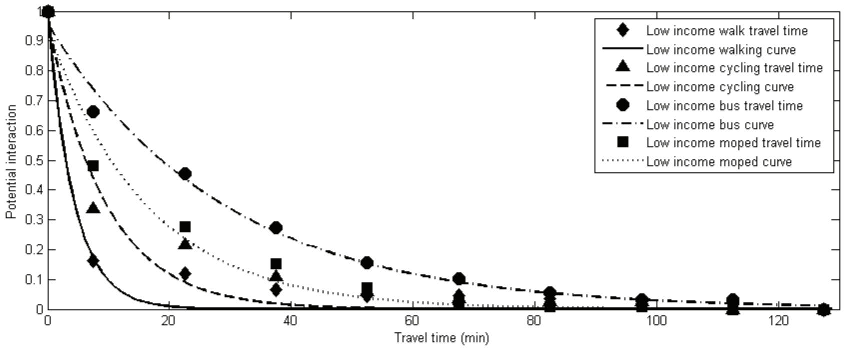


Figure 5.5: Travel time decay function for urban poor mobility

5.5.3 Potential job accessibility for urban poor

Figure 5.6 shows the potential job opportunities for the low-income job opportunities. By walking, the higher values of potential job opportunities for urban poor are mainly in the periphery area. In the periphery area, there are certain industrial zones that become the potential job opportunities for urban poor as factory labour. The pattern of accessibility to job opportunities by walking tends to form the leapfrog pattern. This situation illustrates that if urban poor use walking as the primary transport mode, it brings widely benefit to reach job opportunity for the poor in the periphery area, particularly the poor who live in the western part of JMA. However, accessibility to potential job opportunities by walking is less beneficial for urban poor who live in the south-eastern part of the JMA. This can be seen by the less potential accessibility value in the south-eastern part of JMA. This issue occurs due to smaller number of potential job opportunities in the south-eastern part of the city.

By cycling, the more opportunities for urban poor can be reached. It is clear that inner city area (CBD and its surrounding area) are the area with high accessibility to potential job opportunities for urban poor. Unlike the pattern of accessibility to urban poor job opportunities by walking, the pattern of accessibility by cycling is more evenly distributed. Cycling significantly improves the ability to reach potential job opportunities at both periphery and inner city zones. Promoting cycling provides greatly benefit for urban poor who live in the inner city area (CBD and its surrounding area). The accessibility to potential job opportunities in the south-eastern part of JMA has improved by cycling. The area is able to reach higher potential job opportunities but in comparison to the other area, the south-eastern part of JMA has the least accessibility to potential job opportunities for the poor.

By public transport, the potential accessibility to job opportunities is substantially improved. The pattern of accessibility to job opportunity is more evenly distributed. Job for the poor is widely accessible from both inner city zone and periphery area. The area in the south-eastern part of the

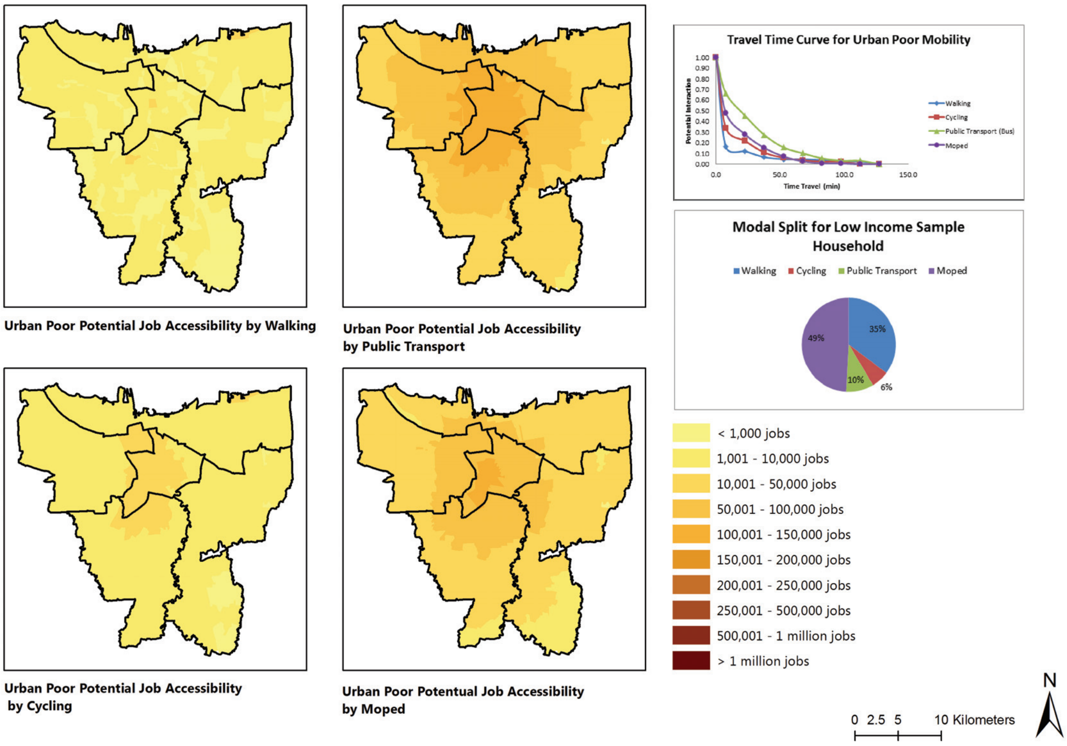


Figure 5.6: Urban poor potential job accessibility map

city is able to reach higher potential job opportunities if the public transport system is improved.

By moped, the potential accessibility to job opportunities has relatively similar pattern with the potential accessibility to job opportunities by public transport. However, the potential accessibility values are smaller than the one by public transport. This is an exceptional case since the modal split shows that moped is the most preferred transport mode by the poor. However, travel time decay function shows that if travel time becomes longer, moped is not quite attractive for urban poor. In contrast, public transport is still attractive for longer travel time. This is the reason that can explain why public transport has higher potential accessibility value in comparison to moped.

5.5.4 Travel time decay function for middle-income group

The travel time decay function for middle-income group utilises two functions: (1) negative exponential function; and (2) Gaussian function. The negative exponential function is used to fit the travel time distribution for accessibility to potential job opportunities by walking, cycling, public transport (bus), and moped. The Gaussian function is used to fit the travel time distribution by car. Table 5.16 and Figure 5.7 show the travel time decay function for transport modes that are available for the middle-income group.

Table 5.16 Travel time decay function for middle-income potential job accessibility

Transport mode	Formula	RMSE
Walking	$0.77.\exp(-0.566.time) + 0.22.\exp(-0.01.time)$	0.01
Cycling	$0.53.\exp(-0.042.time) + 0.46.\exp(-2.23.time)$	0.001
Public transport (bus)	$0.95.\exp(-0.03.time)$	0.03
Moped	$0.94.\exp(-0.04.time)$	0.05
Car	$1.78.\exp(-((time + 75.68)/95.74)^2)$	0.003

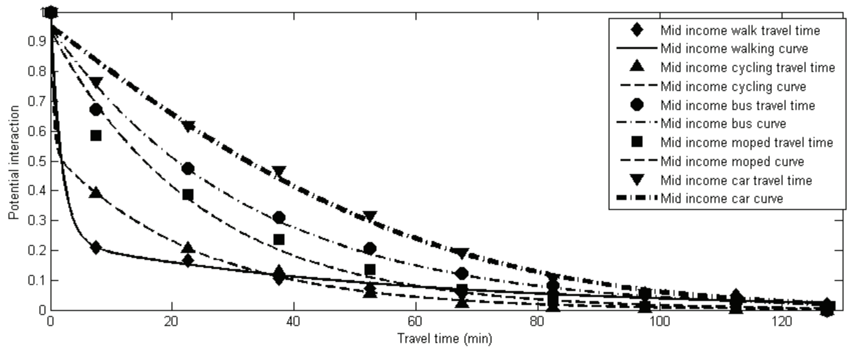


Figure 5.7: Travel time decay function for middle-income group mobility

5.5.5 Potential job accessibility middle-income group

Figure 5.8 shows the potential job accessibility for middle-income group. The pattern of potential job accessibility to middle-income job opportunities by walking has the concentric pattern. Certain zones in the inner city have the highest potential accessibility to job opportunity by walking. Since the job opportunity for middle-income group is concentrated in the inner city zone, the areas that are close to the inner city have the high value of potential job opportunities by walking. The periphery areas in the northern, eastern part of JMA have the high value of potential job accessibility by walking. This is due to the presence of the industrial and port activities in these areas.

The potential job accessibility by cycling provides significant benefit for middle-income who lives in the inner city zones (CBD and its surrounding areas). This situation occurs due to the agglomeration of middle-income job opportunities in the inner zones.

A significant improvement to access potential job opportunities for middle-income group is undertaken by public transport. By using public transport, the access to potential job opportunity for middle-income group is more evenly distributed in comparison to walking and cycling. In addition, the potential job accessibility for middle-income group by public transport is higher rather than moped. This circumstance is identical to the potential job accessibility for urban poor. This situation can be explained by the travel time decay function in which moped is not so attractive for longer travel time distance whereas public transport (bus) is quite attractive for longer travel time.

The accessibility to potential job opportunity for middle-income group has the highest value by using private car. The middle-income group who live in the inner city zone (CBD and the surrounding area) obtain the highest benefit from the accessibility by private car. The higher potential

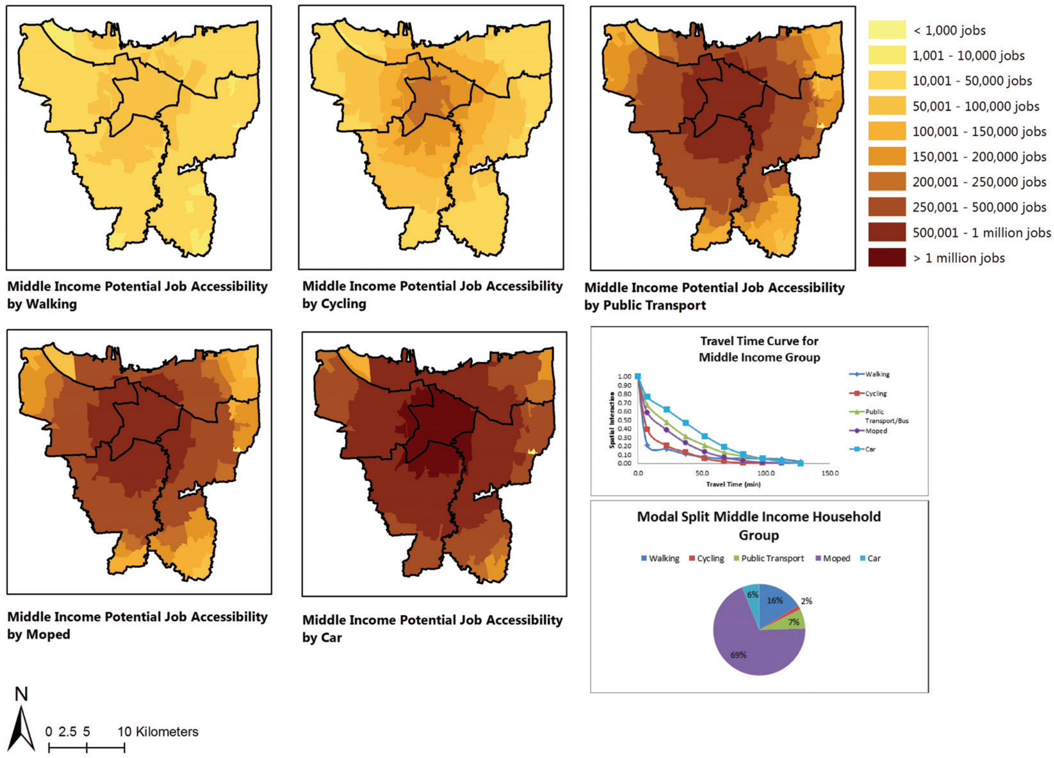


Figure 5.8: Middle-income group potential job accessibility map

job accessibility value by private car is because private car is able to reach the long job opportunities by travelling through highway. In addition, the travel time curve shows that car is quite attractive for undertaking trip at the longer distance. In fact, this is one of the major factors that causes overdependence on the usage of private car in Jakarta Metropolitan Area.

