Coordinating Ministry for Economic Affairs
Republic of Indonesia

JABODETABEK Urban Transportation Policy Integration Project Phase 2 in the Republic of Indonesia

Annex 06: Travel Demand Forecast

October 2019

Japan International Cooperation Agency (JICA)

ALMEC Corporation

IN
JR
20-004

Exchange rates used in the report

EUR	1.00	= IDR 15,610.00
USD	1.00	= IDR 14,181.97
JPY	1.00	= IDR 131.69

(as of September 2019)

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Abbreviations

ABM	Activity-Based Model
ADS	Activity-Travel Diary Survey
AGT	Automated Guideway Transit
AIC	Akaike Information Criterion
Angkot	Small Bus (*Angkutan Kota*)
APM	Automated People Mover
ARS	Airport Railink Service
ATD	Auto drive alone
ATR/BPN	*Kementerian Agraria Tata Ruang/Badan Pertanahan Nasional* (Ministry of Agrarian and Spatial Planning/National Land Board)
ATS	Auto Shared Ride
BRT	Bus Rapid Transit
CBD	Central Business District
CTS	Commuter Trip Survey
BPTJ	Greater Jakarta Transportation Authority
DAP	Daily Activity Pattern
Desa	Village
DKI Jakarta	*Provinsi Daerah Khusus Ibukota Jakarta* (Jakarta Special Capital Province)
ERP	Electronic Road Pricing
GIS	Geographic Information System
GDP	Gross Domestic Products
GDRP	Gross Domestic Regional Products
GPS	Global Positioning System
IDR	Indonesian Rupiah
IHCM	Indonesian Highway Capacity Manual
JA	Jabodetabek Airport
JABODETABEK	Jakarta, Bogor, Depok, Tangerang, and Bekasi
Jabodetabekpunjur	Jakarta, Bogor, Depok, Tangerang, Bekasi, Puncak, and Cianjur
JICA	Japan International Cooperation Agency
JR	Jabodetabek Residence
JUTPI	Project for JABODETABEK Urban Transportation Policy Integration
JUTPI 1	JUTPI Phase 1 (2010)
JUTPI 2	JUTPI Phase 2 (2018)
JUTPI-MP	JABODETABEK Urban Transportation Master Plan revised by the Project for JABODETABEK Urban Transportation Policy Integration
Kab. (Kabupaten)	Regency
Kelurahan	Sub district (in a city)
Kota	City
LRT	Light Rail Transit
LTRUCK	Large truck
MC	Motorcycle
MP	Master Plan
MRT	Mass Rapid Transit
MTC	Motorcycle
MTRUCK	Medium truck
NMT	Non-motorized transport
OD	Origin-Destination

OECD	Organization for Economic Co-operation and Development
PCE	Passenger Car Equivalent
PCU	Passenger Car Unit
PT	Public Transport
PT. KAI	*PT. Kereta Api Indonesia (Persero)* (State-Owned Railway Company)
RITJ	JABODETABEK Urban Transportation Master Plan
RTRW	Rencana Tata Ruang Wilayah (Regional Spatial Plan)
SITRAMP	The Study on Integrated Transportation Master Plan for JABODETABEK
STRUCK	Small truck
TAZ	Traffic Analysis Zone
TDM	Transportation Demand Management
TOD	Transit-Oriented Development
ToD	Time-of-Day
TR	Transit
TRANSIT	Transit
TXA	Taxi
TXM	Motorcycle taxi
VoT	Value of Time

Chapter 1 INTRODUCTION

1.1 Background and Objectives

1.1.1 Background

For the purpose of understanding the current and future transportation issues in JABODETABEK, examining possible countermeasures on them and detailing the JABODETABEK Transportation Master Plan (RITJ), the update of the comprehensive travel demand model – and its maintenance – is one of the essential components of JUTPI 2. The model is a key planning tool for the related stakeholders to test various policy scenarios. The model also enables analysis of transportation issues and the impact of transportation policies.

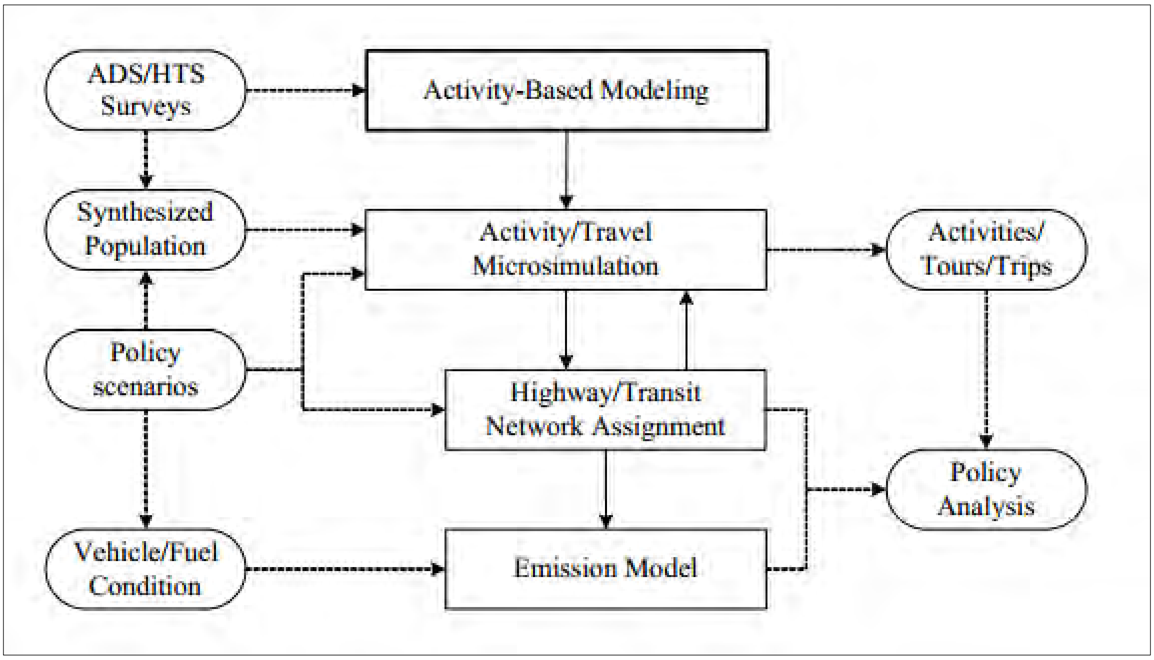
1.1.2 Objectives

All the techniques, methodologies, assumptions, and input data of the travel demand model of JUTPI 2 are described in this report. The travel demand forecast results based on the developed model on various policy scenarios are also described.

1.2 Demand Forecast Workflow

1.2.1 Overall Framework

An overall flowchart that represents significant components of the travel demand model and forecast are depicted in Figure 1. The development of an activity-based model is the core of the study that was based on the activity-travel diary survey (ADS) data. Detailed descriptions of the activity-based model are discussed in Section 1.2.2.



Source: Yagi, Sadayuki (2006). An Activity-Based Microsimulation Model of Travel Demand, Ph.D. Thesis, Department of Civil and Materials Engineering, University of Illinois at Chicago.

Figure 1 Overall Framework

Once the activity-based model has been developed, the next step is to create a microsimulation program that generates activity/tour patterns and trips (with time-of-day and zonal information) of the entire synthesized population. Skimmed time and cost information from the preliminary highway and transit network assignment were utilized as one of the inputs to the microsimulation.

The iterations of highway/transit network assignments and microsimulations are conducted to estimate traffic volumes of highway and transit networks and key performance indicators of the prepared policy scenarios. Emissions of greenhouse gases and other pollutants are estimated with the emission model by inputting outputs of the network assignments. The prepared policy scenarios are analyzed with the outputs of the network assignments and the emission model.

1.2.2 Activity-Based Modelling Structure

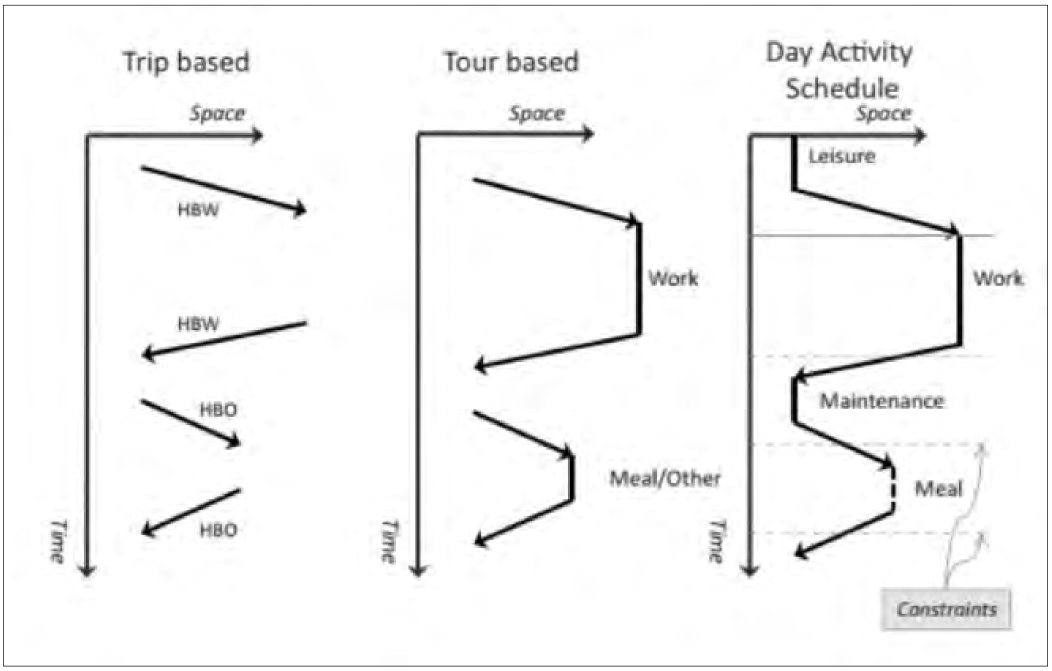
(1) Structural Dimensions

To understand the ABM structure, it is essential to have a uniform definition of technical terminologies. Here are the main definitions of terminologies:

- ” Trip” is defined as a journey between two activities representing the trip purposes (Home to Work, Home to School, and others). In further sections of this report, the “trip” does not have to be always home-based, but it could be non-home-based.

- The term “purpose” in this report is used to present the activity performed at the trip end. While the definition of “trip end” might lead to ambiguity, narrowing the classification of the “purpose” down based on the main activity of a single trip is done. Furthermore, a travel mode (auto, motorcycle, transit, or others) is coded for each trip.
- A “tour” is defined as a chain of trips that start from a base and return to the same base. One or more activities (i.e., purposes) are involved in the course of a tour regardless of the distance of the movement a person makes (e.g., stay at the office from 8 AM to 5 PM). In order to analyze daily activity-travel tour patterns in this report, a tour has been considered as a home-based tour if it starts from home and ends at home.

Figure 2 depicts foregone definitions of “trip” and “tour” whilst the right end figure indicates all activities being made in one specific day. The full image of daily activity includes the activity at the base of both “trip” and “tour” (i.e., home) and to be later distinguished based on the purpose (e.g., some people work from home while others have leisure time when at home).



Source: Ortúzar, S. J. D., & Willumsen, L. G. (1990)

Figure 2 Trip, Tour, and Activities

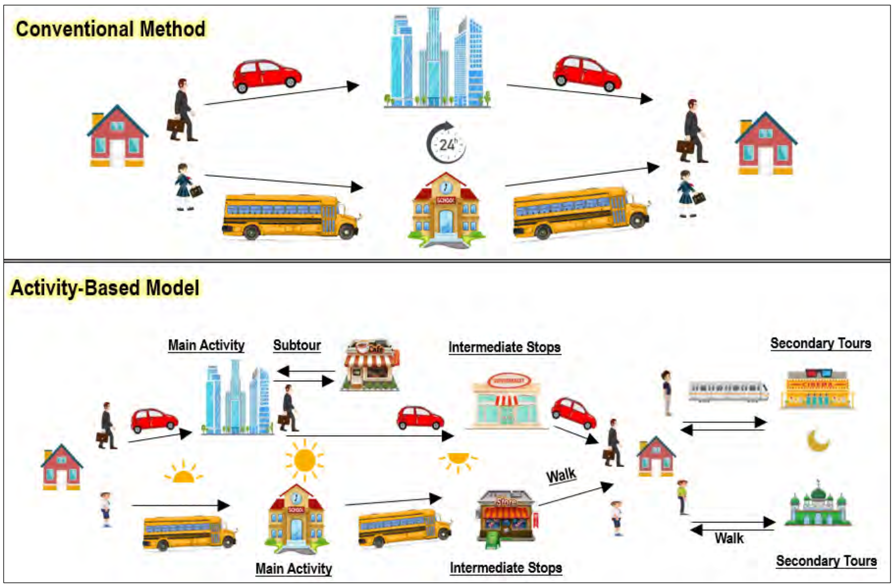
There are three major components of ABM conduct that are important to be done. They are;

- Activity-based platform that implies that modeled travel be derived within a general framework of the daily activities undertaken by households and persons (including in-home activities, intra-household interactions, time allocation to activities, etc. that are typically missing in the conventional travel demand models);
- Tour-based structure of travel where the tour is used as the base unit of modeling travel instead of the elemental trip; this structure preserves consistency across trips included in the same tour, by such travel dimensions as a destination, mode, and time of day.
- Microsimulation modeling techniques that are applied at the fully-disaggregate level of persons and households, which convert activity and travel-related choices from fractional-probability model outcomes into a series of crisp decisions among the discrete choices; this method of model implementation results in realistic model outcomes, with output files that look very much like a real travel/activity survey data.

(2) Advantages over the Conventional Four-Step Approach

The advantages of ABM over the conventional four-step approach are;

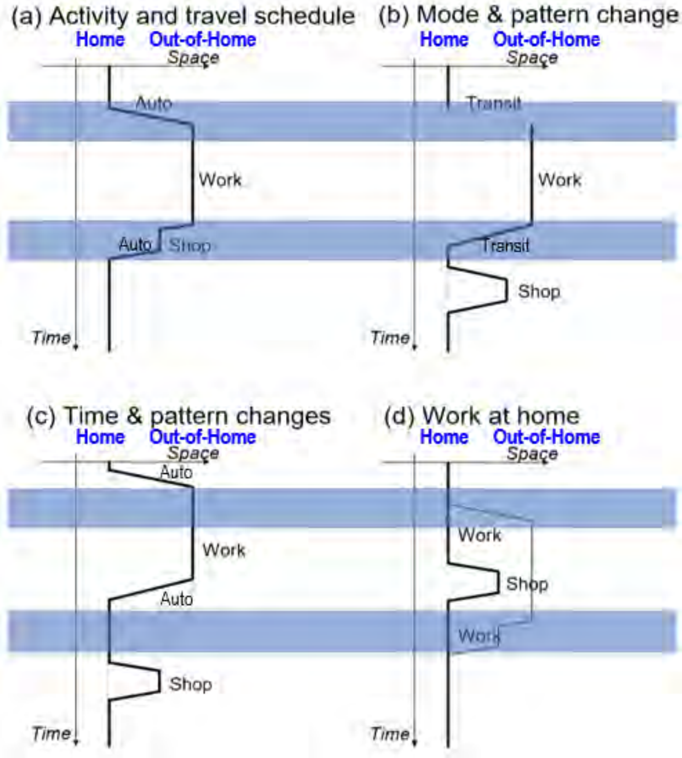
- Conventional trip production models by trip purpose are replaced with a comprehensive daily activity-travel pattern model that takes into account numerous inter-relations, trade-offs, and substitution effects between different tours and activities implemented by a person in the course of a day. Figure 3 depicts such differences.
- Trip attraction models in the activity-based modeling framework are segmented by activity type and primary/secondary role in the tour structure. Conventional models fail to incorporate such a distinction.
- Trip distribution technique has undergone a significant transformation. One of the crucial deficiencies of the conventional four-step models relates to the independent modeling of non-home-based trips while in the tour-based framework, locations of origins and destinations of non-home-based trips, are adequately linked to the location of the correspondent home-based trips in the same tour.



Source: JUTPI 2

Figure 3 Conventional Method and Activity-Based Model

- In particular, the most crucial mode-related decision whether to use a private car or public transit/non-motorized mode is modeled correctly at the level of an entire tour. Meanwhile, in the conventional four-step framework, it is modeled for each trip separately, thus creating numerous illogical mode combinations.
- One of the significant advantages of the activity/tour-based approach over the conventional four-step approach is a full consistency of the time-of-day choices across different tours in the day and different trips in the same tour. It makes the model system sensitive to policy measures and changes in any particular time and track impacts of these changes to all other dimensions of travel demand as depicted in Figure 4 (e.g., blue highlighted time maybe worth analyzing the TDM application).



Source: Bowman, J.L (1998). The Day Activity Schedule Approach to Travel Demand Analysis, Ph.D. Thesis, Department of Civil and Environmental Engineering, Massachusetts Institute of Technology

Figure 4 Activity Schedule Adjustment

In the example above, the original schedule before ERP was (a) travel by auto to work, with a shopping stop on the way back home. Possible responses to a peak period ERP (shown shaded in blue) include:

a. No change
b. changed the mode to avoid ERP
c. A time shift to avoid ERP
d. No travel (work at home).

The network assignment procedures are currently the same for four-step and activity/tour-based models. For this reason, the output of an activity/tour-based microsimulation model is converted into a conventional trip-table format before the assignment. As soon as microsimulation assignment procedures become available and effective for handling regional networks, the additional advantage of the activity/tour-based microsimulation models will take place since these models provide direct input to the traffic microsimulation models.

(3) Activity Types

Activities in this report are grouped into the following three commonly categorized activity types:

- Mandatory activities (e.g., work, university, or school);
- Maintenance activities (e.g., shopping, banking, visiting doctor, and others); and
- Discretionary activities (e.g., social and recreational activities, eating out, and others).

For this report, mandatory activities are further divided into work and school purposes because there is necessarily a difference between work and school as to by whom and when such activities are carried out. The last two activity types, maintenance and discretionary activities, are often treated as one activity type that can be distinguished from mandatory primary activities such as work and school patterns.

(4) Intra-Household Interactions

The analysis of the intra-household interactions is an essential facet of the activity-based transportation demand analysis. They cover:

- Explicit modeling of joint activity and travel in terms of either episode generation or time allocation between individual and joint activities;
- Explicit joint modeling of activity-travel characteristics for several household members, mostly in terms of time allocation of individual activities;
- Explicit modeling of within-household allocation of maintenance activities to household members; and
- Explicit allocation of cars to household members that accounts for the actual availability of a car for a particular travel tour.

As for the first component, joint activity and travel are further categorized into full join tours, half-joint tours, and escorted tours including pick-ups and drop-offs.

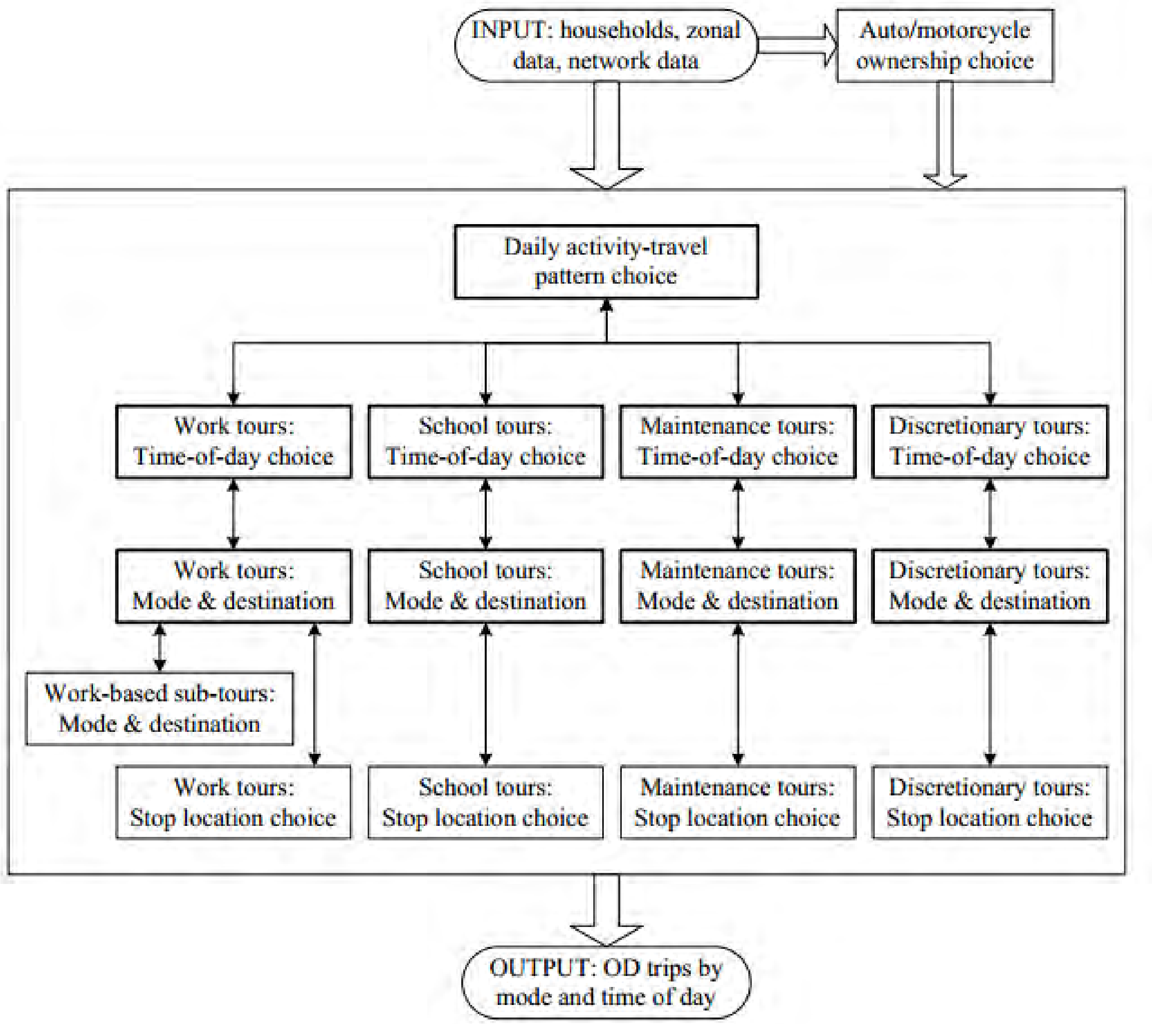
In this study, intra-household interactions are not modeled. However, some of the components of intra-household decision making are applied as rules that are unique to the JABODETABEK area and are incorporated into the activity-based microsimulation. The components to be included are fully joint tour/activity generation and household maintenance tour allocation.

(5) Modelling Framework

The entire activity-based modeling structure is depicted in Figure 5. All models are for home-based tours unless otherwise specified. For modeling purpose, these following assumptions are made:

- Maintenance activities are generated to serve the needs of the household as a whole rather than any single individual, and can be shared or assigned among household members
- Stop and auto allocation decisions are conditional on the number of maintenance stops made by the household and affected by employment status, gender, lifestyle, lifecycle, and accessibility.

The modeling framework adopts a system of random utility based disaggregate logit and nested logit models assuming a hierarchy of model components, with three types of significant models, namely, choices of daily activity-travel patterns, times of day, and mode and destination in the hierarchy. Lower level choices depend on the decisions at the higher level (as indicated by the downward arrows), and higher-level decisions are linked to the lower level choices through the log sum variables reflecting the expected maximum composite utility of lower-level choices (as indicated by the upward arrows). Furthermore, two types of additional sub-models are added to this framework to determine additional characteristics of tours, that is, mode and destination choice for work-based sub-tours and location choice of intermediate stops. These sub-models are placed at the very bottom of the modeling system with two-way vertical linkage to the upper models.



Source: JUTPI 2

Figure 5 Activity-based Modeling System

As a necessary input to the proposed activity-based modeling system, various household and household member information, zone-based socioeconomic and land use data, and highway and transit network-based data are prepared, and the modelling system generates people's daily activity-travel patterns, tours, and trips that can be integrated into OD trips by mode and by the time of day for full network assignment. The base year is set as 2018, and all the models are estimated based on the input as of 2018. For future years, the population data, household, and household member information are updated based on the socioeconomic framework and the synthesized population.

The modeling system is developed by using the available ADS data across JABODETABEK. As one can imagine, the models are depending on individual and household attributes, as well as, habits, customs, preferences, and decision-making processes. In the scope of the study area, these attributes are expected to be quite different from those observed in the U.S. or other developed countries. Although the basic modeling framework is applicable anywhere, a detailed modeling structure, as well as explanatory variables, may also be different.

Chapter 2 SOCIOECONOMIC FRAMEWORK

2.1 Introduction

Socioeconomic framework constitutes the basis for the travel demand forecast and formulation of the transportation master plan. Therefore, it is vital to collect/utilize sufficient years of historical data up to the most recent socioeconomic profile from which the future socioeconomic framework is projected. While there are various plans and inconsistent magnitude/dynamic changes of the future plans, they are important to be considered to make future projection direction. This chapter describes the assumptions and results of the future socioeconomic framework attributed to JUTPI 2.

2.2 Population

2.2.1 Population Profile

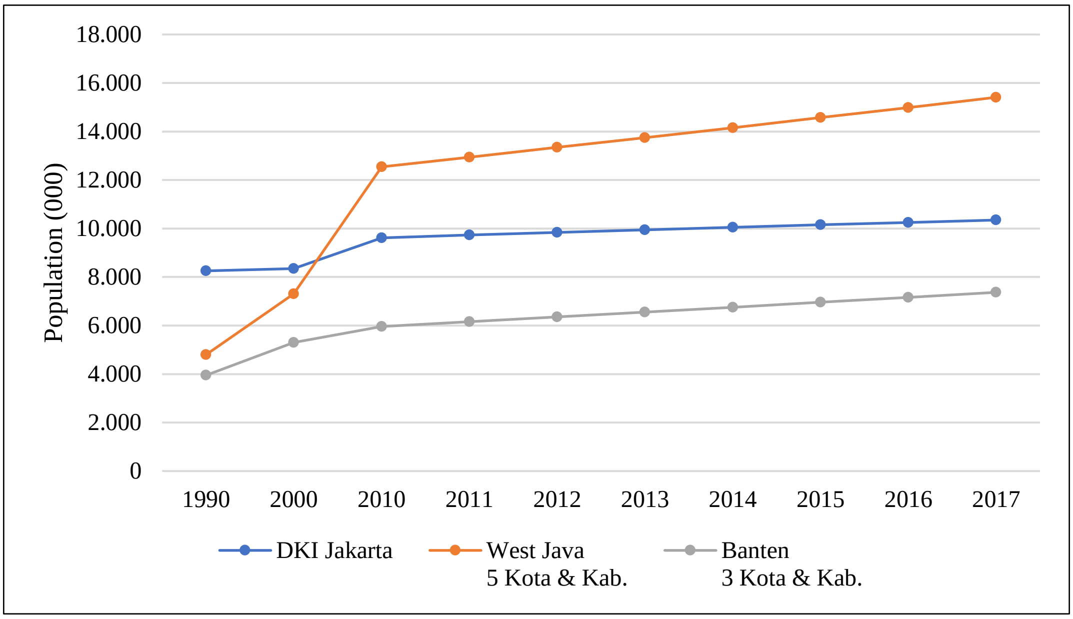
As of 2017, the population of JABODETABEK is roughly 33.1 million; 10.3 million in DKI Jakarta, 15.4 million in five *kota/kabupaten* in West Java province, and 7.4 million in three *kota/kabupaten* in Banten province (see Table 1). It is inferred that from the year of 1990s to now, the growth of the population in DKI Jakarta is rather stable as it has reached the capacity. While the population of the outskirt areas is still showing the tendency of quite significant increase to this day, the urban activities are still centered within the city of DKI Jakarta despite the urban sprawl has begun.

Table 1 Population of JABODETABEK by Region

Region	Population									
	1990	2000	2010	2011	2012	2013	2014	2015	2016	2017
DKI Jakarta	8,254	8,347	9,618	9,730	9,839	9,947	10,052	10,154	10,254	10,350
Kota&Kab. Bekasi, Kota&Kab. Bogor, Kota Depok	4,797	7,300	12,540	12,939	13,343	13,749	14,160	14,574	14,990	15,410
Kota&Kab. Tangerang, Kota Tangerang Selatan	3,949	5,300	5,959	6,155	6,354	6,553	6,757	6,960	7,165	7,369
JABODETABEK	**16,956**	**20,964**	**28,117**	**28,824**	**29,536**	**30,249**	**30,969**	**31,688**	**32,409**	**33,129**

Unit: 1,000 persons
Source: Proyeksi Penduduk Kabupaten/Kota Provinsi DKI Jakarta, Jawa Barat, Banten, 2010 - 2020, BPS-UNFPA 2015

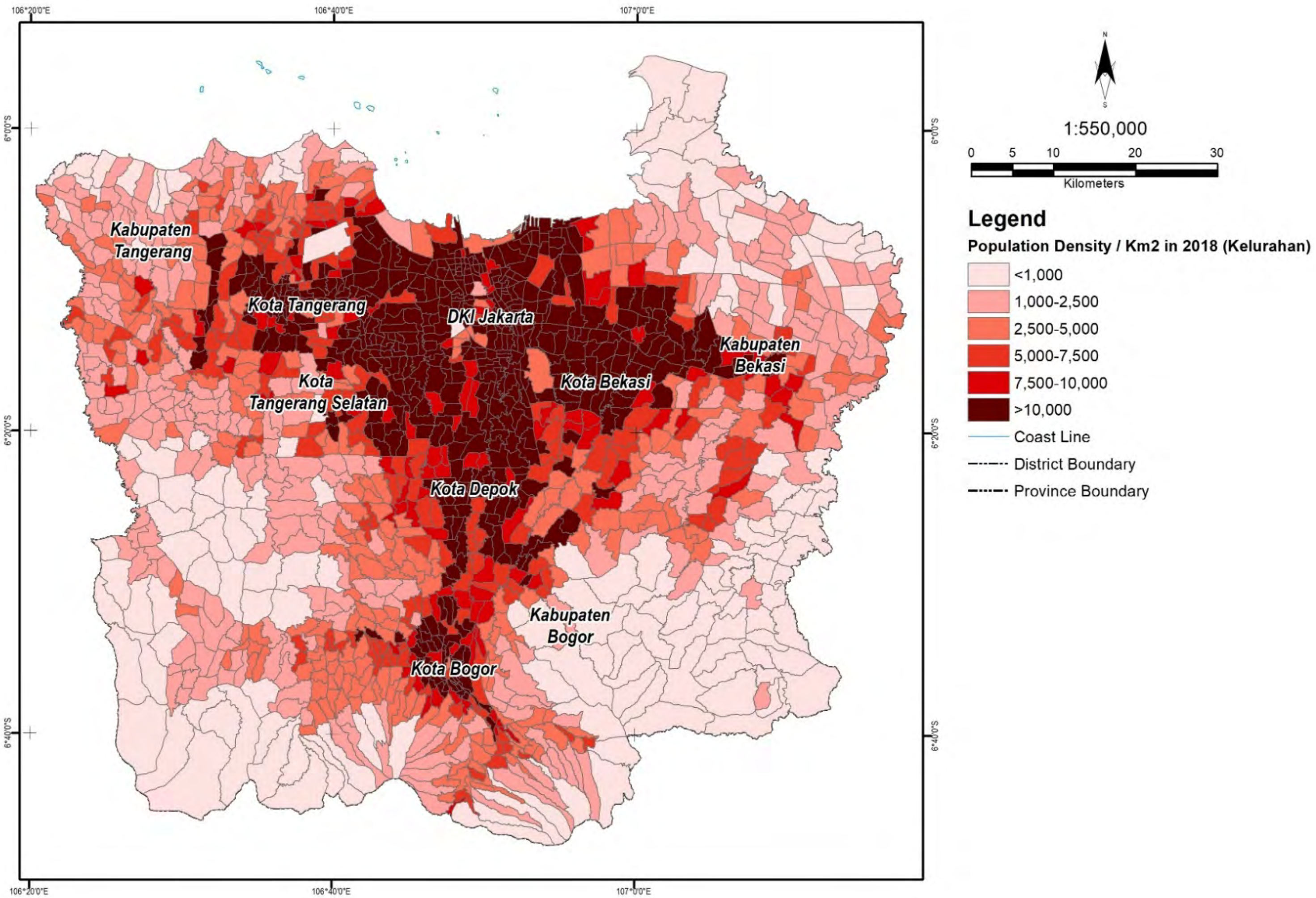
The population growth rate of BODETABEK area has been continuously increasing throughout the period and is currently higher than that of DKI Jakarta (see Figure 6). People prefer to live in the outskirts areas of JABODETABEK for multiple reasons such as; affordable land prices, availability of residential areas, living costs, and so on.



Source: Proyeksi Penduduk Kabupaten/Kota Provinsi DKI Jakarta, Jawa Barat, Banten, 2010 - 2020, BPS-UNFPA 2015

Figure 6 Population Trend in JABODETABEK

As shown in Figure 7 population density distribution by *kelurahan*, the population of DKI Jakarta and other cities bordering DKI Jakarta is relatively high.



Source: JUTPI 2

Figure 7 Population Density Distribution by *Kelurahan* 2018

2.2.2 Population Projection

In this report, JABODETABEK population is projected by using the data based on census 2010, namely Projected Population of *kabupaten/kota* of DKI Jakarta, Jawa Barat, and Banten Provinces 2010 - 2020 (by BPS, UNFPA, 2015). It is forecasted that JABODETABEK population would reach 35 million in 2020 and 46 million in 2030. A significant increase in population is expected in the areas outside of DKI Jakarta. Despite the expected urbanization in the outskirt area, the highest density would still remain in the CBD area.

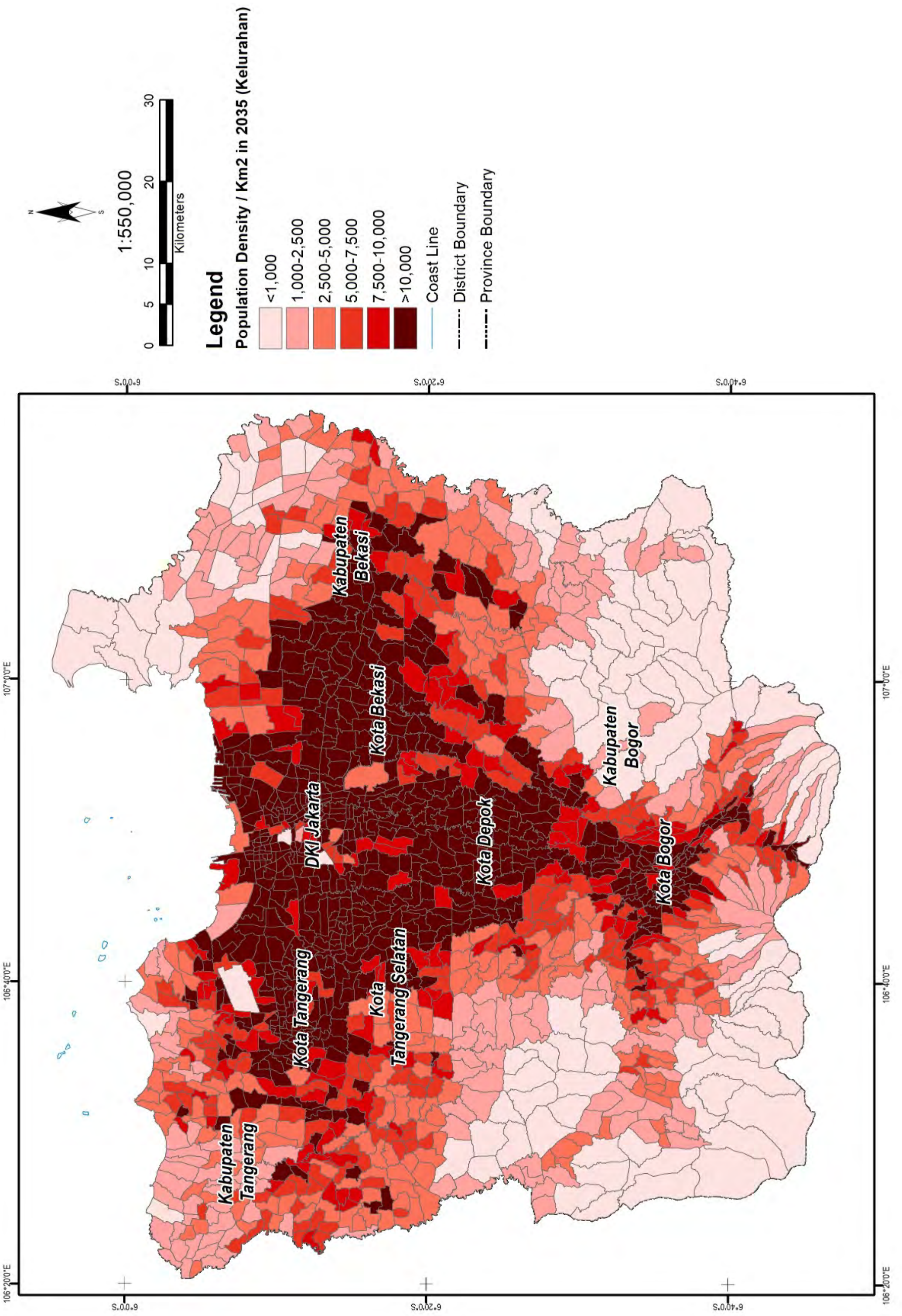
Detail population projection is depicted in Table 2 by the planning year of 2025, 2029/30, and 2035. Population of DKI Jakarta remains the highest among all regions until 2025. The number of populations in DKI Jakarta is surpassed by Bogor and Depok region consists of Kota Bogor, Kabupaten Bogor, and Kota Depok in 2029.

Table 2 Future Population Framework by Region

Region	2010	2015	2017	2020	2025	2029	2030	2035
DKI Jakarta	9,619	10,155	10,350	10,621	10,942	11,029	11,051	11,129
Bogor	7,528	8,614	9,051	9,699	10,815	11,840	12,096	13,443
Tangerang	5,959	6,961	7,370	7,982	9,022	9,847	10,053	11,094
Bekasi	5,013	5,961	6,360	6,975	8,075	9,128	9,391	10,837
Bodetabek	18,500	21,535	22,780	24,656	27,911	30,814	31,540	35,375
JABODETABEK	**28,119**	**31,690**	**33,130**	**35,277**	**38,854**	**41,843**	**42,590**	**46,504**

Unit: 1,000 persons
Source: Population Census and JUTPI 2

Figure 8 shows population distribution in 2035. The population is relatively evenly distributed. This can be seen in *kabupaten* area that starts to be developed so that population distribution is not concentrated in urban areas.

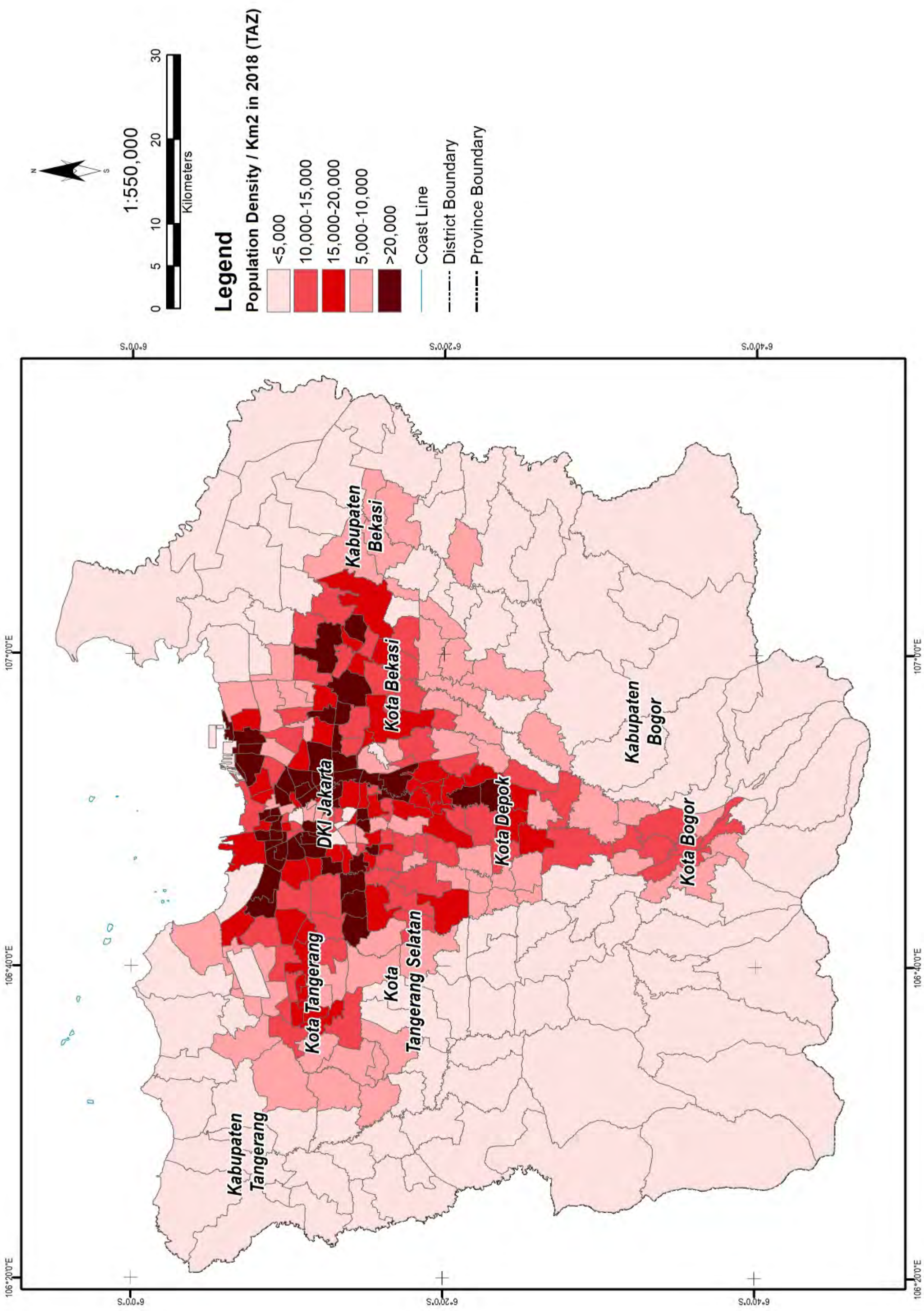


Source: JUTPI 2

Figure 8 Population Density Distribution Projection by *Kelurahan* 2035

2.2.3 Distributing Population to TAZ

Appropriate population distribution to particular areas in future years is essential for the travel demand forecast and transportation planning. Socioeconomic framework data is fundamental for transport modeling exercises to obtain reliable forecast results. The projected socioeconomic framework data in JUTPI 2 is prepared at *kabupaten*/*kota* level, thus, it is spatially distributed to the traffic analysis zones (TAZ). For the distribution of framework data, multiple linear regression analysis, and GIS-based "development potential model" were utilized with various statistical and spatial data. By using these methods, future population and other necessary socioeconomic indicators are properly distributed. Population density distribution in 2018 is shown in Figure 9.



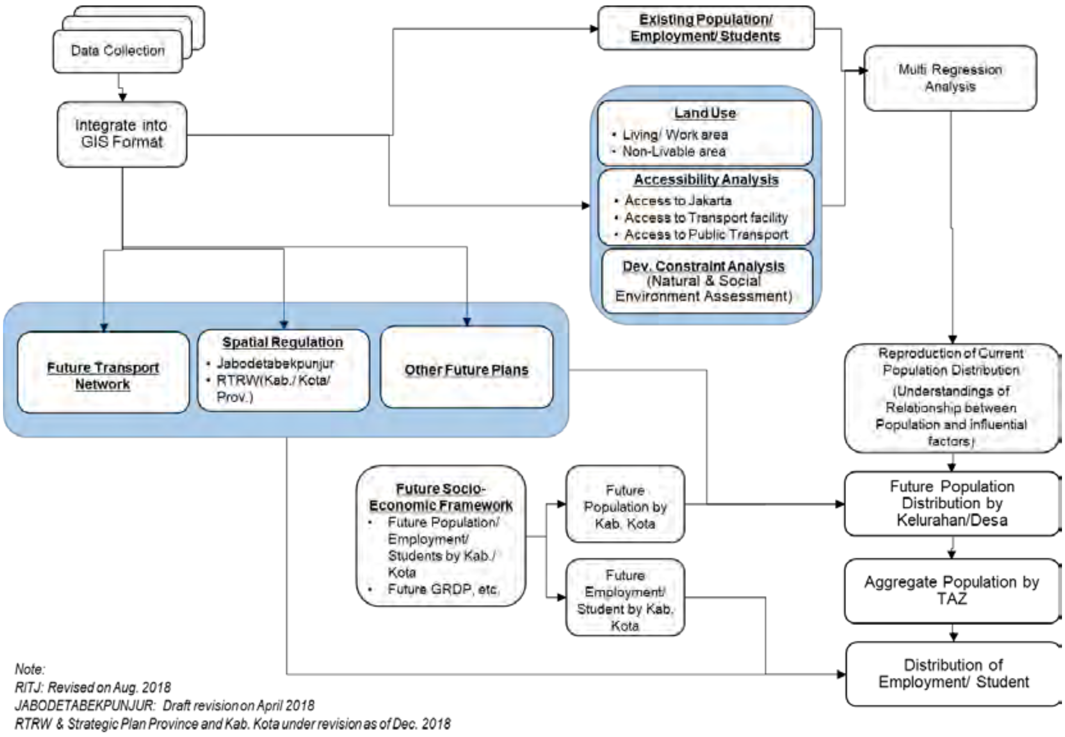
Source: JUTPI 2

Figure 9 Population Density Distribution by TAZ 2018

(1) Overall Methodology of Population Distribution

The overall methodology of population and employment distribution for the Master Plan case (target year 2035) is explained as follows and illustrated in Figure 10;

1) Data collection and integration to GIS dataset
2) The development population/ employment distribution model is prepared to reproduce base year population distribution, using multiple linear regression analysis with population, current land use, accessibility to transport facilities and natural conditions
3) Based on base year model, future socioeconomic indicators are distributed in *Kelurahan/desa* level with given future transport networks and other future development plans such as spatial plans.
4) Aggregate *Kelurahan/desa* level population into TAZ
5) Based on TAZ population, estimate number of employment and students based on total population in 2035 and target year land use



Source: JUTPI 2

Figure 10 Overall Methodology of Population Distribution 2035

On the other hand, intermediate years 2024 and 2029 are estimated using a different method, because of the absence of land use plan of each intermediate year. The summary of the estimation of the intermediate years population is as follows and illustrated in Figure 11.

1) Calculate development potential score of the base year 2018 and target year 2035 by TAZ

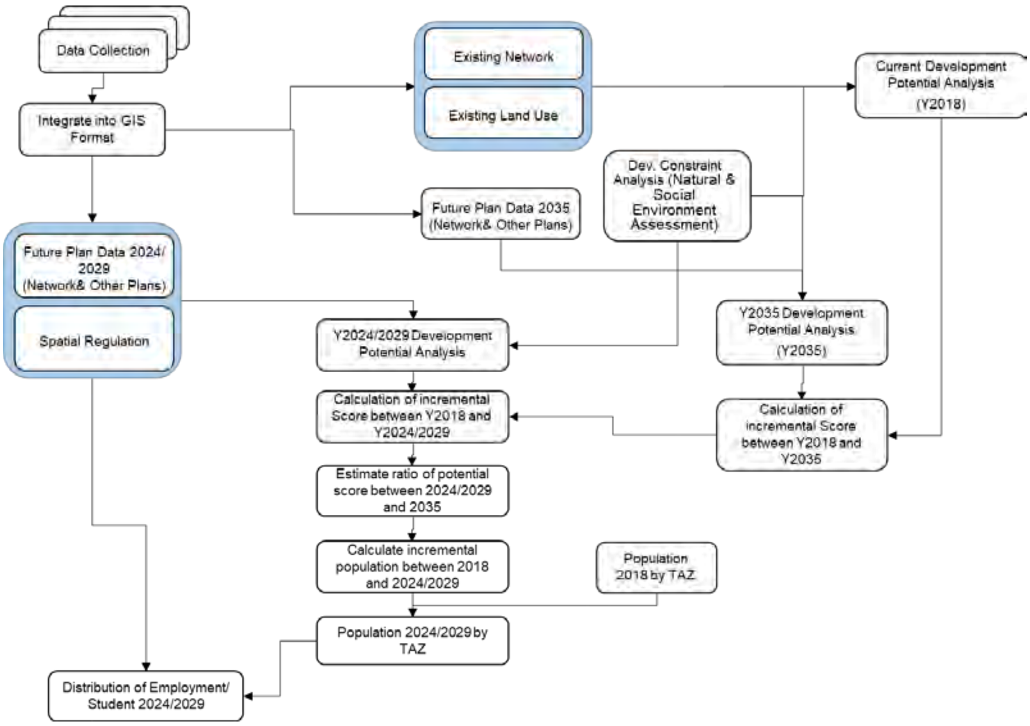
2) Based on the given transport network data of each intermediate year and other development potential data such as TOD development plans, estimates development potential score of intermediate year by TAZ. (This part uses "Development Potential Model" explained in Section 2.2.3(7))

3) Set target year potential score as 100 and base year potential as zero, calculate a ratio of intermediate year potential score (achievement ratio of development potential)

4) Based on base year population, target year population, and achievement ratio of development potential, increments population of intermediate year population by TAZ (Calculation of incremental population between base year to intermediate year) was estimated.

5) Add increment population into base year population by TAZ and

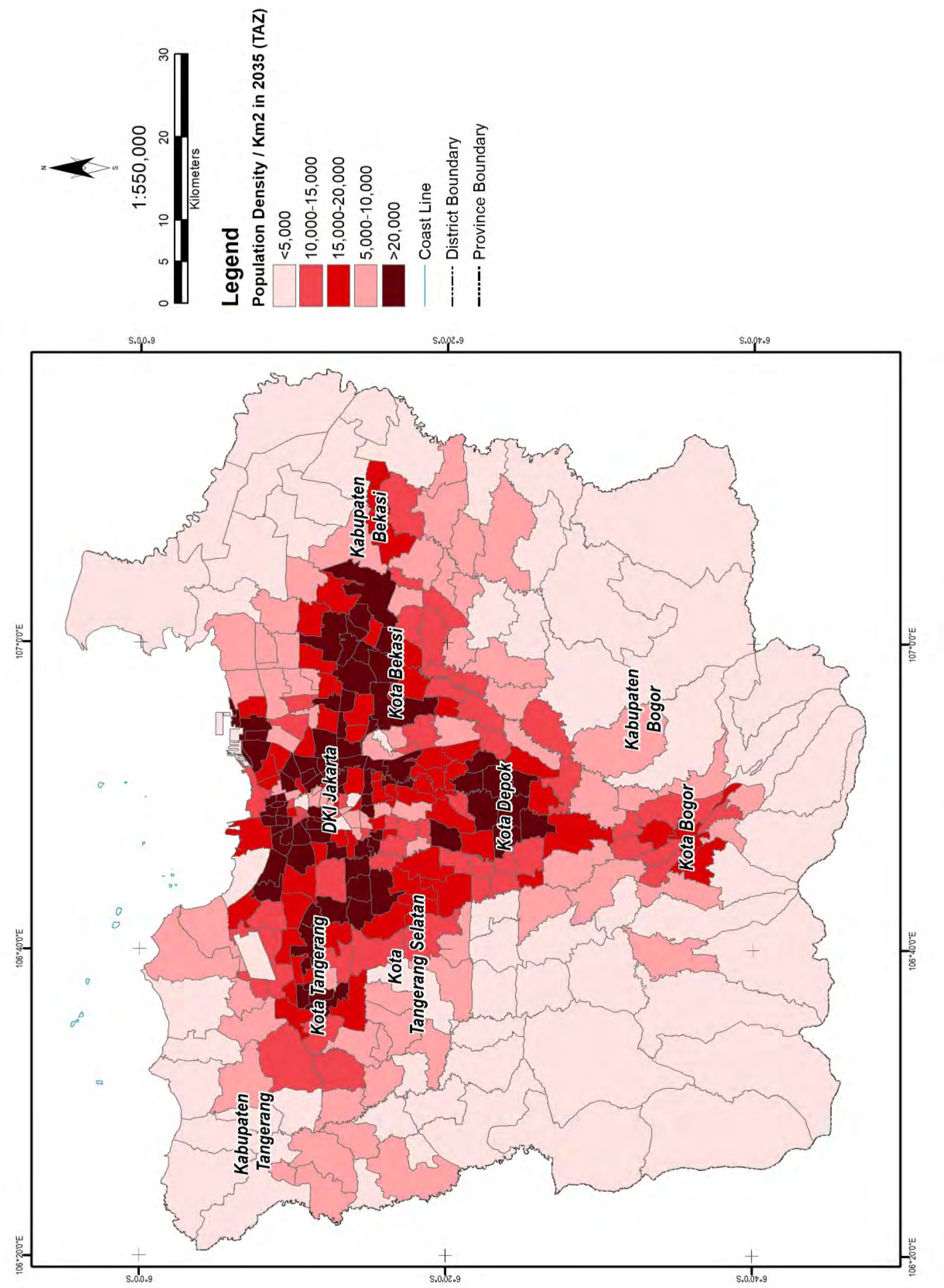
6) Based on the TAZ population, estimate the number of employees and students based on the total population of intermediate year and target year land use.



Source: JUTPI 2

Figure 11 Overall Methodology of Population Distribution 2024 and 2029

By following the methodology as explained in Figure 11, population distribution in 2035 was estimated as shown in Figure 12.



Source: JUTPI 2

Figure 12 Population Density Distribution Projection by TAZ 2035

(2) Data Collection and Preparation

There are various data that are collected from various entities. These data are examined and integrated as a GIS format for further analyses such as estimation of population distribution. Especially spatial plan data prepared by each *kabupaten* and *kota*, JABODETABEK Urban Transportation Master Plan (RITJ) prepared by BPTJ and JABODETABEKPUNJUR plan prepared by Ministry of ATR/BPN (Agrarian and Spatial Planning/National Land Agency) are well-considered for population distribution as fundamental information.

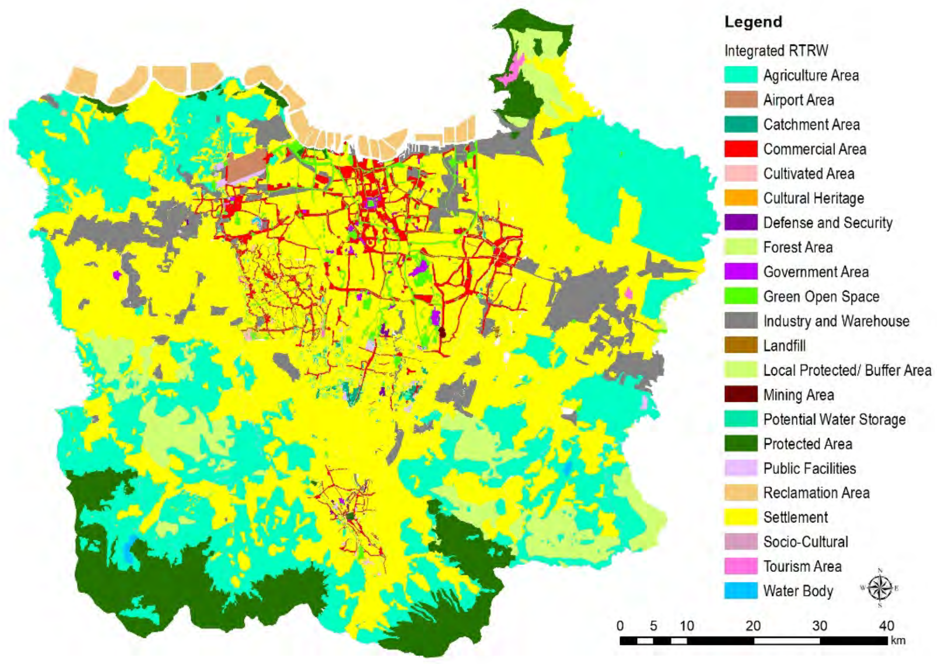
Each *kabupaten/kota* had formulated its spatial plan using its own category or land use type. In this project, in order to integrate and utilize these data as a unified form, their categories were interpreted. This integrated RTRW data also considered the target year land use plan in the Study.

The following table shows a list of main collected data that were integrated into GIS database for socioeconomic framework distribution.

Table 3 Collected Data for Population and Employment Distribution

Base year data	Future year
<GIS data> • Base year road network • Base year public transport network • Base year public transport facilities • Base year land use • Socioeconomic indicators • Administrative boundary • Protected/ Conservation area • JUTPI 1 GIS database • Satellite imagery for DKI Jakarta <non-GIS data> • Socioeconomic framework	<GIS data> • Spatial plan by *Kabupaten/ Kota* (For target year) • Strategic plan by *Kabupaten/Kota* (For target year) • Spatial plan for JABODETABEKPUNJUR • JABODETABEK Urban Transportation Master Plan (RITJ) • Future transport network by JUTPI 2 • Other development plans (industrial area, TOD, etc.) • Protected/ Conservation area <non-GIS data> • Socioeconomic framework

Source: JUTPI 2



Source: RTRW by each *Kabupaten/Kota* and JUTPI 2

Figure 13 Integrated Spatial Plan Prepared by *Kabupaten/Kota*

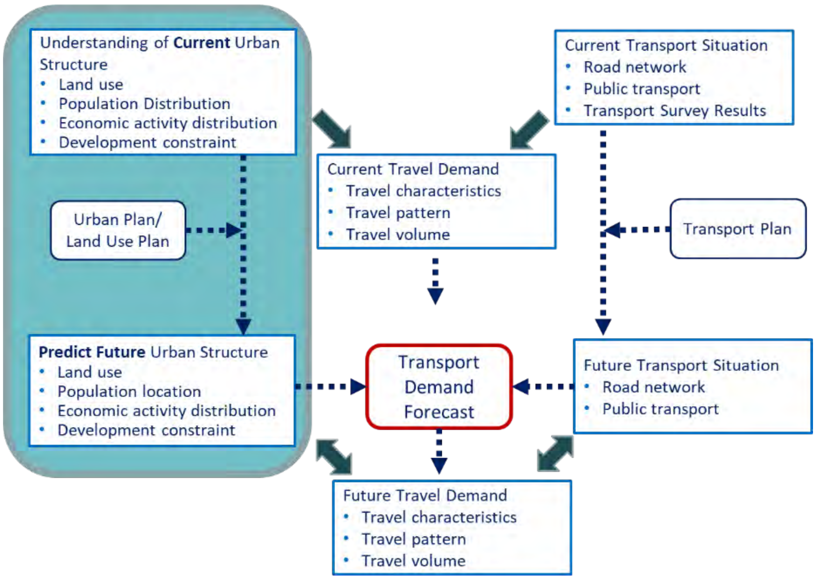
(3) Utilization of GIS

A variety of data/information has been collected from government agencies and relevant agencies in addition to various surveys conducted by JUTPI 2. These collected data were compiled/integrated into the numerical format or in the format of geographical data, so-called GIS format, for further analysis. In JUTPI 2, these collected GIS data are used not only for mapping or visualizing purposes but also as a planning tool. For population and other socioeconomic framework distribution, GIS is also utilized in various ways, and the advantage of the utilization of GIS in transportation planning work are followings:

- Integrate various data/ information into GIS format and visualize data
- Multiple data analysis in a spatial manner
- Manage various types of data easily in GIS format, and
- Good communication with transport planning software.

(4) Relations of Socioeconomic Framework and Travel Demand Forecast

The purpose to formulate socioeconomic framework is as a part of preparation work for input parameters for the travel demand model. Distribute various socioeconomic indicators in the base year was done by at first, estimate total population by *kelurahan/desa* by multiplied population of *kabupaten/kota* by the percentage of the population of each *kelurahan/desa* from the trend of the previous years. As a next step, other variables such as the number of employees by sector and number of students are estimated based on total *kelurahan/desa* population and land use as explained in the following table. To prepare socioeconomic indicators for the travel demand model, these socioeconomic indicators need to be distributed by TAZ level.



Source: JUTPI 2

Figure 14 Relations of Socioeconomic Framework and Travel Demand Forecast Model

The methodology of distributing data by *kabupaten/kota* to the village is described below. Once the population data is distributed by *keluraḥan/desa* level, then the population by *kelurahan/desa* is aggregated into TAZ. The next step is to distribute the number of employees and students based on the estimated population by TAZ.

To estimate the number of employment both residential place and working place, it is necessary to estimate not only the total number of employees but also the number of employments by industrial sectors, namely primary, secondary, and tertiary sectors. Land use information and total population size by TAZ are utilized to distribute employment by sector.

Table 4 Methodology of Employment and Student Distribution at Residential Place

	Methodology to distribute by TAZ from by Kab./Kota
Primary Sector	• Identify agriculture land area distribution by TAZ • 50% of primary sector employment estimates based on total population size • 50% of primary sector employment estimates based on agriculture land size
Secondary Sector	• Identify industrial area distribution by TAZ • 50% of secondary sector employment estimates based on total population size • 50% of secondary sector employment estimates based on agriculture land size
Tertiary Sector	• Identify Commercial/ Education/ Public facility/ Mix use area distribution by TAZ • 50% of tertiary sector employment estimates based on total population size • 50% of tertiary sector employment estimates based on agriculture land size
Students	• Based on population size by TAZ

Source: JUTPI 2

Table 5 Methodology of Workers and Student Distribution at Working/School Place

	Methodology to distribute by TAZ from by Kab./Kota
Primary Sector	• Identify agriculture land area distribution by TAZ • 20% of primary sector employment estimates based on total population size • 80% of primary sector employment estimates based on agriculture land size
Secondary Sector	• Identify industrial area distribution by TAZ • 30% of secondary sector employment estimates based on total population size • 70% of secondary sector employment estimates based on agriculture land size
Tertiary Sector	• Identify Commercial/ Education/ Public facility/ Mix use area distribution by TAZ • 20% of tertiary sector employment estimates based on total population size • 80% of tertiary sector employment estimates based on agriculture land size
Students	• Identify Education distribution by TAZ • 25% of the number of students estimates based on total population size • 75% of the number of students estimates based on agriculture land size

Source: JUTPI 2

(5) Base Year Socioeconomic Indicators

The Base year population was collected by *kelurahan/desa* for the entire JABODETABEK area, so the TAZ population is calculated to integrate based on the corresponding table between *kelurahan/desa* and TAZ. Other socioeconomic indicators, such as employment and students, are estimated based on ADS survey and other referential data, such as statistical data and publications from statistical agencies (BPS) in the level of national, regional, and local (*kota/kabupaten*), Ministry of Education, and Ministry of Manpower.

(6) Target Year 2035 Population and Employment Distribution

1. Multiple Linear Regression Analysis for Population Distribution 2035

Using base year population data, multiple linear regression analysis is adopted to identify the relationship between land use, accessibility to transport facilities, development constraints, and population. As a result, the relationship among a number of populations, land use, accessibility to transport facilities, and spatial regulations are identified. The population for each *kelurahan/desa* is estimated as shown in the following formula.

$$
\begin{aligned}
Pop_{i=}\ & \\
& 0.01401 \times Residential\ area + \\
& 0.006821 \times Industry\ \&\ Warehouse + \\
& 0.007292 \times Commercial, Education\ \&\ Pub. Facility\ area + \\
& 0.005291 \times Agriculture\ area + \\
& 0.005992 \times Swamp, River\ \&\ Pond\ area + \\
& 0.006163 \times Bush\ \&\ Forest\ area + \\
& -0.00838 \times Dev.\ Constraint\ score\ (Natural\ Condition) + \\
& 0.000404 \times Dev. Constraint\ score (Regulation) + \\
& 0.002002 \times Access\ to\ JKT\ score + \\
& 0.000957 \times Access\ to\ Pub. Transport\ score + \\
& 2452.762 \times Access\ to\ Road\ score
\end{aligned}
$$

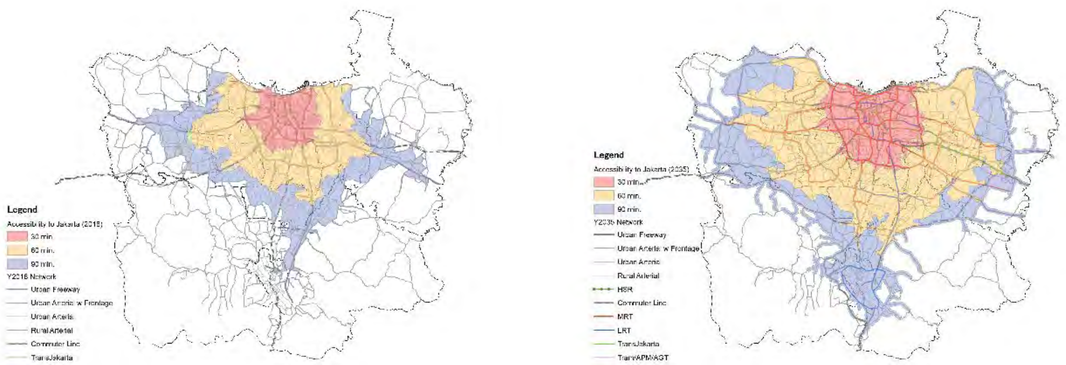
Based on the formula above, target year 2035 population by *kelurahan/desa* are estimated with transport network 2035 and spatial plan data.

Three types of accessibility parameters were included as explanatory variables, which are "Access to JKT (DKI Jakarta)", Access to Public Transport," and "Access to Road" as mentioned in Table 6. These parameters are results of accessibility analysis also using GIS techniques. For "Access to JKT (DKI Jakarta)" analysis, GIS Network Analyst extension is utilized. Using the GIS Network Analyst extension, it is possible to obtain travel distance from a particular location referring to given network data and travel speed. Other variables related to accessibilities, such as accessibility to public transport and accessibility to roads are calculated using simple buffer analysis which calculates a particular distance from railway stations, bus stops, and road networks.

Table 6 Estimated Factors of Development Potential Model

	Explanatory variables	Coefficients	t -value	P-value	R Square	Observation
Land use	Residential area	0.01401	15.19636	1.35E-48	0.831	1501
	Industry & Warehouse	0.006821	6.515418	9.89E-11		
	Commercial, Education & Pub. Facility	0.007292	3.391975	0.000712		
	Agriculture	0.005291	5.927388	3.82E-09		
	Swamp, River & Pond	0.005992	5.979235	2.8E-09		
	Bush & Forest	0.006163	6.392709	2.17E-10		
Dev. Constraint (Natural Condition)	Waterbody, Slope, Elevation	-0.00838	-8.77062	4.76E-18		
Dev. Constraint (Regulation)	Airport, Protected area, Low Capacity area, Technical Irrigation, Buffer for Protected area & Low capacity area, Security area	0.000404	1.956395	0.050605		
Accessibility	Access to DKI Jakarta	0.002002	10.9289	8.46E-27		
	Access to Pub. Transport	0.000957	6.233614	5.92E-10		
	Access to Road	2452.762	11.65018	4.41E-30		

Source: JUTPI 2



2018 **2035**

Source: JUTPI 2

Figure 15 Result of Network Analysis for Accessibility to DKI Jakarta (2018/2035)

2. Future Population Distribution for Target year 2035

For the future socioeconomic indicator distribution, at first, the total population by *Kelurahan/desa* are estimated based on the multiple linear regression analysis as explained in the previous section.

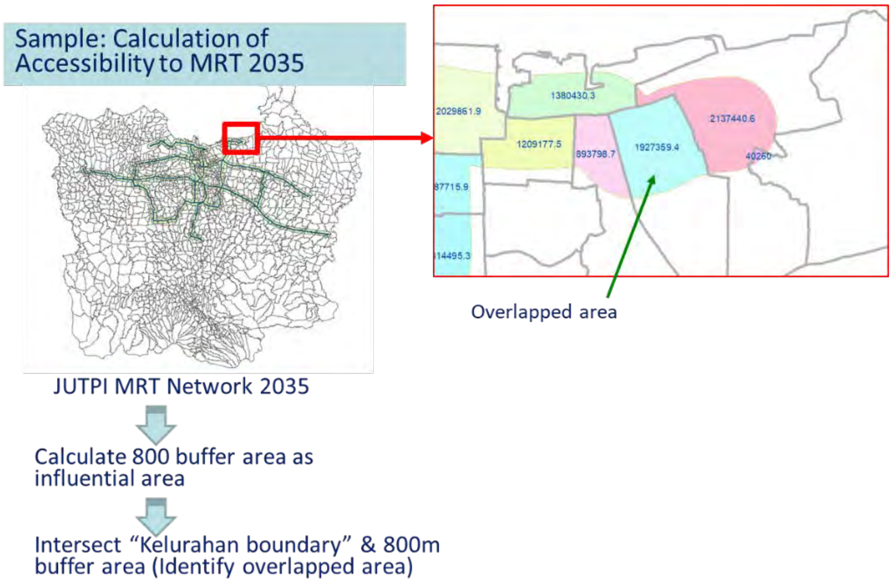
To estimate 2035 population, variables such as network data and land use data are replaced from existing condition data to future plan data. On the other hand, variables related to development constraints use the same data with the existing condition. List of data used shown in Table 7.

Table 7 Data Source of Explanatory Variables

	Explanatory variables	Data source	
		Base year	Target year
Land use	Residential area	Existing land use data prepared by JUTPI 2	RTRW prepared by Kabupaten/ Kota, and Existing land use data
	Industry & Warehouse		
	Commercial, Education & Pub. Facility		
	Agriculture		
	Swamp, River & Pond		
	Bush & Forest		
Dev. Constraint (Natural Condition)	Waterbody, Slope, Elevation	JABODETABEKPUNJUR plan and RTRW prepared by Kabupaten/ Kota	Use same data with base year
Dev. Constraint (Regulation)	Airport, Protected area, Low Capacity area, Technical Irrigation, Buffer for Protected area & Low capacity area, Security area	JABODETABEKPUNJUR plan and RTRW prepared by Kabupaten/ Kota	Use same data with base year
Accessibility	Access to JKT	Base year network data	Target year network data
	Access to Pub. Transport		
	Access to Road		

Source: JUTPI 2

These variables are prepared using overlay operation with GIS software between *kelurahan/ desa* boundary and the variable. The result of the overlay operation overlapped area of each variable and *kelurahan/desa* area is obtained. Using obtained areas, necessary explanatory variables are prepared as a table. Figure 16 shows a sample image of the variables table to apply the formula to estimate the target year population.



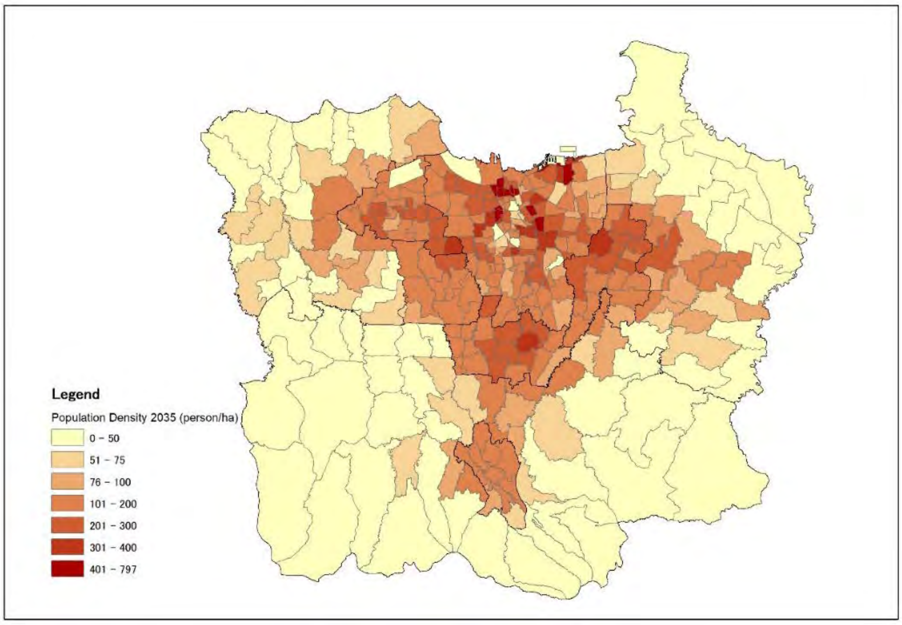
Source: JUTPI 2

Figure 16 Preparation of Explanatory Variables for Target Year

Kelurahan / Desa Code	Total area Kel/Desa	Waterbody score	・・・・・・	Protected area	Low Capacity area	・・・・・・	Access to Road	Access to Pub. Transport	・・・・・・	Residential area
3171010001	4110714.3	101123.3	・・・・・・	258098.4	52809.1	・・・・・・	4001350.8	2101350.8	・・・・・・	3538902.1
3171010002	3322110	221133.4	・・・・・・	112233.4	0	・・・・・・	334455.6	1234.1	・・・・・・	45678.9
・・・・・・										

Source: JUTPI 2

Figure 17 Image of Input Data for Target Year Population Estimation



Source: JUTPI 2

Figure 18 Estimated 2035 Population Density by TAZ

(7) Intermediate Year Socioeconomic Framework Distribution (Year 2024/2029)

In the final stage of the JUTPI 2, it is requested to formulate intermediate year transport plans in 2024 and 2029. To formulate intermediate plans, it is necessary to run the travel demand forecast model of intermediate years. In parallel, intermediate year socioeconomic indicators were also prepared.

However, intermediate year land use plan data is not available so that different method of population estimation is applied using the development potential model.

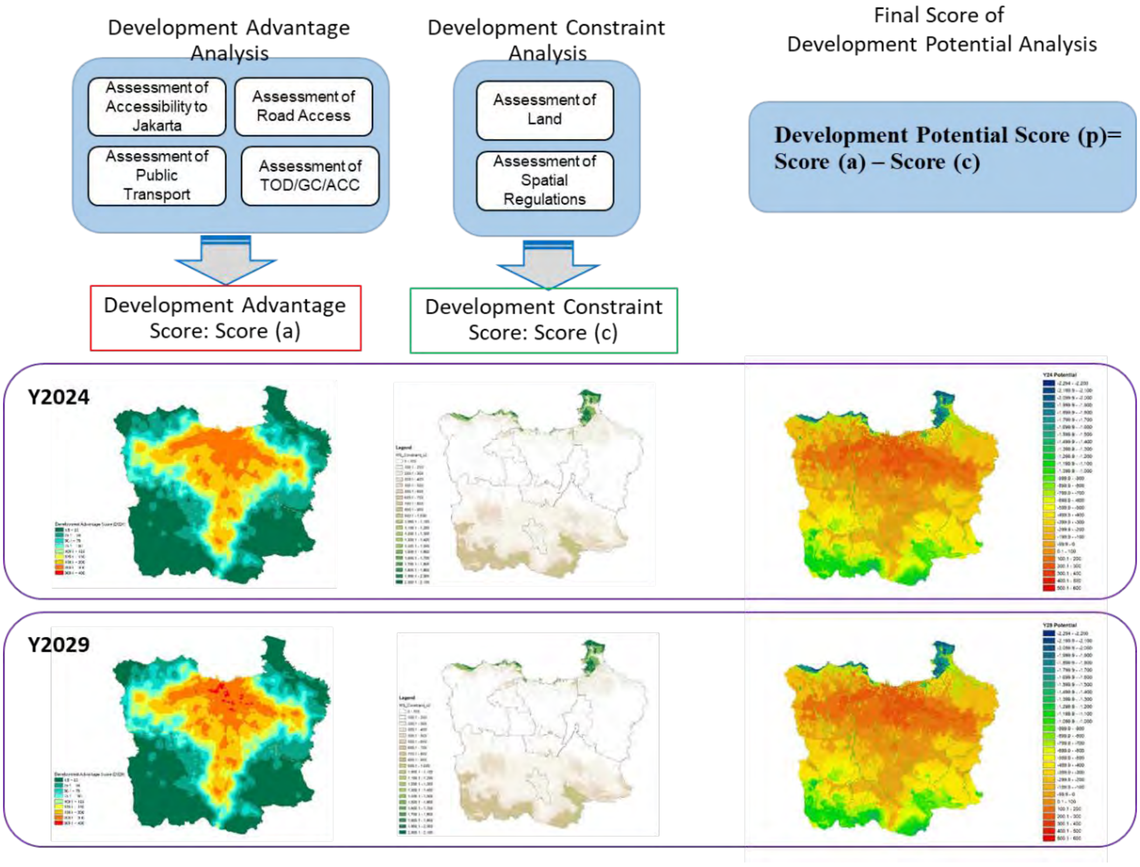
As an initial step, the development potential scores of the base year and target year are calculated. The following potential score of the intermediate years were also calculated. As explained in the previous section, base year and target year population were prepared in advance, using these population data and potential scores of base years, target year and intermediate year, intermediate year total population is estimated without land-use plan data. Figure 19 shows the concept of intermediate year population estimation.

1. Development Potential Model

Development potential model is prepared to distribute the total population by *kabupaten/kota* to *kelurahan/desa* level of the intermediate years, 2024 and 2029 because these intermediate year land use plans are not available.

As explained in 2.2.3(6), population agglomerations have a relationship with land use, accessibility to transport facilities, and development constraints. Considering these relationships, future population distribution patterns for intermediate years are estimated together with a base year and 2035 potentials as the benchmark.

This development potential model is a multi-criteria spatial analysis with population, land use, accessibility (road, railway station, urban centers, etc.), and development constraint area to calculate development potential score by 200 m cell basis in raster format. The calculated total development potential scores by 200 m cell basis are aggregated into a TAZ basis.



Source: JUTPI 2

Figure 19 Development Potential Model

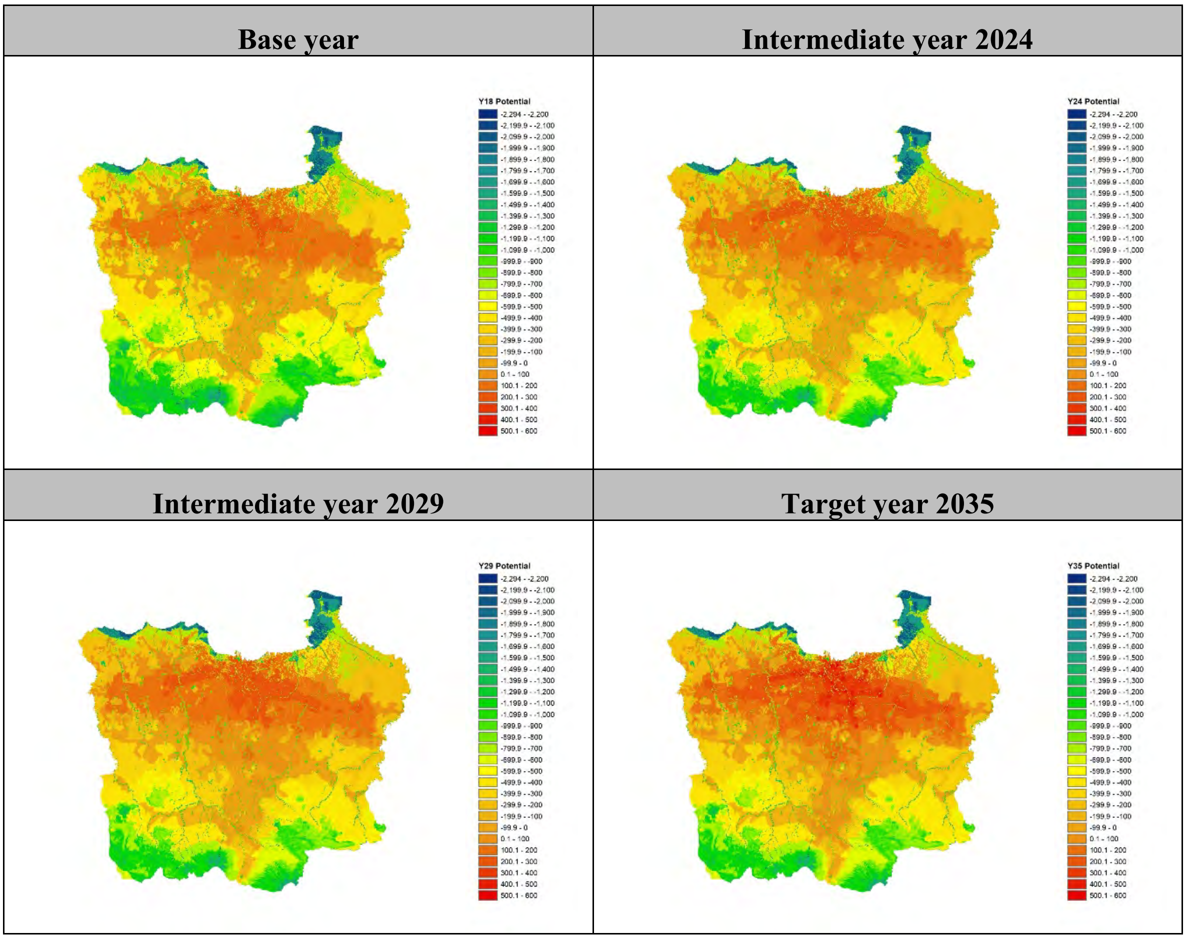
Table 8 Input Parameters for Development Potential Model

	Base year	Target year	Intermediate year	Remarks
Accessibility to DKI Jakarta	• JKT Access (30/60/90 min.) travel time • Distance from DKI Jakarta central area (10km area)	• JKT Access (30/60/90 min.) travel time • Distance from DKI Jakarta central area (10km area)	• JKT Access (30/60/90 min.) travel time • Distance from DKI Jakarta central area (10km area)	Base year uses base year network data, target year and intermediate year uses particular year network data for transport demand forecast model
Road Access	• Access to Urban Freeway • Access to Urban Arterial • Access to Rural Arterial	• Access to Urban Freeway • Access to Urban Arterial • Access to Rural Arterial	• Access to Urban Freeway • Access to Urban Arterial • Access to Rural Arterial	
Public Transport Access	• Access to Commuter rail station • Access to TransJakarta station	• Access to Commuter rail station • Access to TransJakarta station • Access to Tram/APM/AGT station • Access to MRT station • Access to LRT station • Access to TransJakarta station	• Access to Commuter rail station • Access to TransJakarta station • Access to Tram/APM/AGT station • Access to MRT station • Access to LRT station • Access to TransJakarta station	
Land use	• Residential area (Planned house, High density Kampung, Low density kampung) • Industrial area • Commercial, Education & Pub. Facility • Agriculture area • Waterbody (Swamp, River & Pond) • Bush & Forest	• Residential area (Planned house, High density Kampung, Low density kampung) • Industrial area • Commercial, Education & Pub. Facility • Agriculture area • Waterbody (Swamp, River & Pond) Bush & Forest • New Development areas based on RTRW	• Not available	
Other Development Plan	-	• TOD • Growth Center • Activity Center	• TOD • Growth Center • Activity Center	Collected and Prepared by JUTPI 2 for each case
Development Constraint (Natural Condition)	• Airport • Slope condition • Elevation	• Airport • Slope condition • Elevation	• Airport • Slope condition • Elevation	Base year, target year and intermediate year use the same data
Development Constraint (Spatial Regulation: JABODETA	• Protected area and areas to protect protected area (L1, P1, P2)	• Protected area and areas to protect protected area (L1, P1, P2)	• Protected area and areas to protect protected area (L1, P1, P2)	

	Base year	Target year	Intermediate year	Remarks
BEKPUNJUR plan)	• Low environment capacity (B3, B4) • Tech. Irrigation (B5) • Buffer zone for protected area (B7)	• Low environment capacity (B3, B4) • Tech. Irrigation (B5) • Buffer zone for protected area (B7)	• Low environment capacity (B3, B4) • Tech. Irrigation (B5) • Buffer zone for protected area (B7)	
Development Constraint (Spatial Regulation: RTRW by Kab/Kota)	• Military/ Security area	• Military/ Security area	• Military/ Security area	

Source: JUTPI 2

For the development potential model, all of the GIS data are converted into raster format which is a cell size of 200 square meters in a square, after calculating potential score in the cell basis, total potential scores by *kelurahan/desa* are aggregated as a result of the model. Figure 20 shows the results of the model for the base year, both intermediate years (2024 and 2029) and target year 2035.