5.5.6 Travel time decay function for high-income group

The travel time decay function for high-income group implements two types: (1) negative exponential function that is applied to fit travel time decay function for moped; and (2) Gaussian function to fit travel time decay function for car. Table 5.17 and Figure 5.9 show the travel time decay function for transport modes that are used by high-income group.

Table 5.17 Travel time decay function for high-income group potential job accessibility

Transport mode	Formula	RMSE
Moped	$0.96.\exp(-0.03.\text{time})$	0.04
Car	$1.18.\exp(-((\text{time}+34.59)/76.47)^2)$	0.03

5.5.7 Potential job accessibility high-income group

Figure 5.10 shows the potential job accessibility map for high-income group. In general, the potential accessibility to job opportunities by private car is higher in comparison to the potential job

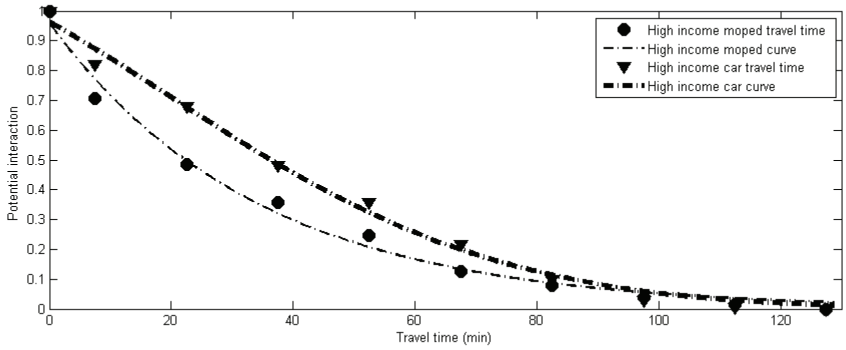


Figure 5.9: Travel time decay function for high-income group mobility

accessibility by using moped. If we analyse this situation by using the travel time decay curve, it is shown that the potential attractiveness of car is significantly higher than moped. For the relatively short travel time less than 20 minutes, the higher income group prefers to use private car rather than the moped. The critical point is in the travel time after 90 minutes. If travel time is higher than 90 minutes, the car is less attractive in comparison to the moped. Although the moped is relatively more attractive for longer travel time, the potential uses for moped to travel in longer travel time is very small.

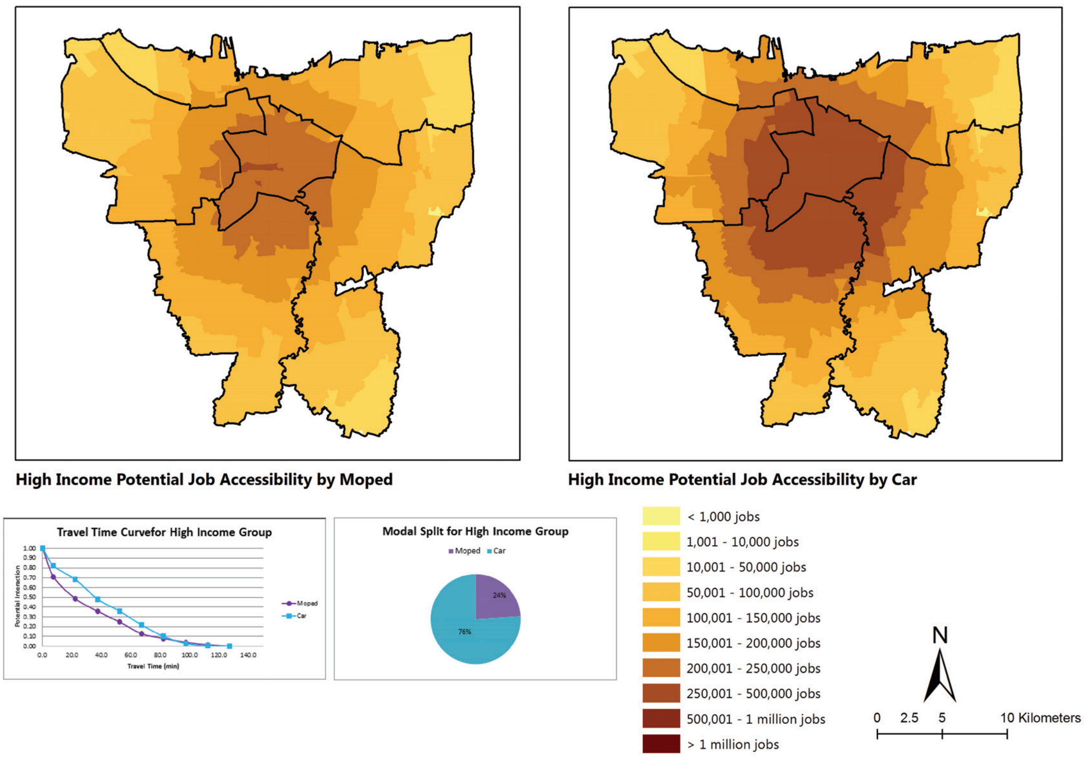


Figure 5.10: High-income group potential job accessibility map

5.5.8 Comparison of potential accessibility to job opportunities

By comparing accessibility to potential job opportunities among low-, middle-, and high-income groups, it shows that low-, and middle-income group may obtain a benefit to reach potential job opportunities by improving public transport. This has the implication to improve public transport service by making public transport more attractive for low- and middle-income group. In contrast, high-income group is overly dependence on the usage of private vehicle. The implication of this condition is that the demand for improving infrastructure to support motorised trips (car and moped) becomes higher in order to be able to support mobility for high-income group.

5.6 CROSS-ACCESSIBILITY ANALYSIS

The cross-accessibility analysis is the change in the potential accessibility if urban poor is able to enter job market for middle-income group. The process for analysing the cross-accessibility is undertaken by multiplying the urban poor time travel impedance function with the number of job opportunity for middle-income group. This analysis is undertaken for four different transport modes that are available for urban poor (walking, cycling, public transport/bus, and moped). The process of calculating the cross-accessibility analysis is undertaken by using MatLab whereas the visualisation is undertaken in ArcGIS.

Figure 5.11 shows the cross-accessibility analysis for four different transport modes that are available for the poor. By walking, the urban poor has limited coverage to reach potential job opportunities for middle-income. The figure shows that certain zones in the inner city area and the periphery area have the high value of potential accessibility index. By cycling, the urban poor accessibility to potential job opportunities for middle-income group is improved. The areas in the inner city zones (CBD and its surrounding) have the high value of potential accessibility index. Urban poor who live in certain zones in the periphery areas have better potential accessibility value to job opportunities for middle-income group by cycling in comparison to walking. By public transport, the opportunity for urban poor to reach potential job that is available for middle-income group is better. This is shown by the higher potential accessibility value to reach job opportunities at both inner city and periphery area. In the inner city zones, public transport provides better accessibility in comparison to moped. This circumstance occurs due to the travel time decay function for moped that is steeper in comparison to public transport. Therefore, the potential job accessibility value by moped is smaller in comparison to public transport.

5.7 WEIGHTED POTENTIAL ACCESSIBILITY TO JOB OPPORTUNITIES

One limitation of potential accessibility measure is that the measure is able show the potential job that can be reached from a particular area but it does not provide insight about the information whether particular group of income obtain the benefit from the potential accessibility in a certain approach. The main concern that is addressed with regard to weighted potential accessibility is a practical question *if small number of population live in a high accessibility area, what are suitable intervention to efficiently improve the accessibility?*. This issue is important for transport plan and policy making purpose. To illustrate, if small number of urban poor lives in the high accessibility area, there are a number of alternative options for improving their accessibility such as improving public transport so that it is accessible for the poor or providing facilities to promote

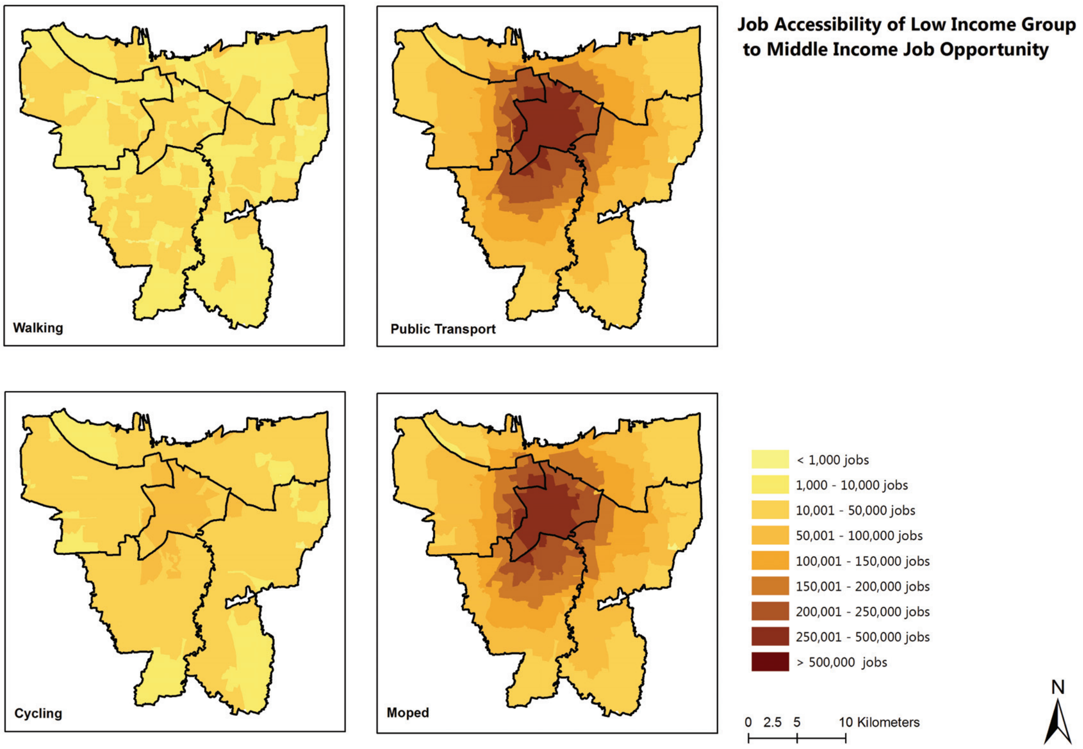


Figure 5.11: Cross-accessibility analysis of urban poor to middle-group income potential job opportunities

non-motorised transport. An important practical implementation of weighted accessibility is that it can be used for determining the priority location for improving accessibility.