Source: JUTPI 2

Figure 20 Result of Development Potential Model

2. Estimation of Intermediate Year Population by TAZ

Based on the result score of the development potential model, the following procedure is applied to estimate the population by TAZ.

1) Set the target year 2035 potential score as 100 and base year potential as zero, calculate the ratio of intermediate year potential score (achievement ratio of development potential)

2) Based on the base year population, target year population and achievement ratio of development potential estimates increment population of intermediate year population by TAZ

3) Add increment population into base year population by TAZ

Table 9 Concept of Intermediate Year Population Estimation

	①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩
	Base Year Pop	**Target Year Pop**	**Base Year Score**	**Target Year Score**	**Score Balance (Target-Base year)**	**Increment population (target year Pop. - base year Pop.)**	**Intermediate year score 2024**	**Achievement of score to target year**	**Incremental population between base year to 2024**	**Population 2024**
Village A	10,000	11,000	1,000	2,000	1,000	1,000	1,050	5%	50	10,050
Village B	15,000	20,000	500	900	400	5,000	600	25%	1250	16,250
Village C	20,000	30,000	1,000	2,000	1,000	10,000	1,100	10%	1000	21,000
Village D	30,000	33,000	1,200	1,400	200	3,000	1,300	50%	1500	31,500

① base year population by *kelurahan/desa* are collected by JUTPI 2
② target year population was estimated using multiple linear regression analysis with base year population, land use, accessibility, and development constraint
③ base year development potential score calculated using the development potential model
④ target year development potential score calculated using the development potential model
⑤ calculate an incremental score between the base year and target year
⑥ calculate an incremental number of populations between base year and target year
⑦ intermediate year development potential score calculated using the development potential model
⑧ calculate the ratio of intermediate year score with an incremental score between the base year and target year: = (⑦-③)/⑤
⑨ estimated incremental population between the base year and the intermediate year: =⑥*⑧
⑩ the estimated total population in the intermediate year: =①+⑨

Source: JUTPI 2

2.3 Employment and School Enrollment

2.3.1 Workers at Residential and Workplace Profile

The number of workers is identified based on residential place and workplace. It is found out that the number of primary sectors fluctuates throughout the years. The share in 2002 is the highest (8%) and after 2002, the share of primary workers decreases to 3% in 2017 and the share of the secondary sector has been quite the same trend from 2002 to 2017 although the numbers by provincial- and city- levels do not indicate the same trend. The tertiary sector increases from 68% in 2002 to 73% in 2017. Average growth shows that the tertiary sector has the highest rate compared to other sectors as depicted in Table 10.

Table 10 Worker Share by Work Sector in JABODETABEK

Sector	2002 (SITRAMP)	2010 (JUTPI 1)	BPS Data			2002	2010	2014	2015	2017	Average Share
			2014	2015	2017						
Primary	576	532	555	386	449	8%	6%	4%	3%	3%	5%
Secondary	1,856	2,125	3,367	3,252	3,229	24%	25%	25%	24%	24%	24%
Tertiary	5,161	5,889	9,472	9,819	10,016	68%	69%	71%	73%	73%	71%
Total	7,592	8,545	13,394	13,456	13,695	100%	100%	100%	100%	100%	100%

Unit: 1,000 persons
Source: JUTPI 2

Furthermore, workers' density distribution by *kelurahan* and TAZ can be seen in Figure 21 and Figure 22.

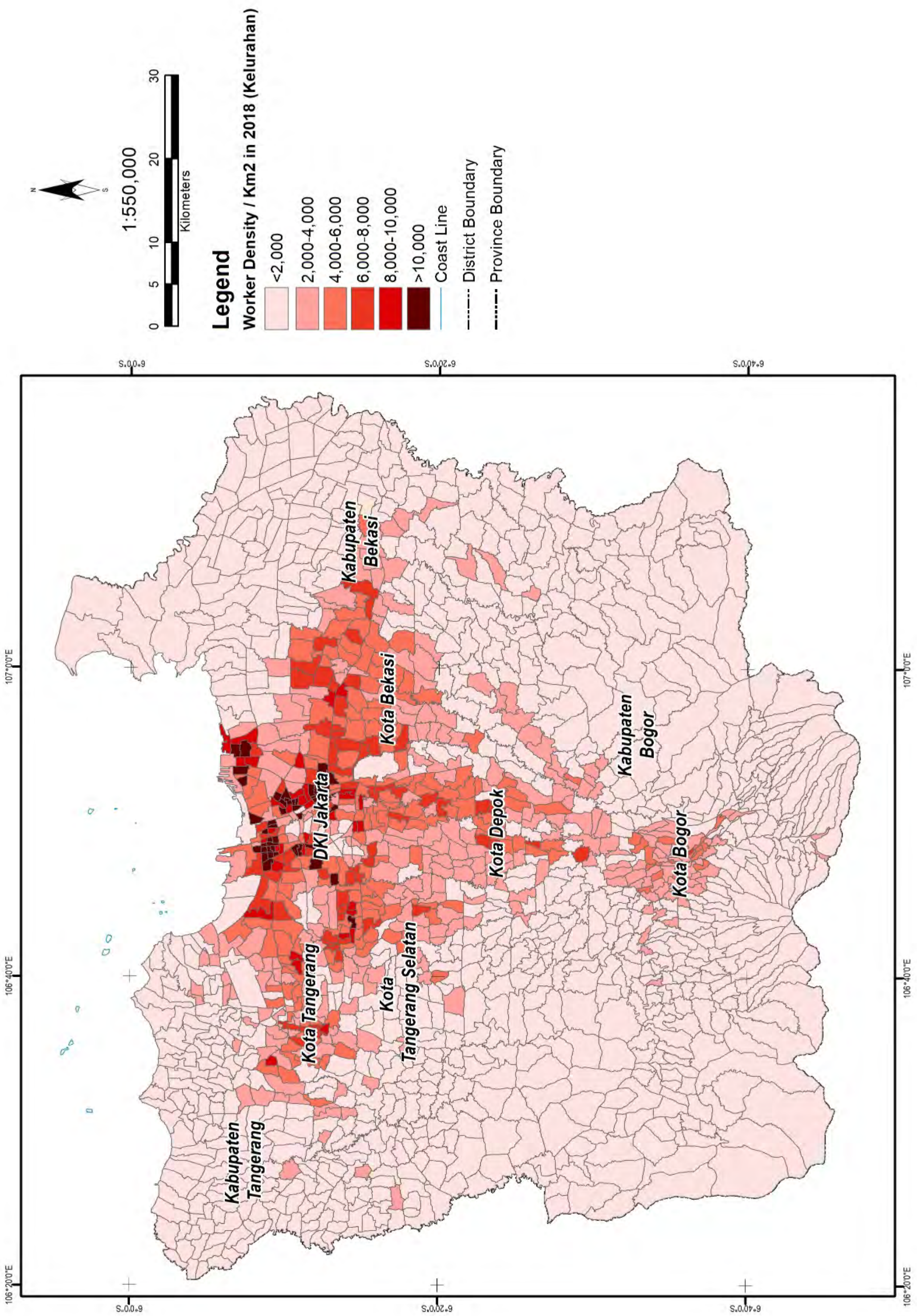


Figure 21 Workers Density by *Kelurahan* 2018

Source: JUTPI 2

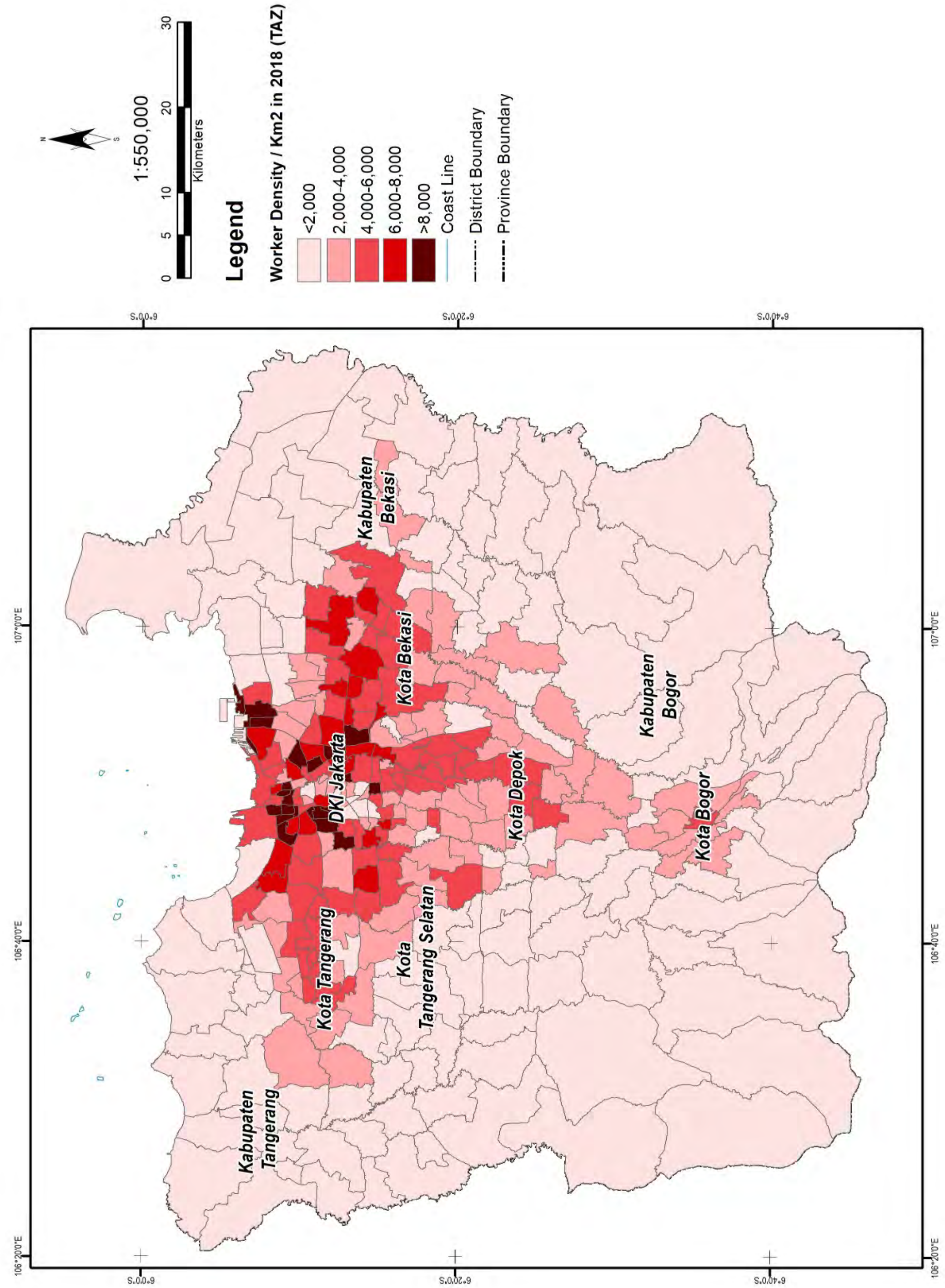


Figure 22 Workers Density by TAZ 2018

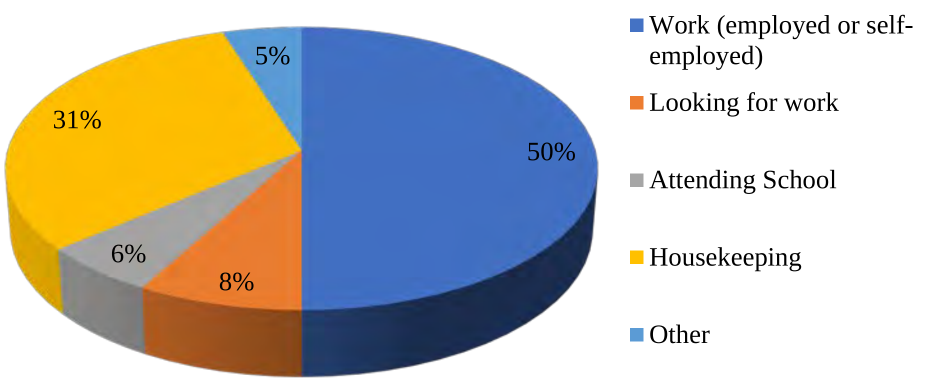
Source: JUTPI 2

Labor force portion relatively different by gender. In 2017 as for males, its portion accounts for 86.6%, while the female is 31.7%. From the percentage, the ratio of people who are looking for work ratio is 8%. On the other hand, the non-economically active population as for males is 13.4% and 68.3% for females. From the non-economically active population, things to focus is housekeeping portion, which is substantially large, accounting for 59.9%.

Table 11 Economic and Non-Economic Active Population Share

Classification	SITRAMP (2002)			JUTPI1 (2010)			(2017)		
	Male (%)	Female (%)	Total (%)	Male (%)	Female (%)	Total (%)	Male (%)	Female (%)	Total (%)
Labour Force	66.9	27.6	47.5	88.5	32.0	59.1	86.6	31.7	58.0
Work (employed or self-employed)	57.7	21.3	39.7	76.1	24.5	49.2	76.7	25.4	50.0
Looking for work	9.2	6.3	7.8	12.4	7.5	9.8	9.9	6.3	8.0
Non-economically active population	33.1	72.4	52.5	4.6	65.2	36.2	13.4	68.3	42.0
Attending School	28.8	27.9	28.4	3.9	4.2	4.1	5.6	5.8	5.7
Housekeeping	0.5	43.6	21.9	0.7	61.0	32.1	0.5	59.9	31.4
Other	3.8	0.9	2.4	6.9	2.8	4.8	7.3	2.7	4.9

Source: JUTPI 2 based on BPS (2017), JUTPI1 (2010), and SITRAMP (2002)



Source: JUTPI 2

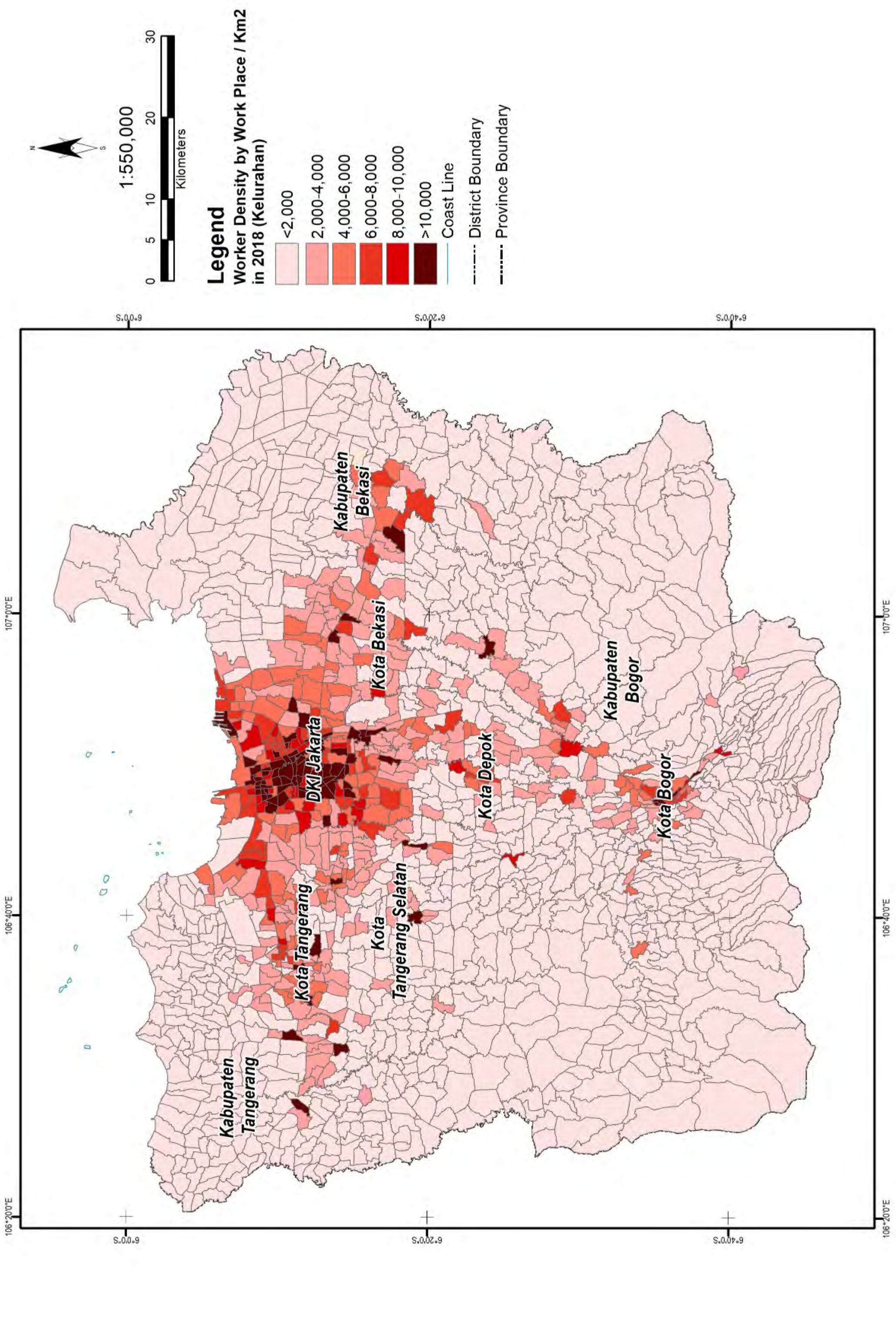
Figure 23 Types of Economic Activity Among JABODETABEK as of 2017

The number of primary sector workers by workplace in Table 12 shows decrease from 2002 to 2010 while that of secondary and tertiary sectors show increase. The tertiary sector made a significant increase in 2018 compared to 2010. Moreover, DKI Jakarta workers' portion shows the trend of decreasing from 2002 to 2018 while trend of increasing is shown in Kabupaten Bogor and Kabupaten Bekasi. The distribution of workers density at workplace by *kelurahan* and TAZ shows a highly concentrated distribution in DKI Jakarta as depicted in Figure 24 and Figure 25.

Table 12 Workers at Workplace

	SITRAMP (2002)							
	Primary		Secondary		Tertiary		Total	
	No. ('000)	%	No. ('000)	%	No. ('000)	%	No. ('000)	Share by region
DKI Jakarta	90	2.5%	627	17.6%	2,849	79.9%	3,565	46.8%
Tangerang	336	46.7%	166	23.1%	218	30.3%	719	9.4%
Kab. Tangerang	108	15.5%	209	30.0%	379	54.5%	696	9.1%
Tangerang Selatan	-	-	-	-	-	-	-	-
Depok	181	46.8%	49	12.7%	157	40.6%	387	5.1%
Bogor	219	49.1%	50	11.2%	177	39.7%	446	5.9%
Kab. Bogor	187	20.1%	256	27.6%	486	52.3%	929	12.2%
Bekasi	132	38.8%	142	41.8%	66	19.4%	340	4.5%
Kab. Bekasi	201	37.6%	133	24.9%	200	37.5%	534	7.0%
Total	1,454	19.1%	1,631	21.4%	4,532	59.5%	7,617	100.0%
	JUTPI 1 (2010)							
	Primary		Secondary		Tertiary		Total	
	No. ('000)	%	No. ('000)	%	No. ('000)	%	No. ('000)	Share by region
DKI Jakarta	86	3.0%	818	28.5%	1,969	68.5%	2,873	40.7%
Tangerang	10	1.7%	146	24.6%	438	73.9%	593	8.4%
Kab. Tangerang	18	3.0%	154	25.7%	428	71.5%	599	8.5%
Tangerang Selatan	23	13.0%	37	20.9%	117	66.1%	177	2.5%
Depok	54	13.1%	135	32.7%	224	54.2%	413	5.8%
Bogor	22	14.0%	78	49.7%	57	36.3%	157	2.2%
Kab. Bogor	85	7.9%	500	46.4%	492	45.6%	1,078	15.3%
Bekasi	20	6.8%	89	30.1%	187	63.2%	296	4.2%
Kab. Bekasi	48	5.5%	281	32.2%	545	62.4%	873	12.4%
Total	365	5.2%	2,238	31.7%	4,457	63.1%	7,060	100.0%
	JUTPI 2 (2018)							
	Primary		Secondary		Tertiary		Total	
	No. ('000)	%	No. ('000)	%	No. ('000)	%	No. ('000)	Share by region
DKI Jakarta	72	1.9%	701	18.7%	2,973	79.3%	3,747	41.1%
Tangerang	8	1.3%	227	37.0%	378	61.6%	614	6.7%
Kab. Tangerang	48	6.4%	346	46.1%	355	47.3%	751	8.2%
Tangerang Selatan	7	1.9%	62	16.5%	306	81.4%	376	4.1%
Depok	9	2.4%	92	24.1%	280	73.5%	381	4.2%
Bogor	13	4.1%	66	21.0%	235	74.6%	315	3.5%
Kab. Bogor	279	19.7%	437	30.9%	696	49.2%	1414	15.5%
Bekasi	9	1.5%	170	28.1%	424	70.1%	605	6.6%
Kab. Bekasi	78	8.6%	461	51.0%	364	40.3%	904	9.9%
Total	528	5.8%	2,566	28.2%	6,015	66.0%	9,110	100.0%

Source: JUTPI 2



Source: JUTPI 2

Figure 24 Workers Density at Workplace by *Kelurahan* 2018

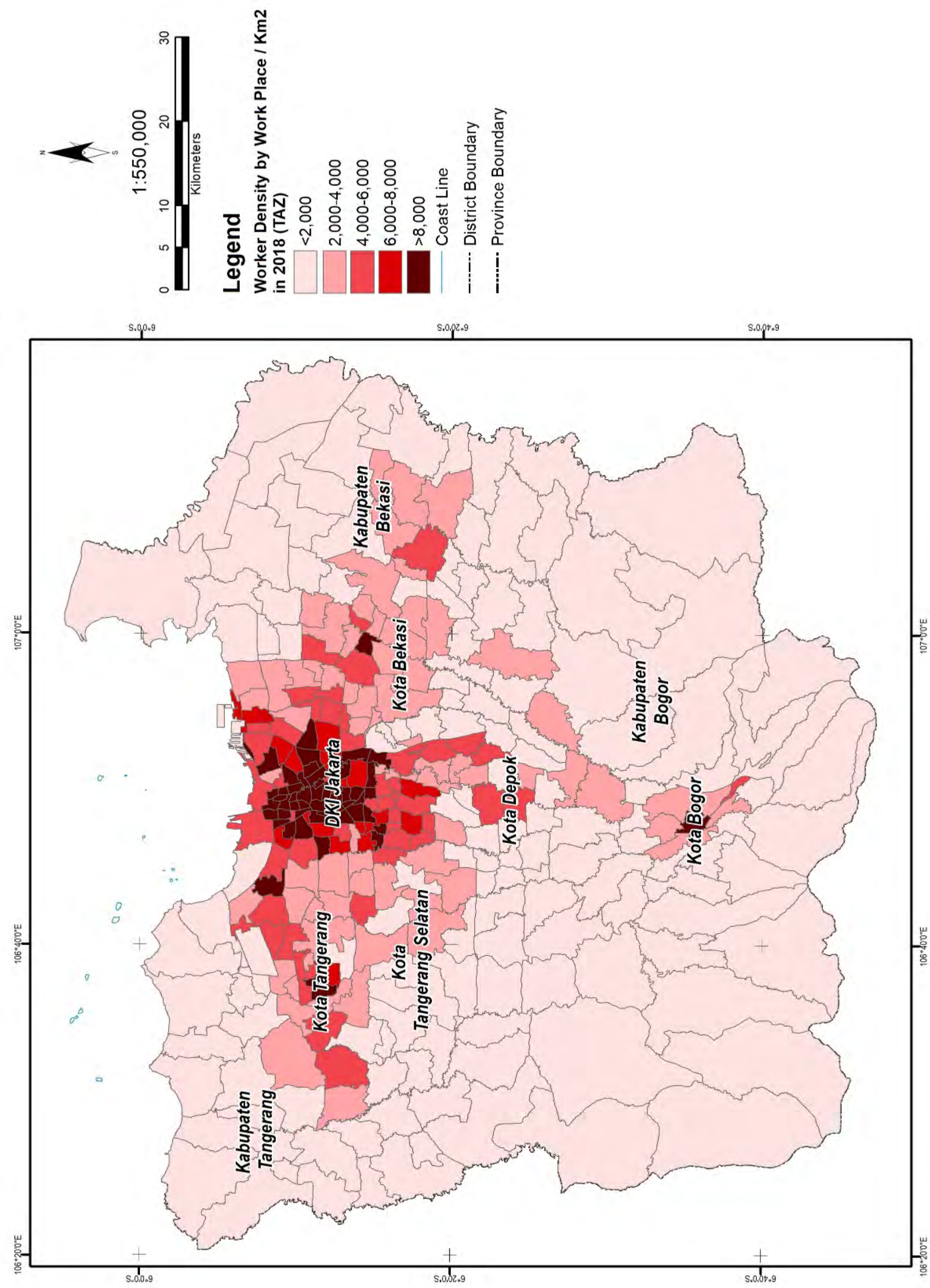


Figure 25 Workers Density at Workplace by TAZ 2018

Source: JUTPI 2

2.3.2 Workers at Residential and Workplace Projection

The number of workers at the residential place and that of the workplace were calculated with population structure and composition as shown in Table 13 and Table 16. The number of workers increases from 7 million in 2010 to 18 million in 2035, and the number of students increases from 6.5 million in 2010 to 10.3 million in 2035 as shown in Table 13.

Table 13 Number of Workers at Residential Place in the Future

City	2010 (JUTPI 1)	2017	2020	2025	2029	2030	2035
Jakarta Selatan	794	739	768	811	849	859	911
Jakarta Timur	621	999	1,034	1,086	1,132	1,144	1,209
Jakarta Pusat	569	323	331	342	351	353	364
Jakarta Barat	453	919	960	1,025	1,085	1,102	1,193
Jakarta Utara	228	627	648	677	707	715	757
Kab. Tangerang	628	1,166	1,308	1,561	1,792	1,852	2,187
Kota Tangerang	536	785	859	984	1,090	1,117	1,262
Kota Tangerang Selatan	215	566	638	765	880	910	1,071
Kab. Bogor	1,221	1,746	1,928	2,250	2,525	2,597	2,976
Kab. Bekasi	807	1,166	1,342	1,679	1,997	2,080	2,560
Kota Bogor	180	335	363	410	448	458	507
Kota Bekasi	344	947	1,052	1,239	1,397	1,439	1,657
Kota Depok	570	752	855	1,047	1,221	1,266	1,518
Total	7,164	11,069	12,087	13,873	15,474	15,891	18,174

Unit: 1,000 persons
Source: JUTPI 2

The number of workers is estimated considering the share of the work sector and growth rate. As the trend is different by each *kabupaten/kota*, the share of the work sector is considered by averaging the number of shares in *kabupaten/kota*. Considering the recent trend, it is assumed that the share of workers in the primary and secondary sectors will decrease while the share of the tertiary sector will increase. The estimated share of workers by sector is shown in Table 14.

Table 14 The Future Share of Worker by Sector in 2035

Sector	City	2002 (SITRAMP)	2010 (JUTPI 1)	Average share	2035 Assumption
Primary	DKI Jakarta	2%	2%	1%	0.4%
	Kab. Tangerang	12%	8%	8%	3%
	Kota Tangerang	2%	2%	1%	0.4%
	Kota Tangerang Selatan	-	3%	1%	0.4%
	Kab. Bogor	18%	17%	13%	4%
	Kab. Bekasi	21%	15%	11%	4%
	Kota Bogor	6%	5%	3%	1%
	Kota Bekasi	3%	2%	1%	0.5%
	Kota Depok	4%	3%	2%	1%
	Total	8%	6%	5%	2%
Secondary	DKI Jakarta	19%	17%	19%	11%
	Kab. Tangerang	29%	40%	40%	29%
	Kota Tangerang	34%	29%	32%	20%
	Kota Tangerang Selatan	-	14%	11%	6%
	Kab. Bogor	26%	28%	25%	17%
	Kab. Bekasi	32%	38%	36%	26%
	Kota Bogor	24%	21%	18%	11%
	Kota Bekasi	27%	29%	25%	16%
	Kota Depok	21%	21%	16%	9%
	Total	24%	25%	24%	16%
Tertiary	DKI Jakarta	78%	81%	80%	89%
	Kab. Tangerang	60%	51%	52%	68%
	Kota Tangerang	64%	70%	67%	79%
	Kota Tangerang Selatan	-	84%	88%	93%
	Kab. Bogor	56%	54%	62%	79%
	Kab. Bekasi	47%	47%	53%	70%
	Kota Bogor	69%	74%	79%	88%
	Kota Bekasi	69%	69%	73%	84%
	Kota Depok	74%	76%	82%	90%
	Total	68%	69%	71%	82%
Total	DKI Jakarta	100%	100%	100%	100%
	Kab Tangerang	100%	100%	100%	100%
	Kota Tangerang	100%	100%	100%	100%
	Kota Tangerang Selatan	-	100%	100%	100%
	Kab. Bogor	100%	100%	100%	100%
	Kab. Bekasi	100%	100%	100%	100%
	Kota Bogor	100%	100%	100%	100%
	Kota Bekasi	100%	100%	100%	100%
	Kota Depok	100%	100%	100%	100%
	Total	100%	100%	100%	-

Source: JUTPI 2

Based on population structure and the assumption of the worker by sector, the number of workers by residential place in 2035 is estimated. Most of the workers are engaged in tertiary activities for 82%, followed by secondary sectors with 16% and primary sectors with 2%. The tertiary sector is distinguished in DKI Jakarta, Kabupaten Bogor, and Kabupaten Bekasi in terms of the number of workers. Primary sector has a large portion in Kabupaten Bogor, Kabupaten Bekasi, and Kabupaten Tangerang, while secondary sector has a large portion in Kabupaten Bekasi and Kabupaten Tangerang. Further information of the number of workers can be seen in the table below.

Table 15 The Number of Workers by Sector at Residential Place in 2035

	Primary		Secondary		Tertiary		Total	
	No. ('000)	%	No. ('000)	%	No. ('000)	%	No ('000)	Share by region
DKI Jakarta	22	0.5%	459	10.3%	3,954	89.2%	4,435	24.4%
Kota Tangerang	6	0.5%	246	19.5%	1,009	80.0%	1,262	6.9%
Kab. Tangerang	76	3.5%	605	27.7%	1,507	68.9%	2,187	12.0%
Kota Tangerang - Selatan	5	0.5%	66	6.2%	1,001	93.5%	1,071	5.9%
Kota Depok	12	0.8%	134	8.8%	1,372	90.4%	1,518	8.4%
Kota Bogor	7	1.4%	57	11.2%	443	87.4%	507	2.8%
Kab. Bogor	187	6.3%	486	16.3%	2,303	77.4%	2,976	16.4%
Kota Bekasi	10	0.6%	249	15.0%	1,398	84.4%	1,657	9.1%
Kab. Bekasi	119	4.6%	641	25.0%	1,801	70.4%	2,560	14.1%
Total	305	1.7%	2,896	15.9%	14,973	82.4%	18,174	100.0%

Source: JUTPI 2

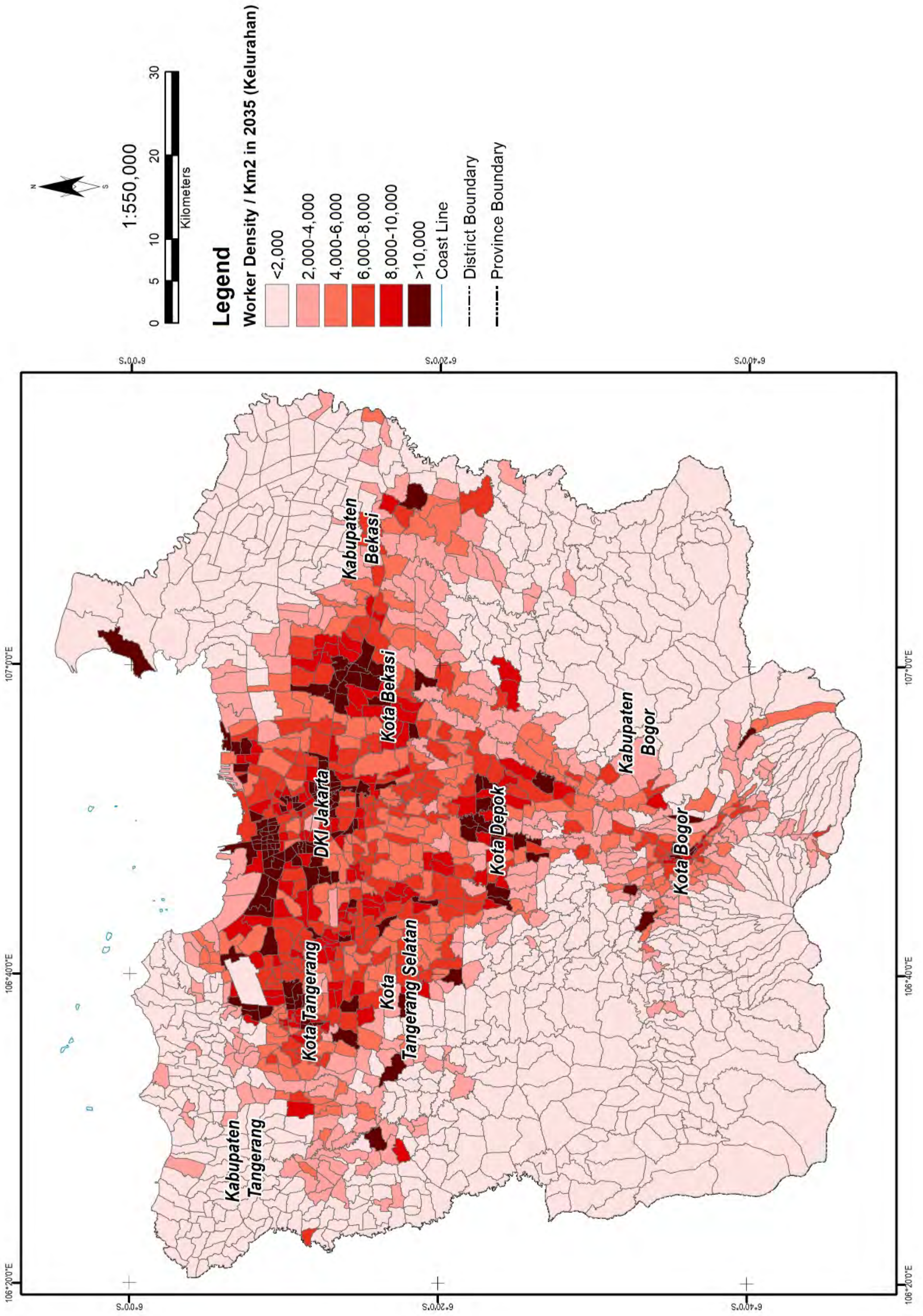
According to the population structure, it is assumed that workers at the workplace are affected by regional industries' development plans. In the future, most of the workers are in the tertiary sector. Roughly half of the workers in the secondary sector will work at Kabupaten Bekasi that accounts for 50.3% of the total workers in that regency.

Table 16 Number of Workers at Workplace in 2035

2035	Workplace Base							
	Primary		Secondary		Tertiary		Total	
	No. ('000)	%	No. ('000)	%	No. ('000)	%	No. ('000)	Share by region
DKI Jakarta	62	0.8%	790	10.4%	6,776	88.8%	7,628	39.4%
Tangerang	6	0.4%	103	6.4%	1,487	93.1%	1,597	8.2%
Kab. Tangerang	13	0.6%	615	28.6%	1,523	70.8%	2,151	11.1%
Tangerang Selatan	17	3.9%	26	5.9%	398	90.2%	441	2.3%
Kota Depok	41	5.1%	96	12.0%	663	82.9%	800	4.1%
Kota Bogor	17	8.2%	56	27.1%	135	65.2%	207	1.1%
Kab. Bogor	65	3.2%	470	23.4%	1,477	73.4%	2,011	10.4%
Kota Bekasi	14	1.9%	63	8.7%	644	89.2%	722	3.7%
Kab. Bekasi	36	0.9%	1,913	50.3%	1,854	48.7%	3,804	19.6%
Total	273	1.4%	4,132	21.3%	14,956	77.2%	19,362	100.0%

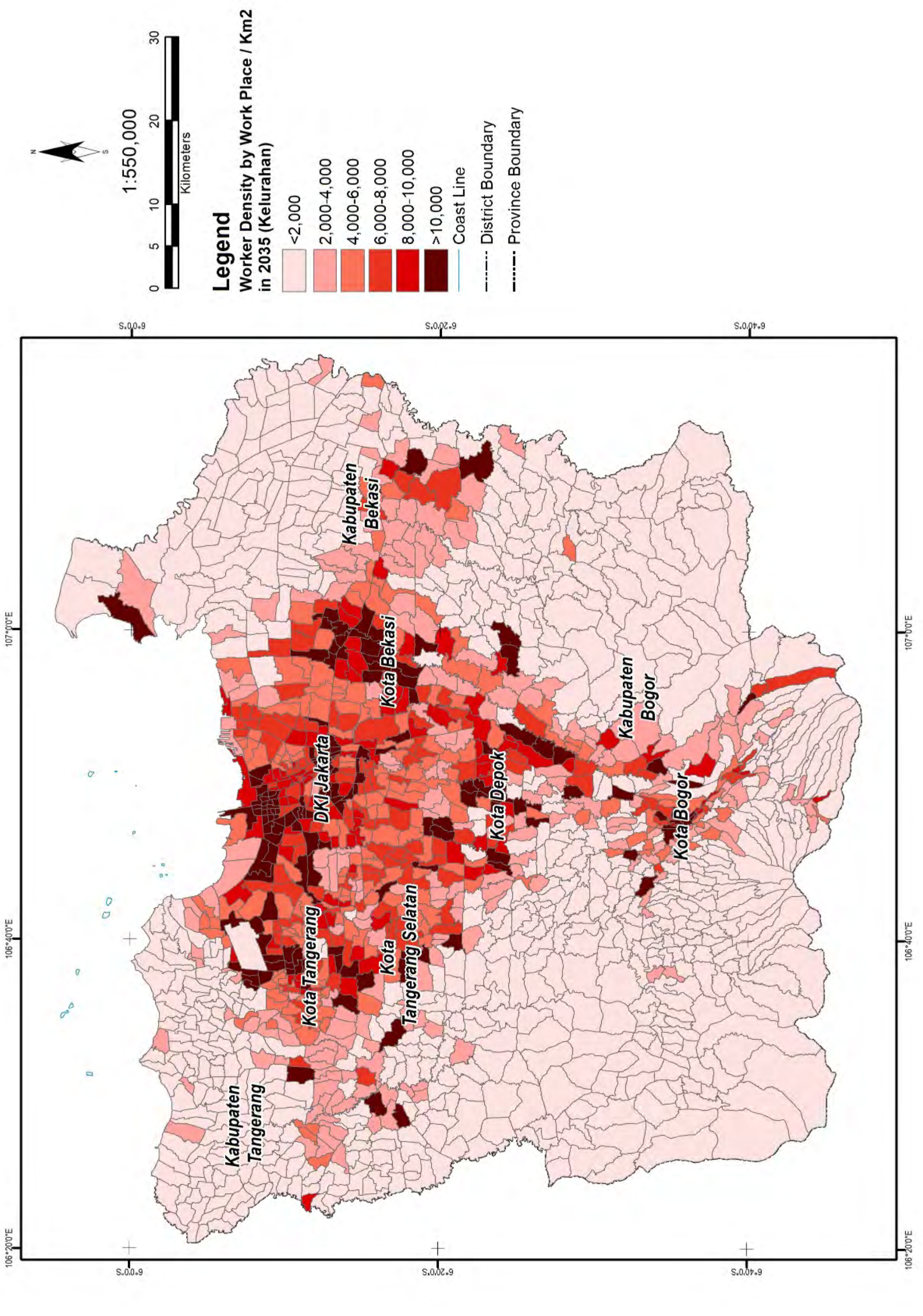
Source: JUTPI 2

Areas traversed by good infrastructure have a fairly large number of workers. Moreover, several industrial estates in *kabupaten* are labor-intensive locations that make the area dense with workers as illustrated in Figure 26 and Figure 27.



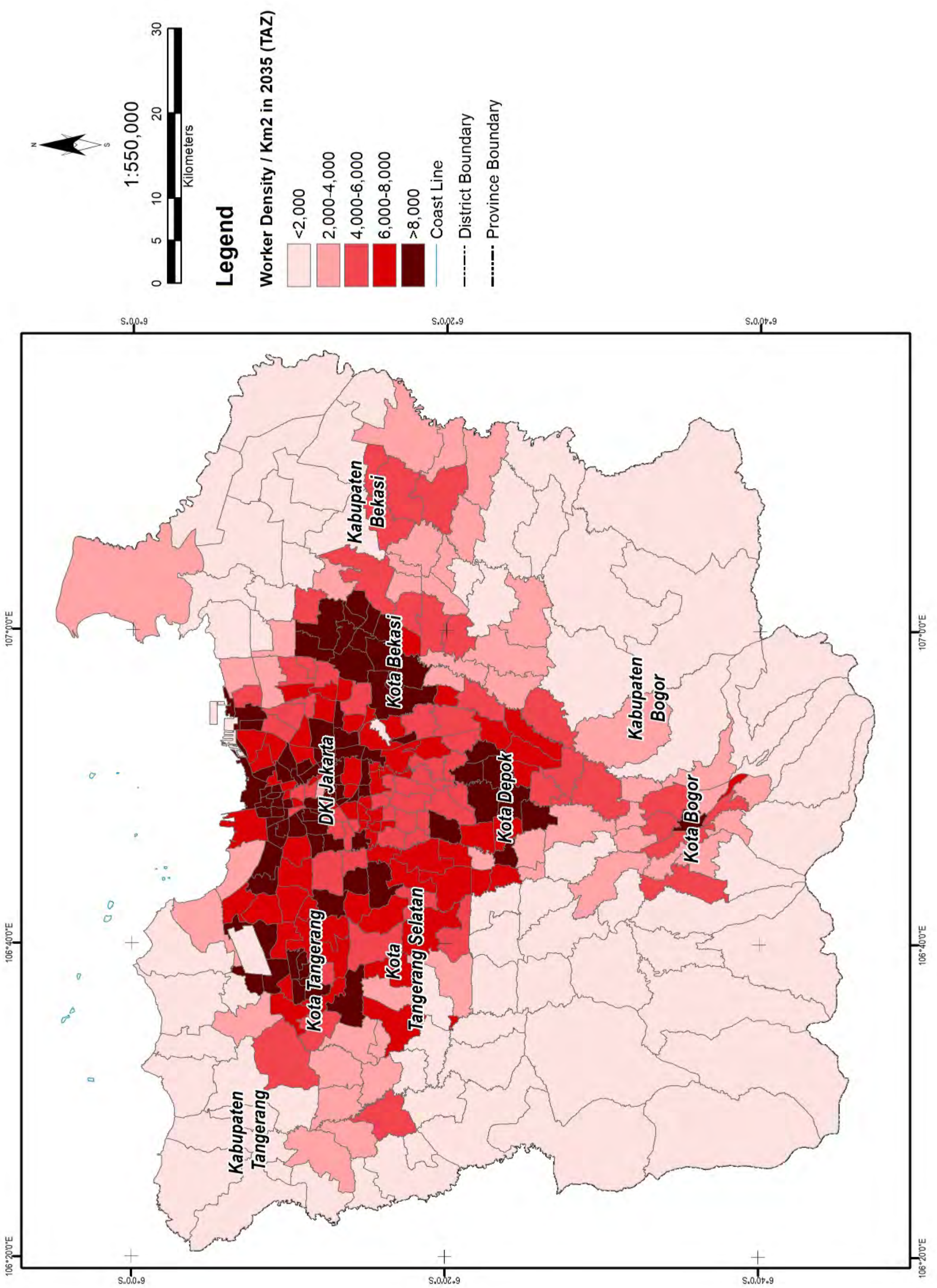
Source: JUTPI 2

Figure 26 Density of Workers at Residential Place by Kelurahan 2035



Source: JUTPI 2

Figure 27 Density of Workers at Workplace by *Kelurahan* 2035



Source: JUTPI 2

Figure 28 Density of Workers at Residential Place by TAZ 2035

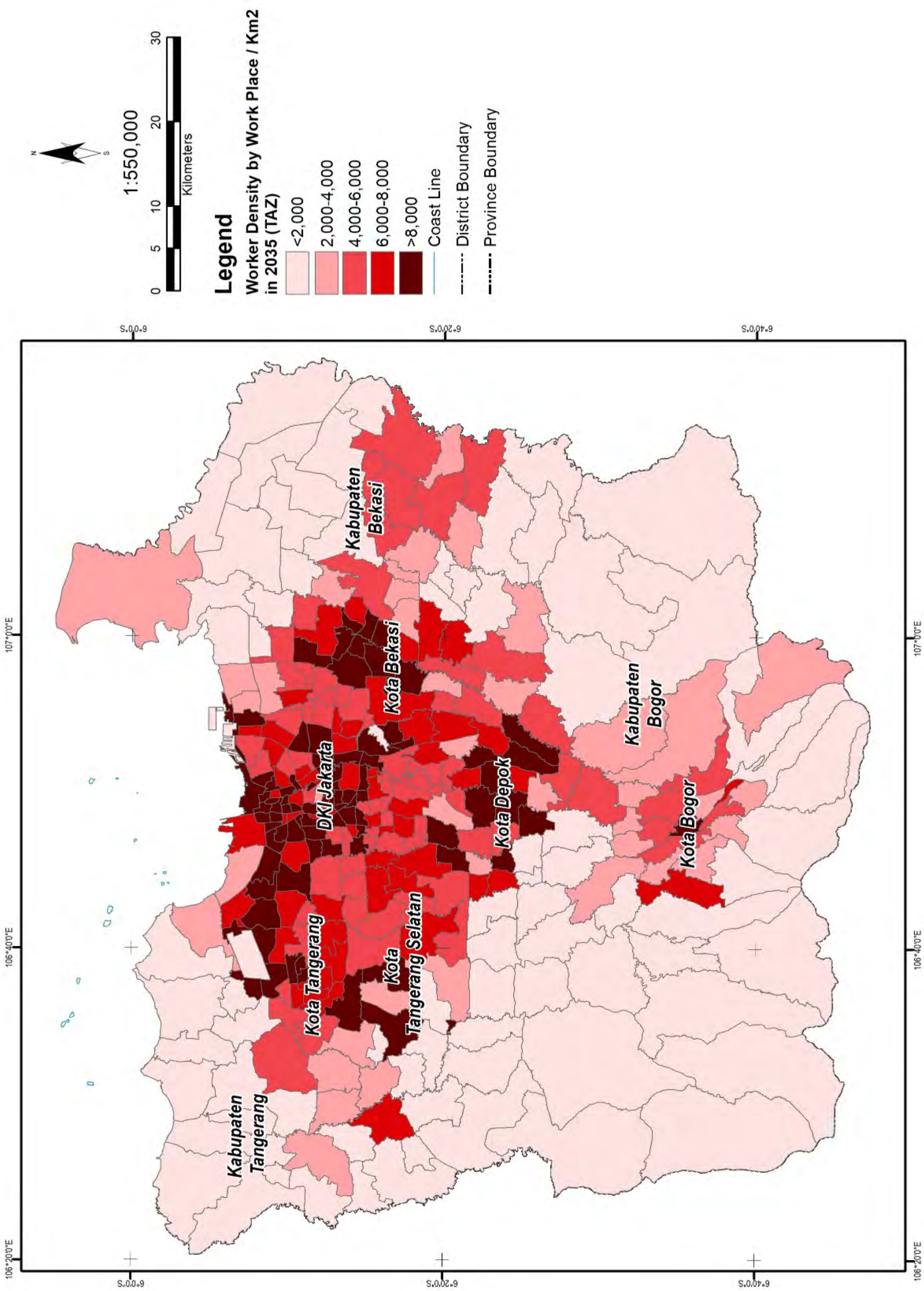


Figure 29 Densithy of Workers at Workplace by TAZ 2035

Source: JUTPI 2

2.3.3 Students at Residential and School Place Profile

The number of students at the residential place is calculated based on BPS data by considering the trend of population growth and pattern of the previous study (SITRAMP and JUTPI 1). Based on prior studies, the number of students in residential place has been increasing from 5.6 million in 2002 to 6.5 million in 2010. Kabupaten Bogor has the highest share followed by Kabupaten Tangerang and Kabupaten Bekasi.

Table 17 The Number of Students at Residential Place

Students	SITRAMP (2002)		JUTPI 1 (2010)		JUTPI 2 (2018)	
	No. (‘000)	%	No. (‘000)	%	No. (‘000)	%
Jakarta Selatan	454	8%	880	13%	459	6%
Jakarta Timur	642	11%	570	9%	616	8%
Jakarta Pusat	195	3%	483	7%	196	3%
Jakarta Barat	498	9%	433	7%	574	7%
Jakarta Utara	380	7%	234	4%	405	5%
Kota Tangerang	389	7%	530	8%	478	6%
Kota Tangerang Selatan	-	-	199	3%	334	4%
Kabupaten Tangerang	759	13%	603	9%	887	12%
Kota Depok	321	6%	432	7%	502	7%
Kota Bogor	196	3%	146	2%	243	3%
Kabupaten Bogor	870	16%	952	15%	1,516	20%
Kota Bekasi	518	9%	349	5%	640	8%
Kabupaten Bekasi	420	8%	734	11%	814	11%
Total	5,643	100%	6,545	100%	7,664	100%

Source: JUTPI 2 based on SITRAMP (2002), and JUTPI 1 (2010)

In terms of density, the distribution of students is concentrated in an urbanized area in all *kota*, particularly, in the northern part of JABODETABEK, as illustrated on two maps based on *kelurahan* and TAZ in Figure 30 and Figure 31.

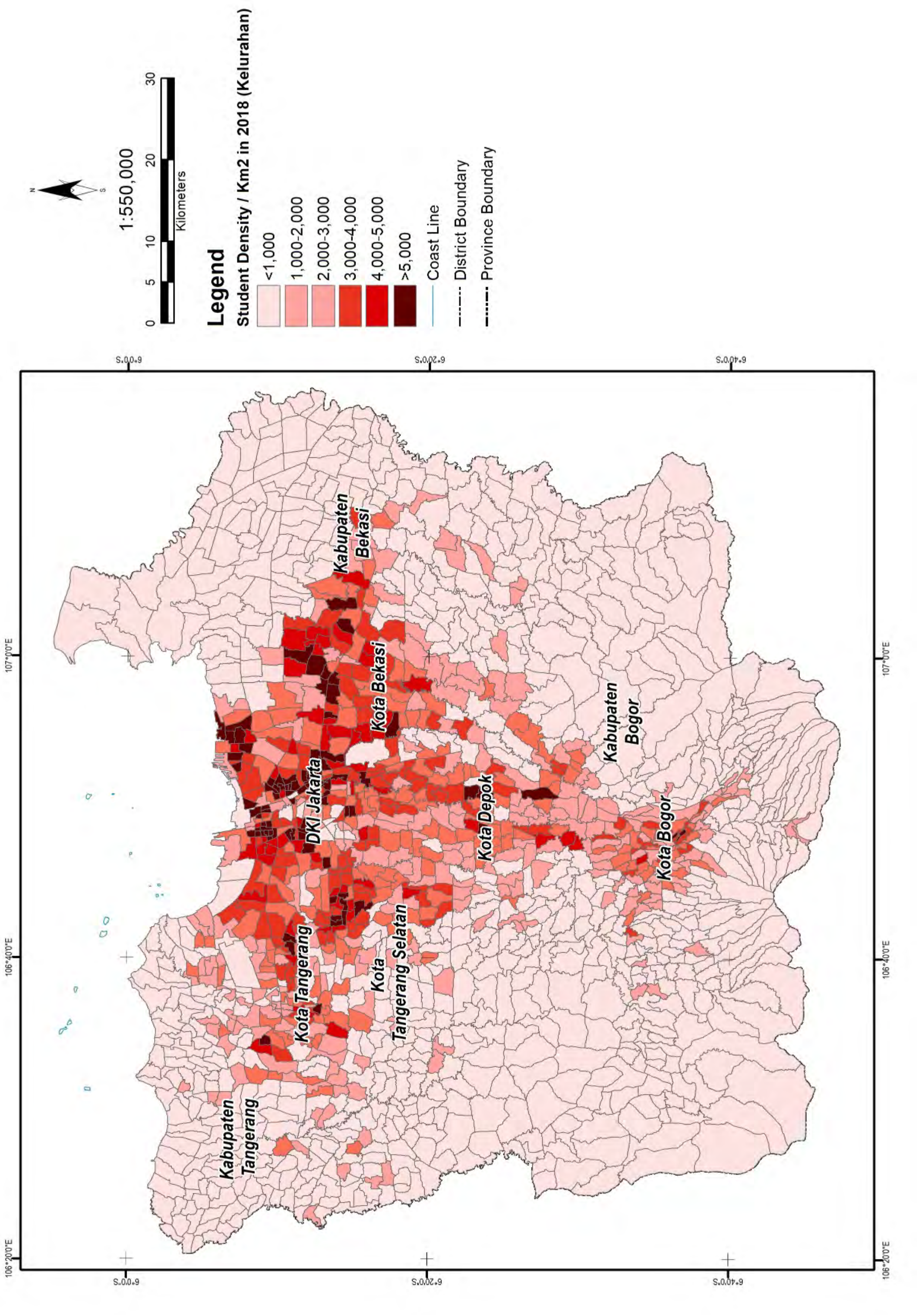
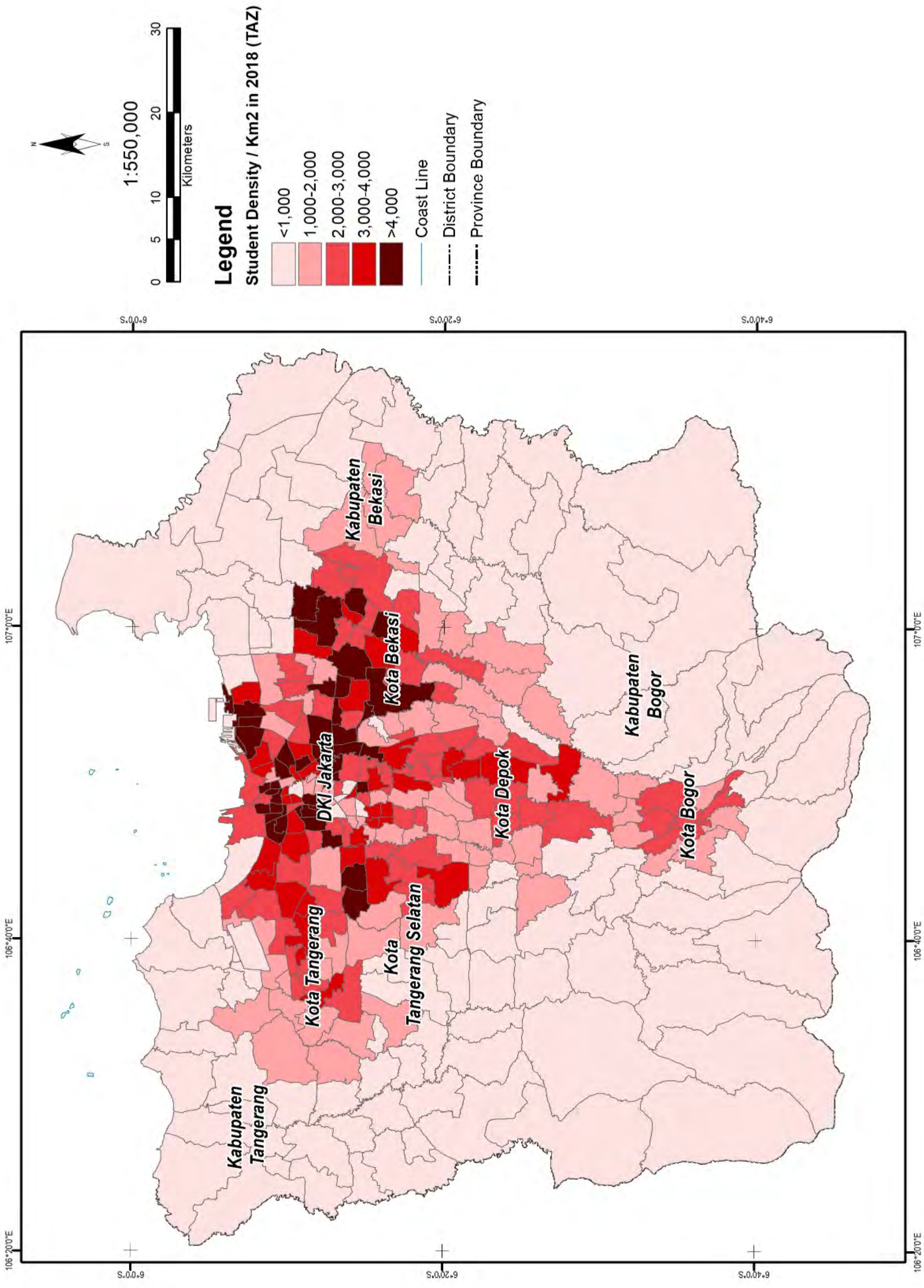


Figure 30 Students Density by *Kelurahan* 2018

Source: JUTPI 2



Source: JUTPI 2

Figure 31 Students Density at Residential Place by TAZ 2018

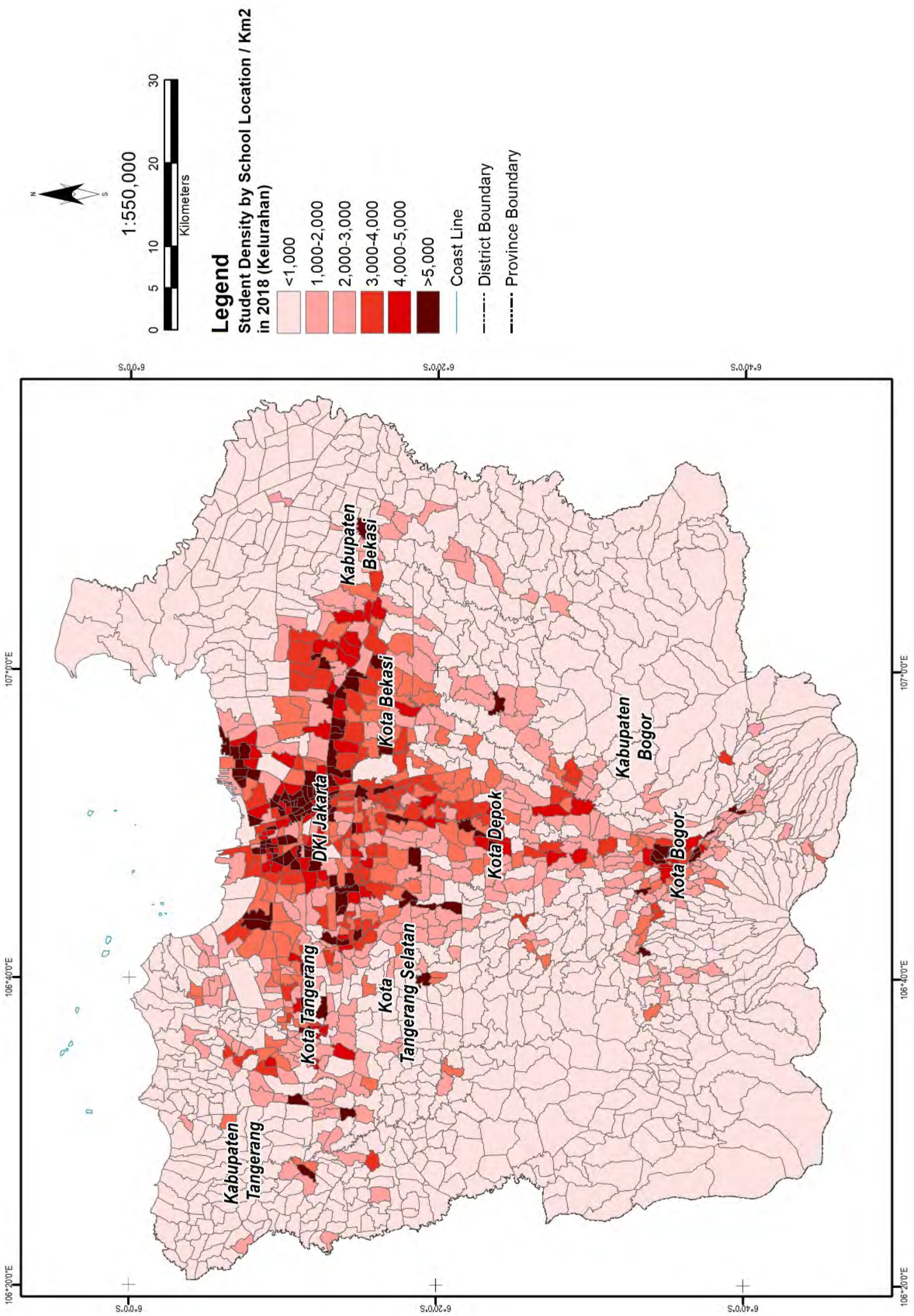
Regarding the school place, the distribution of students by BPS data is almost the same between years as it is dependable on population structure. Below is further information on the number of students at the school place.

Table 18 Number of Students at School Place

Students	SITRAMP (2002)		JUTPI 1 (2010)		2016 (BPS)		2017 (BPS)	
	No. ('000)	%	No. ('000)	%	No. ('000)	%	No. ('000)	%
Jakarta Selatan	576	10%	755	12%	622	9%	617	8%
Jakarta Timur	684	12%	579	9%	641	10%	627	9%
Jakarta Pusat	287	5%	545	8%	278	4%	280	4%
Jakarta Barat	525	9%	426	7%	488	7%	489	7%
Jakarta Utara	313	6%	272	4%	278	4%	275	4%
Kota Tangerang	338	6%	535	8%	411	6%	403	5%
Kota Tangerang Selatan	-	-	236	4%	743	11%	809	11%
Kabupaten Tangerang	707	13%	660	10%	699	10%	700	10%
Kota Depok	312	6%	369	6%	302	5%	384	5%
Kota Bogor	232	4%	135	2%	220	3%	513	7%
Kabupaten Bogor	834	15%	886	14%	1,152	17%	1,134	15%
Kota Bekasi	412	7%	324	5%	369	6%	524	7%
Kabupaten Bekasi	406	7%	754	11%	544	8%	610	8%
Total	5,628	100%	6,383	100%	6,746	100%	7,365	100%

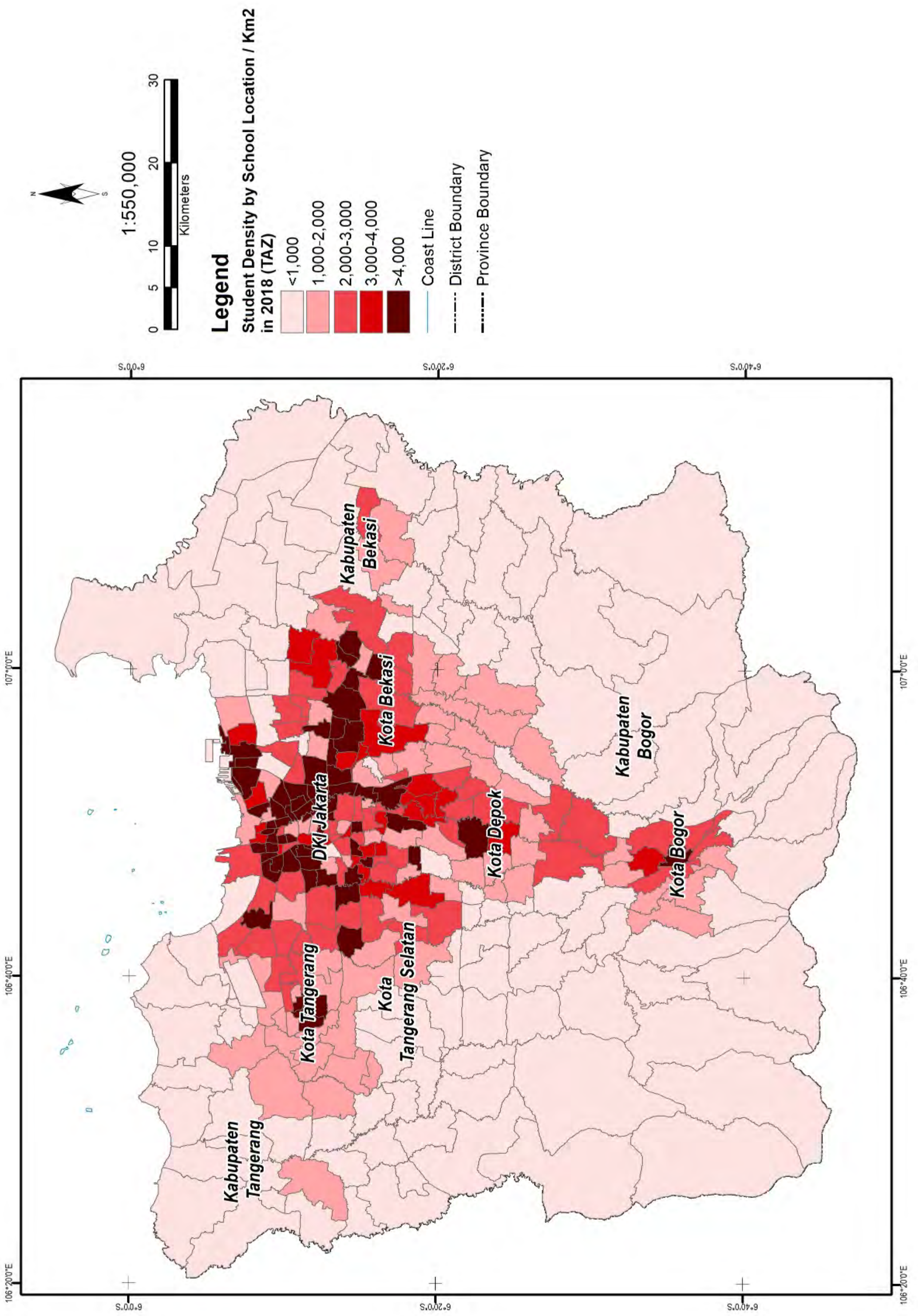
Source: JUTPI 2 based on BPS (2017), JUTPI1 (2010), and SITRAMP (2002)

In the following figures about student density at school location by *kelurahan* and TAZ, it is shown that DKI Jakarta, Kota Bekasi, and Kota Depok have a uniform student distribution. Moreover, some areas in DKI Jakarta and Kota Bekasi have dense student distribution. Similar to student distribution by residential place case, Kabupaten Bogor, Kabupaten Tangerang, and Kabupaten Bekasi have uneven student distribution, due to a broader area and not fully developed.



Source: JUTPI 2

Figure 32 Student Density at School Locations by Kelurahan 2018



Source: JUTPI 2

Figure 33 Student Density at School Locations by TAZ 2018

2.3.4 Students at Residential and School Place Projection

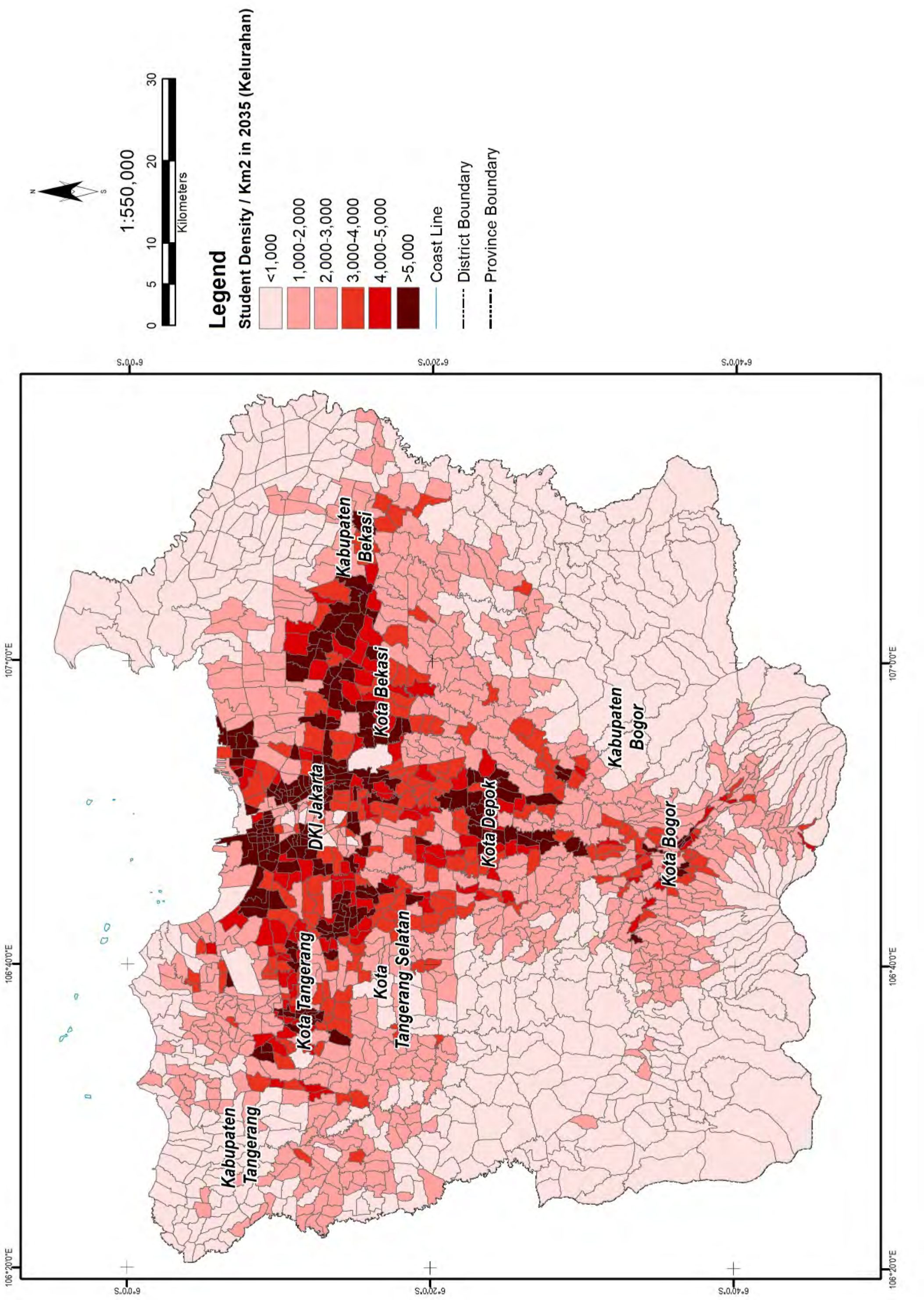
The number of students in JABODETABEK area in year 2035 is predicted at 10.2 million with the highest portion of distribution located in three *kabupaten* area, namely Kabupaten Bogor, Kabupaten Tangerang, and Kabupaten Bekasi. Both students by residential place and school location are almost similar in total students.

Table 19 Estimation of Student Distribution

Students	JUTPI 1 (2010)				2018				2035 Assumption			
	School Place	%	Residential Place	%	School Place	%	Residential Place	%	School Place	%	Residential Place	%
Jakarta Selatan	755	12%	880	13%	617	8%	357	6%	475	5%	493	5%
Jakarta Timur	579	9%	570	9%	627	9%	523	8%	667	7%	652	6%
Jakarta Pusat	545	8%	483	7%	280	4%	182	3%	186	2%	182	2%
Jakarta Barat	426	7%	433	7%	489	7%	419	7%	627	6%	670	7%
Jakarta Utara	272	4%	234	4%	275	4%	323	5%	450	4%	440	4%
Kota Tangerang	535	8%	530	8%	403	5%	374	6%	609	6%	600	6%
Kab. Tangerang	660	10%	603	9%	809	11%	319	5%	1,361	13%	1,320	13%
Kota Tangerang Selatan	236	4%	199	3%	700	10%	669	11%	611	6%	500	5%
Kota Depok	369	6%	432	7%	384	5%	374	6%	787	8%	805	8%
Kota Bogor	135	2%	146	2%	513	7%	221	4%	280	3%	287	3%
Kab. Bogor	886	14%	952	15%	1,134	15%	1,124	18%	1,912	19%	2,009	20%
Kota Bekasi	324	5%	349	5%	524	7%	656	11%	866	8%	884	9%
Kab. Bekasi	754	12%	734	11%	610	8%	603	10%	1,405	14%	1,420	14%
Total	6,477	100%	6,545	100%	7,365	100%	6,144	100%	10,234	100%	10,263	100%

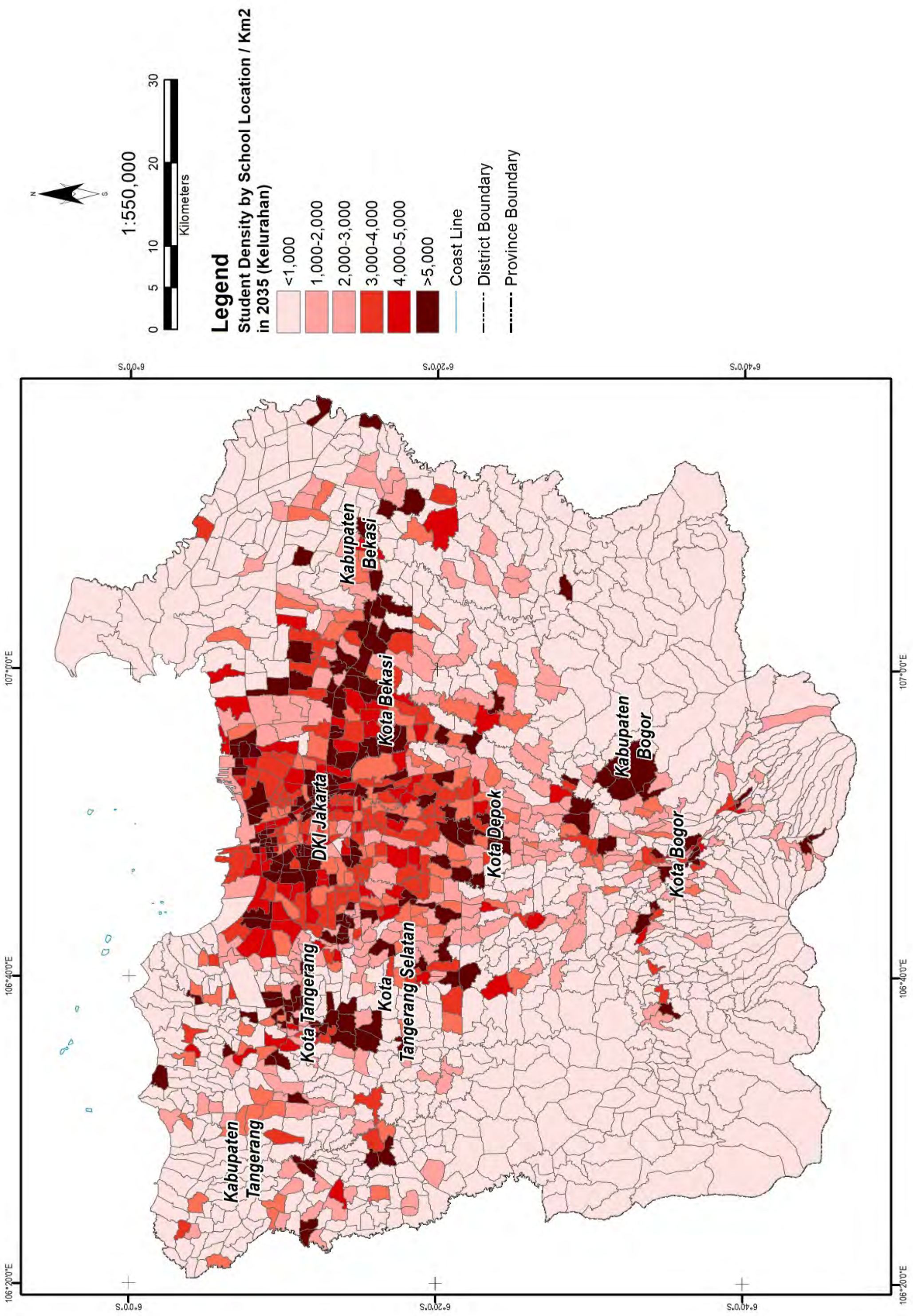
Unit: 1000 persons
Source: JUTPI 2

In the following Figure 34 and Figure 35, it is shown that locations with good transportation infrastructures have higher density. Moreover, certain locations such as Kota Bekasi and Jakarta Barat have a dense student number. In some locations in the *kabupaten* area, the number of students looks dense due to the population in that area.