Weighted potential job accessibility is calculated by using weighted factor. The weighted factor is based on the number of population. Calculating the weighted factor is undertaken by dividing the number of people at particular zone that belongs to particular income group with total number of population at that particular group. Once the weighted factor is obtained, the weighted factor is multiplied with the potential accessibility value. This process is undertaken in MatLab. The result of weighted accessibility to potential job opportunities is visualised in ArcGIS.

5.7.1 Weighted accessibility to potential job opportunities for urban poor

Figure 5.12 shows the potential and weighted accessibility value for urban poor. In general, the weighted accessibility results in the smaller accessibility values. The weighted accessibility by walking shows that areas in the southern part of JMA experience significant decrease in the accessibility value. This situation occurs because the number of urban poor in southern part of JMA is small. The weighted accessibility has the scattered pattern with the zones that are located in the inner city and periphery (western, northern, and eastern) part of JMA have the highest accessibility to potential job opportunities. An implication that can be derived from the weighted accessibility to potential job opportunities is that the improvement of pedestrian to improve accessibility will bring benefit to be prioritised in the inner city and periphery locations that are close to potential job opportunities for the urban poor.

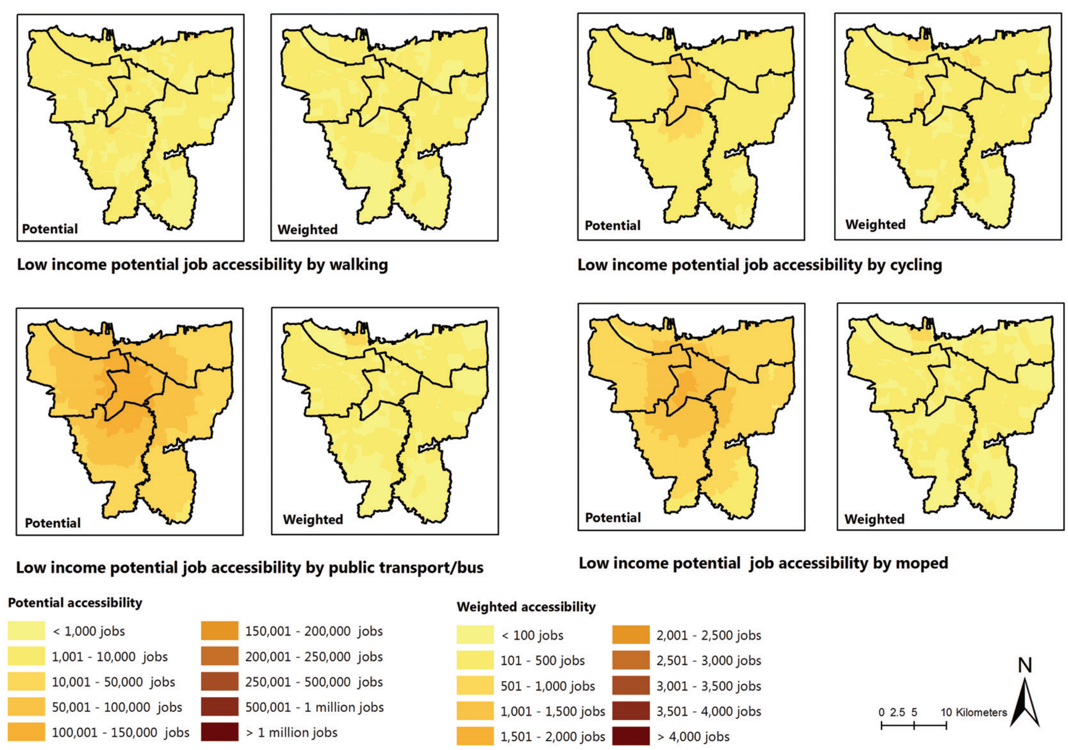


Figure 5.12: Weighted potential job accessibility for urban poor group

The weighted accessibility to potential job opportunities by cycling shows that the potential job opportunities for urban poor provide significant benefit in the zones that are located in the periphery area. In comparison to the potential accessibility to urban poor job opportunities by cycling, it is clear that the inner city area (CBD and its surrounding location) experiences the decline in the potential accessibility by walking. The implication that can be derived from this circumstance is the priority for improving the cycling facilities (i.e. bike lane and bike sheed) will provide a significant benefit for urban poor if it is prioritised in the periphery area. The weighted accessibility to potential job opportunities by public transport shows an interesting finding. The pattern of the weighted potential job opportunities by public transport (bus) is relatively similar to the accessibility by cycling but in certain zones it has smaller accessibility value.

This situation shows that improvement of cycling facilities will provide a greater benefit in the prioritised location. An implication that can be derived is that it is beneficial to integrate public transport and non-motorised transport (particularly cycling) in the prioritised areas so that it provides benefit to improve accessibility to potential job opportunities.

The weighted accessibility by moped shows the significant decrease in comparison to the value of potential accessibility to job opportunities by moped. The weighted accessibility to potential job opportunities for urban poor indicates that urban poor in the periphery area attains the highly benefit from the improvement of road facility to support mobility by mopped. From the weighted accessibility analysis for urban poor, it can be interpreted that that cycling provides the highest potential accessibility value to potential job opportunities for urban poor in comparison to the other available transport modes for urban poor in JMA. Therefore, the general policy implication that can be derived from this finding is that the improvement of cycling infrastructure such as developing bike lanes, and bike transit station will bring a significant benefit for urban poor to be able to access their potential job opportunities. The further intervention that can be derived is that the integration between public transport and non-motorised transport through transit oriented development concept will provide a significant benefit for improving urban poor job accessibility.

5.7.2 Weighted accessibility to potential job opportunities for middle-income group

Figure 5.13 shows the weighted accessibility to potential job opportunities for middle-income group. The weighted accessibility to potential job opportunities for middle-income group in general shows that the pattern of weighted accessibility is incline to be dispersed rather than concentrated. This means that after including the weighting factor, the location with the high value of accessibility to potential job opportunity is no longer concentrated in the inner city area. Instead, areas outside the CBD are the area with high number of accessibility.

The accessibility to potential job opportunities for middle-income group by walking shows that certain zones in the periphery have the high number of potential accessibility. In general, the periphery areas in the northern, eastern, and southern part of JMA have the higher accessibility index. The weighted potential accessibility by public transport shows that the areas that have the high value of potential accessibility to job opportunities for middle-income group are predominantly situated in the northern part of JMA. However, the areas with high value of potential accessibility by public transport are relatively close to CBD. An interesting finding is that the weighted accessibility by public transport has relatively similar result with the accessibility to potential job opportunities by cycling. The implication of this situation is that if weighted factor by population is considered in the calculation of accessibility, promoting the integration between public transport and cycling as the strategy to improve accessibility will provide the significant benefit for the middle-income group to reach their potential job opportunity.

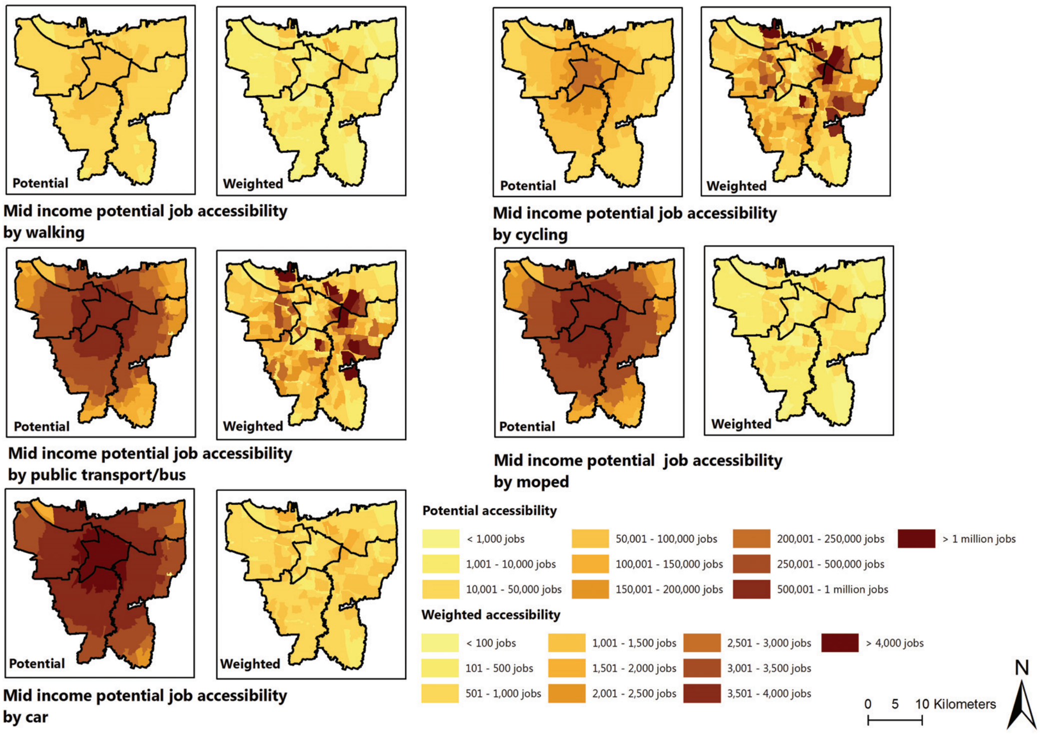


Figure 5.13: Weighted potential job accessibility for middle-income group

The weighted potential accessibility by moped shows relatively similar pattern with walking. There is an interesting fact that the potential accessibility by moped (after it is multiplied by population as weighting factor) has smaller number in comparison to the weighted accessibility by walking. This situation shows that the overdependence on the moped uses can be minimised if walking facilities (i.e. pedestrian) is improved in the priority areas.