Source: JUTPI 2

Figure 34 Students Density by Kelurahan 2035



Source: JUTPI 2

Figure 35 Density of Students at School Locations by Kelurahan 2035

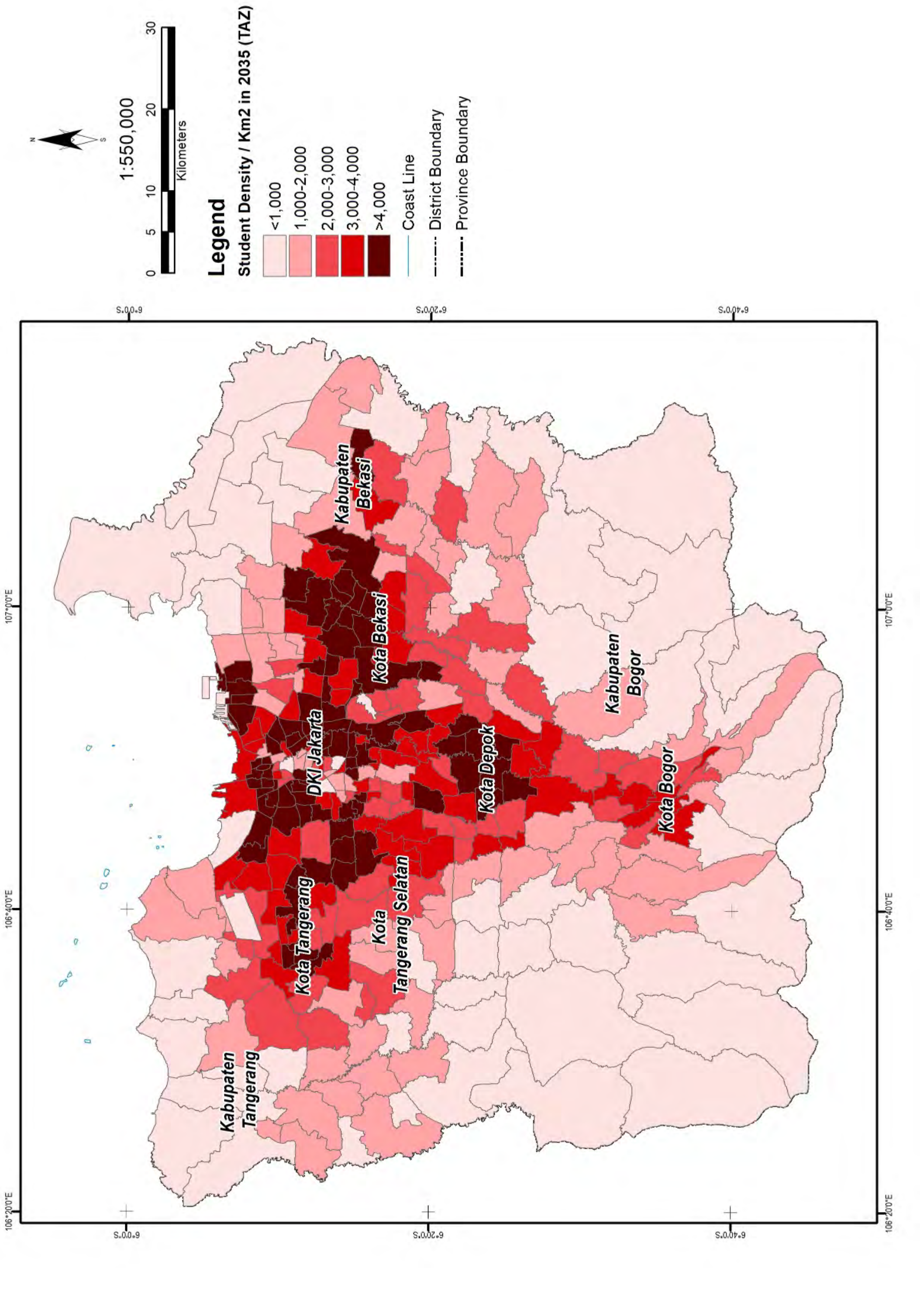
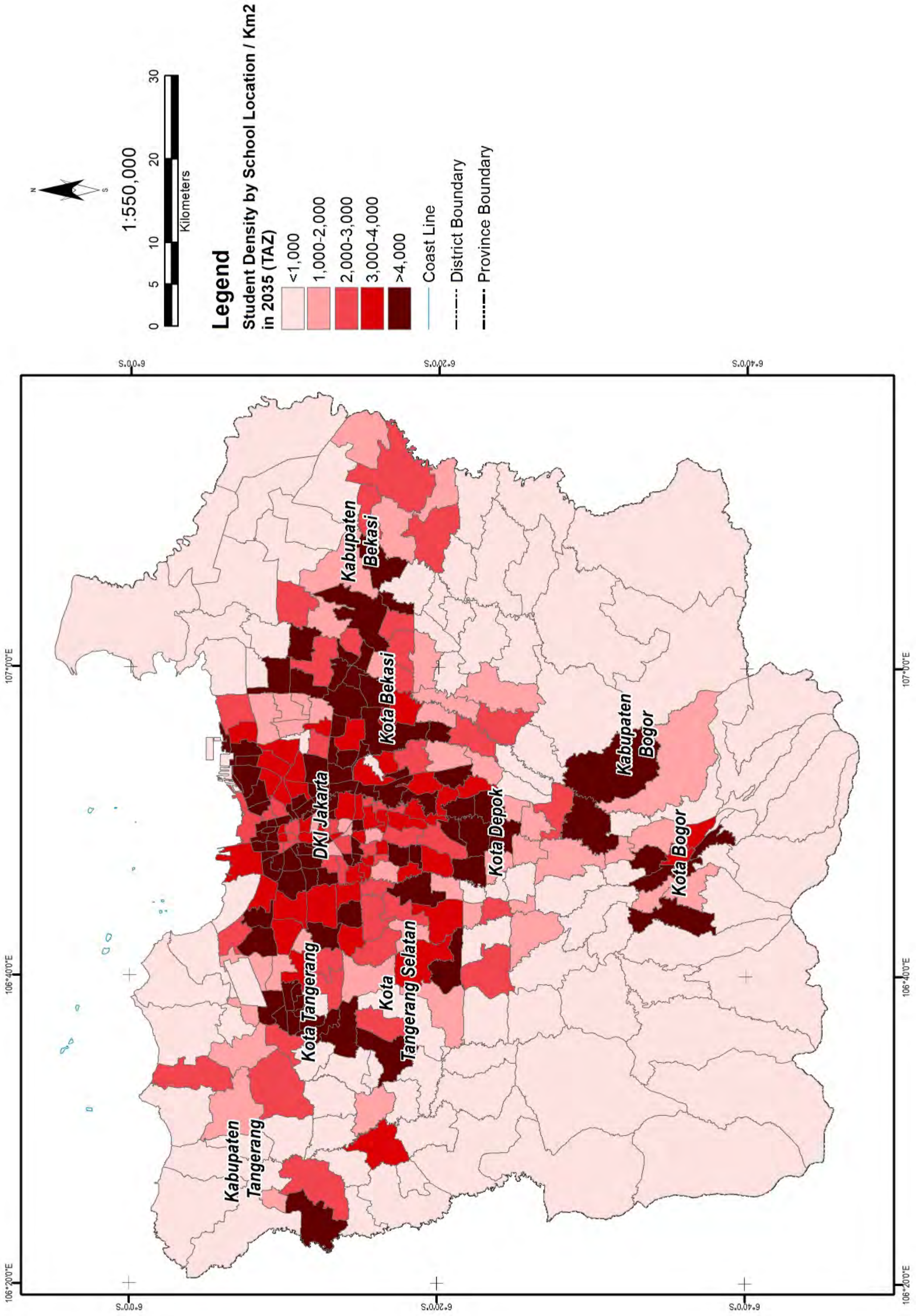


Figure 36 Students Density by TAZ 2035

Source: JUTPI 2



Source: JUTPI 2

Figure 37 Density of Students at School Locations by TAZ 2035

School enrollment will be further promoted in the 5-24-year-old segment of both males and females. Therefore, the population of young inhabitants is forecasted. However, the number of students will account for 25.8%, with an increase of 1.9 points between 2017 and 2035. The increment number of students between 2017 – 2035 has a similar growth between 2010 – 2017. It was forecasted that the number of students will increase by around 3 million between 2017 and 2035.

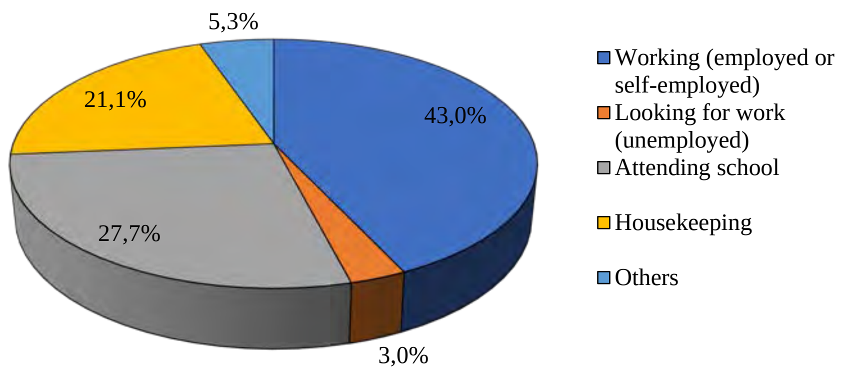
Other non-economically active populations such as students, housewives, and retirees will decrease its share from 56.0% in 2002 to 54.0% mainly due to the decrease of housewives and others (aged inhabitants). As a result, the labor force population share will slightly increase from 44.0% in 2017 to 46.0% in 2035. It is expected that the existing unemployment rate of 6.7% will be improved to 3.0% on the conditions of steady economic growth and moderate migration as shown in the table below.

Table 20 Forecasted Socioeconomic Data of JABODETABEK Residents, 2017, 2035

Category	2017			2035		
	Male (%)	Female (%)	Total (%)	Male (%)	Female (%)	Total (%)
Labor Force	64.4	23.0	44.0	66.5	26.2	46.0
Working (employed or self-employed)	56.3	17.7	37.3	62.1	23.3	43.0
Looking for work (unemployed)	8.1	5.2	6.7	4.4	3.0	3.0
Non-economically Active Population	35.6	77.0	56.0	34.9	73.8	54.0
Attending school	25.9	25.8	25.8	27.7	27.6	27.7
Housekeeping	0.4	47.2	23.5	0.1	42.8	21.1
Others	9.3	4.0	6.7	7.2	3.3	5.3

Source: JUTPI 2

Economic activity composition in 2035 can be illustrated in the following chart, where the worker population (employed or self-employed) will dominate the economic types, followed by groups of attending school and housekeeping.



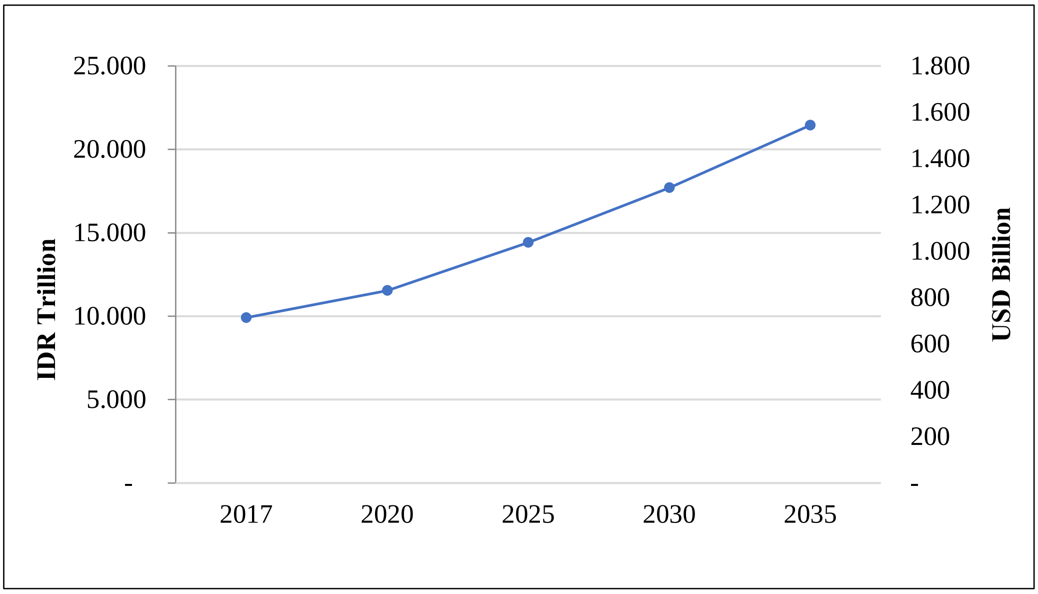
Source: JUTPI 2

Figure 38 Types of Economic Activity among JABODETABEK Inhabitants in 2035

2.4 GDP and GRDP

GDP of Indonesia as of 2017 at the 2010 constant market price is IDR 9,913 trillion or grew 5.4% annually during 2010-2017. For the long-term, future GDP is obtained from OECD data which projected the nation's GDP based on the trend of gross domestic product, assessment of the economic climate and the world economy, using a combination of model-based analyses and measured at constant prices and Purchasing Power Parities (PPPs) of 2010.

Projected GDP is calculated based on the assumption that the economy is in a good condition which generated by household spending and fixed capital investment with an interest rate of 4.25% and targeted to be controlled at 3.0 – 4.0%. After 2020, the growth rate is starting to slow down, and the country's GDP will reach IDR 21,447 trillion in 2035 as depicted in the following figure.



Note: 1 USD = IDR 14,182 (2019)
Source: OECD

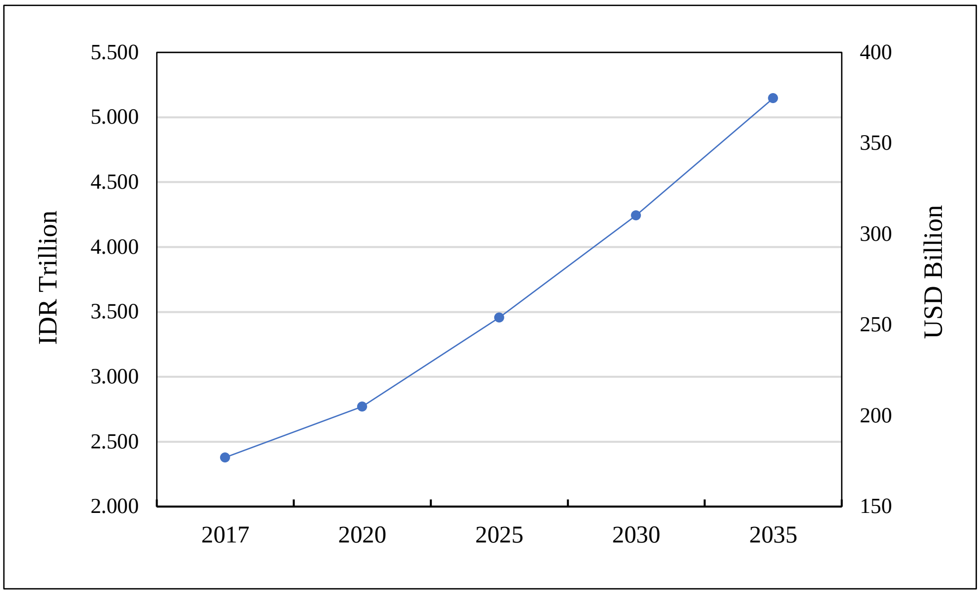
Figure 39 Long-Term GDP Projection Year 2017 – 2035

JABODETABEK's economy has grown more rapidly compared to that of the entire country. JABODETABEK growth surpassed the national GDP with a 0.66% margin. Following the forecast of GDP, it is assumed that the GRDP growth rate of JABODETABEK will be stable around 5% for a couple of years to come by considering the recent trend of GRDP.

Table 21 Projected GRDP and GRDP Per Capita

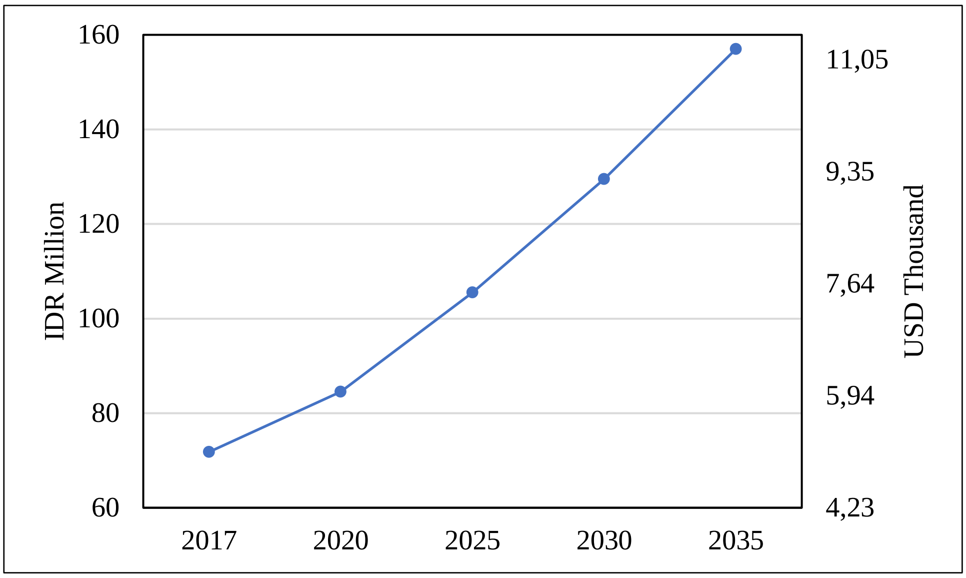
	2017	2020	2025	2030	2035
GRDP (trillion IDR)	2,379	2,770	3,457	4,245	5,147
GRDP (billion USD)	168	195	244	299	363
Population (million persons)	33.1	35.3	38.8	42.1	45.3
GRDP Per Capita (million IDR)	71.8	84.5	105.5	129.5	157
GRDP Per Capita (USD)	5,063	5,958	7,439	9,131	11,070

Note: 1 USD = IDR 14,182 (2019)
Source: JUTPI 2



Note: 1 USD = IDR 14,182 (2019)
Source: JUTPI 2

Figure 40 GRDP Projection of JABODETABEK Year 2017 – 2035



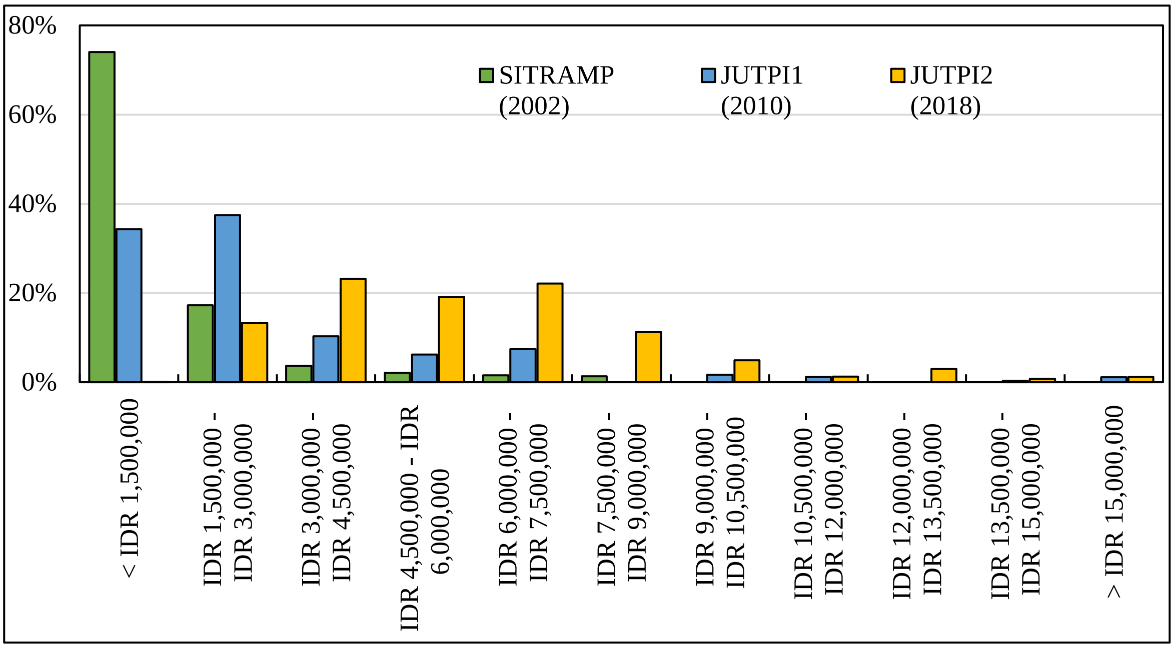
Source: JUTPI 2
Note: 1 USD = IDR 14,182 (2019)

Figure 41 GRDP Per Capita Projection of JABODETABEK Year 2017 - 2035

In the long-term, it is assumed that the economic growth period will be continued until the next 5 years before starting to slow down in the next few years. On the other hand, GRDP and GRDP per capita projection will make a growth due to the completion of RITJ, some infrastructure projects, and improvement in the transportation system.

2.5 Household Income

Household income level is an important factor in choosing modes of transportation. This study estimated household income distributions in future years. The household income value is growing over the years and depicts the overall growth of economic conditions in JABODETABEK. In the early 2000s, most of the households' monthly income was less than IDR 3 million, and even more than 70% of households were within "less than IDR 1.5 million." In 2010, the highest share of households was within the range of "IDR 1.5 to 3 million" (37.5%) and is followed by 34% of households in "less than IDR 1.5 million." On the other hand, almost 90% of households in 2018 are fairly grouped in the income range of "IDR 1.5 – 9 million" and the largest share of 64% is in "IDR 3 to 7.5 million." As depicted in the figure below.



Source: JUTPI 2 based on SITRAMP (2002) and JUTPI 1 (2010)

Figure 42 Changing Household Income Distribution in JABODETABEK (in 2002, 2010, and 2018)

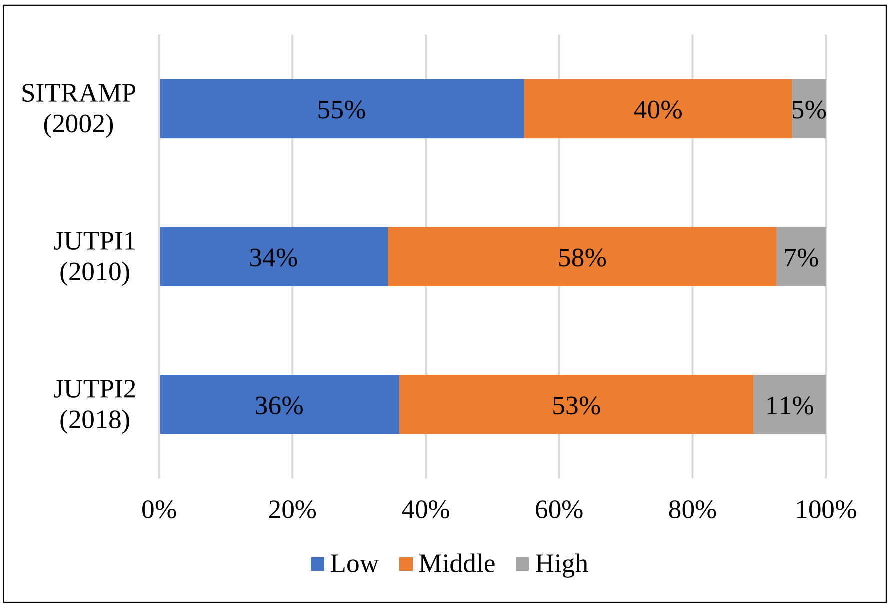
For further analysis, household income is classified into three income groups: Low-, Middle-, and High-income groups. The definition of income range has been adjusted by considering the income distribution of respondents in each survey period (SITRAMP, JUTPI 1, and JUTPI 2), the regional economic condition, and the Consumer Price Index (CPI) throughout the years. Below table shows the changing of household income group and average household income in the year of 2002, 2010, and 2018.

Table 22 Changing Household Income Group (Year of 2002, 2010, and 2018)

SITRAMP (2002) – Avg. Income: 1.30 Mill IDR/month -
INCOME GROUP: Low : < IDR 1,000,000 Middle : IDR 1,000,000 – IDR 4,000,000 High : > IDR 4,000,000
JUTPI 1 (2010) – Avg. Income: 2.75 Mill DR/month -
INCOME GROUP: Low : < IDR 1,500,000 Middle : IDR 1,500,000 – IDR 6,000,000 High : > IDR 6,000,000
JUTPI 2 (2018) – Avg. Income: 6.15 Mill IDR/month -
INCOME GROUP: Low : < IDR 4,000,000 Middle : IDR 4,000,000 – IDR 10,000,000 High : > IDR 10,000,000

Source: JUTPI 2

With an increase of average income over the years, high-income share increases for more than doubled; from only 5% in 2002 to 11% in 2018. On the other hand, low-income share decreases from 55% to 35% and middle-income share increases from 40% in 2002 to 53% in 2018 as shown in the following figure.



Source: JUTPI 2

Figure 43 Changing Household Income Composition

Household income ratio by *kota/kabupaten* shows that Kabupaten Bogor has the largest share of low-income householda, while the proportion of middle-income households is the largest in Kabupaten Bekasi. High-income household is mostly found in Jakarta Selatan and Kota Tangerang Selatan. The number of household income and its ratio by *kota/kabupaten* can be seen in the table below.

Table 23 Household Income Ratio by *Kota/kabupaten*

City	Low-Income		Middle-Income		High-Income		Total (000)
	No. (000)	%	No. (000)	%	No. (000)	%	
Jakarta Selatan	190	27%	393	55%	130	18%	713
Jakarta Timur	280	30%	528	56%	135	14%	943
Jakarta Pusat	96	33%	157	55%	35	12%	288
Jakarta Barat	267	32%	477	56%	104	12%	848
Jakarta Utara	178	30%	319	54%	99	17%	596
Kabupaten Bogor	871	59%	570	39%	36	2%	1,477
Kabupaten Bekasi	321	36%	520	59%	46	5%	888
Kota Bogor	137	52%	113	43%	13	5%	263
Kota Bekasi	193	28%	401	58%	96	14%	690
Kota Depok	212	37%	313	55%	46	8%	571
Kab. Tangerang	317	38%	457	55%	53	6%	828
Kota Tangerang	211	36%	324	56%	47	8%	581
Kota Tangerang Selatan	141	32%	230	52%	70	16%	441
Total	3,414	37%	4,802	53%	910	10%	9,126

Source: JUTPI 2

Chapter 3 ZONE SYSTEM AND NETWORK DEVELOPMENT

3.1 Coverage Area for Travel Demand Forecast

The coverage area of the travel demand forecast encompasses JABODETABEK, which comprises DKI Jakarta and 8 *kota/kabupaten* around it (Kota Tangerang, Kabupaten Tangerang, Kota Tangerang Selatan, Kota Depok, Kota Bogor, Kabupaten Bogor, Kota Bekasi, and Kabupaten Bekasi).

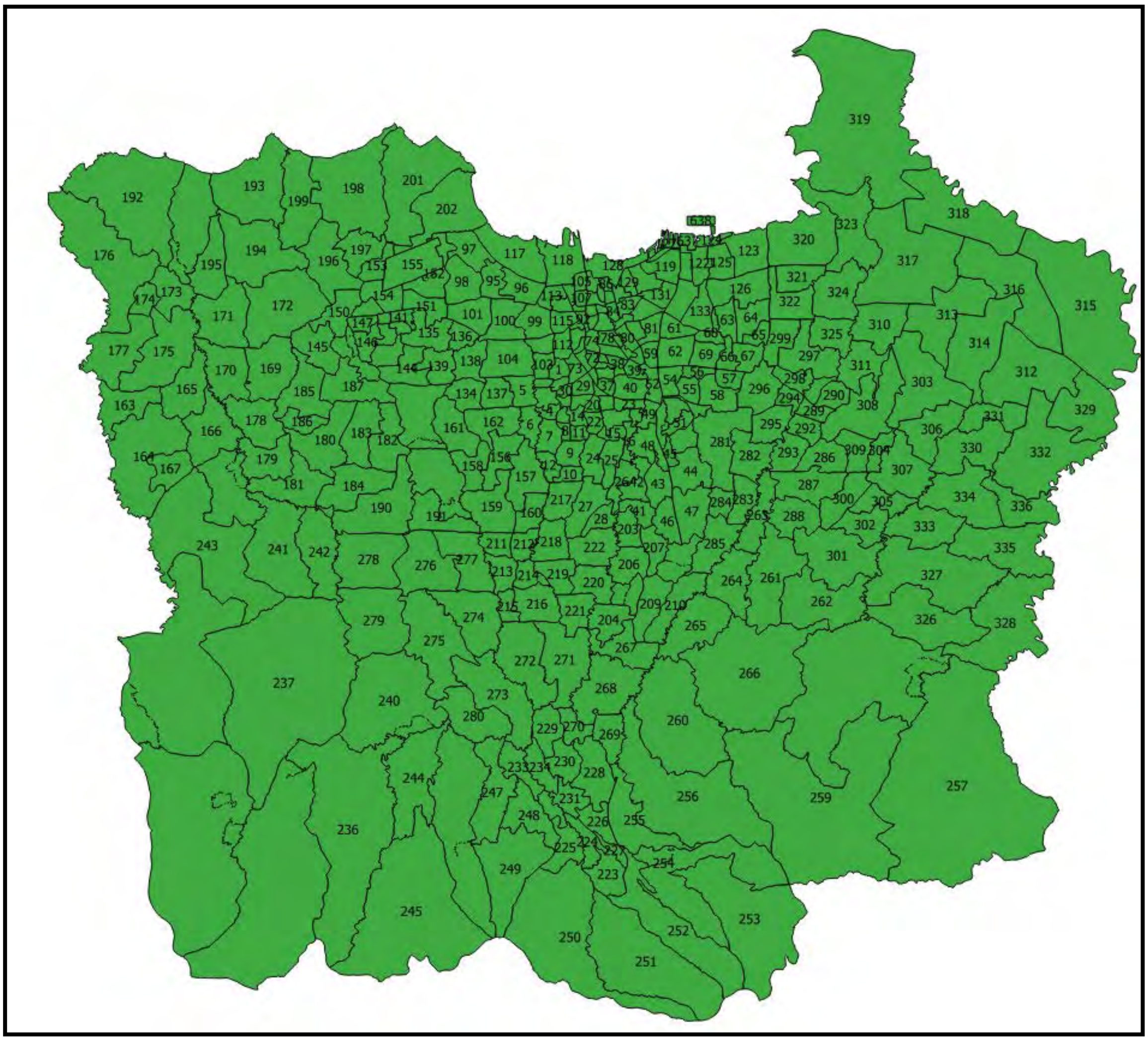
Source: OpenStreetMap, processed

Figure 44 Coverage Area

3.2 Zone System

The study area is divided into analysis zones that can be accurately represented by a few variables and that all movement to and from a zone can be described as starting and ending at a single point in a zone – the centroid.

JUTPI 2 adopted the SITRAMP 343 zone system for the analysis. The zoning is mainly based on *kelurahan* boundary. However, through the course of JUTPI 2 forecasting procedure, there are 6 additional zones (4 additional external zone and 2 additional zones as a result of Tanjung Priok Port development). Thus, JUTPI2 utilized 349 traffic analysis zones system including external zones. The following figures show the 349 zone system.



Source: JUTPI 2

Figure 45 Traffic Analysis Zone System

3.3 Vehicle Type Classification

There are many modes of transport in JABODETABEK, and each survey has different a mode classification to accommodate the purpose of each survey. Transport modes with similar characteristics are aggregated in demand forecast modes.

Table 24 Vehicle Type Classification

List of Mode	ABM Mode	Aggregated Mode for Network Assignment
Walking	NMT	NMT
Bicycle	NMT	NMT
Becak/horse wagon	NMT	NMT
Motorcycle	MTC	MTC
Motorcycle taxi	TXM	MTC
Online motorcycle taxi (GoJek, GrabBike)	TXM	MTC
Private car (driver)	ATD	CAR
Private car (passenger)	ATS	CAR
Pick up, box	ATD	CAR
Truck	ATD	CAR
Conventional Taxi	TXA	CAR
GoCar, GrabCar (private)	TXA	CAR
GrabHitchCar (share)	TXA	CAR
Bajaj, *kancil*	TXA	CAR
Omprengan	TR	TRANSIT
Commuter line	TR	TRANSIT
Airport Railink Service (ARS)	TR	TRANSIT
Economy long train haul	TR	TRANSIT
TransJakarta (articulated)	TR	TRANSIT
TransJakarta, feeder TransJakarta (large bus)	TR	TRANSIT
Feeder TransJakarta (medium bus)	TR	TRANSIT
TransJabodetabek	TR	TRANSIT
TransPakuan	TR	TRANSIT
JR Connexion, JA Connexion	TR	TRANSIT
DAMRI Airport, Primajasa, Hiba Utama	TR	TRANSIT
Patas, Patas AC, Mayasari	TR	TRANSIT
Economy/ executive medium bus long haul	TR	TRANSIT
Metromini, *kopaja*	TR	TRANSIT
Angkot, *bemo*	TR	TRANSIT
Large chartered bus (company bus, school bus, tourist bus, rental bus)	TR	TRANSIT
Medium chartered bus (company bus, school bus, tourist bus, rental bus)	TR	TRANSIT

List of Mode	ABM Mode	Aggregated Mode for Network Assignment
Small chartered bus (company bus, school bus, tourist bus, rental bus)	TR	TRANSIT
Pickup		PICKUP
Small Truck		STRUCK
Medium Truck		MTRUCK
Large Truck		LTRUCK

Note:

NMT:	Non-motorized transport	TR:	Transit
MTC:	Motorcycle	CAR:	Passenger car
ATS:	Auto shared ride	TRANSIT:	Transit
ATD:	Auto drive alone	STRUCK:	Small truck
TXM:	Motorcycle taxi	MTRUCK:	Medium truck
TXA:	Taxi	LTRUCK:	Large truck

Source: JUTPI 2

3.4 Project Year

The project year of the travel demand forecast is set up as follows:

Table 25 Project Year for Travel Demand Forecast

	2018	2024	2029/2030	2035
Population Synthesis	●	●	●	●
Microsimulation	●	●	●	●
Assignment	●	●	●	●

Source: JUTPI 2

3.5 Study Network

The study network is a computerized network that originated from SITRAMP and JUTPI 1 which consists of the road network and public transport network. The network has been revised under JUTPI 2 study not only to reflect the accomplishment of the road network and public transport network in JABODETABEK after the year 2010 but also to include the development plan of the transportation network for its analyses.

3.5.1 Road Network

The computerized transportation network used in the JUTPI 2 has its root in the previous JUTPI 1 project in the 2010 and SITRAMP in 2004. To account for changes occurred since then, the base year (2018) highway network was prepared by updating the following points:

- Updating the network with newly developed road since 2010;
- Updating the network connectivity by adding ramp and connection links;
- Updating the network attributes by incorporating the present road condition.

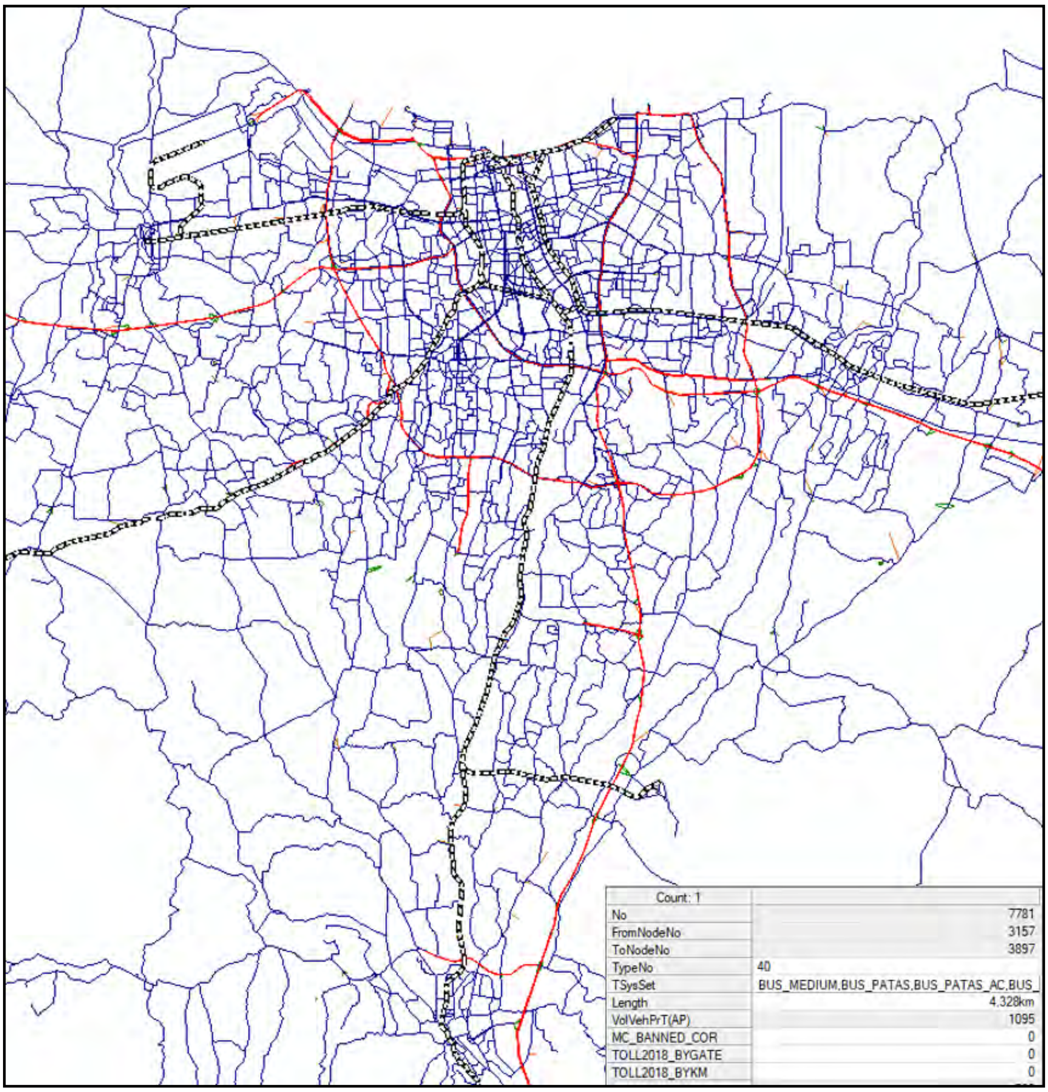
Physical descriptive data for links were obtained from various data sources as well as field inventory surveys. This information was observed thoroughly, and less important roads (such as local roads in the housing area) were excluded from the network leaving only the toll, arterial, collector, and selected local roads to ensure network connectivity and to allow for bus transit route coding. Speed and link capacity data were updated based on speed and capacity parameters described in the Indonesian Highway Capacity Manual (IHCM).

JUTPI 1 network developed in the CUBE network program was transferred to traffic modeling software, and several processes were conducted to ensure all attributes would be read correctly in traffic modeling software. The base year highway network and attributes on one selected link are shown in Figure 46. Each link on the road network at least contains the following important attributes listed in Table 26.

Table 26 Structure of Road Network Database

Field Name	Data Type	Content
No	Integer	Numeric code to define link number;
From Node No	Integer	Numeric values identify the "from" of a link
To Node No	Integer	Numeric values identify the "to" ends of a link
Length	Float	Defining the length of a link in kilometers
Project Code	Character	Coding for future network plan
Toll Total	Integer	Calculate total toll fare for each toll road segment
Type No	Integer	A numeric code to group links with common characteristics for subsequent referencing, updating, and reporting which is defining free flow speed, capacity, and TSysSet
TSysSet	Character	Set of permitted transport systems which may use each link
NumLanes	Integer	Number of lanes
CapPrT	Integer	Maximum capacity (PCU)
V0PrT	Integer	Free flow speed (km/h)

Source: JUTPI 2 and Traffic Modeling Manual



Source: JUTPI 2

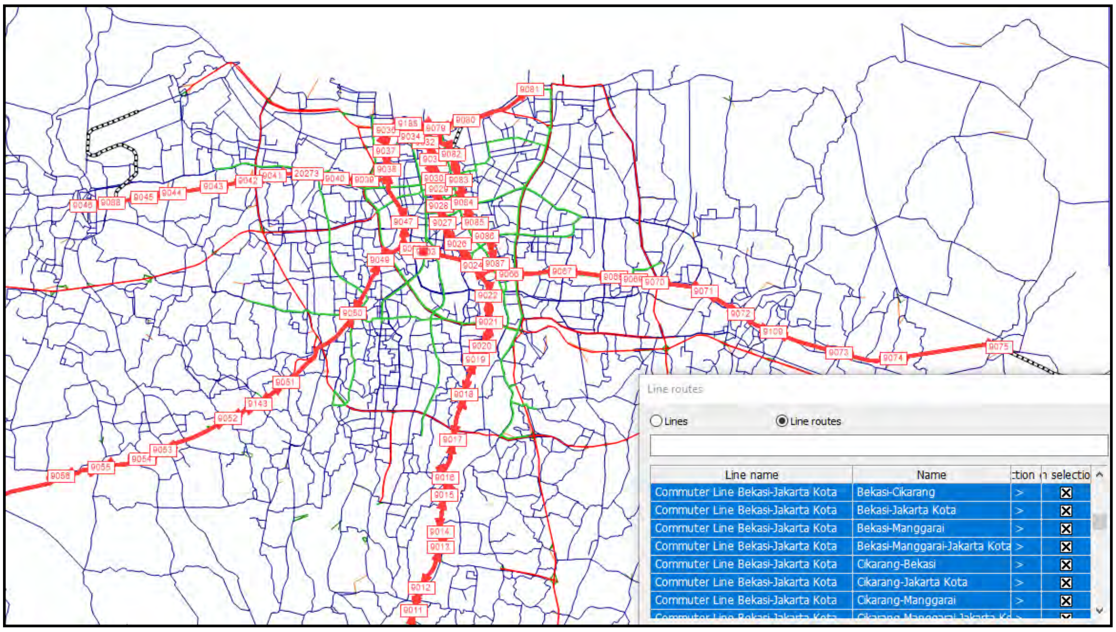
Figure 46 Base Year Network

3.5.2 Public Transport Network

The existing coded public transport network was obtained from JUTPI 1, then JUTPI 2 team updated this public transport network by integrating the latest transit operations obtained from local governments, public transport operators, and other sources.

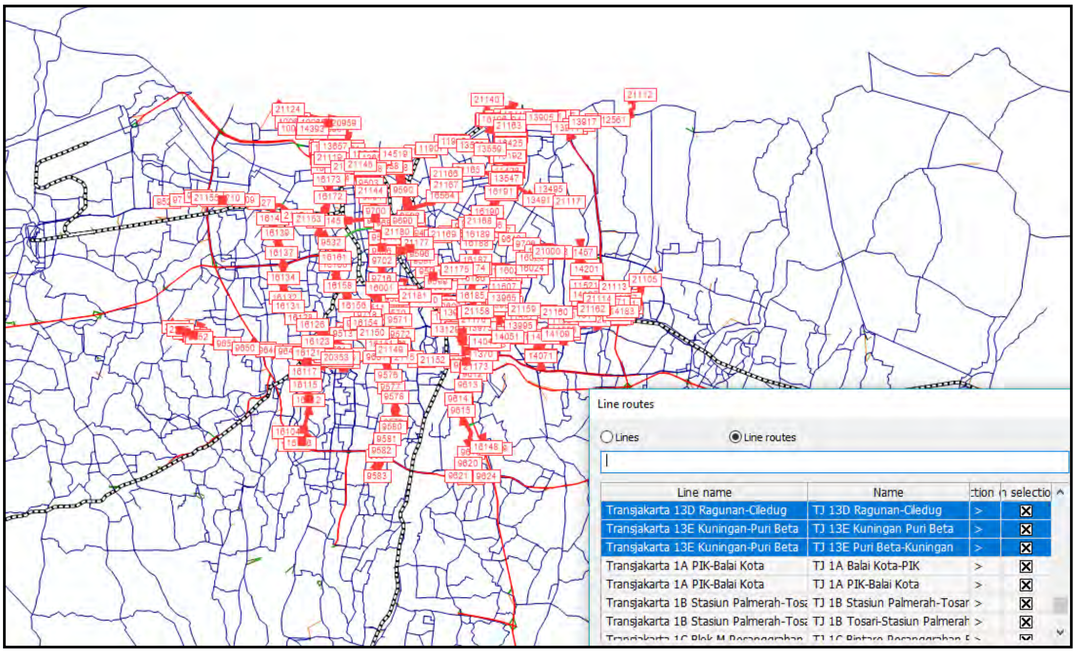
The modification of the public transport networks was coded in the traffic modeling software network program resulting in comprehensive coverage of transit networks throughout JABODETABEK area, consisting of hundreds of bus and railway lines.

An example of a computerized transit line coding result, i.e. railway, busway, and regular bus are shown in the following figures.



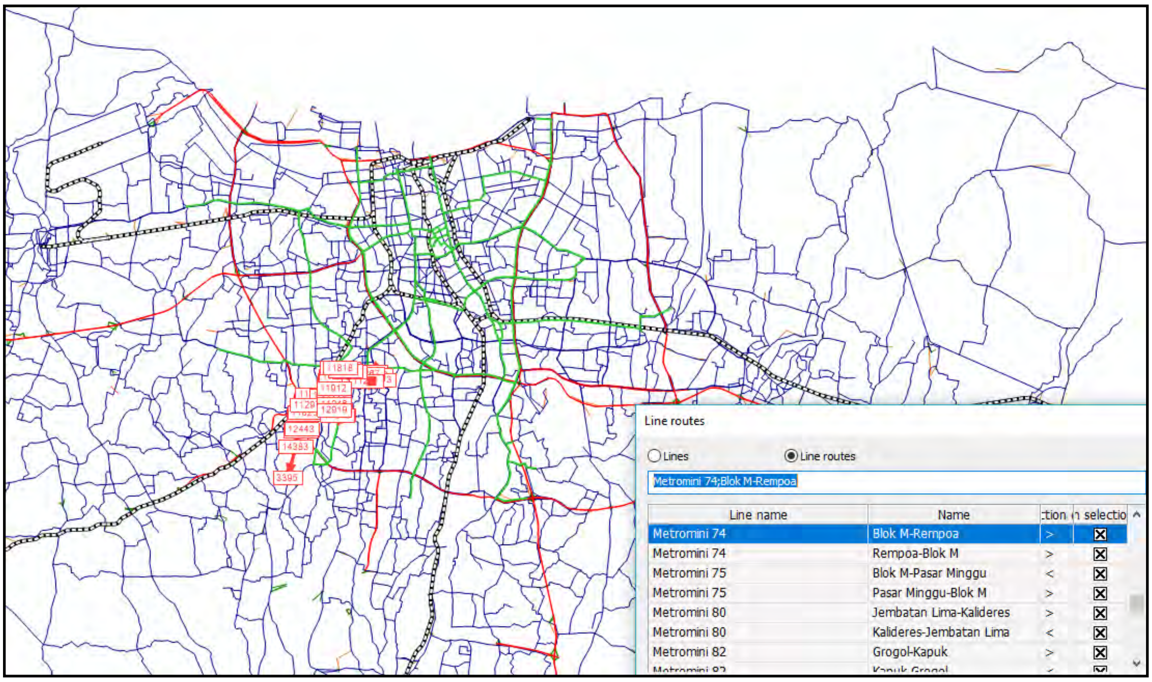
Source: JUTPI 2

Figure 47 Commuterline Lines on Base Year Network



Source: JUTPI 2

Figure 48 Transjakarta Lines on Base Year Network



Source: JUTPI 2

Figure 49 Example of Regular Bus Lines on Base Year Network

Chapter 4 MODEL DEVELOPMENT

4.1 Explanatory Variables

4.1.1 Individual Status

For modeling purpose, an individual status has been classified into two main types based on age which then detailed into occupations. Since the minimum age requirement for driving autos/motorcycles is 17 in Indonesia, it is reasonable to define an "adult" as a person whose age is 17 years or older. In addition, students and their school types cannot properly define by age, partly because of the existence of young workers.

- Adult (17 or older):
  - Full-time worker (35 hours or more per week),
  - Part-time worker (less than 35 hours per week),
  - Student (university, college, academy, high school, etc.) of a driving age,
  - Homemaker,
  - Retiree,
  - Unemployed.
- Child (under 17):
  - Preschool age child (e.g., infant under 5),
  - Student (kindergarten, elementary school, high school, etc.) of a pre-driving age,
  - Other (e.g., young worker).

4.1.2 Household Income

Income-related variables are very important to be included in many dimensions of the activity-based modeling system. In addition to actual figures of the household income (often treated as logarithms), households are classified into the following three income groups:

- Low-income household: households with monthly income of less than 4 million Indonesian rupiahs (IDR),

- Middle-income household: households with monthly income between IDR 4 million and IDR 10 million, and
- High-income household: households with monthly income of 10 million IDR or more.

Based on JUTPI Phase 2 latest survey result called Activity-Travel Diary Survey, in JABODETABEK, as of 2018, low-, middle-, and high-income households approximately account for 36%, 53%, and 11% of the total households respectively.

4.2 Model Estimation Results

Parameters of the models are actually estimated from lower to upper models in this order to generate and pass logsums to the upper models, while the model estimation results are described first from the top model. For nested logit models, parameters are estimated simultaneously across the two tiers using Full Information Maximum Likelihood estimation (FIML) approach.

Summary statistics used for overall goodness-of-fit measures and tests of entire models are as follows:

- $L(0)$, which is the value of the log likelihood function with zero coefficients;
- $L(\mathrm{C})$, which is the value of the log likelihood function for the constants only model;
- $L(\hat{\beta})$, which is the value of the log likelihood function for the estimated model;
- $-2[L(0) - L(\hat{\beta})]$, which is a statistic used to test the null hypothesis that all the parameters are zero. It is asymptotically distributed as χ^2 with K, which is the number of degrees of freedom (parameters) used in the model (Ben-Akiva and Lerman, 1985);
- Adjusted rho-squared, $\bar{\rho}^2$, which is similar to rho-squared, ρ^2, but corrected for the number of parameters estimated. This index provides a practical and theoretically sound index of goodness of fit (Domencich and McFadden, 1975). The adjusted rho-squared with respect to zero, $\bar{\rho}_0^2$, is:

$$\bar{\rho}_0^2 = 1 - \frac{L(\hat{\beta}) - K}{L(0)}$$

and the adjusted rho-squared with respect to the constants only model, $\bar{\rho}_c^2$, is:

$$\bar{\rho}_C^2 = 1 - \frac{L(\hat{\beta}) - K}{L(0) - K_C}$$

where K_C is the number of degrees of freedom (parameters) used in the constants only model; and

- $2K - 2\ L(\hat{\beta})$, which is the value called Akaike Information Criterion (AIC). AIC not only rewards goodness of fit, but also includes a penalty that is an increasing function of the number of parameters estimated (Akaike, 1974). The preferred model is the one with the lowest AIC value.

4.2.1 Daily Activity-Travel Pattern Choice

Table 27 shows the estimated nested logit model. Direct modeling output is also included in Appendix A. The adjusted rho-squared value, as a measure of goodness-of-fit of the model, is 0.417, showing data pretty good model fit. The log sum coefficient capturing the effect of the expected maximum utility from out-of-home activity patterns has a value of 0.80. Coefficients of the log sums taken externally from the lower time-of-day choice models are ranging from 0.007 to 0.425. These coefficients all fall within the theoretically acceptable range between 0 and 1 in a nested logit structure with significant t-stat values. Modeling outcomes are summarized and discussed below.

Respondent type and age seem to be significant factors for the DAP choice model in JABODETABEK. Workers which comprise 57% of the respondents have more trips rather than other respondent types (student and others). Workers have a higher chance to travel at least 2 trips per day, including a work-based sub tour where they make travel from office to meeting or another place. Such tendencies may coincide with the fact that those of economically active age (i.e., 18-60) are most likely to have work tours.

Adults are most likely to have school tours because the minimum age parameter for the respondent is 15 years old. Meanwhile, female adult tends to have more trips on school tours. On the other hand, a household with children has high tendencies to make a stop on the primary tour.

Since all household members age 15 or older are included for modeling, there is not much diversity of individuals' status. The worker is the majority of the samples while the student is the least in the sample. Other respondent types such as homemakers, retirees, and unemployed are the second-largest type of respondent as a whole. Some of those variables are quite reasonable following the DAP choice model result. For example, full-time workers tend to have more work-based sub-tours, mainly male workers. Being a homemaker increases the utility of primary maintenance tours. As for school purpose, due to respondent lower age limit, which make student education level starts from senior high school, university students have more trips. Meanwhile, senior high school students tend to have an intermediate stop while doing primary maintenance tours. It also applied for an intermediate stop on the primary discretionary tour. Thus, a variety of variables regarding status much helped for better estimation of the DAP choice model for all generations.

Table 27 Daily Activity-Travel Pattern Choice Model (1/2)

Observations = 21,634, Parameters = 94, L(0) = 89,204, L(β) = -51,972
ρ2 = 0.417

Logsums	coeff.	t-stat
Out-of-home DAP logsum	0.800	fixed
Time-of-Day Choice Logsums		
Primary work tour	0.123	28.7
Primary school tour	0.425	15.1
Primary maintenance tour	0.087	23.4
Primary discretionary tour	0.180	37.4
Secondary maintenance tour	0.007	2.3
Secondary discretionary tour	0.095	2.1
Alternative / Variable	**coeff.**	***t-stat***
Home Variables		
Dummy: the age is under 17	0.725	3.2
Dummy: the individual is a worker	-0.421	-4.6
Primary Work Tour Variables		
Dummy: child (5 <= age < 17) in household	-0.151	-4.0
Dummy: middle-income hhd (4 - 10 mil. Rp./mo.)	-0.369	-8.2
Log of age of the individual	0.202	1.8
Intermediate Stop Variables		
Dummy: the age is under 30	-0.146	-3.2
Dummy: zone in the odd-even number regulation area	0.181	4.0
Dummy: female adult (age >= 17)	-0.477	-9.4
Dummy: a homemaker	0.488	6.2
Work-Based Sub-Tour Variables		
Dummy: infant (age < 5) in household	0.369	4.7
Dummy: male	0.485	6.5
Dummy: full-time worker	0.215	3.1
Intermediate Home Return Variables		
Dummy: middle-income hhd (4 - 10 mil. Rp./mo.)	0.293	3.7
Dummy: zone in the odd-even number regulation area	0.279	3.2
Dummy: female adult with no children/infants in the household	-0.428	-4.3
Primary School Tour Variables		
Dummy: female adult with infants in the household	-1.285	-3.8
Log of age of the individual	-6.551	-18.2
Dummy: male adult (age >= 17)	-0.301	-3.0
Log of monthly household income (million Rp.)	0.166	1.8
Number of adults (age >= 17)	0.213	4.5
Dummy: zone in the odd-even number regulation area	-0.410	-3.3
Intermediate Stop Variables		
Dummy: middle-income hhd (4 - 10 mil. Rp./mo.)	-0.841	-7.1
Dummy: car plate does not match the odd-even regulation	0.463	2.8
Dummy: senior high school student	-0.662	-5.2
Dummy: zone in urban area	0.341	2.0

Alternative / Variable	coeff.	t-stat
Primary Maintenance Tour Variables		
Dummy: a homemaker	1.047	17.5
Dummy: low-income hhd (< 4 mil. Rp./mo.)	0.273	5.6
Dummy: zone in Jakarta proper	0.159	4.8
Dummy: female adult with no children/infants in the househol	-0.259	-5.6
Log of age of the individual	-0.232	-2.1
Intermediate Stop Variables		
Dummy: senior high school student	0.604	7.0
Dummy: infant (age < 5) in household	-0.108	-2.0
Log of monthly household income (million Rp.)	-0.086	-2.3
Dummy: zone in urban area	-0.292	-4.8
Dummy: male adult with children in the household	-0.227	-4.4
Dummy: the age is under 35	-0.265	-6.3
Primary Discretionary Tour Variables		
Dummy: male adult (age >= 17)	-0.234	-2.6
Dummy: the individual is a worker	-0.901	-9.6
Intermediate Stop Variables		
Dummy: student	0.532	3.1
Number of motorcycles owned by household	0.186	2.7
All Primary Tour Variables		
Stop on the Way Variables		
Dummy: female adult with infants in the household	-0.483	-4.2
Ratio of children (age < 17) to adults (age >= 17)	0.213	3.1
Dummy: low-income hhd (< 4 mil. Rp./mo.)	-0.100	-2.0
Dummy: zone in urban area	-0.248	-3.3
Dummy: full-time worker	0.169	3.4
Stop on the Way Back Variables		
Household size	0.029	2.7
Dummy: middle-income hhd (4 - 10 mil. Rp./mo.)	0.142	4.6
Dummy: zone in Jakarta proper	-0.106	-3.5
Dummy: female adult (age >= 17)	-0.271	-7.2
Dummy: student	-0.154	-2.6
Secondary Maintenance Tour Variables		
Dummy: female adult (age >= 17)	-0.317	-7.7
Dummy: the age is under 30	-0.261	-5.8
Secondary Discretionary Tour Variables		
Dummy: zone in urban area	0.155	1.7
Dummy: male adult with no children/infants in the household	0.317	4.7

Source: JUTPI 2

Table 28 Daily Activity-Travel Pattern Choice Model (2/2)

Alternative-Specific Constants	coeff.	*t-stat*
Home Constants		
Home (no travel)	-1.703	*-5.6*
Primary Work Tour Constants		
No secondary tour	-1.162	*-5.1*
1+ maintenance tour(s)	-2.064	*-9.0*
1 discretionary tour	-4.139	*-16.9*
2+ discretionary tours	-6.338	*-18.0*
1+ sec. main. & 1+ sec. disc. tours	-4.808	*-18.0*
Stop on the way	-1.769	*-7.4*
Stop on the way back	-0.820	*-3.5*
Sub-tour, no secondary tour	-3.665	*-15.3*
Sub-tour, 1+ sec. maintenance tour(s)	-5.082	*-19.0*
Sub-tour, 1 sec. discretionary tour	-6.680	*-19.5*
Sub-tour, stop on the way	-3.927	*-15.5*
Sub-tour, stop on the way back	-3.104	*-12.5*
Intermediate home return	-2.742	*-11.6*
Intermediate home return, 1+ sec. main.	-3.320	*-13.8*
Intermediate home return, 1 sec. disc.	-5.739	*-19.2*
Primary School Tour Constants		
No secondary tour	17.743	*17.6*
1+ maintenance tour(s)	17.360	*17.2*
1 discretionary tour	14.888	*14.4*
2+ discretionary tours	13.292	*11.7*
1+ sec. main. & 1+ sec. disc. tours	15.012	*14.4*
Stop on the way	17.131	*16.5*
Stop on the way back, no sec. tour	18.498	*17.8*
Stop on the way back, 1 sec. disc. tour	16.098	*15.3*
Primary Maintenance Tour Constants		
No secondary tour	--	--
1+ maintenance tour(s)	0.023	*0.5*
1 discretionary tour	-2.123	*-33.7*
2+ discretionary tours	-4.304	*-26.1*
1+ sec. main. & 1+ sec. disc. tours	-2.261	*-29.0*
Stop on the way	-1.030	*-12.0*
Stop on the way back	0.783	*10.3*
Primary Discretionary Tour Constants		
No secondary tour	-1.520	*-4.1*
1 discretionary tour	-3.503	*-9.0*
2+ discretionary tours	-5.632	*-12.3*
Stop on the way back	-3.016	*-7.6*

Source: JUTPI 2

4.2.2 Time-of-Day Choice

The home-based time-of day choice model shows the estimated multinomial logit models with the adjusted rho-squared value, as a measure of goodness-of-fit of the model, depends on the tour purposes and ranges from 0.021 to 0.124. The external log sum coefficients capturing the effect of the expected maximum utility from the lower mode and destination choice models also depend on the tour purposes and are estimated as 0.275 – 0.911. These coefficients all fall within the theoretically acceptable range between 0 and 1 with significant t-stat values. The most significant value comes from the discretionary tour. The Modeling outcomes can be illustrated in Table 29 to Table 34 and are summarized and discussed below.

ToD choice models have successfully included all variables that reflect all tour types. They are conditional on DAPs and therefore essential to generate utility log sums for the upper DAP choice. The results show that there is a tendency to stop on the way back home even though in PM peak and night for work and maintenance tour purposes. Secondary tours increase the utilities of a rather late tour starts like in the midday or later.

Male adult with a child in the household tends to do maintenance or discretionary tour purpose early in the morning until evening. Meanwhile, a person of a one-member household tends to have a maintenance tour in the nighttime.

The household income variable has quite a significant impact on the ToD choice that varies across four types of tours. ToD choice of work tour indicates the start time at a rather early morning for those who are mid- and high-income household and at rather latter time for those who are low-income households. This may be related to the job level of worker that has a more standard obligation of office hours as the responsibility (hence the income) gets higher.

ToD choice for school tours is observed rather fixed, that is, from early morning until midday. This may be related to the government regulation of time duration (start and end) in school as well as in the university. It needs to be noted that the survey collects respondents that is 15 years old and older. Therefore, school represents high school (15 to 17 years old) and university (under 20 years old) students only. Despite the age range, it may be safe to say that the same tendency applies toward younger students, as well.

Maintenance and discretionary tours do not show clear implication from the household income variable as it does for work and school tours. However, the tendency indicates that maintenance and discretionary tours are shorter for low- and mid-income households and longer for the high-income household. This may be related to the possibility of more maintenance and discretionary activities that are necessary (there are to offer) as the household income gets higher.

Gender- and age-related variables are also significant and available inclusively for the four types of tours across all ToD choices. Obvious tendency across all ToD choices shows positive utility function for male and female adults for work tours and younger males and females for school tours. However, the tendency of positive utility function towards male and younger age can be only seen at those ToD choice set that involves early morning and night time especially for work and discretionary tours. Also, it is quite interesting that these two variables are widely attributing to both maintenance and discretionary tours across all ToD choice.

As shown by the result, people tend to make a stop on their tour. For work and school purposes mostly in the morning and noon, while maintenance and discretionary activities are conducted later in the afternoon until night time. Some status-related variables used in the model simply implies typical trend of respondents. For example, full-time workers tend to choose longer-duration ToD combinations and homemakers tend to select maintenance or discretionary tours during the daytime period.

The scheduling and time-of-day models included in activity-based models' systems are sensitive to a broad range of factors, including personal and household characteristics, trip and tour characteristics, accessibilities, change of lifestyle, and individual activity patterns and scheduling pressure. These models reflect the fact that the higher-income workers may work longer hours. These models can also show how, as more activities are scheduled during a day, the duration of these activities is reduced to compensate for the maintenance and discretionary tours.

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Table 29 Home-Based Time-Of-Day Choice Model (1/6)

Tour Type	Work		School		Maintenance		Discretionary	
Observations =	10205		1778		12336		2976	
Parameters =	104		50		88		80	
$L(0)$ =	-19814		-4034		-26513		-6786	
$L(\beta)$ =	-17351		-3805		-24552		-6644	
ρ^2 =	0.124		0.057		0.074		0.021	
Alternative / Variable	**coeff.**	***t-stat***	**coeff.**	***t-stat***	**coeff.**	***t-stat***	**coeff.**	***t-stat***
Mode/destination choice logsum variable	0.690	*4.2*	0.275	*1.8*	0.869	*3.0*	0.911	*2.7*
Early Morning - Early Morning								
Alternative-specific constant	-10.096	*-3.2*	-4.174	*-5.8*	-1.020	*-3.4*	-1.276	*-2.0*
Dummy: intermediate stop is included in the tour	2.822	*6.7*						
Dummy: secondary tour with work primary tour					2.165	*16.3*	1.670	*2.1*
Dummy: only one adult in household	1.550	*3.4*						
Dummy: middle-income hhd (4 - 10 mil. Rp./mo.)	1.095	*2.2*						
Dummy: male adult with no children/infants in the household			2.052	*2.6*			1.012	*1.7*
Dummy: male adult with children in the household					0.291	*2.4*		
Dummy: male					1.877	*7.3*		
Log of age of the individual	1.731	*2.1*						
Dummy: the individual is an executive					1.156	*7.2*		
Dummy: the individual is a driver of public transport	2.634	*4.6*						
Early Morning - AM Peak								
Alternative-specific constant	-2.126	*-6.6*	-4.431	*-4.8*	-0.307	*-1.3*	-2.423	*-6.3*
Dummy: intermediate stop is included in the tour	2.836	*10.9*						
Dummy: secondary tour with work primary tour					0.66323	3.39		
Dummy: middle-income hhd (4 - 10 mil. Rp./mo.)			1.60765	2.59				
Dummy: male adult with no children/infants in the household	0.559	*2.3*	2.433	*3.2*			1.069	*2.7*
Dummy: female adult with children in the household			2.529	*3.1*				
Dummy: male					1.321	*7.0*		
Dummy: the age is under 20			-1.186	*-2.8*				
Dummy: university/academy student	1.330	*2.5*						
Dummy: the individual is an executive					1.129	*6.1*	1.938	*3.1*
Dummy: the individual is a clerk/waiter							2.051	*1.9*
Dummy: the individual is a salesman	1.065	*3.1*			1.039	*7.3*		
Dummy: the individual is a driver of public transport	2.711	*7.1*						
Dummy: the workplace is a restaurant					1.089	*3.6*		

Source: JUTPI 2

Table 30 Home-Based Time-Of-Day Choice Model (2/6)

Tour Type	**Work**		**School**		**Maintenance**		**Discretionary**	
Alternative / Variable	**coeff.**	***t-stat***	**coeff.**	***t-stat***	**coeff.**	***t-stat***	**coeff.**	***t-stat***
Early Morning - Midday								
Alternative-specific constant	-3.202	*-3.0*	-2.232	*-5.8*	-0.740	*-3.3*	-6.089	*-3.1*
Dummy: stop(s) included on the way from home	1.406	*3.2*			1.722	*3.5*		
Dummy: secondary tour			-0.864	*-1.8*				
Dummy: only one adult in household	0.544	*2.2*						
Dummy: high-income hhd (>= 10 mil. Rp./mo.)							1.083	*3.4*
Dummy: male adult with children in the household							0.639	*2.2*
Dummy: female adult (age >= 17)			1.436	*3.5*				
Log of age of the individual	0.846	*3.0*					1.037	*2.1*
Dummy: the age is under 17			1.488	*3.3*				
Dummy: the age is under 20					0.888	*2.8*		
Dummy: the individual is a worker							1.0	
Dummy: the individual is a driver of public transport	1.307	*2.8*						
Dummy: the individual is a guard	1.252	*3.9*						
Dummy: the workplace is farm/forest/sea	1.871	*2.9*						
Early Morning - PM Peak								
Alternative-specific constant	-0.086	*-0.3*	-3.431	*-8.0*	-2.838	*-4.7*	-6.805	*-8.3*
Dummy: stop(s) included on the way from home	1.458	*4.3*	2.113	*3.0*				
Dummy: one-member household							1.180	*2.9*
Log of monthly household income (million Rp.)							1.454	*8.8*
Dummy: high-income hhd (>= 10 mil. Rp./mo.)	0.664	*5.8*			1.708	*4.9*		
Dummy: male	0.754	*4.6*						
Dummy: male adult (age >= 17)							1.414	*2.7*
Dummy: the age is under 17					2.770	*3.0*		
Dummy: age over 65	1.243	*3.5*						
Dummy: the individual is a worker					1.820	*3.0*	2.535	*4.3*
Dummy: the individual is a guard	0.747	*2.6*					1.994	*3.7*
Early Morning - Night								
Alternative-specific constant	-2.536	*-6.3*	-3.897	*-7.5*	-3.082	*-6.5*	-6.225	*-4.9*
Dummy: stop(s) included on the way from home	2.604	*4.2*						
Dummy: infant (age < 5) in household	0.997	*2.5*						
Dummy: one-member household							4.069	*3.7*
Dummy: high-income hhd (>= 10 mil. Rp./mo.)	0.830	*2.4*						
Dummy: male adult with children in the household	0.772	*2.1*						
Dummy: the age is under 20							3.551	*2.8*
Dummy: a homemaker							2.336	*1.7*

Source: JUTPI 2

Table 31 Home-Based Time-Of-Day Choice Model (3/6)

Tour Type	**Work**		**School**		**Maintenance**		**Discretionary**	
Alternative / Variable	**coeff.**	***t-stat***	**coeff.**	***t-stat***	**coeff.**	***t-stat***	**coeff.**	***t-stat***
AM Peak - AM Peak								
Alternative-specific constant	-1.377	*-11.2*	-0.593	*-3.7*	-0.932	*-2.6*	-3.429	*-3.8*
Dummy: intermediate stop is included in the tour	2.346	*6.5*						
Dummy: stop(s) included on the way from home							1.471	*3.5*
Dummy: stop(s) included on the way back home	1.289	*3.7*			1.311	*8.1*		
Dummy: secondary tour							1.044	*5.7*
Dummy: secondary tour with work primary tour					0.589	*6.2*	1.028	*4.1*
Dummy: infant (age < 5) in household			1.220	*3.7*				
Dummy: one-member household							0.883	*3.6*
Dummy: only one adult in household	0.438	*2.9*						
Dummy: low-income hhd (< 4 mil. Rp./mo.)	0.563	*4.9*			0.188	*3.6*	0.308	*1.8*
Dummy: male adult with children in the household					0.597	*10.6*		
Log of age of the individual					0.951	*10.8*	0.769	*3.3*
Dummy: full-time worker					0.515	*9.6*		
Dummy:a homemaker							0.518	*2.4*
Dummy: the individual is a driver of public transport	2.245	*12.0*						
AM Peak - Midday								
Alternative-specific constant					-0.331	*-0.9*		
Dummy: stop(s) included on the way from home	2.311	*15.8*			1.109	*6.0*		
Dummy: stop(s) included on the way back home	2.060	*23.5*			1.670	*10.0*		
Dummy: secondary tour with work primary tour					0.756	*6.3*	0.800	*3.3*
Dummy: infant (age < 5) in household			0.790	*2.9*				
Dummy: child (5 <= age < 17) in household					0.349	*5.4*	0.552	*4.3*
Dummy: only one adult in household					0.5			
Log of monthly household income (million Rp.)							0.252	*2.2*
Dummy: low-income hhd (< 4 mil. Rp./mo.)	0.186	*2.5*			0.162	*2.5*		
Dummy: male	0.848	*9.8*						
Log of age of the individual					0.655	*6.6*		
Dummy: the age is under 20			0.435	*2.8*				
Dummy: the individual is a clerk/waiter	0.945	*3.3*						
Dummy: 1 if the individual is a farmer/fisherman	1.230	*3.2*						

Source: JUTPI 2

Table 32 Home-Based Time-Of-Day Choice Model (4/6)

Tour Type	Work		School		Maintenance		Discretionary	
Alternative / Variable	**coeff.**	***t-stat***	**coeff.**	***t-stat***	**coeff.**	***t-stat***	**coeff.**	***t-stat***
AM Peak - PM Peak								
Alternative-specific constant	-1.269	*-3.6*	-1.003	*-5.1*			-3.662	*-4.1*
Dummy: stop(s) included on the way from home	1.930	*12.2*			1.853	*7.5*		
Dummy: stop(s) included on the way back home					1.473	*7.0*		
Dummy: infant (age < 5) in household			1.090	*2.8*			0.334	*2.0*
Dummy: only one adult in household					0.672	*3.7*		
Log of monthly household income (million Rp.)	0.374	*8.9*						
Dummy: high-income hhd (>= 10 mil. Rp./mo.)			0.929	*2.8*	0.688	*3.6*	1.141	*7.8*
Dummy: male adult with no children/infants in the household			-0.689	*-2.2*				
Dummy: male adult with children in the household					0.484	*2.7*		
Dummy: female adult with no children/infants in the household	0.377	*2.9*			0.429	*2.2*		
Dummy: male	1.038	*9.8*						
Dummy: male adult (age >= 17)							0.739	*3.4*
Dummy: female adult (age >= 17)					0.472	*2.4*		
Log of age of the individual	0.372	*4.1*					0.702	*3.0*
Dummy: the individual is a worker	0.468	*5.4*					1.444	*7.6*
Dummy: full-time worker					0.327	*2.3*		
Dummy: the individual is a clerk/waiter	1.077	*4.2*					1.404	*3.0*
Dummy: the workplace is a department store/shopping mall							1.635	*4.5*
AM Peak - Night								
Alternative-specific constant	-0.874	*-5.4*	-2.972	*-8.5*	-1.453	*-4.5*	-2.389	*-5.2*
Dummy: stop(s) included on the way from home	2.598	*12.1*	1.837	*3.4*	2.654	*7.3*		
Dummy: child (5 <= age < 17) in household					0.971	*3.1*		
Dummy: one-member household							1.135	*2.0*
Dummy: high-income hhd (>= 10 mil. Rp./mo.)					1.150	*3.5*		
Dummy: male adult with children in the household							0.836	*2.1*
Dummy: female adult with no children/infants in the household					0.948	*2.4*		
Dummy: the age is under 17							1.961	*2.4*
Dummy: full-time worker	0.515	*3.5*					0.814	*1.8*
Dummy: part-time worker					0.850	*2.4*		
Dummy: car plate does not match the odd-even regulation			1.258	*2.3*				
Dummy: the individual is an executive	1.153	*9.1*						
Dummy: the individual is a clerk/waiter	1.279	*3.7*						
Dummy: the individual is a salesman	0.786	*5.2*						
Dummy: the individual is a guard	1.180	*5.0*						
Dummy: the workplace is a restaurant	1.613	*8.8*						
Dummy: the workplace is a retail store/market	0.621	*3.5*						

Source: JUTPI 2

Table 33 Home-Based Time-Of-Day Choice Model (5/6)

Tour Type	Work		School		Maintenance		Discretionary	
Alternative / Variable	**coeff.**	***t-stat***	**coeff.**	***t-stat***	**coeff.**	***t-stat***	**coeff.**	***t-stat***
Midday - Midday								
Alternative-specific constant	0.182	*0.8*	-1.542	*-2.1*	0.372	*1.2*	1.549	*5.5*
Dummy: intermediate stop is included in the tour			1.131	*8.5*			1.030	*4.6*
Dummy: stop(s) included on the way from home	0.943	*5.7*			0.801	*4.9*		
Dummy: stop(s) included on the way back home	3.420	*34.7*			2.254	*14.2*		
Dummy: secondary tour					1.868	*30.0*		
Dummy: child (5 <= age < 17) in household					0.260	*5.2*		
Dummy: only one adult in household	0.765	*7.0*					0.759	*4.4*
Dummy: low-income hhd (< 4 mil. Rp./mo.)	0.286	*3.1*						
Dummy: middle-income hhd (4 - 10 mil. Rp./mo.)			0.358	*2.9*				
Dummy: female adult with no children/infants in the household					0.160	*2.3*		
Log of age of the individual					0.560	*7.8*		
Dummy: the age is under 25			1.617	*2.2*				
Dummy: the age is under 35	0.271	*3.5*						
Dummy: the individual is a clerk/waiter	1.096	*3.3*						
Dummy: the individual is a salesman	0.543	*4.7*					0.885	*4.8*
Dummy: the individual is a driver of public transport	1.092	*5.7*						
Midday - PM Peak								
Alternative-specific constant	0.005	*0.0*	0.014	*0.1*	1.301	*7.8*	-0.211	*-0.3*
Dummy: intermediate stop is included in the tour	1.680	*7.3*	0.762	*4.4*				
Dummy: stop(s) included on the way from home	1.824	*10.1*	0.443	*1.8*	1.906	*11.6*	1.116	*3.0*
Dummy: stop(s) included on the way back home	1.205	*5.9*			2.300	*13.8*		
Dummy: secondary tour					1.739	*21.4*	0.456	*3.4*
Dummy: only one adult in household	0.572	*4.4*	-0.618	*-2.1*	0.557	*5.9*		
Dummy: low-income hhd (< 4 mil. Rp./mo.)	0.463	*4.5*						
Dummy: female adult (age >= 17)					0.261	*3.8*		
Log of age of the individual							0.358	*2.1*
Dummy: the age is under 20			-0.257	*-1.7*				
Dummy: the individual is an executive	0.368	*2.3*						
Midday - Night								
Alternative-specific constant	-0.334	*-1.5*	-1.702	*-5.6*	-0.245	*-1.2*	-0.461	*-1.5*
Dummy: stop(s) included on the way from home	3.503	*18.2*	2.294	*7.7*	2.578	*11.7*		
Dummy: stop(s) included on the way back home					2.012	*9.4*		
Dummy: secondary tour					1.139	*7.0*		
Dummy: child (5 <= age < 17) in household			-0.739	*-2.4*				
Dummy: one-member household	0.628	*3.4*					1.078	*2.7*
Dummy: only one adult in household					0.493	*2.5*		
Dummy: middle-income hhd (4 - 10 mil. Rp./mo.)			0.554	*1.9*				
Dummy: the age is under 35	0.637	*5.4*						
Dummy: part-time worker					0.708	*3.6*		
Dummy:a homemaker					0.726	*4.1*		
Dummy: the individual is a clerk/waiter	1.603	*4.5*					2.402	*3.6*
Dummy: the individual is a salesman	0.815	*4.8*						
Dummy: the individual is a driver of public transport	0.940	*2.7*						
Dummy: the individual is a guard	1.178	*4.1*						
Dummy: the workplace is a restaurant	1.648	*6.7*						
Dummy: the workplace is a retail store/market							1.640	*2.2*

Source: JUTPI 2

Table 34 Home-Based Time-Of-Day Choice Model (6/6)

Tour Type	**Work**		**School**		**Maintenance**		**Discretionary**	
Alternative / Variable	**coeff.**	***t-stat***	**coeff.**	***t-stat***	**coeff.**	***t-stat***	**coeff.**	***t-stat***
PM Peak - PM Peak								
Alternative-specific constant	-1.413	*-9.6*	-0.542	*-3.1*	0.348	*1.0*	0.244	*0.8*
Dummy: intermediate stop is included in the tour	3.638	*27.4*						
Dummy: stop(s) included on the way from home					0.578	*3.0*		
Dummy: stop(s) included on the way back home			0.920	*5.4*	2.146	*13.0*	0.976	*3.8*
Dummy: secondary tour			1.066	*6.5*	2.251	*29.8*	1.388	*10.7*
Dummy: secondary tour with work primary tour					0.545	*7.2*	0.447	*2.2*
Dummy: child (5 <= age < 17) in household							0.405	*3.4*
Dummy: one-member household					0.369	*3.8*		
Dummy: only one adult in household	0.442	*2.7*					0.588	*3.0*
Dummy: low-income hhd (< 4 mil. Rp./mo.)	0.382	*3.1*						
Dummy: high-income hhd (>= 10 mil. Rp./mo.)					0.214	*2.3*	0.408	*2.3*
Dummy: male adult with infants in the household							0.547	*3.1*
Log of age of the individual					0.352	*4.1*		
Dummy: the age is under 25	0.389	*2.5*						
Dummy: the age is under 35	0.322	*2.5*						
Dummy: the individual is a worker							0.298	*2.3*
Dummy: the individual is an executive							0.694	*2.6*
Dummy: the individual is a driver of public transport	1.119	*4.2*						
PM Peak - Night								
Alternative-specific constant	-1.656	*-10.8*	-0.675	*-3.7*	0.865	*5.0*	0.541	*1.9*
Dummy: intermediate stop is included in the tour							1.321	*5.3*
Dummy: stop(s) included on the way from home					1.848	*10.3*		
Dummy: stop(s) included on the way back home	3.181	*20.0*	0.794	*4.2*	2.051	*11.8*		
Dummy: secondary tour			0.706	*3.7*	2.180	*24.3*	1.008	*7.0*
Dummy: secondary tour with work primary tour							1.307	*6.6*
Dummy: one-member household	0.791	*3.7*						
Dummy: only one adult in household					0.478	*4.3*		
Dummy: high-income hhd (>= 10 mil. Rp./mo.)							0.563	*3.2*
Dummy: the age is under 25	0.795	*4.5*						
Dummy: part-time worker							0.535	*2.5*
Dummy: the individual is a salesman	0.654	*3.2*						
Dummy: the workplace is a restaurant	2.165	*7.3*						
Night - Night								
Alternative-specific constant	-2.476	*-12.3*	-1.471	*-6.8*	0.626	*3.6*	0.058	*0.2*
Dummy: intermediate stop is included in the tour							1.432	*5.7*
Dummy: stop(s) included on the way back home	3.060	*14.0*	1.019	*4.8*	2.461	*14.1*		
Dummy: secondary tour			1.511	*7.5*	2.217	*21.8*	1.523	*9.6*
Dummy: secondary tour with work primary tour					0.576	*5.4*	1.489	*7.8*
Dummy: one-member household	0.946	*3.5*						
Dummy: only one adult in household					0.636	*5.7*		
Dummy: low-income hhd (< 4 mil. Rp./mo.)	0.549	*2.5*						
Dummy: male adult with children in the household			0.834	*3.6*				
Dummy: female adult with infants in the household			1.602	*3.1*				
Dummy: the age is under 25	0.944	*4.0*						
Dummy: the age is under 30							0.452	*3.3*
Dummy: the individual is a driver of public transport	1.513	*3.6*						

Source: JUTPI 2

4.2.3 Mode and Destination Choice

Table 35 presents the results of the home-based mode and destination choice models. The models by purpose show a good fit with the adjusted rho-squared value ranging from 0.35 to 0.43. The log-sum parameters from the lower branches range from 0.11 to 0.18 for private modes and from 0.15 to 0.21 for taxi and transit modes, staying within a reasonable range. The external log sum coefficient capturing the effect of the expected maximum utility from the lower work-based sub-tour mode and destination choice model has been estimated as 0.15 in the work tour model. Coefficients of the external log sums from the lower intermediate stop location choice models depend on the tour purposes and are estimated as 0.06 – 0.19. These coefficients all fall within the theoretically acceptable range between 0 and 1 with significant t-stat values. Modeling outcomes are summarized and discussed below.

Among several types of cost and time-related variables, a composite variable of generalized travel time proved to work best in the model. It is computed from the preliminary network assignment highway or transit network by origin-destination zone pair and by mode. These generalized travel time then convert to monetary cost to get the generalized cost, including transit fares and highway tolls. Data from an activity-travel diary survey conducted in JUTPI 2 study is used to obtain three kinds of time values (these are for low, middle, and high-income households) which utilize to calculate the generalized cost. In particular, for work and school tours, coefficients of the generalized cost are estimated separately for auto, motorcycle, and transit. While the coefficients for auto and taxi have higher absolute values, the coefficient for motorcycle shows the lowest sensitivity to the generalized time. This result seems reasonable because auto and taxi are generally used by middle to high-income people and the motorcycle is used by low to middle-income people, as indicated by other income-related variables included in each mode.

The generalized travel cost also works as one of the variables that determine the utilities for destination choice. So, does natural logarithm of the size variable (i.e., total jobs for work, total students at school place for school, total service industry jobs for maintenance, and the sum of service industry jobs and households for discretionary activities). As for other destination-related variables, the origin zone dummy has a very high t-stat value across for work tour purposes followed by maintenance tour purposes Dummy variables identifying zones inside the urban area have also been included in school, maintenance, and discretionary tours. Other variables included in the mode and destination choice are densities of jobs, service jobs, students (at school place), and households by zone. In addition, fractions of land for business and recreational use have been included in the models.

As a whole, the models have captured the key significant variables, including not only the above-mentioned trip and zone attributes, but also tour or activity-related variables such as the presence of intermediate stops, distinction of primary or secondary tours, and start times of the tour or returning segment of the tour. To put it briefly, the presence of intermediate stops in a tour increases the utilities of private modes, including taxis that are more convenient for making stops. Tours start in the nighttime increase the utilities of private modes including taxis, probably because of convenience and security reasons.

A new trend started in JABODETABEK area since 2014 when online-taxi and online-motor taxi emerged. Door to door service and on-demand service makes this mode as one of popular transport mode in JABODETABEK. This phenomenon also generated a more secondary tour.

Furthermore, various socioeconomic attributes of both households and individuals also play significant roles in the models. The modeling results show the following characteristic implications in the context of JABODETABEK.

- In JABODETABEK, auto share-ride more often indicates those who do not drive but have chauffeurs. Carpools or vanpools do exist in DKI Jakarta, but those are more commercially operated and treated as unofficial transit. As a result, auto shared ride is characterized instead as a mode for high-income people.
- Income has a significant influence on mode choice. Generally, utilities of auto and taxi increase as the income becomes higher, while utilities of motorcycle, transit (with non-motorized access), and non-motorized transport increase as the income becomes lower.
- Gender and age also play more active and distinct roles in the models. That is, the male has more significant utilities of private modes, while the female has more exceptional utilities of taxi and transit especially non-motorized transit. Also, older people have higher utilities of private modes (including taxis) and non-motorized transport rather than transit (except for school tours).
- Some variables are indicating that the status of individuals directly increases the utilities of specific travel modes. For example, full-time workers have greater utilities of autos or motorcycles for almost all tour purposes.
- The employer commonly provides a variety of commuting allowances in the case of the JABODETABEK. As such, the availability of such benefits mainly increases the utilities of private modes in work tours.