The weighted potential accessibility by car has the similar pattern with the accessibility by public transport. However, the accessibility value by car to reach potential job opportunities for middle-income group is smaller in comparison to public transport. An interesting intervention with regard to this finding is that the overdependence on private vehicle is potentially able to be minimised if the public transport service is greatly improved in the priority areas.

5.7.3 Weighted accessibility to potential job opportunities for high-income group

Figure 5.14 shows the weighted accessibility to potential job opportunities for high-income group. In general, the weighted accessibility to job opportunities by moped has the higher value in comparison to the weighted accessibility to job opportunities by car.

The weighted potential accessibility index for mopped is incline to show the scattered pattern in the periphery area. The weighted accessibility value to potential job opportunities in the periphery area by mopped has the higher value in comparison to in the inner city areas. In the periphery area, the zones in the eastern and northern part of the JMA are the areas with high number of accessibility by moped.

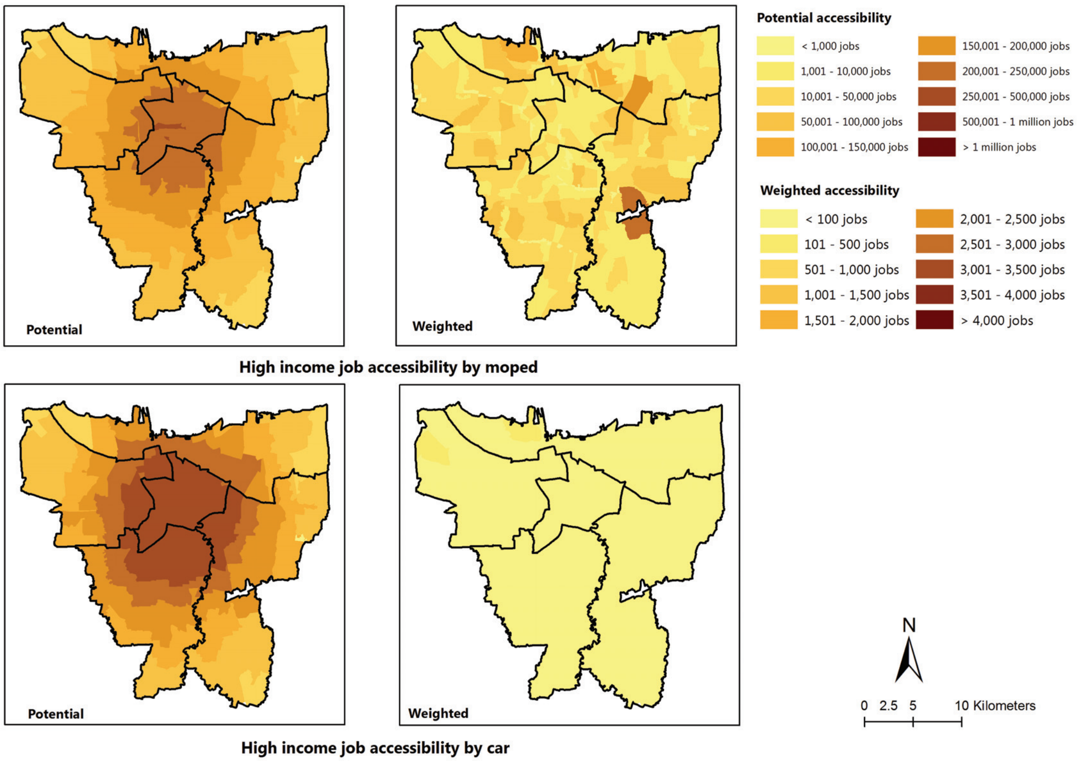


Figure 5.14: Weighted potential job accessibility for high-income group

The weighted accessibility to potential job opportunities for high-income group by car has the high value for certain areas in the periphery area of JMA. Certain zones in the periphery area in the western, northern, and eastern part of the JMA are the areas that have the high number of potential job opportunities. This situation has the implication that the improvement in the infrastructure to support mobility for high-income group by car provides significant benefit for people who lives in the periphery area.

Chapter 6

Conclusion and recommendation

This chapter provides the summary of this research by responding to the research questions. The general conclusion is provided as the synthesis of the response to research questions. This chapter discusses the strong points of this research as well as the limitation of this study. In the last part, the recommendation for further study is given based on the aspects that are not completely addressed in this study.

6.1 ANSWER TO RESEARCH QUESTIONS

This research is aimed to investigate the mobility behaviour of urban poor and non-poor and their accessibility to job opportunities in Jakarta Metropolitan Area (JMA)-Indonesia. The primary problem that is addressed in this research is the lack of the information that examines urban poor mobility from both of socio-economic and spatial point of view in JMA. In addition, the absence of previous studies that specifically compare the mobility and accessibility between urban poor and non-poor in JMA has the consequence on the lack of understanding to derive appropriate transport policies to improve accessibility to job opportunities in JMA. From the technical point of view, this research is addressed to deal with applying suitable techniques to derive normative concept of urban poor into the spatial-analytical perspective that is not yet covered in previous accessibility studies in JMA. The conclusion of this research is achieved by answering the specific research questions. The answer for the research questions in this research are:

Q1: *What are the definitions of urban poor based on the global and Indonesian context?*

In global context, urban poor is defined by using two measurements: (1) absolute poverty; and (2) relative poverty. Absolute poverty is the approach to define urban poor by using certain set of threshold. For example, World Bank defines the poor as individuals with the purchasing power less than 1.25 USD per day. In contrast, relative poverty measure is an approach to define poverty by comparing the socio-economic condition of an individual with the socio-economic conditions of the entire population in the study area. For example, relative poverty is measured by analysing the distribution of income in EU. If an individual has the level of income belom 50% of the median income of EU population, the individual is categorised as poor people.

The concept of defining urban poor in Indonesian context is based on the socio-economic indicators. The Central Bureau of Statistics (CBS) indicates 14 the indicators of urban poor in Indonesia (see Chapter 2). Due to the lack of available data, this research focusses on defining urban poor based on the level of income as the indicator. In this research, a household is defined as urban poor if the level of income of the household head is less approximately less than IDR 600,000 (USD 54.5).

Q2: *How to define urban poor for the context of JMA?*

The major challenge in this research is to apply suitable technique to define urban poor in th context of JMA. The definition of urban poor according to the criteria for CBS is not entirely supported with the available data. This research utilises the dataset from Jakarta Urban Transport Policy Integration Project (JUTPIP) dataset that consists of commuting survey questionnaire and GIS database. The primary concern is that only the criteria of urban poor based on the level of income can be integrated into the JUTPIP database. In order to deal with this problem, certain adjustments are undertaken.

First, the criterion of urban poor based income level (CBS) is accommodated into JUTPIP dataset by using the lowest cut-off value of the household income. In JUTPIP dataset, the lowest value for household income level is IDR 1 million (USD 90.9). The justification for this approach is that the smallest cut-off value in JUTPIP is able to accommodate the urban poor criteria based on CBS. Second, the non-poor group are defined by the researcher by defining the interval based on the available data in the JUTPIP. The middle-income group is categorised into two: (1) middle-low; and (2) middle-upper income. The middle-low income that is defined as the household with the income level of head of household between IDR 1 million (USD 90.9) and IDR 3.9 million (USD 354.54) whereas the middle-upper income with the range between IDR 3.9 million (USD 354.54) and IDR 12.4 million (USD 1,136.27). The high-income group is defined as the household with the income level of the household head more than IDR 12.4 million (USD 1,136.27).

Q3: *What are transport modes that are used by the poor to travel from home to work location?*

The urban poor group is mainly used four types of transport modes: walking, cycling, public transport, and moped. In general, most of the urban poor depends on the use of moped (49%) and walking (35%) while the usage of public transport only 10% and cycling 6%. This situation reflects situation in the mega cities in developing countries in which the lack of public transport service has the implication to the rise of moped users and non-motorised transport for poor people. For the case of high number of moped user for the poor, this situation can be associated with the ease to acquire credit for moped in Indonesia.

Q4: *What are transport modes that are used by non-poor to travel from home to work location?*

The middle-income group has almost similar situation with the urban poor in term of modal split. The middle-income group is overdependence on moped as the major transport mode. The proportion of moped users in the middle-income group modal split reaches 69%. An interesting finding is that walking is the second most widely used transport mode (16%). The proportion of public transport users reaches 7% while car is 6%. There is small number of middle-income group that cycling to their workplace (2%).

The higher-income group utilises two type of transport modes: (1) moped; and (2) car. The proportion of car user is approximately 76% whereas moped user is 24%. Due to the limitation in data availability, the number of high-income group that uses public transport and non-motorised transport cannot be discovered. However, this situation reflects the condition in the metropolitan area in developing countries where the rich people are overdependence on private vehicles (automobile and moped).

Q5: *How does the variation in the travel time distribution of urban poor group?*

The urban poor relatively travel in short travel time period. By walking, the average travel time of urban poor is 15.38 minutes. By cycling, the average travel time is 19.61 minutes. By bus, the average travel time is 33.98 minutes. By moped, the average travel time is 21.67 minutes.

Q6: *How does the variation in the travel time distribution of non-poor group?*

The middle-income group travel longer in comparison to the urban poor. By walking, the average travel time is 18.24 minutes. By cycling, the average travel time is 19.68 minutes. By bus, the average travel time is 36.75 minutes. By moped, the average travel time is 29.40 minutes. By car, the average travel time is 45.68 minutes.

The high-income group have the highest travel time in comparison to urban poor and middle-income group. By moped the average travel time is 38.33 minutes whereas by car the average travel time is 47.78 minutes.

Q7: *What is the suitable decay function for measuring accessibility for urban poor mobility?*

The decay function for measuring accessibility for urban poor mobility is the negative exponential function. The decay function is applied to calculate the time travel decay function for four different transport modes. Based on the decay function analysis, this research found that walking has the steepest travel time decay function. This reflects the situation that the propensity trip by walking is limited to relatively short travel time. The travel time decay function for cycling is relatively flatter than walking. This indicates that the propensity of trip making by cycling is larger for longer travel time rather than walking.

An interesting finding is that the time travel decay function for moped is steeper rather than public transport. In the urban poor modal split, it is found that moped has the highest percentages. Most of the urban poor travels by moped for relatively short travel time. When the trip consumes longer travel time, most of the poor people are likely to choose public transport rather than moped.

Q8: *What is the suitable decay function for measuring accessibility for non-urban poor mobility?*

For middle-income group, the suitable decay function is the negative exponential decay function. By analysing the decay function, it is found that the non-motorised transport (walking and cycling) has the steepest curve. As it is found in the travel time decay function for urban poor, walking has the steepest curve and cycling is relatively flatter than walking. The interesting finding found in the middle-income group travel time decay function where public transport has the smoother curve in comparison to moped. It illustrates a fact that if travel time is relatively longer, there are possibility that middle-income group prefers to travel by public transport rather than by moped. The decay function shows that car has the smoothest decay curve. This situation illustrates that for longer travel time, car is preferred as the major transport mode for journey to work.

For high-income group, two different patterns of decay functions are discovered. Moped has the negative exponential decay function whereas car has the Gaussian decay function. An interesting finding is that although the car generally has smoother curve rather than moped, after certain threshold for travel time (longer travel time), moped curve is flatter. This situation reflects that for longer travel time, there is a possibility to choose moped as the transport modes. However, this is uncommon situation since typically in the condition for longer travel time, car is ideally preferred.

Q9: *How does the pattern of urban poor distribution in JMA?*

The urban poor are mainly distributed in the periphery area with the high concentration of the poor in the inner city zones and the area in the northern part of JMA that is close to Tanjung Priok port.

Q10: *How does the pattern of urban non-poor distribution JMA?*

The distribution of middle-income group is mainly in the periphery area with high concentration in the inner city zone (CBD and its surrounding area) and northern part of the city that is close to Tanjung Priok port. The distribution of high-income group is mainly in the periphery area in the northern, eastern, and southern part of JMA. The population density of high-income group is relatively uniformly distributed JMA.

Q11: *How does the pattern of job opportunities for the poor?*

The concentration of job opportunities for the poor is primarily located in the inner city (CBD and its surrounding) and periphery areas, particularly western part of the city. In the inner city, there are potential job opportunities for low-skilled labour whereas in the periphery is the opportunity for factory labour.

Q12: *How does the pattern of job opportunities for the non-poor?*

The concentration of job opportunities for middle-income group is mainly located in the inner city area (CBD and its surrounding). In this area, most of the jobs that are available are related to office and commercial activities. The concentration of job opportunities for high-income group is mainly located in the inner city area and certain zones in the periphery area in southern part of the city.

Q13: *Does urban poor live in the area that has good accessibility to potential job opportunities?*

The analysis of urban poor accessibility is undertaken by using two approaches. First, accessibility is analysed by using potential accessibility measure. Second, accessibility is analysed by using weighted accessibility in which weighted factor is based on the number population for specific income group in a particular zone.

In general, potential accessibility shows that the zone in the inner city area (CBD and its surrounding zones) has the high value of accessibility to potential job opportunities. By assessing the spatial distribution of urban poor, it is found that the distribution of urban poor is primarily located in the periphery area with the high agglomeration of urban poor is located in the inner city areas. By considering the potential accessibility, it can be derived that urban poor who live in the inner city area obtain benefit from the accessibility whereas urban poor in the periphery area has smaller potential accessibility value.

The weighted accessibility to potential job opportunities is the analysis to explore the change in the potential accessibility value by taking into account the number of population in a particular zone. In essence, the value of weighted accessibility to potential job opportunities shows that the area that has the high value of potential accessibility to job opportunities is the area with high number of urban poor. The accessibility to potential job opportunities in the inner city zones (CBD and its surrounding) experiences a significant decrease since the number of poor people who live in the inner city zones is small in comparison to the periphery area.

Q14: *Is there any discrepancy between the settlement and the job location for the poor and non-poor?*

For urban poor, the high number of job opportunities is concentrated in the inner city and periphery area. The distribution of urban poor is mainly in the periphery (western, northern, and eastern part of the city) and inner city zones. By deriving from the job density and population density map, it is found that the majority of urban poor live relatively close to the potential job opportunity. An exceptional case is the urban poor who live in the periphery area in the southern part of JMA. The job opportunity for the poor in the southern part is smaller than in other area. As a consequent, the poor in the southern part of JMA experience spatial mismatch to reach potential job opportunities that is available in the periphery area in the eastern, northern, and western part of JMA.

For middle-income group, the high number of job opportunities is concentrated in the inner city zones (CBD and its surrounding area). The distribution of middle-income group is primarily concentrated in the periphery area but relatively close to the CBD. By interpreting from population and job density maps (Chapter 5), it can be interpreted that the middle-income group is relatively experience spatial mismatch to their potential job opportunities.

For high-income group, the high number of potential job opportunities for is concentrated in CBD and its surrounding area. In addition, there are certain areas with the high number of high-income job opportunities in the western (commercial area) and northern part of the city (Tanjung Priok port). The distribution of high income group is relatively uniformly distributed in the JMA. It can be interpreted that the high-income group that live in close to CBD does not experience spatial mismatch but the one who live in the periphery area experience spatial mismatch since the job concentration for high-income group is agglomerated in the CBD and its surrounding area.

Q15: *What are suitable policy implication that can be derived from the potential accessibility to job opportunities for the poor and non-poor?*

The important research finding is that the improvement of public transport system will significantly improve the accessibility to job opportunities for urban poor and middle-income group. The potential accessibility maps (Chapter 5) shows that the accessibility to potential job opportunities by public transport (bus) is significantly greater in comparison to car, moped and non-motorised transport. Therefore, it is important to make public transport to be more attractive in order to encourage shift from motorised transport (moped and car) to public transport. Certain strategies that can be undertaken to make public transport more attractive are:

- Improving public transport infrastructures such as establishing specific lane for bus so that it is not mixed with the other vehicles, subsiding bus fare to attract passenger to shift from motorised transport, and increasing the supply of bus fleet so to balance the demand for bus service.
- Enhancing the management of public transport service through the concept of public private partnership. In this case, the government may invite private sectors in providing reliable public transport service. For example, the government provides the infrastructure for public transport such as bus lane and bus station whereas the private sector provides the bus fleet and managing the service.
- If it is assumed that the urban poor is able to access potential job opportunities for the middle-income group, the cross-potential accessibility analysis shows that the improvement of public transport brings a significant benefit for accessing job opportunities.

In relation to non-motorised transport, a strategy that can be proposed is to promote the utilisation of non-motorised transport is to integrate walking and cycling facilities. The potential accessibility maps (Chapter 5) show that for relatively short travel time, walking and cycling provides higher accessibility for people who live close to their potential job opportunities (in particular the urban poor group). Integrating walking and cycling infrastructure will be financially efficient for reducing transport cost for urban poor as well as environmentally beneficial for reducing the carbon emission.

A further strategy that can be proposed is to integrate non-motorised transport and public transport service through transit oriented concept. Typically, this concept has been applied in the European countries such as the Netherlands where a transit station is designed for accommodating not only motorised transport but also non-motorised transport by providing facilities for non-motorised transport in the surrounding the transit station (i.e. bike lanes, bicycle sheed). In the JMA context, the inner city zones (CBD and its surrounding area with the high job density) are the potential locations for integrated motorised and non-motorised transit station.

The weighted accessibility to potential job opportunities (Chapter 5) illustrates the information regarding the potential accessibility to job opportunities with regard to the proportion of people for certain specific income level in a particular zone. From the weighted accessibility to potential job opportunities, it can be derived the priority locations for improving the transport infrastructure.

- For urban poor group, improving the transport system is ideally prioritised in the periphery area. The weighted accessibility to potential job opportunities for urban poor shows that urban poor who live in the periphery area will obtain higher benefit in comparison to urban poor in the inner city locations.
- For middle-income group, improving the transport system is prioritised in the periphery and certain areas close to the CBD. These areas have the high number of middle-income group so that the accessibility to potential opportunities to job opportunities for middle-income group will be high in these areas.
- For high-income group, improving the transport system to support mobility by moped is ideally undertaken evenly distributed within the JMA. For the high-income group who utilises car, certain zones in the periphery area should be prioritised. This because in the periphery area, the value of potential accessibility to job opportunities by using car is higher in comparison to in the inner city zones.

6.2 GENERAL CONCLUSION

In general, this research is able to answer all the research questions in order to reach the research aim to understand the mobility behaviour of urban poor and its implication to the potential job accessibility. The urban poor and middle-income group primarily depend on the usage of moped instead of public transport and non-motorised transport whereas the high-income group overreliance on car usage. Although there is overdependence on moped for urban poor and middle-income, the potential accessibility analyses show that the potential job opportunities are more efficiently reached if there is a significant improvement in public transport. Therefore, it is important to make public transport to become more attractive so that there can be a shift from moped to public transport. The high-income group is overdependence on car usage but the potential accessibility analyses show that both car and moped provide high accessibility to potential job opportunities for the high-income group. Based on the potential accessibility analyses, car is efficiently used for reaching potential job opportunities for the high-income group who live in the periphery areas whereas moped is efficient for high-income group who live in the inner city zones.

In order to develop accessibility measures, this research implements travel time decay function based on the actual home-to-work data in Jakarta Metropolitan Area. This is one of the novelties in this research since lack of previous studies provided the suitable time travel decay function to measure accessibility. The accessibility analyses are undertaken by using (1) potential accessibility measure; (2) cross-accessibility; and (3) weighted accessibility measure by considering the number of population as the weighted factor for analysing accessibility. These analyses provide the comprehensive understanding of accessibility to job opportunities in JMA.

Whereas potential accessibility measure provides the information with regard to the ease to reach potential job opportunities from spatial perspective the cross-accessibility shows the condition for urban poor if they are able to reach potential job opportunities for middle income group. These two analyses shows that the improvement of public transport is necessary since this provides highly benefit to improve job accessibility and to reduce overdependence on motorised transport modes. The weighted accessibility provides the information related to the priority locations for proposing the policy intervention to improve accessibility. These three accessibility measures are complementary to each other so that it could be useful to be applied for deriving appropriate transport policy in JMA. This research suggests that improvement in public transport is a crucial aspect to improve accessibility in JMA. The improvement of public transport should be prioritised in the periphery areas to be able to release prevent urban poor from the spatial exclusion. Another intervention that follows the result of this research is the integration between motorised and non-motorised transport throughout transit oriented development concept. This intervention is advised to be implemented in the inner city area (CBD and its surrounding area) where the job density is high.

6.3 RECOMMENDATION

One limitation of this research is that the decay function is constructed based on the travel time. The travel time is susceptible to the performance of transport mode. If the transport mode is assumed to have different speed from the one that is used in this research, it may affect the travel time decay function. This situation is crucial since the calibration of travel time decay function may be different from the functions that are used in this research. Consequently, the outcome of potential accessibility and weighted accessibility measures may be different. Therefore, this research recommends the further research to apply the distance as the basis for calculating potential and weighted accessibility and then compare the distance-based accessibility calculation with the result of travel-time accessibility analysis that is undertaken in this research.

An opportunity to follow up this research can be undertaken by trying to incorporate the multimodal transport as part of accessibility analysis. The main assumption in the accessibility analysis in this research is that the mobility is based on the single mode. There is no consideration about multimodal transport. By considering the multimodal analysis, it can be analysed to what extent the multimodal transport can improve the potential accessibility to job opportunities for different income group in JMA. Specifically, this research suggests to incorporate the Bus Transit System TransJakarta and rail system as part of the multimodal transport model. These two modes are not considered in this research. In addition, as the penalty, waiting time and walking time to transit station need to be incorporated in the future research instead of using the entirely travel time. This situation is important since this research considers only travel time during the congestion without incorporating waiting time, walking time due to limitation in time availability.