Table 35 Home-Based Tour Mode/Destination Choice Model (1/3)

Tour Type	Work	School	Maintenance	Discretionary
Observations =	10267	1804	12529	2941
Parameters =	54	40	37	44
$L(0)$ =	-43708	-7676	-51888	-11883
$L(\beta)$ =	-28311	-4599	-29570	-6947
ρ^2 =	0.352	0.401	0.430	0.415

Alternative / Variable	coeff.	*t-stat*	coeff.	*t-stat*	coeff.	*t-stat*	coeff.	*t-stat*
Logsum								
Private mode logsum	0.172	*32.1*	0.113	*11.1*	0.107	*26.9*	0.184	*17.5*
Public mode/taxi mode logsum	0.148	*16.6*	0.164	*7.3*	0.219	*13.1*	0.191	*9.2*
Sub-tour mode/destination choice logsum variable	0.146	*4.0*						
Stop location choice logsum variable	0.055	*8.6*	0.116	*7.0*	0.073	*1.9*	0.192	*2.2*
Trip Attributes	**coeff.**	***t-stat***	**coeff.**	***t-stat***	**coeff.**	***t-stat***	**coeff.**	***t-stat***
Vehicle impedance (thousand Rp.)	-0.490	*-23.2*	-1.060	*-10.6*	-0.990	*-26.3*	-0.590	*-12.6*
Motorcycle impedance (thousand Rp.)	-0.520	*-26.3*	-1.140	*-11.6*				
Transit impedance (thousand Rp.)	-0.150	*-10.1*	-0.220	*-6.9*	-0.110	*-12.3*	-0.180	*-5.4*
Destination Land Use								
Dummy: origin zone	7.289	*31.3*					6.648	*18.0*
Dummy: zone in Jakarta proper	0.617	*6.7*						
Service job density (/ha) in the zone	0.003	*4.4*						
Log of relevant size variable in the zone	1.000	*constr.*	1.000	*constr.*	1.000	*constr.*	1.000	*constr.*
Auto Drive Alone (ATD)								
Alternative-specific constant	3.734	*3.2*	1.055	*1.6*	4.538	*18.4*	17.803	*6.9*
Vehicle impedance (thousand Rp.) (network skim)	-0.490	*-23.2*	-1.060	*-10.6*	-0.990	*-26.3*	-0.590	*-12.6*
Log of travel (network) distance (km)	1.112	*7.9*						
Dummy: stop(s) included on the way back home					0.551	*5.0*		
Dummy: tour starts in the a.m. peak period	8.855	*12.7*					1.147	*3.3*
Dummy: tour starts in the p.m. peak period or later	6.506	*9.1*	0.759	*1.9*				
Dummy: zone in urban area					0.661	*3.8*		
Dummy: infant (age < 5) in household					-0.240	*-1.9*		
Dummy: child (5 <= age < 17) in household							0.824	*3.8*
Dummy: one-member household							5.490	*5.5*
Dummy: low-income household (< 4 million Rp./mo.)							1.016	*2.9*
Dummy: high-income household (>= 10 million Rp./mo.)	0.594	*6.9*	1.175	*2.8*			1.496	*6.4*
Number of cars (sedans + vans) owned by household	0.435	*6.9*	2.779	*8.1*				
Dummy: car plate does not match the odd-even regulation	-0.555	*-7.1*	-1.083	*-2.7*			-0.761	*-3.6*
Number of motorcycles owned by household							0.364	*2.0*
Dummy: male adult (age >= 17)					1.335	*7.2*		
Dummy: age is over 65					1.993	*4.9*		
Dummy: high school student			2.356	*3.8*				
Dummy: allowance provided for private mode	8.575	*10.6*						

Source: JUTPI 2

Table 36 Home-Based Tour Mode/Destination Choice Model (2/3)

Tour Type	Work		School		Maintenance		Discretionary	
Alternative / Variable	**coeff.**	***t-stat***	**coeff.**	***t-stat***	**coeff.**	***t-stat***	**coeff.**	***t-stat***
Auto Shared Ride (ATS)								
Alternative-specific constant	-0.444	*-0.4*	-	-	-	-	8.584	*2.8*
Vehicle impedance (thousand Rp.) (network skim)	-0.490	*-23.2*	-1.060	*-10.6*	-0.990	*-26.3*	-0.590	*-12.6*
Log of travel (network) distance (km)	1.155	*7.9*					0.669	*5.6*
Dummy: tour starts in the early morning period			2.479	*5.9*				
Dummy: tour starts in the a.m. peak period	8.543	*11.9*						
Dummy: tour starts in the p.m. peak period or later	6.284	*8.5*						
Dummy: origin zone			0.949	*2.7*	13.329	*22.0*		
Dummy: one-member household							3.280	*2.9*
Log of monthly household income (million Rp.)							1.506	*7.7*
Dummy: high-income household (>= 10 million Rp./mo.)	2.159	*14.4*	1.386	*3.0*				
Number of cars (sedans + vans) owned by household	0.435	*6.9*	2.617	*8.7*	2.338	*21.2*		
Dummy: car plate does not match the odd-even regulation	-0.555	*-7.1*						
Log of age of the individual							1.307	*2.8*
Dummy: age is over 65	2.372	*4.9*						
Dummy: full-time worker	0.784	*3.3*						
Dummy: high school student			1.479	*2.9*				
Dummy: university/academy student							1.526	*2.4*
Dummy: allowance provided for private mode	8.846	*10.8*						
Motorcycle (MTC)								
Alternative-specific constant	2.952	*2.5*	2.493	*4.7*	2.464	*15.9*	18.684	*7.2*
Vehicle impedance (thousand Rp.) (network skim)					-0.990	*-26.3*	-0.590	*-12.6*
Motorcycle impedance (thousand Rp.) (network skim)	-0.520	*-26.3*	-1.140	*-11.6*				
Log of travel (network) distance (km)	0.977	*7.3*						
Dummy: tour starts in the a.m. peak period	9.020	*13.1*					1.301	*4.4*
Dummy: tour starts in the p.m. peak period or later	6.572	*9.4*						
Dummy: origin zone					14.130	*24.0*		
Dummy: zone in urban area			0.618	*2.2*	0.780	*5.5*		
Dummy: infant (age < 5) in household			4.572	*3.8*				
Dummy: one-member household							4.225	*4.4*
Dummy: car-owning household					3.116	*18.3*		
Number of motorcycles owned by household	0.705	*17.3*	1.795	*8.8*			1.091	*7.5*
Dummy: male	0.560	*4.9*						
Dummy: male adult (age >= 17)			1.988	*5.0*	0.995	*6.8*		
Dummy: allowance provided for private mode	8.692	*10.8*						
Taxi (TXA)								
Alternative-specific constant	-1.046	*-1.6*	-15.233	*-10.6*	-15.638	*-23.0*	3.300	*3.2*
Vehicle impedance (thousand Rp.) (network skim)	-0.490	*-23.2*			-0.990	*-26.3*	-0.590	*-12.6*
Transit impedance (thousand Rp.) (network skim)			-0.220	*-6.9*				
Dummy: tour starts in the p.m. peak period or later	1.705	*4.2*			0.711	*2.2*		
Dummy: zone in the odd-even number regulation area			2.385	*2.8*				
Dummy: zone in urban area					1.463	*3.7*		
Dummy: high-income household (>= 10 million Rp./mo.)	7.416	*9.3*						
Dummy: motorcycle-owning household	-0.692	*-1.7*						
Dummy: age is over 65					1.771	*3.2*		
Dummy: full-time worker	-3.588	*-4.5*						

Source: JUTPI 2

Table 37 Home-Based Tour Mode/Destination Choice Model (3/3)

Tour Type	Work		School		Maintenance		Discretionary	
Alternative / Variable	**coeff.**	***t-stat***	**coeff.**	***t-stat***	**coeff.**	***t-stat***	**coeff.**	***t-stat***
Motorcycle Taxi (TXM)								
Alternative-specific constant	1.701	*5.2*	-11.990	*-9.8*	-13.639	*-24.2*	3.412	*3.1*
Vehicle impedance (thousand Rp.) (network skim)			-1.060	*-10.6*	-0.990	*-26.3*	-0.590	*-12.6*
Motorcycle impedance (thousand Rp.) (network skim)	-0.520	*-26.3*						
Dummy: tour starts in the early morning period	-1.072	*-3.4*					7.959	*4.9*
Dummy: tour starts in the p.m. peak period or later							1.107	*2.1*
Dummy: zone in urban area			2.180	*4.1*	0.662	*2.7*		
Dummy: high-income household (>= 10 million Rp./mo.)	6.254	*8.8*						
Dummy: female adult (age >= 17)					1.027	*5.0*		
Dummy: full-time worker	-3.840	*-5.7*						
Dummy: high school student			2.259	*3.3*				
Dummy:a homemaker							2.120	*2.7*
Transit with Motorized Access (TRM)								
Alternative-specific constant	-	-	-16.070	*-10.2*	-19.259	*-23.9*	-	-
Transit impedance (thousand Rp.) (network skim)	-0.150	*-10.1*	-0.220	*-6.9*	-0.110	*-12.3*	-0.180	*-5.4*
Dummy: stop(s) included on the way back home							1.755	*2.3*
Dummy: tour starts in the early morning period							11.415	*7.5*
Dummy: returning segment of sub tour starts in the late night period							1.213	*1.8*
Dummy: zone in the odd-even number regulation area					1.541	*3.0*		
Dummy: zone in Jakarta proper			1.684	*1.9*				
Dummy: zone in urban area							1.480	*2.6*
Log of monthly household income (million Rp.)							0.713	*1.8*
Dummy: high-income household (>= 10 million Rp./mo.)	6.705	*9.2*						
Dummy: full-time worker	-3.932	*-5.6*						
Dummy: university/academy student			1.627	*1.9*				
Transit with Non-Motorized Access (TRN)								
Alternative-specific constant	2.408	*9.5*	-15.894	*-9.6*	-13.505	*-26.3*	3.845	*3.9*
Transit impedance (thousand Rp.) (network skim)	-0.150	*-10.1*	-0.220	*-6.9*	-0.110	*-12.3*	-0.180	*-5.4*
Transit wait time (min) (network skim)	-0.238	*-5.9*						
Log of travel (network) distance (km)					-0.975	*-6.5*		
Dummy: tour starts in the early morning period							9.705	*6.7*
Dummy: origin zone			1.933	*3.7*	1.427	*5.5*		
Dummy: zone in the odd-even number regulation area							1.520	*2.9*
Dummy: low-income household (< 4 million Rp./mo.)			1.914	*3.9*				
Dummy: high-income household (>= 10 million Rp./mo.)	5.987	*8.5*						
Dummy: motorcycle-owning household			3.296	*3.7*				
Dummy: female adult (age >= 17)							0.958	*2.3*
Dummy: age is over 65; 0 otherwise							5.916	*3.0*
Dummy: full-time worker	-3.992	*-6.0*						
Dummy: part-time worker							1.543	*2.4*
Non-Motorized Transport (NMT)								
Alternative-specific constant	-14.679	*-42.2*	-9.264	*-7.7*	-14.911	*-46.2*	-15.288	*-18.4*
Transit impedance (thousand Rp.) (network skim)			-0.220	*-6.9*	-0.110	*-12.3*		
Transit wait time (min) (network skim)	0.019	*8.8*			0.008	*5.7*	0.013	*6.0*
Dummy: secondary tour					0.400	*7.8*	0.773	*8.3*
Dummy: tour starts in the early morning period	-1.783	*-7.6*			0.936	*10.4*		
Dummy: origin zone			3.081	*6.0*	3.131	*29.7*		
Dummy: one child (5 <= age < 17) in household			0.482	*2.4*				
Dummy: one-member household	0.479	*3.9*						
Dummy: low-income household (< 4 million Rp./mo.)	0.347	*4.0*						
Dummy: car plate does not match the odd-even regulation			-0.931	*-2.7*				
Log of age of the individual			-0.610	*-2.1*	1.179	*14.6*	1.115	*8.3*
Dummy: age is over 65	1.321	*4.0*						
Dummy: high school student			0.629	*2.0*				

Source: JUTPI 2

4.2.4 Additional Sub-Models

Intermediate Stop Location Choice

Table 38 presents the results of the estimated multinomial logit model. Four different models have been estimated for work, school, maintenance, and discretionary primary tour purposes. The number of observations available for sampling differs by purpose; however, each model shows a reasonably good fit with the adjusted rho-squared value ranging from 0.25 to 0.53. Modeling outcomes are summarized and discussed below.

As a variable related to the cost of tours with an intermediate stop, an extra generalized vehicle impedance to make the stop as compared to making no stop has been included in the model. Furthermore, variables indicating ToD in which a stop is made have been included in the models except for school tours.

For the intermediate stop location choice, some unique variables have been adopted in the models. Variables indicating the geographical relationship between the origin (home) and destination zones of the tour are among such variables. In general, if a destination zone was selected from the zone group further from the origin in the home-based tour mode and destination choice model, it would increase the utility of making a stop in a zone of the zone group further from both the origin and the destination and vice versa. Variables indicating the travel mode of the tour have also been included in the models. Non-motorized transport is expected to increase the utilities of doing a stop in home zone or the destination zone.

Among the zone-related variables included in the models, a dummy variable indicating whether the zone inside the Central Business District (CBD) which is designated for the "odd/even" policy has been included in the models. This variable reduces the utilities of the CBD zones for stop location. Some household-related variables have proved to be significant in the models; for example, people with children or infants in the household are more likely to make stops in the zones that are the same as the origin or destination (except for school tours). Higher-income household is more likely to make stops in the home zone for maintenance trip since they mostly live in an area where it has a complete public facility like bank, hospital, school, etc. Middle-income household tends to make a stop vary in each zone depends on their other attribute of household/personal status. Some variables indicating the status of individuals have also been included in the models.

Table 38 Home-Based Tour Stop Location Choice Model (1/3)

Main Tour Type	**Work**		**School**		**Maintenance**		**Discretionary**	
Observations =	3217		528		5252		537	
Parameters =	46		34		65		32	
$L(0)$ =	-10334		-1089		-15148		-1911	
$L(\beta)$ =	-5812		-815		-9214		-902	
ρ^2 =	0.438		0.252		0.392		0.528	
Alternative / Variable	**coeff.**	***t-stat***	**coeff.**	***t-stat***	**coeff.**	***t-stat***	**coeff.**	***t-stat***
Stop in Home Zone								
Alternative-specific constant	-	-	-	-	-	-	-	-
Additional vehicle impedance (thousand Rp.)	-0.130	*-23.2*	-0.150	*-9.1*	-0.087	*-17.6*	-0.083	*-6.4*
Additional travel (network) distance (km)	0.845	*6.5*			0.448	*3.4*		
Log of additional travel distance (km)	-1.393	*-6.8*			-0.619	*-3.0*		
Dummy: stop in the a.m. peak period (6:00-10:00)					0.240	*2.4*		
Dummy: main tour OD distance is in 60-100 percentile	0.218	*2.2*						
Dummy: main tour mode is motorcycle	0.577	*4.0*			1.250	*9.7*		
Dummy: main tour mode is taxi					0.980	*2.4*		
Dummy: main tour mode is non-motorized	2.784	*12.1*	1.513	*3.7*	2.527	*12.1*	2.215	*5.0*
Dummy: infant (age < 5) in household	0.271	*2.6*					2.075	*2.7*
Dummy: child (5 <= age < 17) in household					0.181	*2.7*	0.395	*1.9*
Dummy: low-income hhd (< 4 mil. Rp./mo.)			0.761	*2.5*				
Dummy: high-income hhd (>= 10 mil. Rp./mo.)					0.299	*2.4*		
Dummy: female adult (age >= 17)							0.554	*2.6*
Log of age of the individual	1.260	*6.7*	1.064	*3.7*				
Dummy: age over 65							3.273	*2.5*
Dummy: senior high school student	0.810	*2.1*						
Stop in Tour Destination Zone								
Alternative-specific constant	1.205	*1.8*	2.991	*3.1*	0.020	*0.1*	0.350	*1.7*
Additional vehicle impedance (thousand Rp.)	-0.780	*-23.2*	-0.900	*-9.1*	-0.520	*-17.6*	-0.498	*-6.4*
Additional travel (network) distance (km)					0.791	*6.3*		
Log of additional travel distance (km)					-1.311	*-7.3*		
Dummy: stop in the a.m. peak period (6:00-10:00)			0.784	*2.8*				
Dummy: main tour OD zones are the same					0.125	*1.9*		
Dummy: main tour mode is drive alone	0.337	*1.7*	1.270	*2.8*				
Dummy: main tour mode is motorcycle	0.805	*4.3*			1.000	*8.2*		
Dummy: main tour mode is taxi							2.062	*1.9*
Dummy: main tour mode is non-motorized	2.808	*10.8*	1.449	*3.6*	2.226	*10.9*	1.661	*3.6*
Dummy: infant (age < 5) in household							1.702	*2.2*
Dummy: low-income hhd (< 4 mil. Rp./mo.)			1.134	*3.9*				
Log of age of the individual	0.985	*5.4*						

Source: JUTPI 2

Table 39 Home-Based Tour Stop Location Choice Model (2/3)

Main Tour Type	Work		School		Maintenance		Discretionary	
Alternative / Variable	**coeff.**	***t-stat***	**coeff.**	***t-stat***	**coeff.**	***t-stat***	**coeff.**	***t-stat***
Stop in "Inner" Zone (< 20th Percentile Distance)								
Alternative-specific constant	3.516	*4.8*	0.158	*0.1*	0.949	*1.7*	-1.632	*-4.1*
Additional vehicle impedance (thousand Rp.)	-0.780	*-23.2*	-0.900	*-9.1*	-0.520	*-17.6*	-0.498	*-6.4*
Log of additional travel distance (km)					-0.165	*-5.5*		
Dummy: stop in the a.m. peak period (6:00-10:00)					-0.361	*-2.0*		
Dummy: stop in the midday period (10:00-16:00)							0.919	*2.0*
Dummy: stop in the p.m. peak period (16:00-20:00)	0.340	*2.6*					1.130	*2.6*
Dummy: main tour OD distance is in 20-60 percentile	0.654	*4.2*			0.211	*1.9*		
Dummy: main tour OD distance is in 60-100 percentile	0.461	*2.9*						
Dummy: main tour mode is drive alone							-1.600	*-2.0*
Dummy: main tour mode is shared ride			2.405	*2.4*				
Dummy: main tour mode is motorcycle	0.848	*4.4*			0.848	*5.4*		
Dummy: main tour mode is motorcycle taxi	1.238	*3.5*						
Dummy: main tour mode is non-motorized	1.174	*3.4*			1.286	*4.9*		
Dummy: infant (age < 5) in household							1.814	*2.0*
Dummy: child (5 <= age < 17) in household			1.423	*3.1*				
Dummy: one-member household			1.680	*2.2*				
Dummy: only one adult in household							0.817	*2.0*
Dummy: middle-income hhd (4 - 10 mil. Rp./mo.)			0.975	*2.1*				
Dummy: female adult (age >= 17)	0.293	*2.3*			0.229	*2.2*		
Log of age of the individual					-0.384	*-2.6*		
Dummy: part-time worker					0.286	*1.9*	1.792	*3.8*
Stop in "Middle" Zone (20-60th Percentile Distance)								
Alternative-specific constant	1.352	*1.7*	4.036	*2.9*	-0.474	*-1.9*	0.563	*1.5*
Additional vehicle impedance (thousand Rp.)	-0.780	*-23.2*	-0.900	*-9.1*	-0.520	*-17.6*	-0.498	*-6.4*
Additional travel (network) distance (km)					-0.046	*-4.7*		
Log of additional travel distance (km)					-0.085	*-2.3*		
Dummy: stop(s) included on the way from home	0.189	*1.7*	0.943	*3.0*				
Dummy: stop in the early morning period (3:00-6:00)					0.730	*1.9*		
Dummy: stop in the midday period (10:00-16:00)					0.360	*3.8*		
Dummy: stop in the p.m. peak period (16:00-20:00)	0.303	*2.5*			0.242	*2.4*		
Dummy: main tour OD distance is in 20-60 percentile	0.309	*2.7*						
Dummy: main tour mode is motorcycle	0.365	*2.5*	0.763	*1.8*	0.757	*6.0*		
Dummy: main tour mode is taxi			4.466	*3.3*				
Dummy: main tour mode is motorcycle taxi	0.856	*2.9*					1.294	*2.6*
Dummy: main tour mode is non-motorized					0.755	*3.2*		
Dummy: child (5 <= age < 17) in household					-0.197	*-2.4*		
Dummy: middle-income hhd (4 - 10 mil. Rp./mo.)					0.255	*3.1*		
Dummy: female adult (age >= 17)	0.369	*3.5*			0.180	*2.3*		
Log of age of the individual	0.544	*2.7*	-0.899	*-2.1*				
Dummy: part-time worker					0.208	*1.8*		
Dummy: university/academy student	1.053	*3.8*			0.477	*2.7*		

Source: JUTPI 2

Table 40 Home-Based Tour Stop Location Choice Model (3/3)

Main Tour Type	Work		School		Maintenance		Discretionary	
Alternative / Variable	**coeff.**	***t-stat***	**coeff.**	***t-stat***	**coeff.**	***t-stat***	**coeff.**	***t-stat***
Stop in "Outer" Zone (> 60th Percentile Distance)								
Alternative-specific constant	5.917	*8.2*	-2.171	*-1.1*	1.488	*4.7*	1.952	*4.7*
Additional vehicle impedance (thousand Rp.)	-0.780	*-23.2*	-0.900	*-9.1*	-0.520	*-17.6*	-0.498	*-6.4*
Log of additional travel distance (km)					-0.269	*-5.8*	-0.316	*-3.1*
Dummy: stop(s) included on the way back home	0.266	*2.2*			0.352	*2.5*		
Dummy: stop in the early morning period (3:00-6:00)	0.443	*1.7*						
Dummy: stop in the midday period (10:00-16:00)					0.674	*3.9*		
Dummy: stop in the p.m. peak period (16:00-20:00)					0.818	*4.7*		
Dummy: stop in the late night period (20:00-3:00)					0.571	*3.2*		
Dummy: main tour OD zones are the same	0.742	*5.2*	1.035	*2.6*	0.381	*3.3*		
Dummy: main tour OD distance is in 20-60 percentile	0.411	*2.8*			0.292	*2.4*		
Dummy: main tour mode is shared ride			2.355	*2.8*				
Dummy: main tour mode is transit w/ motor. access	1.301	*2.0*					2.276	*1.8*
Dummy: main tour mode is transit w/ non-motor. access			2.323	*3.9*				
Dummy: infant (age < 5) in household			2.674	*4.2*			2.430	*3.0*
Dummy: middle-income hhd (4 - 10 mil. Rp./mo.)	0.345	*3.2*			0.242	*2.5*		
Dummy: female adult (age >= 17)			0.667	*2.1*			0.601	*2.3*
Log of age of the individual			1.267	*2.5*				
Dummy: full-time worker					0.215	*2.2*		
Dummy: part-time worker							1.195	*3.0*
Dummy: senior high school student							-1.097	*-1.7*
Dummy: university/academy student			0.814	*1.9*	0.792	*3.9*		
Stop Location Land Use								
Dummy: zone in Jakarta area					0.409	*4.2*		
Dummy: zone in urban area					-0.388	*-4.1*		
Job density (/ha) in the zone	-0.007	*-12.7*			-0.027	*-7.6*		
Service job density (/ha) in the zone					0.020	*5.3*		
Student (at school place) density (/ha) in the zone			-0.022	*-3.7*				
Household density (/ha) in the zone					0.003	*2.1*		
Fraction of land for business & commercial use			0.032	*2.1*				
Fraction of land for recreational use			0.063	*2.0*				
Log of relevant size variable (service jobs)	1.000	*constr.*			1.000	*constr.*		
Log of relevant size variable (service jobs + hhds)			1.000	*constr.*			1.000	*constr.*

Source: JUTPI 2

4.3 Application to a Microsimulation Model

All the models that have been estimated and described above are the bases for a microsimulation model. The microsimulation model takes the input of each synthesized household (including household size and income group) and person (including age, gender, and status of the person). This process then generates activities/tours with full information including purpose, time of day, origin and destination zones, travel mode, and presence and details of sub-tours and intermediate stops for each household and individual. During application, Monte Carlo random draws are applied to simulate discrete choices at the individual level. Those attributes of tours generated by the microsimulation are detailed enough to create OD trip tables by mode and by the time of day.

There are following three main activity-based microsimulation stages:

- DAP choice which takes the synthesized household and person data as inputs and produces a daily number of home-based tours by activity/purpose with/without intermediate stop(s) and with/without a work-based sub-tour.
- ToD choice takes the above inputs then gives ToD period information for each leg of the tour (i.e., outward and homeward legs), that is, a further breakdown of the tour into two tour legs that are identical to elementary trips if there is no intermediate stop made; and
- Mode and destination choice which takes the above inputs and gives information on travel mode and destination zone for the main activity of the home-based tour.

In addition, some tours need to go through the following stages as well.

- Work-based sub-tour mode and destination choice which require ToDs, mode, and destination of the home-based tour as inputs and gives information on travel mode and destination zone of the work-based sub-tour only if it is included in the DAP.
- Intermediate stop location choice which takes ToDs, mode, and destination of the tour as inputs and gives the location of the intermediate stop only if it is included in the DAP that is a further breakdown of each tour leg into elementary trips.

Furthermore, in order to make the microsimulation more realistic, several important aspects of activity-based modeling should also be considered and incorporated into the microsimulation, such as auto and motorcycle ownership choice, activity rescheduling, joint tour/activity generation, and household maintenance tour allocation. These are explained in the next sections.

4.3.1 Auto/Motorcycle Ownership Model

The auto/motorcycle ownership model is an important parameter of travel demand and implies congestion in both private and public corridors. For this reason, the travel demand model is required to model the vehicle ownership as it is often viewed as a household level choice with subsequent impacts on personal and household activity and travel patterns. Naturally, a less-owned-vehicle household would have a higher tendency of using public transport or sharing the ride. When the option is to share the ride, it significantly affects the interaction of intra-household and influences any further activity-travel pattern.

While the ownership of the vehicle – either auto, or motorcycle, or none – might be then determined by only specific parameters such as income-related ones, nowadays, such parameters become more complex and the process of achieving the optimum model has become time-consuming.

JUTPI 2 considered more than thirty parameters that were presumed significant in course of auto/motorcycle ownership model construction. They are sub-categorized to these divisions; home location, land-use, work type, household characteristics, income, and vehicle availability.

Further details of attributes significances can be seen in the auto ownership model result as described in Table 41. The model reflects a notable relationship with various variables, which are indicated by significant t-stat values and coefficients. Household size and household income seem to be remarkably significant factors for this model. It is observed that household income value influences the model in almost all alternatives. Moreover, the existence of an adult in household and land-use type also affects the model considerably in a certain alternative.

Table 41 Auto Ownership Model

Observations = 8,731, Parameters = 23, L(0) = -16,221, L(β) = -9,876 ρ2 = 0.391

Alternative / Variable(s)	**coeff.**	***t-stat***
Alternative 1 (0C, 0MC)		
Dummy: only one adult in the household	1.080	*9.38*
Dummy: urban area	0.721	*6.52*
Alternative 2 (0C, 1MC)		
Log of monthly household income (million IDR)	1.084	*3.26*
Dummy: infant (age<5) in household	0.746	*9.37*
Dummy: urban area	0.654	*4.85*
Alternative 3 (0C, 2MC)		
Log of monthly household income (million IDR)	2.296	*6.55*
Number of adults (Age >=17)	0.241	*5.50*
Household Size	0.349	*10.55*
Dummy: urban area	0.298	*2.27*
Alternative 4 (1C, 0MC)		
Log of monthly household income (million IDR)	11.832	*5.61*
Dummy: infant (age<5) in household	1.002	*3.36*
5.37		
Log of monthly household income (million IDR)	11.175	*5.37*
Dummy: infant (age<5) in household	0.403	*1.94*
Household Size	0.842	*10.95*
Alternative 6 (2C, 0MC)		
Log of monthly household income (million IDR)	12.956	*6.19*
Household Size	0.526	*4.66*
NON	1.000	-
MC	0.644	*4.95*
CAR	0.345	*5.25*

Note: C = Car; MC = Motorcycle
Source: JUTPI 2

4.3.2 Activity Rescheduling

Scheduling, or time-of-day, model components are included in the activity-based models to represent the important fundamental dimension of time in the activity and travel choice. At the simplest level, time-of-day models are used to predict when activities start and end, as well as their duration. In most activity-based model systems, there are two levels at which schedule choice is considered: the tour level and the trip level. Trip-level scheduling is constrained by tour-level scheduling. In the modeling system developed in this study, all activities/tours are first generated on the individual level. Most activity-based models used in practice have implemented a scheduling hierarchy. By this hierarchy, mandatory purposes activities such as work tour and school tour are scheduled first or in another word, the primary tour. Though both primary and secondary tours are simultaneously generated for each individual in the microsimulation, it is the primary tour that should have priority in the ToD choice. Then, secondary tour(s) should then select the ToDs for the start of the tour and start of the returning segment of the tour from the remaining time windows of the day. The ToD choice models developed in this study include variables indicating whether the tour is a secondary tour and especially whether it is attached to a work primary tour so that a combination of ToDs would be most likely selected from the available time windows for the secondary tour. However, it is not assured that the primary and secondary tours have no time conflict. This logic ensures that no person can be in more than one place at one time. Therefore, if such a conflict has occurred, ToDs of a secondary tour should be selected again based on some stochastic rules to clear the conflict.

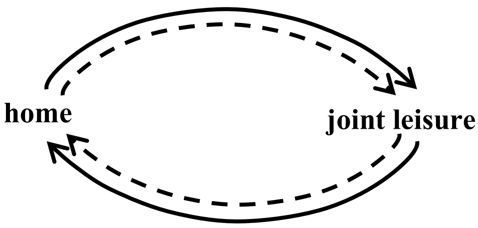
An important aspect of activity-based models is properly representing the effect of time constraints on people’s activity and travel choices. Some early activity-based models did not rigorously do this, allowing tours to be scheduled during overlapping time periods. Moreover, sometimes a case occurs in which two or more secondary tours have been generated for an individual with a time conflict between them. Secondary tours are classified into either maintenance or discretionary tours, and maintenance tours should be given priority in the ToD choice. As such, secondary discretionary tours should be rescheduled if a time conflict occurs between these two activity purposes. In the case of a conflict between secondary tours of the same purpose, one of the tours is given priority on a random basis and the other is rescheduled.

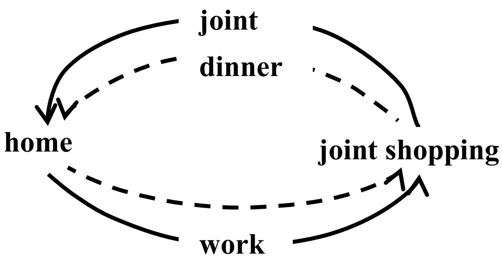
The use of time windows also extends to the scheduling of joint activities in activity-based models with intra-household interactions. These models take into account the schedules of multiple persons within the household, scheduling joint activities only when all participants have sufficient time for the activity and associated travel.

4.3.3 Joint Tour/Activity Generation

The definitions of independent, joint, and escort trips depend on the level of involvement between individuals, as can be determined from available household diary data. In older trip-based surveys, it could be difficult to determine whether two household members participated in an activity together or shared a ride because older survey methods did not stress consistency across individuals when reporting events. This definition is also known as intra-household interactions. Intra-household interactions and decisions, and their potential effect on daily activity-travel patterns should also be considered in the microsimulation. In particular, the analysis of the joint tours/activities made by several members of the same household is an important facet of the activity-based transportation demand analysis and has been the subject of several studies in this area.

As depicted in Figure 50, a fully joint tour is one in which two or more household members travel together to some out-of-home location at which they participate in an activity together. In this case, the activity is a leisure activity, but generally, any no-mandatory out of home activity type would qualify. Usually, two or more household members who commute to work or school together are considered to be not engaged in a joint activity, the assumption being that they are engaging in independent work or school activities, even if in close proximity. In such cases, there is joint travel on the tour, but this is simply represented as a shared-ride mode choice for both persons, not as an instance of joint activity participation. If, however, they were to stop on the way home from work for a meal, the meal event would indeed represent joint activity participation, making this a partially joint tour.





Source: National Academies of Sciences, Engineering, and Medicine 2014. Activity-Based Travel Demand Models: A Primer. Washington, DC: The National Academies Press.

Figure 50 Fully Joint Tour **Figure 51 Partially Joint Tour**

For microsimulation development, only fully joint activities/tours are considered. As such, based on the results obtained from an exploratory analysis of the ADS and HTS datasets, several important rules have been adopted to generate fully joint tours/activities.

First, one of the basic findings, which has been replicated in several metropolitan regions, is that if a child stays home (e.g., sick child), this decreases the probability that adult household members will conduct their 'typical' mandatory travel for that day (Vovsha et al., 2004c). Based on the above case, some of the following rules have been made.

- If at least one of the school children of pre-driving age has a home (i.e., no travel) pattern, it is likely that at least one of the household adults has a home pattern to take care of the child.
- If more than one worker in the household has the same job category and their primary activity is a work tour, it is likely that they work and travel together. The probability of having a joint primary work tour depends on the job category.
- If more than one school children belong to the same school type (elementary school, junior high school, senior high school, or university) and have a primary school tour, it is likely that they go to school and return home together. The probability that they have a joint primary school tour depends on the school type.
- If at least one of the school children of pre-driving age has a non-mandatory (i.e., maintenance or discretionary) primary tour, it is often associated with visiting a doctor, family event, and so on. In this case, each non-worker, part-time worker, full-time worker, or university student in the household has a chance of escorting the child and having the same primary non-mandatory tour at a certain probability depending on the status. Adults having a higher chance of escorting the child are non-workers, part-time workers, full-time workers, and university students, in this order, and each adult household member should be tested with the probability derived from the observations.
- If a full-time worker or a university student in the household does not have a primary work or school tour (i.e., having a day off) and chooses a non-mandatory (i.e., maintenance or discretionary) primary tour, it is often associated with major shopping, family event, vacation, and so on. In this sense, he or she is likely accompanied by at least one of the other adult household members. In this case, each non-worker, part-time worker, full-time worker, or university student in the household has a chance of accompanying the worker/student and having the same primary non-mandatory tour at a certain probability depending on the status.

In microsimulation, if one of the above rules is applicable to a household, a Monte Carlo random draw is picked for each individual to be investigated. If the value falls within the probability derived from the statistics, the tour/activity is modified to form a fully joint tour/activity.

Due to survey limitations, joint trip/ tour generation is not utilized in JUTPI 2 microsimulation. This will not have a tremendous effect on the final result since it only affects a small portion of total trips/tours.

4.3.4 Household Maintenance Tour Allocation

Another important feature of the intra-household interactions and decisions is a maintenance tour allocation in the household. In the context of activity-based modeling, some model systems have modeled the generation of maintenance tours (such as shopping, escort, and personal business) at the household level and then allocated each tour to a specific household member.

Though all activities are first generated at the individual level in the modeling system developed in this study, the following rule has been applied to the microsimulation to take the above concept into consideration.

- Maximum number of maintenance tours per household for each household size is determined through the lookup table based on the 95th percentile values of the observed data. If the number of simulated maintenance tours exceeds this maximum, maintenance tours are deleted from workers, students, homemakers, or whoever has an exceeding number of maintenance tours.

However, this type of model has not gained widespread use in practice due to its efficiency. It is not apparent whether including such model will substantially affect the forecast, and also that the coding of activity purposes in most survey data is not precise enough to know when someone is performing an activity on behalf of the household versus for the individual (e.g., grocery shopping versus shopping for personal items).

Chapter 5 MICROSIMULATION

5.1 Population Synthesis

5.1.1 Introduction

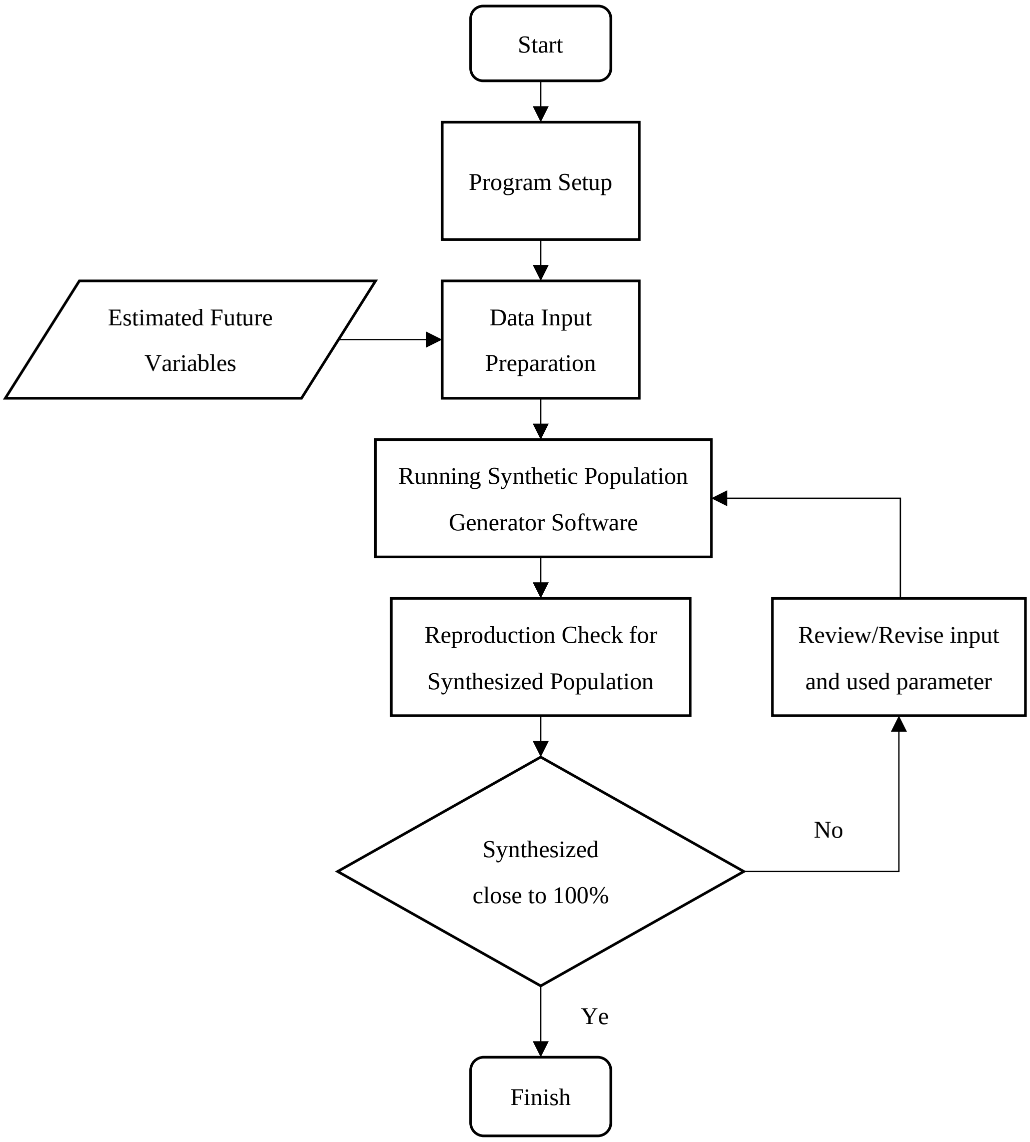
The synthetic population whose attribute distribution matches to those of the general population by TAZ and region is required to estimate the disaggregated travel behavior of each household and person in the study area for microsimulation modeling.

As a population synthesizer, "Synthetic Population Generator Software", software developed by Arizona State University and widely utilized for population synthesis in the United States and other countries, was used. It utilizes typical Iterative Proportional Fitting (IPF) as a way for matching persons and households based on their control total by TAZ.

For household and person samples, the combined result of Commuter Survey in JUTPI 1 and Activity – Travel Diary Survey in JUTPI 2 was utilized as it contains fundamental household and personal attributes that affect the estimation of travel behavior.

5.1.2 Population Synthesis Methodology

The population synthesis process was implemented in several steps as described in Figure 52.