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Appendix A

MatLab Scripting

A.1 MATLAB SCRIPTING FOR USER DEFINED FUNCTION

```
function [ low_walking_taccess, low_walking_tdecay ] = lowtwalking( x,y )
% this function is to calculate walking decay function for low-income group
low_walking_tdecay = 0.9988 .* exp(-0.2343 .* x)
low_walking_taccess = low_walking_tdecay .* y
end

function [ low_cycling_taccess, low_cycling_tdecay] = lowtcycling( x,y )
% this function is to calculate cycling decay function for low income group
low_cycling_tdecay = 0.9678 .* exp(-0.1055 .* x)
low_cycling_taccess = low_cycling_tdecay .* y
end

function [ low_bus_taccess, low_bus_tdecay ] = lowtbus(x,y)
% this function is to calculate bus decay function for low income group
    low_bus_tdecay = 0.957 .* exp(-0.03487 .* x)
    low_bus_taccess = low_bus_tdecay .* y
end

function [ low_moped_taccess, low_moped_tdecay ] = lowtmoped(x,y)
    % this function is to calculate moped decay function for low income group
    low_moped_tdecay = 0.945 .* exp(-0.06169 .* x)
    low_moped_taccess = low_moped_tdecay .* y
end

function [ mid_walking_taccess, mid_walking_tdecay ] = midtwalking( x,y )
% this function is to calculate walking decay function for mid income group
mid_walking_tdecay = 0.773 .* exp(-0.566 .* x) + 0.227 .* exp(-0.01777 .* x)
mid_walking_taccess = mid_walking_tdecay .* y
end

function [ mid_cycling_taccess, mid_cycling_tdecay ] = midtcycling( x,y )
% this function is to calculate cycling decay function for mid income group
mid_cycling_tdecay = 0.5357 .* exp(-0.04198 .* x) + 0.4643 .* exp(-2.232 .* x)
mid_cycling_taccess = mid_cycling_tdecay .* y
```

```
end

function [ mid_bus_taccess, mid_bus_tdecay ] = midtbus( x,y )
% this function is to calculate bus decay function for mid income group
mid_bus_tdecay = 0.9481 .* exp(-0.03093 .* x)
mid_bus_taccess = mid_bus_tdecay .* y
end

function [ mid_moped_taccess, mid_moped_tdecay ] = midtmoped( x,y )
% this function is to calculate moped decay function for mid income group
mid_moped_tdecay = 0.9394 .* exp(-0.04102 .* x)
mid_moped_taccess = mid_moped_tdecay .* y
end

function [ mid_car_taccess, mid_car_tdecay ] = midtcar( x,y )
% this fucntion is to calculate car decay function for mid income group
mid_car_tdecay = 1.781 .* exp(-((x + 75.68)/95.74).^2)
mid_car_taccess = mid_car_tdecay .* y
end

function [ hi_moped_taccess, hi_moped_tdecay ] = hitmoped( x,y )
% this function is to calculate moped decay function for high income group
hi_moped_tdecay = 0.95 .* exp(-0.03313 .* x)
hi_moped_taccess = hi_moped_tdecay .* y
end

function [ hi_car_taccess, hi_car_tdecay ] = hitcar( x,y )
% this function is to calculate car decay function for high income group
hi_car_tdecay = 1.181 .* exp(-((x + 34.59)/76.47) .^ 2)
hi_car_taccess = hi_car_tdecay .* y
end
```

A.2 MATLAB SCRIPTING FOR ACCESSIBILITY CALCULATION

```
% approximate 23 mins simulation time

tic

% calculating accessibility modelling
filename = 'OD_DIST_JOBS.xlsx';
sheet = 'OD_DIST_JOBS';

% distance
distance_range = 'F2:F148227';

% time walking
time_walking = 'L2:L148227';
```

```
% time cycling
time_cycling = 'M2:M148227';

% time bus
time_bus = 'N2:N148227';

% time moped
time_moped = 'O2:O148227';

% time car
time_car = 'P2:P148227';

% time ff bus
time_ffbus = 'Q2:Q148227';

% time ff moped
time_ffmoped = 'R2:R148227';

% time ff car
time_ffcar = 'S2:S148227';

% low job opportunities
low_job = 'I2:I148227';

% mid job opportunities
mid_job = 'J2:J148227';

% high job opportunties
hi_job = 'K2:K148227';

% read distance, time,  and job variables

DISTANCE = xlsread(filename,sheet,distance_range);

TIME_WALKING = xlsread(filename,sheet,time_walking);
TIME_CYCLING = xlsread(filename,sheet,time_cycling);
TIME_BUS = xlsread(filename,sheet,time_bus);
TIME_MOPED = xlsread(filename,sheet,time_moped);
TIME_CAR = xlsread(filename,sheet,time_car);

LOW_JOB = xlsread(filename,sheet,low_job);
MID_JOB = xlsread(filename,sheet,mid_job);
HI_JOB = xlsread(filename,sheet,hi_job);

% accessibility to low job opportunities
% low distance
```

```
LOW_WALK_DISTANCE = low_walking_distance(DISTANCE,LOW_JOB);
LOW_CYCLE_DISTANCE = low_cycling_distance(DISTANCE,LOW_JOB);
LOW_BUS_DISTANCE = low_bus_distance(DISTANCE,LOW_JOB);
LOW_MOPED_DISTANCE = low_moped_distance(DISTANCE,LOW_JOB);

LWD_range = 'T2:T148227';
LCD_range = 'U2:U148227';
LBD_range = 'V2:V148447';
LMD_range = 'W2:W148227';

% low time

LOW_WALK_TIME = lowtwalking(TIME_WALKING,LOW_JOB);
LOW_CYCLE_TIME = lowtcycling(TIME_CYCLING,LOW_JOB);
LOW_BUS_TIME = lowtbus(TIME_BUS,LOW_JOB);
LOW_MOPED_TIME = lowtmoped(TIME_MOPED,LOW_JOB);

LWT_range = 'X2:X148227';
LCT_range = 'Y2:Y148227';
LBT_range = 'Z2:Z148227';
LMT_range = 'AA2:AA148277';


% accessibility to mid job opportunities
% mid distance

MID_WALK_DISTANCE = mid_walking_distance(DISTANCE,MID_JOB);
MID_CYCLE_DISTANCE = mid_cycling_distance(DISTANCE,MID_JOB);
MID_BUS_DISTANCE = mid_bus_distance(DISTANCE,MID_JOB);
MID_MOPED_DISTANCE = mid_moped_distance(DISTANCE,MID_JOB);
MID_CAR_DISTANCE = mid_car_distance(DISTANCE,MID_JOB);

MWD_range = 'AB2:AB148227';
MCD_range = 'AC2:AC148227';
MBD_range = 'AD2:AD148227';
MMD_range = 'AE2:AE148227';
MCRD_range = 'AF2:AF148227';



% mid time

MID_WALK_TIME = midtwalking(TIME_WALKING,MID_JOB);
MID_CYCLE_TIME = midtcycling(TIME_CYCLING,MID_JOB);
MID_BUS_TIME = midtbus(TIME_BUS,MID_JOB);
MID_MOPED_TIME = midtmoped(TIME_MOPED,MID_JOB);
MID_CAR_TIME = midtcar(TIME_CAR,MID_JOB);
```

```
MWT_range = 'AG2:AG148277';
MCT_range = 'AH2:AH148227';
MBT_range = 'AI2:AI148277';
MMT_range = 'AJ2:AJ148277';
MCRT_range = 'AK2:AK148277';

% accessibility to high job opportunities
% hi distance

HI_MOPED_DISTANCE = hi_moped_distance(DISTANCE,HI_JOB);
HI_CAR_DISTANCE = hi_car_distance(DISTANCE,HI_JOB);

HMD_range = 'AL2:AL148227';
HCD_range = 'AM2:AM148227';


% hi time

HI_MOPED_TIME = hitmoped(TIME_MOPED,HI_JOB);
HI_CAR_TIME = hitcar(TIME_CAR,HI_JOB);

HMT_range = 'AN2:AN148227';
HCT_range = 'AO2:AO148227';


% write low distance

DACCESS_LOW_WALK = xlswrite(filename,LOW_WALK_DISTANCE,sheet,LWD_range);
DACCESS_LOW_CYCLE = xlswrite(filename,LOW_CYCLE_DISTANCE,sheet,LCD_range);
DACCESS_LOW_BUS = xlswrite(filename,LOW_BUS_DISTANCE,sheet,LBD_range);
DACCESS_LOW_MOPED = xlswrite(filename,LOW_MOPED_DISTANCE,sheet,LMD_range);

% write low time
TACCESS_LOW_WALK = xlswrite(filename,LOW_WALK_TIME,sheet,LWT_range);
TACCESS_LOW_CYCLE = xlswrite(filename,LOW_CYCLE_TIME,sheet,LCT_range);
TACCESS_LOW_BUS = xlswrite(filename,LOW_BUS_TIME,sheet,LBT_range);
TACCESS_LOW_MOPED = xlswrite(filename,LOW_MOPED_TIME,sheet,LMT_range);

% write mid distance
DACCESS_MID_WALK = xlswrite(filename,MID_WALK_DISTANCE,sheet,MWD_range);
DACCESS_MID_CYCLE = xlswrite(filename,MID_CYCLE_DISTANCE,sheet,MCD_range);
DACCESS_MID_BUS = xlswrite(filename,MID_BUS_DISTANCE,sheet,MBD_range);
DACESS_MID_MOPED = xlswrite(filename,MID_MOPED_DISTANCE,sheet,MMD_range);
DACCESS_MID_CAR = xlswrite(filename,MID_CAR_DISTANCE,sheet,MCRD_range);

% write mid time
TACCESS_MID_WALK = xlswrite(filename,MID_WALK_TIME,sheet,MWT_range);
TACCESS_MID_CYCLE = xlswrite(filename,MID_CYCLE_TIME,sheet,MCT_range);
```

```
TACCESS_MID_BUS = xlswrite(filename,MID_BUS_TIME,sheet,MBT_range);
TACCESS_MID_MOPED = xlswrite(filename,MID_MOPED_TIME,sheet,MMT_range);
TACCESS_MID_CAR = xlswrite(filename,MID_CAR_TIME,sheet,MCRT_range);

% write hi distance
DACCESS_HI_MOPED = xlswrite(filename,HI_MOPED_DISTANCE,sheet,HMD_range);
DACCESS_HI_CAR = xlswrite(filename,HI_CAR_DISTANCE,sheet,HCD_range);

% write hi time
TACCESS_HI_MOPED = xlswrite(filename,HI_MOPED_TIME,sheet,HMT_range);
TACCESS_HI_CAR = xlswrite(filename,HI_CAR_TIME,sheet,HCT_range);

toc
```

A.3 CROSS ACCESSIBILITY CALCULATION

```
tic

% measuring cross accessibility for urban poor to mid income job
% opportunity

% approximate simulation time 4 mins

% file preparation
filename = 'CROSS_ACCESSIBILITY.xlsx';
sheet = 'DATASET';

% distance
distance_range = 'F2:F148227';

% time walking
time_walking = 'L2:L148227';

% time cycling
time_cycling = 'M2:M148227';

% time bus
time_bus = 'N2:N148227';

% time moped
time_moped = 'O2:O148227';

% time car
time_car = 'P2:P148227';

% low job opportunities
low_job = 'I2:I148227';
```

```
% mid job opportunities
mid_job = 'J2:J148227';

% high job opportunties
hi_job = 'K2:K148227';

% read distance, time,  and job variables

DISTANCE = xlsread(filename,sheet,distance_range);

TIME_WALKING = xlsread(filename,sheet,time_walking);
TIME_CYCLING = xlsread(filename,sheet,time_cycling);
TIME_BUS = xlsread(filename,sheet,time_bus);
TIME_MOPED = xlsread(filename,sheet,time_moped);
TIME_CAR = xlsread(filename,sheet,time_car);

LOW_JOB = xlsread(filename,sheet,low_job);
MID_JOB = xlsread(filename,sheet,mid_job);
HI_JOB = xlsread(filename,sheet,hi_job);

% calculating cross accssibility of the poor to middle job opportunities

CRLOW_WALK_DISTANCE = low_walking_distance(DISTANCE,MID_JOB);
CRLOW_CYCLE_DISTANCE = low_cycling_distance(DISTANCE,MID_JOB);
CRLOW_BUS_DISTANCE = low_bus_distance(DISTANCE,MID_JOB);
CRLOW_MOPED_DISTANCE = low_moped_distance(DISTANCE,MID_JOB);

LWD_range = 'Q2:Q148227';
LCD_range = 'R2:R148227';
LBD_range = 'S2:S148447';
LMD_range = 'T2:T148227';

% calculating the time travel

CRLOW_WALK_TIME = lowtwalking(TIME_WALKING,MID_JOB);
CRLOW_CYCLE_TIME = lowtcycling(TIME_CYCLING,MID_JOB);
CRLOW_BUS_TIME = lowtbus(TIME_BUS,MID_JOB);
CRLOW_BUS_FFTIME = lowftbus(TIME_BUS,MID_JOB);
CRLOW_MOPED_TIME = lowtmoped(TIME_MOPED,MID_JOB);
CRLOW_MOPED_FFTIME = lowftmoped(TIME_MOPED,MID_JOB);

LWT_range = 'U2:U148227';
LCT_range = 'V2:V148227';
LBT_range = 'W2:W148227';
LMT_range = 'X2:X148277';

% write the low distance potential accessibility
```

```
CRDACCESS_LOW_WALK = xlswrite(filename,CRLOW_WALK_DISTANCE,sheet,LWD_range);
CRDACCESS_LOW_CYCLE = xlswrite(filename,CRLOW_CYCLE_DISTANCE,sheet,LCD_range);
CRDACCESS_LOW_BUS = xlswrite(filename,CRLOW_BUS_DISTANCE,sheet,LBD_range);
CRDACCESS_LOW_MOPED = xlswrite(filename,CRLOW_MOPED_DISTANCE,sheet,LMD_range);

% write low travel time potential accessibility

CRTACCESS_LOW_WALK = xlswrite(filename,CRLOW_WALK_TIME,sheet,LWT_range);
CRTACCESS_LOW_CYCLE = xlswrite(filename,CRLOW_CYCLE_TIME,sheet,LCT_range);
CRTACCESS_LOW_BUS = xlswrite(filename,CRLOW_BUS_TIME,sheet,LBT_range);
CRTACCESS_LOW_MOPED = xlswrite(filename,CRLOW_MOPED_TIME,sheet,LMT_range);

toc
```

A.4 WEIGHTED ACCESSIBILITY CALCULATION

```
tic

% calculating the weighted accessibility
% simulation time approx. 38 seconds
% read xls file
filename = 'WEIGHTED_ACCESSIBILITY.xls';
sheet = 'WEIGHTED_ACCESSIBILITY';

% low population range
low_range = 'F2:F387';

% mid population range
mid_range = 'G2:G387';

% high population range
high_range = 'H2:H387';

% the potential accessibility value
% LWT
lwt_range = 'L2:L387';

% LCT
lct_range = 'M2:M387';

% LBT
lbt_range = 'N2:N387';

% LMT
lmt_range = 'O2:O387';
```

```
% MWT
mwt_range = 'P2:P387';

% MCT
mct_range = 'Q2:Q387';

% MBT
mbt_range = 'R2:R387';

% MMT
mmt_range = 'S2:S387';

% MCRT
mcrt_range = 'T2:T387';

% HMT
hmt_range = 'U2:U387';

% HCRT
hcrt_range = 'V2:V387';

% read file population

LOW_POP = xlsread(filename,sheet,low_range);
MID_POP = xlsread(filename,sheet,mid_range);
HIGH_POP = xlsread(filename,sheet,high_range);

% read file accessibility

LWT = xlsread(filename,sheet,lwt_range);
LCT = xlsread(filename,sheet,lct_range);
LBT = xlsread(filename,sheet,lbt_range);
LMT = xlsread(filename,sheet,lmt_range);
MWT = xlsread(filename,sheet,mwt_range);
MCT = xlsread(filename,sheet,mct_range);
MBT = xlsread(filename,sheet,mbt_range);
MMT = xlsread(filename,sheet,mct_range);
MCRT = xlsread(filename,sheet,mcrt_range);
HMT = xlsread(filename,sheet,hmt_range);
HCRT = xlsread(filename,sheet,hcrt_range);

% calculate sum population per class

MAX_LOW = sum(LOW_POP);
MAX_MID = sum(MID_POP);
MAX_HIGH = sum(HIGH_POP);

% calculate weighted population
```

```
wlow = LOW_POP/ MAX_LOW;
wmid = MID_POP / MAX_MID;
whigh = HIGH_POP / MAX_HIGH;

% calculate weighted accessibility

W_LWT = wlow .* LWT;
W_LCT = wlow .* LCT;
W_LBT = wlow .* LBT;
W_LMT = wlow .* LMT;
W_MWT = wmid .* MWT;
W_MCT = wmid .* MCT;
W_MMT = wmid .* MMT;
W_MBT = wmid .* MBT;
W_MCRT = wmid .* MCRT;
W_HMT = whigh .* HMT;
W_HCRT = whigh .* HCRT;

% range for weighted accessibility

wlwt = 'V2:V387';
wlct = 'W2:W387';
wlbt = 'X2:X387';
wlmt = 'Y2:Y387';
wmwt = 'Z2:Z387';
wmct = 'AA2:AA387';
wmbt = 'AB2:AB387';
wmmt = 'AC2:AC387';
wmcrt = 'AD2:AD387';
whmt = 'AE2:AE387';
whcrt = 'AF2:AF387';

% write into xls file

WLWT = xlswrite(filename,W_LWT,sheet,wlwt);
WLCT = xlswrite(filename,W_LCT,sheet,wlct);
WLBT = xlswrite(filename,W_LBT,sheet,wlbt);
WLMT = xlswrite(filename,W_LMT,sheet,wlmt);
WMWT = xlswrite(filename,W_MWT,sheet,wmwt);
WMCT = xlswrite(filename,W_MCT,sheet,wmct);
WMMT = xlswrite(filename,W_MWT,sheet,wmmt);
WMBT = xlswrite(filename,W_MBT,sheet,wmbt);
WMCRT = xlswrite(filename,W_MCRT,sheet,wmcrt);
WHMT = xlswrite(filename,W_HMT,sheet,whmt);
WHCRT = xlswrite(filename,W_HCRT,sheet,whcrt);

toc
```

A.5 DECAY FUNCTION ESTIMATION TECHNIQUE

The estimation of decay function is undertaken by using MatLab curve fitting functionality. There are several steps to be undertaken in order to estimate suitable travel time curve:

- Import travel time distribution data into MatLab environment. This is undertaken by converting Microsoft Excel into the format that can be read by MatLab.
- Insert travel time distribution data into MatLab. As the input for x-axis is the mid point of the travel time distribution classification whereas the input for y-axis is the inverse cumulative value.
- Using curve fitting tool box in MatLab and select the suitable function. In this case, the theory suggests that the suitable decay function for measuring spatial interaction is the negative exponential. Use this function as the default function for calculating spatial interaction.
- In the case when the exponential function cannot fit the data, try the other decay function. The other function that can be used to fit the decay function is the Gaussian function. This function is suitable since the basis of this function is essentially the exponential function. Ideally, the RMSE (Root Mean Squared Error) is less than 0.05 or 5%. If it is possible, use the function that results in the smallest RMSE value.
- When the estimation is perceived sufficient, use the paramaters that are resulted from the curve as the basis for calculating accessibility function.

Figure A.1 shows the general process of decay function estimation in MatLab.

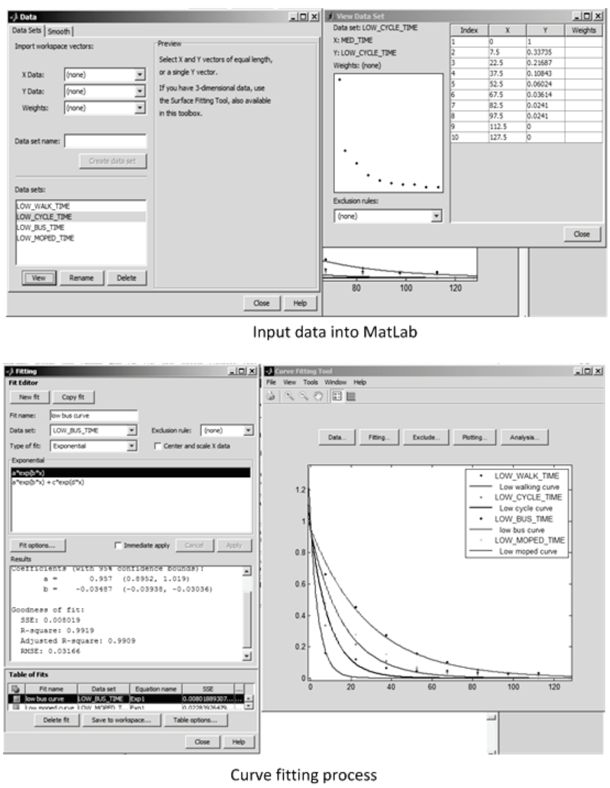


Figure A.1: Illustration of decay function estimation in MatLab

Appendix B

Example of ArcGIS Network Analysis Model Builder

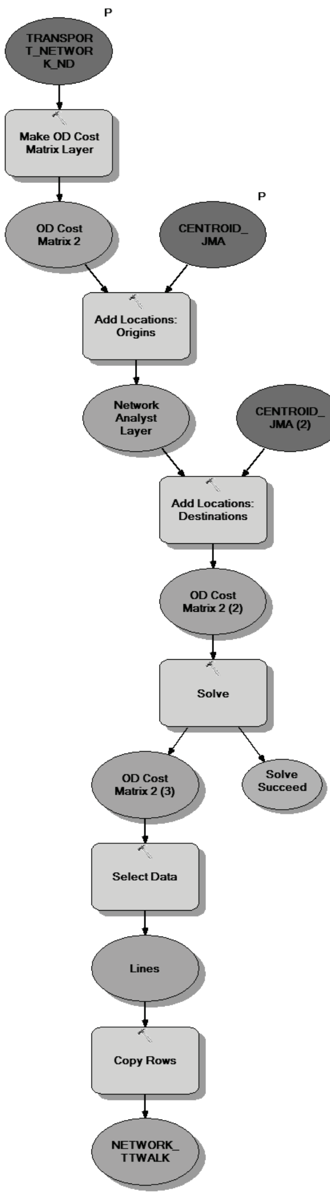
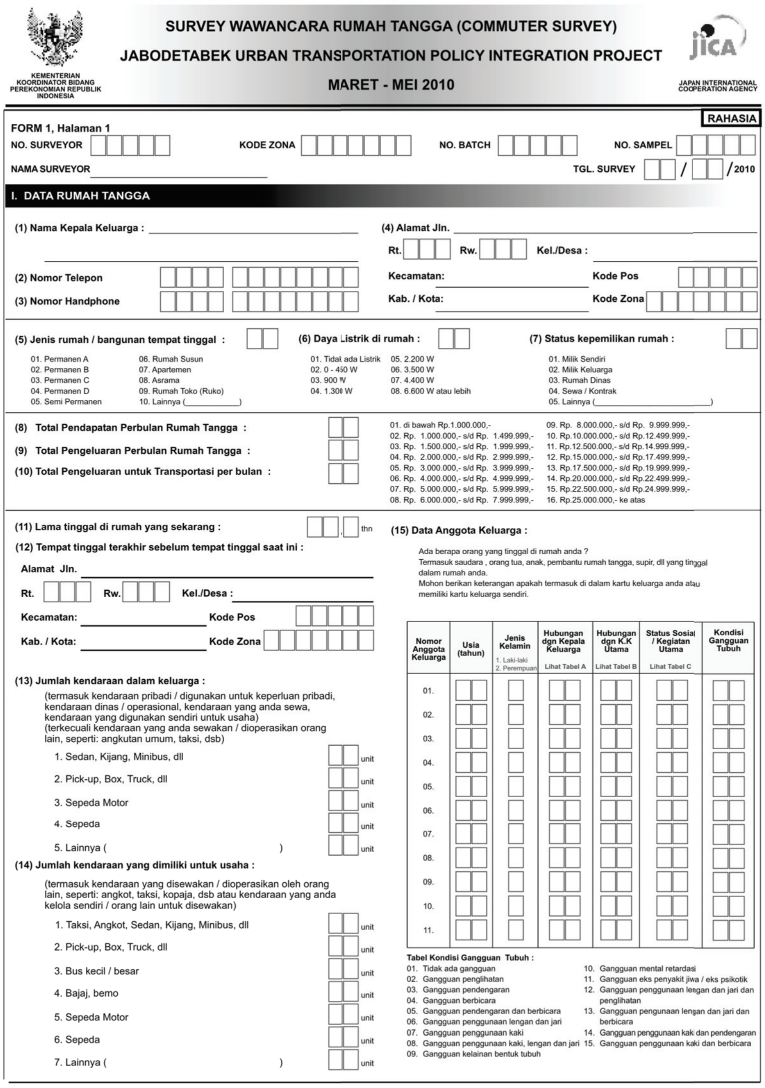


Figure B.1: Example of network analysis in model builder

Appendix C

JUTPIP questionnaire data

C.1 HOUSEHOLD INFORMATION



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 :

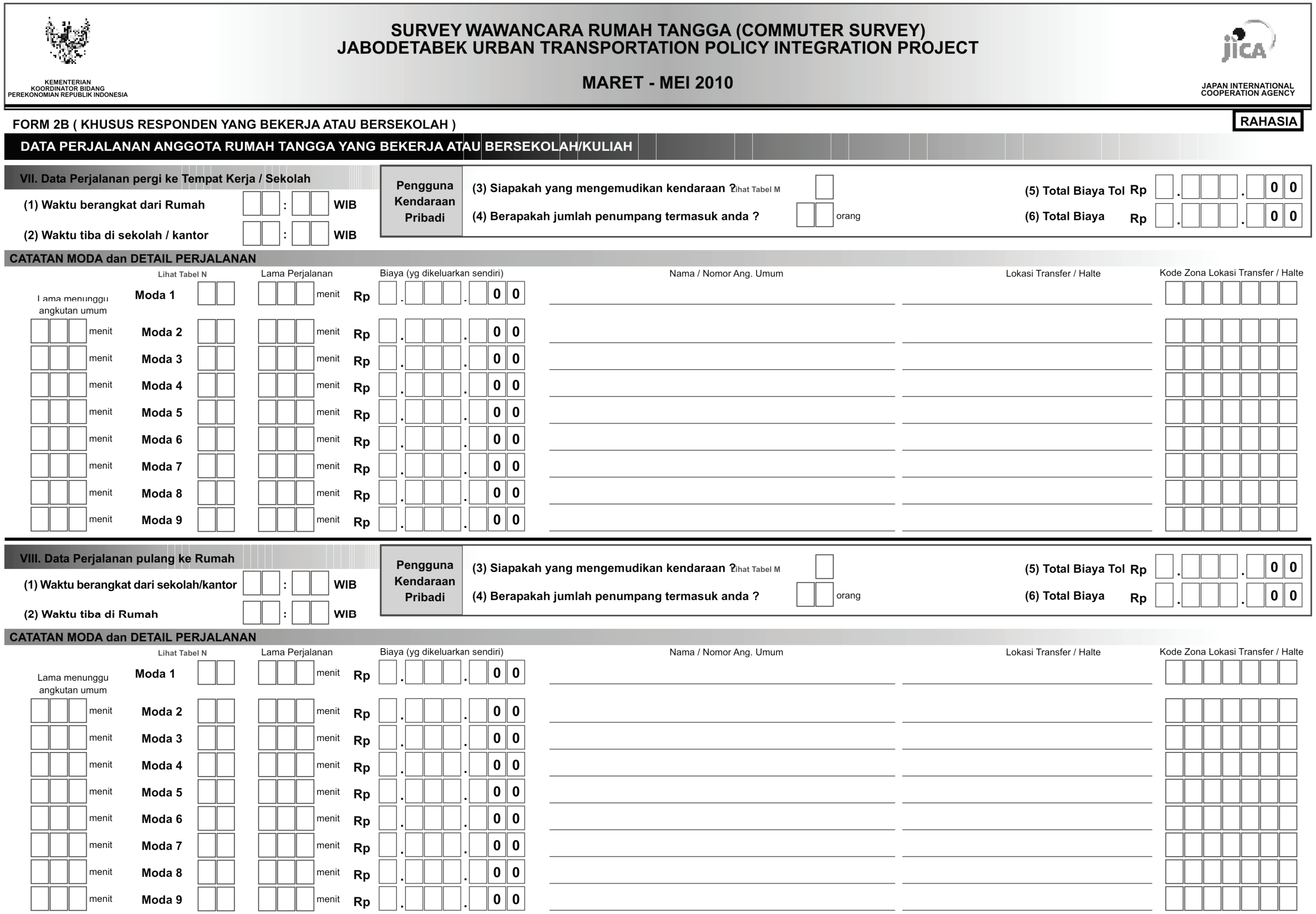
01. Tidak ada gangguan
02. Gangguan penglihatan
03. Gangguan pendengaran
04. Gangguan berbicara
05. Gangguan pendengaran dan berbicara
06. Gangguan penggunaan lengan dan jari
07. Gangguan penggunaan kaki
08. Gangguan penggunaan kaki, lengan dan jari
09. Gangguan kelainan bentuk tubuh
10. Gangguan mental 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

Figure C.1: Household income information

Table C.1 Code explanation for used household variable

Code	Explanation questionnaire (ID)	Explanation questionnaire (EN)
id1	No. surveyor	Surveyor ID
id2	Kode zona	Zone code
id3		
id4	No. batch	Batch No.
idr		Combination code
p4a	Alamat Jln.	Address
p4b	RT	RT Code
p4c	RW	RW Code
p4d	Kelurahan/desa	Sub-district
p4e	Kecamatan	District
p4f	Kode pos	Post code
p4g	Kab./kota	Municipal/regency
p4h	Kode zona	Zone code
p8	Total pendapatan rumah tangga	Monthly income
p9	Total pengeluaran per bulan rumah tangga	Monthly expenditure
p10	Total pengeluaran transpotasi per bulan	Transport expenditure

C.2 INDIVIDUAL HOUSEHOLD MEMBER TRIP 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

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			

Figure C.2: Individual household member trip data

Table C.2 Code explanation for used household variable

Code	Explanation questionnaire (ID)	Explanation questionnaire (EN)
p7b1	Moda 1	First mode
p7c1	Lama perjalanan	Time travel
p7d1	Biaya yang dikeluarkan	Total fare
p7e1	Nama/nomor angkutan	Mode ID
p7f1	Lokasi transfer/halter	Transfer station
p7g1	Kode zona lokasi transfer halte	Zone code for transfer station

C.3 JOB TYPE IN JUTPIP QUESTIONNAIRE DATA

Table C.3 Job type in JUTPIP questionnaire data

No	Job Type
1	Professor, manager, director, etc.
2	Business owner
3	Engineer, lecturer, teacher
4	Doctor, accountant, pilot
5	Military
6	Administrative staff
7	Technician
8	Clerk, bartender
9	Sales, trader
10	Craftsman
11	Construction labour
12	Factory labour
13	Public transport driver
14	Private company driver
15	Housemaid, office boy, gardener
16	Farmer, fisherman
17	Security
18	Others

C.4 THE NUMBER OF SAMPLE TRIPS FOR BASED ON DIFFERENT TRANSPORT MODE

Table C.4 The number of sample trips based on different income classi and transport modes

Class	Walking	Cycling	Public transport (bus)	Moped	Car
Urban poor	476	83	128	662	n/a
Middle-income	6142	585	2650	26548	2328
High-income	n/a	n/a	n/a	126	400

Appendix D

GIS Spatial Dataset Attribute

D.1 POPULATION AND JOB

Table D.1 The number of population and jobs in the GIS dataset

Income class	Population	Jobs
Urban poor	1,675,427	648,527
Middle-income	5,477,267	3,104,671
High-income	1,309,040	739,440