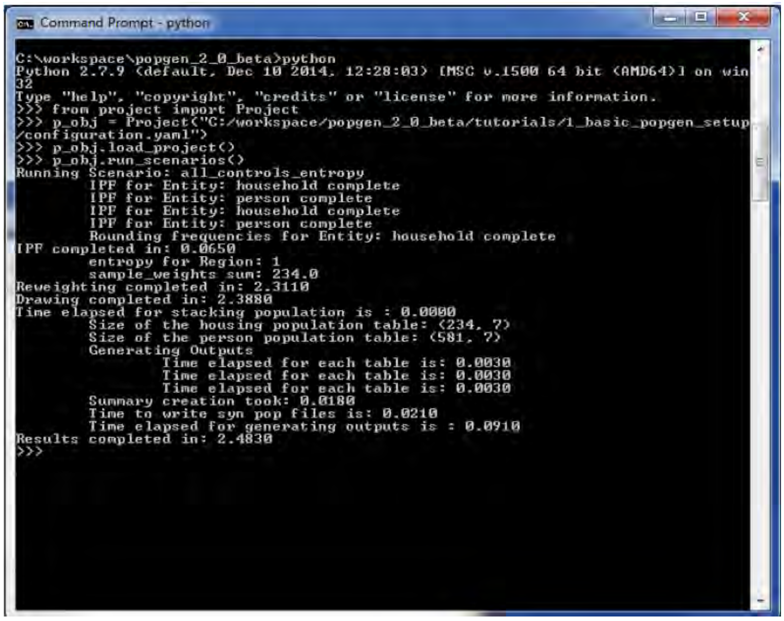


Source: JUTPI 2

Figure 52 Methodology of Population Synthesis

(1) Program Setup

The general population in this study is categorized into two geographical levels, traffic analysis zone (TAZ) and region (*Kota/kabupaten*) level. Synthetic population generator software can control variables from both geographic resolutions simultaneously while controlling and matching both household-level and person-level attribute distributions. Thus, a robust synthetic population can be generated, and all of the available information can be fully utilized. Synthetic population generator software requires a programming language to run correctly since the synthetic population generator software is written entirely in a programming language as can be seen in Figure 53.



Source: JUTPI 2

Figure 53 Synthetic Population Generator Software

Some parameters were used in Synthetic Population Generator Software to synthesize the population. Synthetic population generator software is composed of Iterative Proportional Fitting, Reweighting, Draws, Geos to synthesize, and output, each parameter are used following value:

Table 42 Synthetic Population Generator Software Parameter

Calculation part	Parameter	Value
Iterative Proportional Fitting	Tolerance	0.0001
	Iterations	250
	zero_marginal_correction	0.00001
Reweighting	Procedure	entropy
	Tolerance	0.0001
	inner_iterations	80
	outer_iterations	30
Draws	pvalue_tolerance	0.9999
	iterations	15
	seed	0
Geos to synthesize	All ids	TRUE

Source: JUTPI 2

(2) Data Preparation

a) Present Variables

To synthesize population in 2018, the combined population data of Commuter Trip Survey in JUTPI 1 and Activity – Travel Diary Survey in JUTPI 2 was utilized as an input data. The population data was distributed to TAZ level by each variable to make targeted values in 2018 and to prepare household-level and person-level sample data. This sample is utilized in both present and future population synthesis processes.

b) Estimation of Future Variables

Future population synthesize in two geography levels, so input data is prepared in both levels. Central Bureau of Statistics Indonesia provides estimation of future population by gender and age group up to the year of 2035 in region level. Using this secondary data, future population and household by TAZ level were estimated by JUTPI 2 team as explained in Chapter 0. Future income distribution was estimated using GRDP growth.

The remaining variables such as household size, work type and transportation allowance were assumed to follow the same pattern as in 2018. Meanwhile, data of household's distance from the nearest railway station was estimated by utilizing JUTPI 2 master plan.

c) Input Files

In this study, preparation of input files consists of four steps:

The first step is to link the upper spatial resolution (region level) and lower spatial resolution (TAZ level) in order to invoke multilevel control for different variables of interest. The linking is classified as one-to-many since region is the upper spatial resolution compared to TAZ. On the other hand, link between spatial and sample data in both region and TAZ level are required to satisfy marginal control at both levels and draw households from sample data and assign them to geographical resolution observed in TAZs as synthetic population.

The second step is to prepare marginal dataset at region and TAZ level to be utilized as controls in generating the synthetic population. Each marginal dataset must include the name, category, and marginal distributions of the control variables. There are four marginal datasets prepared as an input:

- Household marginal distributions at the region level
- Person-level marginal distribution at the region level

- Household marginal distributions at the TAZ level
- Person-level marginal distribution at the TAZ level

The third step is to prepare household-level and person-level sample data in the population synthesizer, which includes unique household ID, ID for the sample geography to which the household belongs, and all variables of both levels.

All totals of marginal values across all variables should be consistent.

Marginal control variables by household and personal attribute by each scenario of Master Plan Case and Do Minimum Case in 2018, 2024, 2029, and 2035 as shown in the following table are estimated for 2 levels of TAZ and region level.

Table 43 List of Control Variables of Population Synthesis

Type	Code	Attribute	Control Level	Data format in CS	Code	Category
Household	HHSize	Household Size	*Kota/Kabupaten*	Real number	HHSize1	1 person per HH
					HHSize2	2 persons per HH
					HHSize3	3 persons per HH
					HHSize4	4 persons per HH
					HHSize5	5 persons per HH
					HHSize6	6 persons per HH
					HHSize7	7 persons per HH
					HHSize8	8 persons per HH
					HHSize9	9 persons per HH
					HHSize10	10 persons per HH
					HHSize11	11 persons per HH
					HHSize12	12 or more persons per HH
	HHInc	Household Income	*Kota/Kabupaten*	Choice	HHInc1	Less than IDR1,000,000
					HHInc2	IDR 1.000.000 - IDR 1.499.999
					HHInc3	IDR 1.500.000 - IDR 1.999.999
					HHInc4	IDR 2.000.000 - IDR 2.999.999
					HHInc5	IDR 3.000.000 - IDR 3.999.999
					HHInc6	IDR 4.000.000 - IDR 4.999.999
					HHInc7	IDR 5.000.000 - IDR 5.999.999
					HHInc8	IDR 6.000.000 - IDR 7.999.999
					HHInc9	IDR 8.000.000 - IDR 9.999.999
					HHInc10	IDR10.000.000 - IDR12.499.999
					HHInc11	IDR12.500.000 - IDR14.999.999
					HHInc12	IDR15.000.000 - IDR17.499.999

Type	Code	Attribute	Control Level	Data format in CS	Code	Category
					HHInc13	IDR17.500.000 - IDR19.999.999
					HHInc14	IDR20.000.000 - IDR22.499.999
					HHInc15	IDR22.500.000 - IDR24.999.999
					HHInc16	IDR25.000.000 and over
	Sta_dis	Distance from Railway Station	TAZ	Real number	Sta_dis1	0-400m
					Sta_dis2	400-800m
					Sta_dis3	800-2000m
					Sta_dis4	<2000m
Person	Sex	Sex	TAZ	Choice	Sex1	Male
					Sex2	Female
	Age	Age	*Kota/Kabupaten*	Real number	Age1	Age 0 - 4
					Age2	Age 5 - 9
					Age3	Age 10 - 14
					Age4	Age 15 - 19
					Age5	Age 20 - 24
					Age6	Age 25 - 29
					Age7	Age 30 - 34
					Age8	Age 35 - 39
					Age9	Age 40 - 44
					Age10	Age 45 - 49
					Age11	Age 50 - 54
					Age12	Age 55 - 59
					Age13	Age 60 - 64
					Age14	Age 65 - 69
					Age15	Age 70 - 74
					Age16	Age 75 and over
	SS	Social Status	*Kota/Kabupaten*	Choice	SS1	Full-time Worker
					SS2	Part-time Worker
					SS3	University/ Academy student
					SS4	Homemaker
					SS5	Unemployed
					SS6	Students
					SS7	Others
					SS8	Nothing
	WorkType	Type of Work	*Kota/Kabupaten*	Choice	WorkType1	Work in a private company
					WorkType2	Work in a government office
					WorkType3	Merchant
					WorkType4	Salesclerk / waiter
					WorkType5	Store/ Market

Type	Code	Attribute	Control Level	Data format in CS	Code	Category
					WorkType6	Public transport driver
					WorkType7	Chauffeur
					WorkType8	Farm / forest / fishing
					WorkType9	Security guard
					WorkType10	Others/ Nothing
					WorkType11	Unknown/ Unmatched
	Allowance	Transport Allowance from Company	*Kota/Kabupaten*	Choice	Allowance-1	Not required to answer
					Allowance0	Unknown
					Allowance1	Get Allowance
					Allowance2	Do not get Allowance/ No information
	TollAllowance	Toll Allowance from Company	*Kota/Kabupaten*	Choice	TollAllowance-1	Not required to answer
					TollAllowance0	Unknown
					TollAllowance1	Get Allowance
					TollAllowance2	Do not get Allowance/ No information
	ParkingAllowance	Parking Allowance from Company	*Kota/Kabupaten*	Choice	ParkingAllowance-1	Not required to answer
					ParkingAllowance0	Unknown
					ParkingAllowance1	Get Allowance
					ParkingAllowance2	Do not get Allowance/ No information

Source: JUTPI 2

(3) Running Synthetic Population Generator Software

In this study, the population is synthesized for 7 cases as follows:

1. Present case in 2018
2. Master Plan Case in 2024
3. Master Plan Case in 2029
4. Master Plan Case in 2035
5. Do Minimum Case in 2024
6. Do Minimum Case in 2029
7. Do Minimum Case in 2035

The number of persons and household samples that are used for each case is the same as the total of 186,507 households and 682,463 persons. The synthesized population that is almost equal to the target each year is shown below.

Table 44 Comparison of Synthesized and Estimated of Population and Household by JUTPI 2

Case	HH			Person		
	Estimated Total (JUTPI 2)	Synthesized	Reproduction rate	Estimated Total (JUTPI 2)	Synthesized	Reproduction rate
Present Case in 2018	9,139,981	9,139,982	100.000011%	33,848,672	33,861,024	100.036492%
Master Plan Case in 2024	10,217,267	10,217,268	100.000007%	38,855,371	38,855,724	100.000908%
Master Plan Case in 2029	10,826,231	10,826,232	100.000013%	41,713,398	41,719,955	100.015719%
Master Plan Case in 2035	11,884,922	11,884,921	99.999994%	45,969,648	45,976,544	100.015000%
Do Minimum Case in 2024	10,218,278	10,218,284	100.000059%	38,855,371	38,851,759	99.990704%
Do Minimum Case in 2029	10,828,198	10,828,203	100.000049%	41,713,011	41,708,727	99.989730%
Do Minimum Case in 2035	11,889,490	11,889,492	100.000018%	45,969,648	45,970,195	100.001190%

Source: JUTPI 2

5.1.3 Reproduction Check for Synthesized Population

Even though the population is synthesized, the result should be validated in the TAZ/ individual level because this method is controlled with just only macroscopic indices. Therefore, this section checks the difference between JUTPI 2 database and Synthesized results and shows the accuracy of it.

Indices for checking were decided considering utilization in demand forecast. At the demand forecast stage, trips are strongly related to all attributes. Thus, a reproduction check should be done to all of the attributes using the following indices:

Table 45 Reproduction Check List

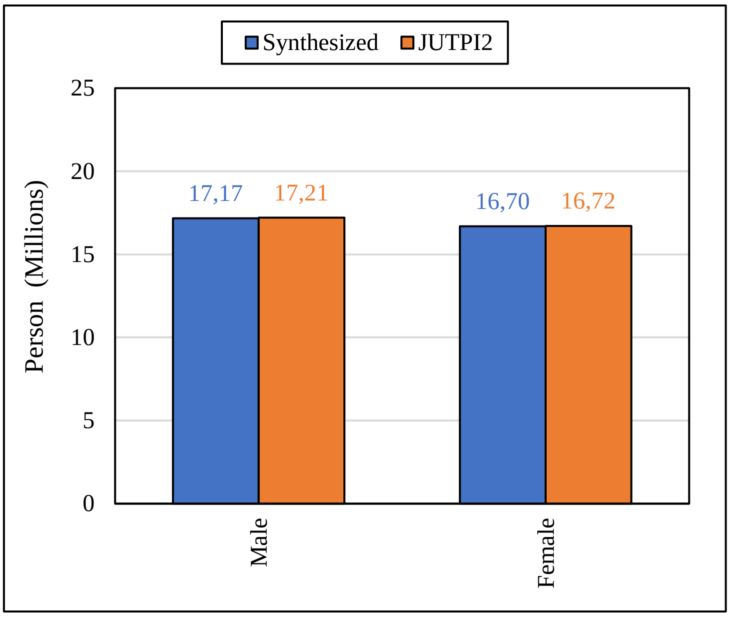
Attribute	Controlled level	Validation level
Sex	TAZ	TAZ
Age	TAZ	TAZ
Social Status	*Kota/Kabupaten*	TAZ
Type of Work	*Kota/Kabupaten*	TAZ
Allowance	*Kota/Kabupaten*	TAZ
Toll Allowance	*Kota/Kabupaten*	TAZ
Parking Allowance	*Kota/Kabupaten*	TAZ
Household income	*Kota/Kabupaten*	TAZ
Household Size	*Kota/Kabupaten*	TAZ
Distance from railway station	TAZ	TAZ

Source: JUTPI 2

The Reproduction check results of Case 1 is shown below, further results of Case 2 to Case 7 can be found in Appendix A: Verification Synthesized Population. All 10 indices in Case 1 are almost matched to the marginal variables.

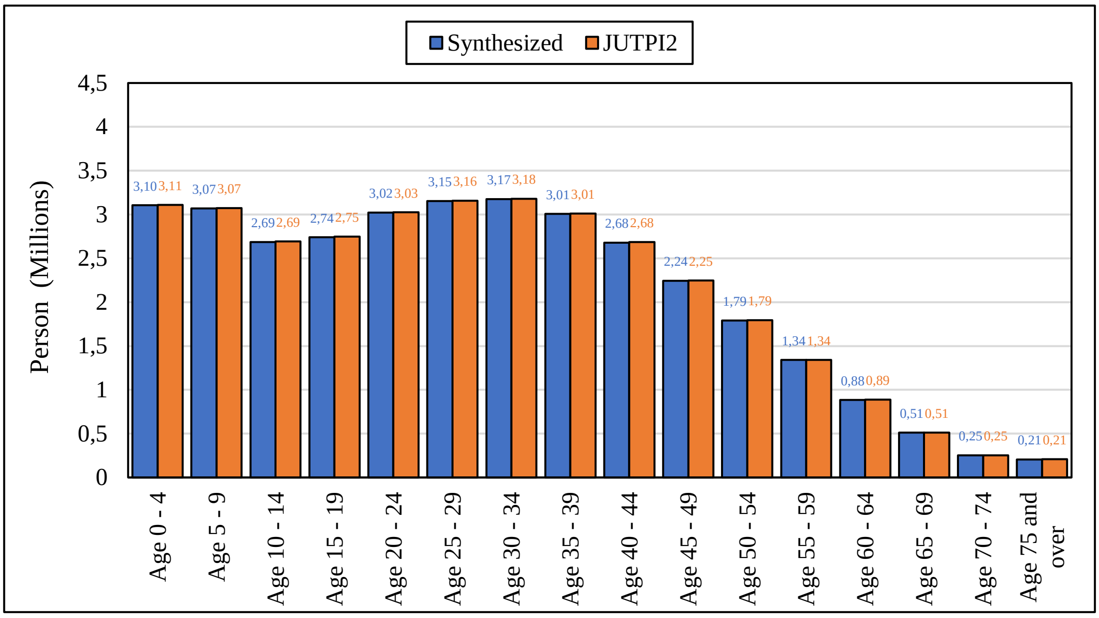
(1) Case 1 – Present Case in 2018

Person Synthetic Data



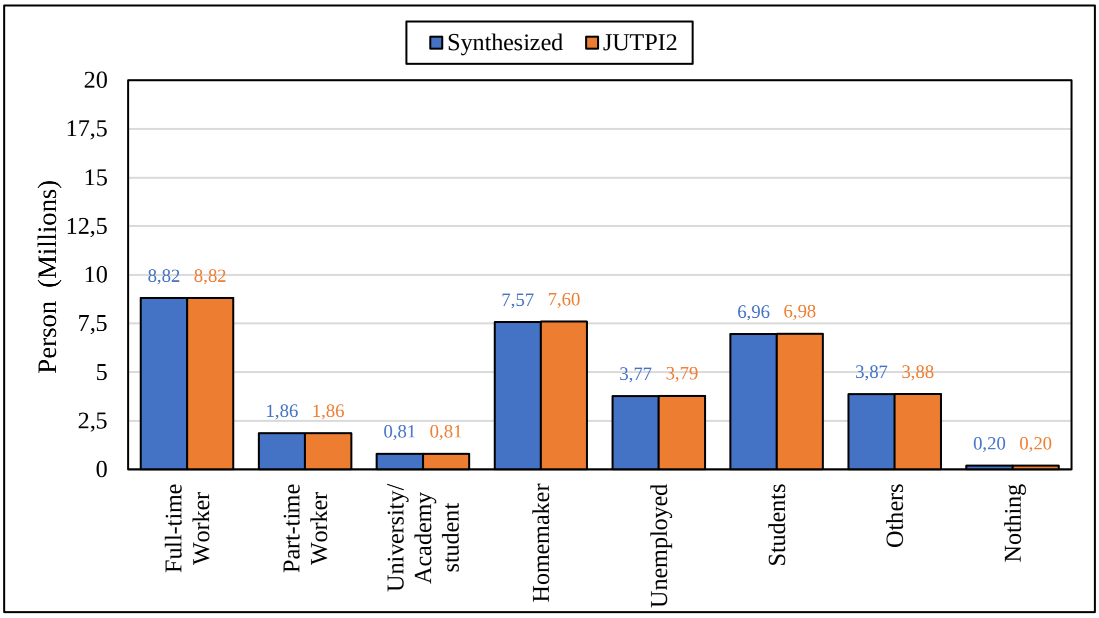
Source: JUTPI 2

Figure 54 Estimation of Population by Gender at TAZ Level in 2018



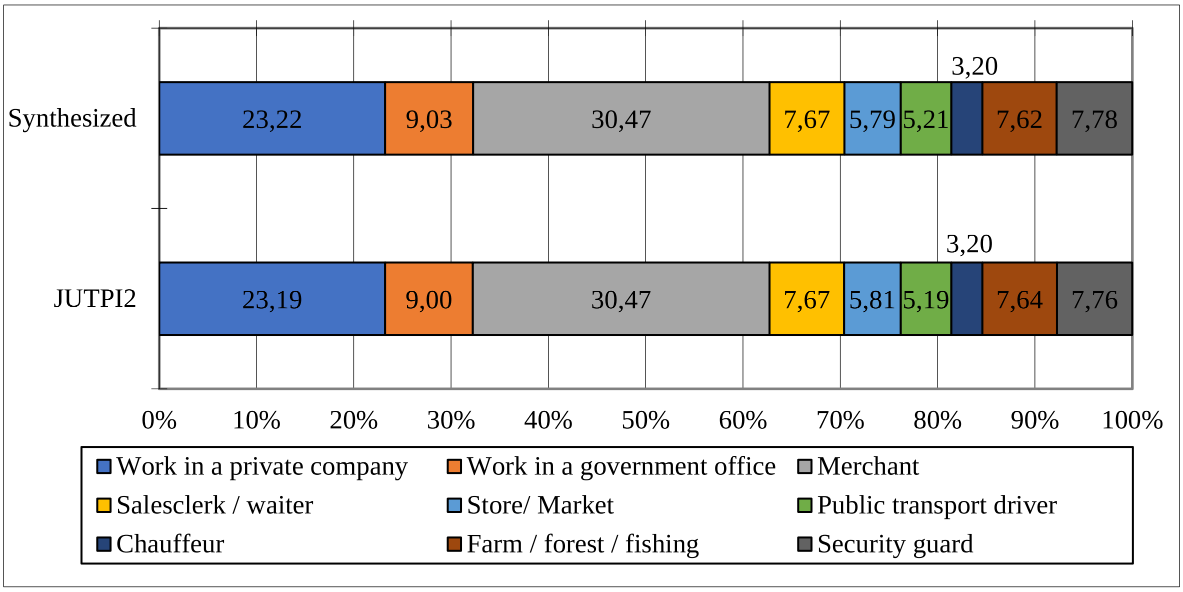
Source: JUTPI 2

Figure 55 Estimation of Population by Age Group at TAZ Level in 2018



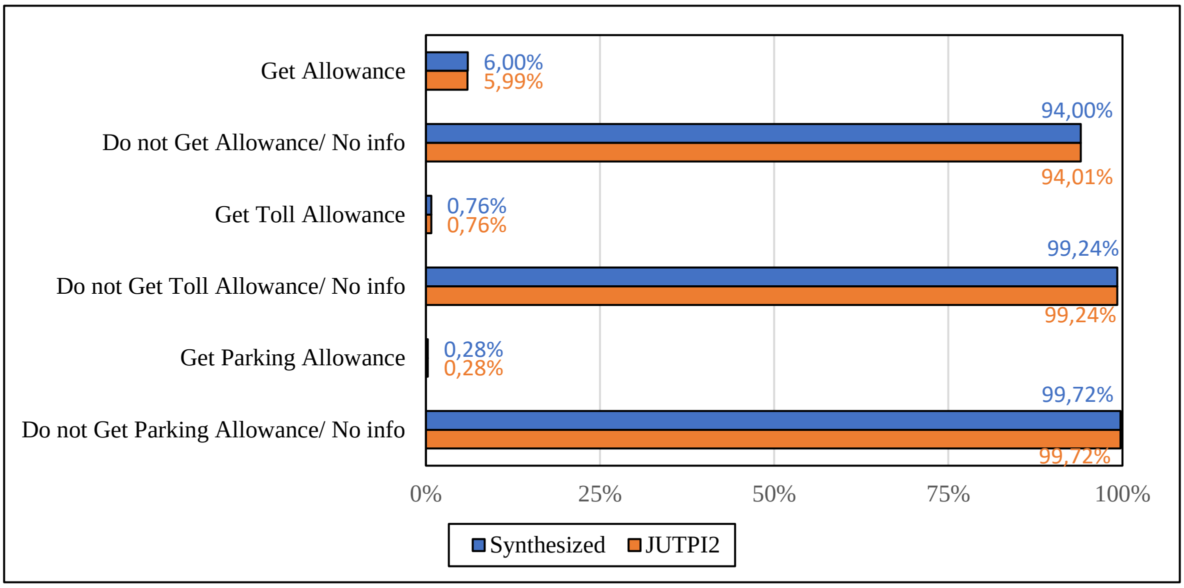
Source: JUTPI 2

Figure 56 Estimation of Population by Main Activity at TAZ Level in 2018



Source: JUTPI 2

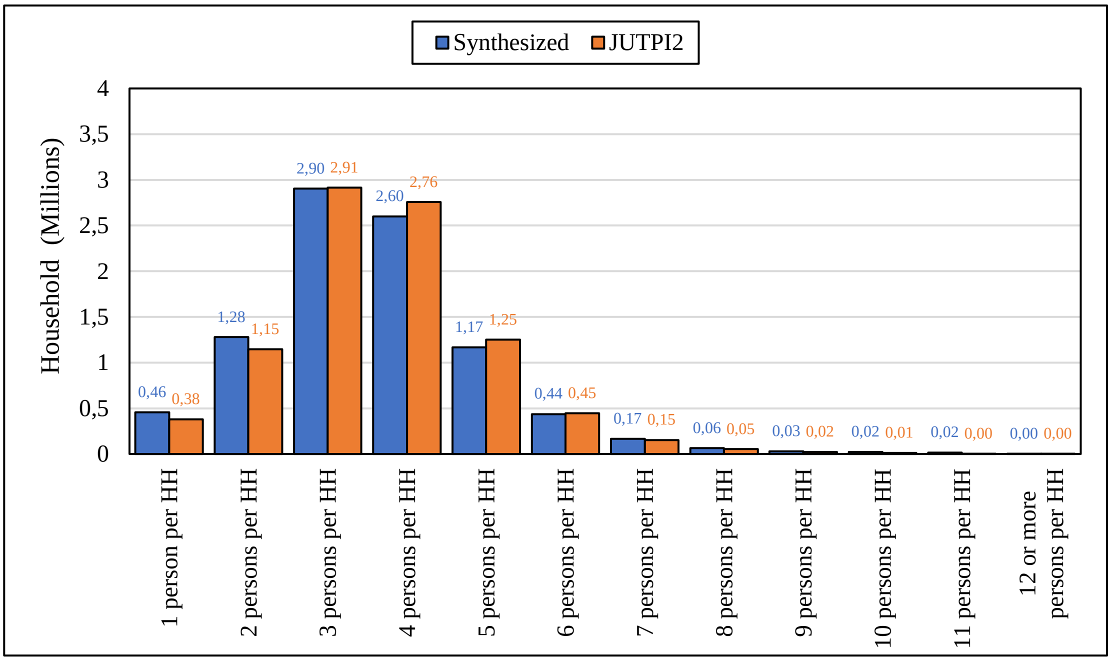
Figure 57 Estimation of Worker by Type of Work at TAZ Level in 2018



Source: JUTPI 2

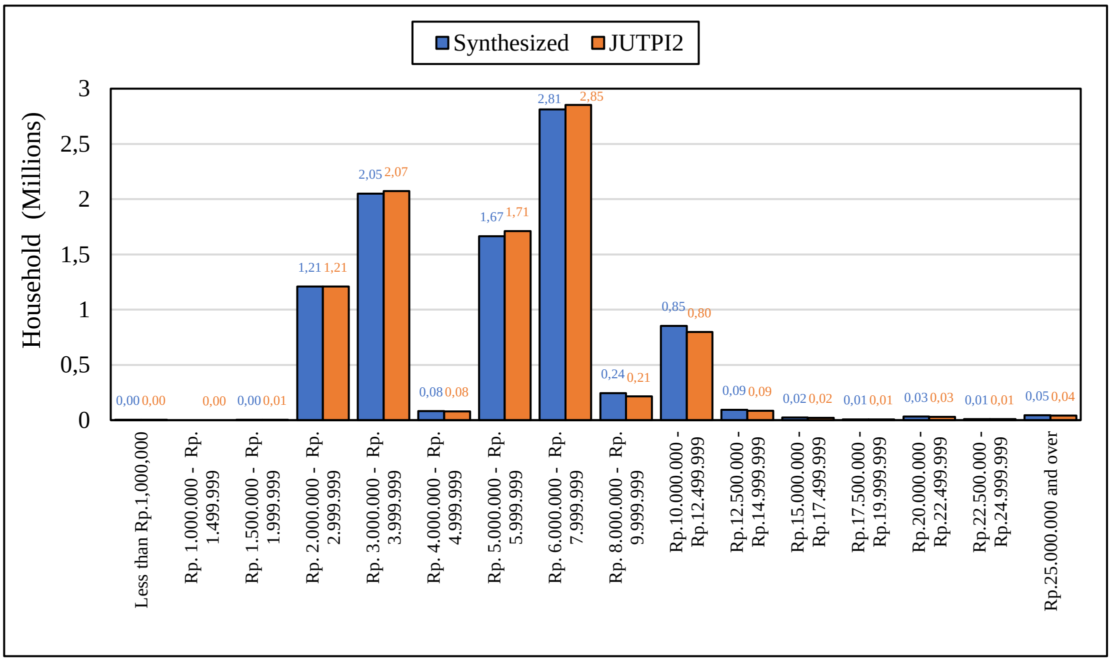
Figure 58 Estimation of Worker's Allowance at TAZ Level in 2018

Housing Synthetic Data



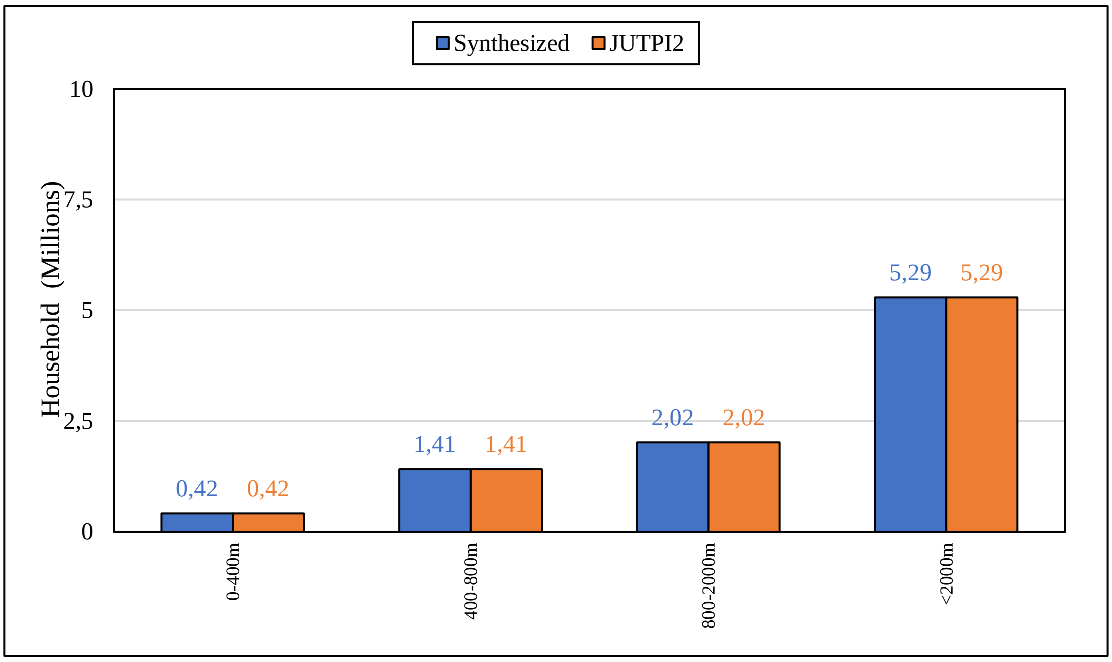
Source: JUTPI 2

Figure 59 Estimation of Household Size at TAZ Level in 2018



Source: JUTPI 2

Figure 60 Estimation of Household Income at TAZ Level in 2018



Source: JUTPI 2

Figure 61 Estimation of Household Distance from the Nearest Railway Station at TAZ Level in 2018

5.1.4 Summary

All targeted values in each variable and the synthesized results are matched closely to each other. The synthesized population result can be utilized for the next process, which is input preparation for Microsimulation (Chapter 5.2). In this step, only 5% of the total population that systematically selected will be an input for the next process.

5.2 Input Preparation

At this stage, all variables act as an input for the activity-based models are prepared based on the policy scenario and the synthesized population. Those variables are zone data, land-use info, car/motorcycle availability, and lookup values (tour distribution for each tour purpose, ToD distribution, and immediate home return for work-based sub tour). Other inputs are highway and transit network skim and attributes from activity-based modeling systems like log sum value and activity/tour variables from each upper and lower model.

The activity-based models need the input of the number of autos and motorcycles owned by a household as well as auto/motorcycle availability to an individual. The probability of each household owned auto/motorcycle is acquired from an auto/motorcycle ownership choice model. Then the number of auto/motorcycle ownership is decided as part of the microsimulation for each household through a stochastic Monte Carlo approach. Meanwhile, the actual availability of auto/motorcycle for each individual is determined by the lookup table from the result of an auto/motorcycle choice model and undergoing the stochastic process again with Monte Carlo draws.

5.3 Activity-Based Models

Activity-based models are based on behavioral theories about how people make decisions about activity participation in the presence of constraints, including decisions about where to participate in activities, when to participate in activities, and how to get to these activities. The activity-based modeling system that is presented in Figure 5 takes attributes of each household, individual, and zone as inputs. Then, utilities are computed in the lower models first and later in the upper models with log sums from the lower models. The only purpose of this step is to obtain log sums to calculate the utilities of upper models. Hence the system then stored the log sums in the memory for microsimulation then based on computed cumulative probabilities and Monte Carlo random draws of which values range between 0 and 1, the microsimulation first chooses the uppermost daily activity-travel pattern (DAP) model for an individual. If an out-of-home DAP is selected for each tour produced, probabilities of ToD alternatives then computed, and another random draw is taken to determine the choice in the ToD model. This process then repeated for the (home-based tour) mode and destination choice as well for work-based sub-tour mode and destination choice and intermediate stop location choice. Thus, actual microsimulation is applied to the upper model first, and then to lower models because of the single outcome chosen in the upper model (s).

Mode and destination choice together with the DAP choice model are two-tier nested logit models, so Monte Carlo random draw is taken twice, one for each tier. In addition, for mode and destination choice and intermediate stop location choice, a set of representative zones available to an individual for each sampling stratum (i.e., group of zones based on distance and size variable percentiles) are selected based on the random draws, and this process should be done prior to the log sum calculations.

Moreover, some activity patterns and tours as model outputs are still representative ones and need further explicit specifications. Necessary additional procedures that should be taken for some activity patterns and tours are as follows:

- Subdividing the primary pattern based on the DAP;
- Subdividing the secondary tour type based on the primary pattern and DAP;
- Setting number of secondary tours based on the secondary tour type;
- Setting pattern (presence of intermediate stops) of the secondary tour based on the secondary tour type;

- Setting ToD of the work-based sub-tour; and
- Setting ToD of the work tour with an intermediate home return.

These are determined by looking up the frequency tables that have been developed based on the statistics of the ADS and HTS. The adjustment process is again stochastic with Monte Carlo random draws.

5.4 Intra-Household Interaction Rules

It is being known that individuals do not make their travel decisions in isolation of the household context and have produced a growing interest in intra-household interactions. The travel demand models that explicitly accommodate intra-household interactions are expected to provide more insight into travel behavior and more credible analysis. From a conceptual standpoint, the inclusion of intra-household interactions adds aspects of behavioral realism to the models.

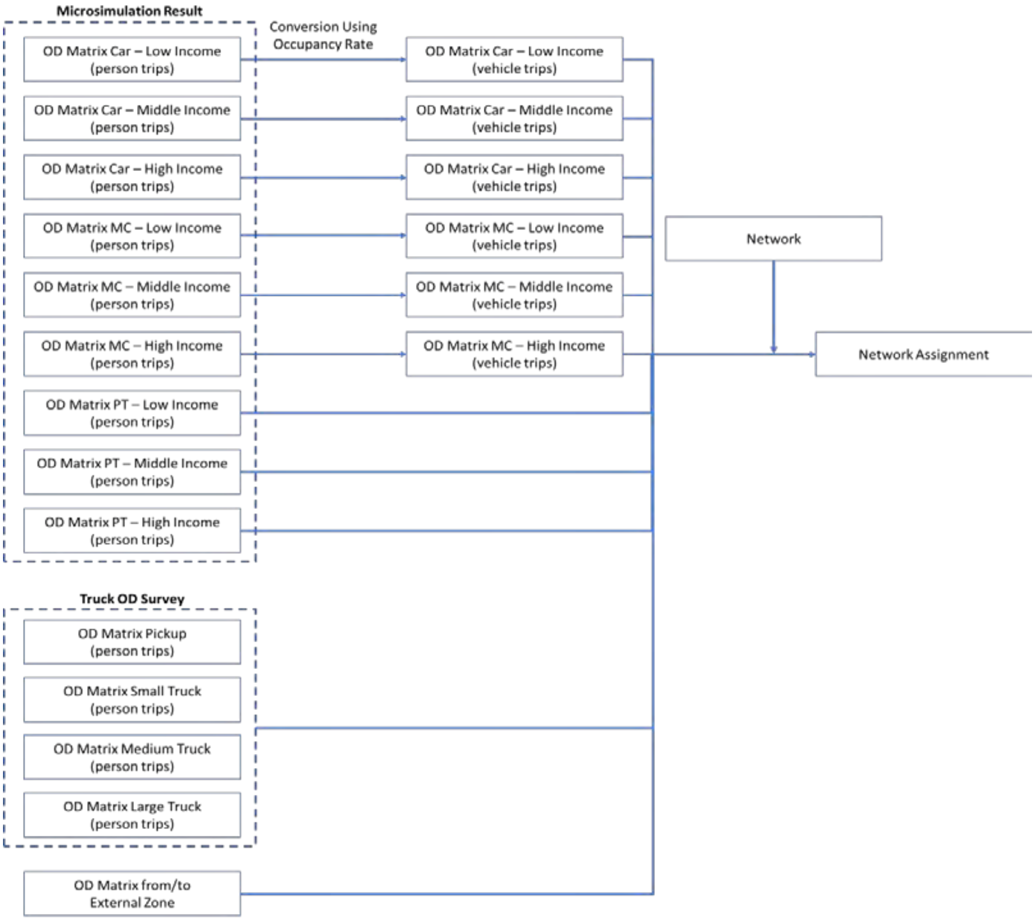
Individuals of the same household are processed through the microsimulation at the same time and the order of processing members of a household has been pre-determined. The head of the household and its spouse are processed first, and then other adult household members. Children of a pre-driving age are processed last in the sense that they are generally considered more dependent on determining their activities than adults.

Finally, the consideration of intra-household interactions, in which household members may allocate or coordinate activity participation in complex ways, results in greater internal consistency at both the person and household level.

5.5 Output Processing

Microsimulation output is processed to create numerous summary tables such as frequencies of primary activities, secondary tours, ToDs for tour start/return, trip modes, and trip distances. Some tables may be segmented by purpose or ToD, or some may focus on the tours/trips to and from a certain part of the JABODETABEK though focusing on a small area like a TAZ should be avoided due to the microsimulation variability concern. These are used for policy analysis as well as for validation of the activity-based modeling system.

On the other hand, the microsimulation output is aggregated along several travel demand dimensions for transportation network assignment. OD Matrices, segmented by mode, ToD, and household income group should be created for this purpose.



Source: JUTPI 2

Figure 62 OD Matrix for Network Assignment

Conversion from person trips to vehicle trips is needed for private network assignment, occupancy rate that has been derived from the observations in the ADS and the screen line survey are used for the private modes and taxis (paratransit), as shown in Table 46 below.

Table 46 Occupancy Rate for Motorcycle and Car

Mode of Travel	Occupancy Rate
Car	1.63
Motorcycle	1.37
Motorcycle Taxi	
Taxi	1.59

Source: JUTPI 2

Based on the OD matrices result, the intra-zonal ratio can be estimated. Intra-zonal ratio explains the number of trips leaving and ending inside the same zone compared to the total trips. Table 47 shows the percentage of intra-zonal trips. While the average trip length (excluding intra-zonal trip and trip to external zones) shown in Table 48.

Table 47 Intra-zonal Ratio

Mode of Travel	Intra-zonal Ratio
Car	52%
Motorcycle	53%
Public Transport	40%

Source: JUTPI 2

Table 48 Average Trip Length

Mode of Travel	Average Trip Length		
	Low Income	Middle Income	High Income
Car	12.82	10.51	8.29
Motorcycle	13.10	10.97	9.03
Public Transport	20.96	17.51	14.00

Source: JUTPI 2

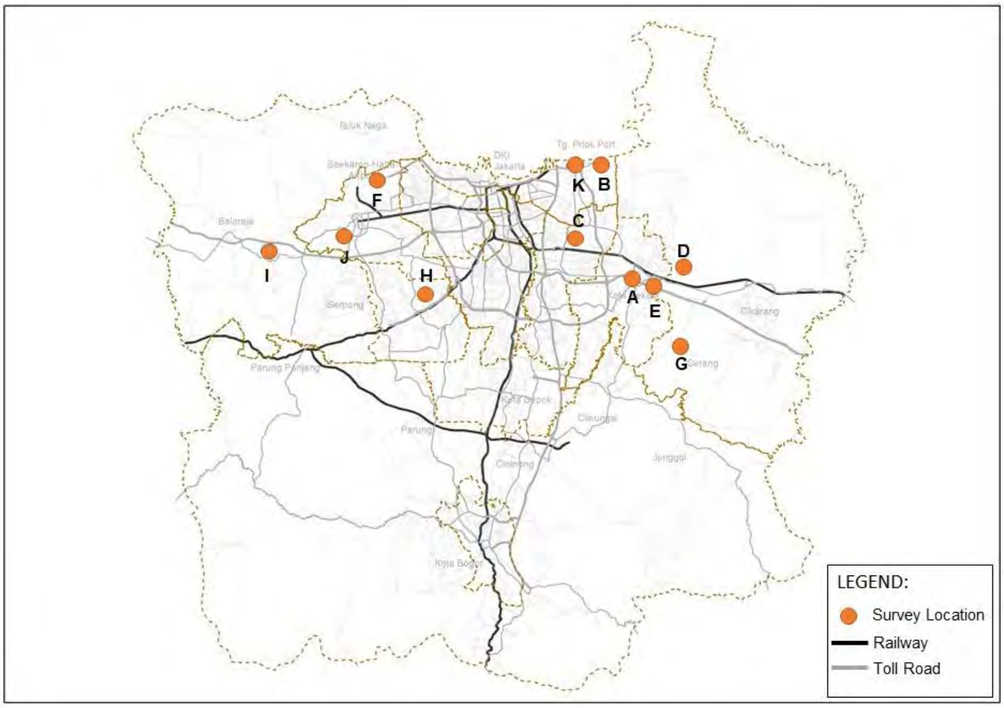
Chapter 6 TRUCK AND EXTERNAL OD

6.1 Cargo Traffic Model

6.1.1 Truck OD Survey

The objective of Truck OD Interview Survey is to understand the travel characteristics of truck vehicular trips and goods movement generated or attracted to/from major origin and destination such as ports and industrial estates.

Many industrial estates have been operated in the JABODETABEK region. Pulo Gadung Industrial Estates located in the east of Jakarta has long been operated as the first industrial estate in Indonesia. In BODETABEK, a considerable number of industrial estates have been developed near toll road interchanges. In particular, medium- to large-scale industrial estates have been developed in Cikarang and Balaraja districts. As it is not possible to cover all of these in this survey, the focus will be on selected industrial areas and Tanjung Priok Port. The selected industrial estates for the survey are shown in Figure 63.



Source: JUTPI 2

Figure 63 Truck OD Survey Location

6.1.2 Truck OD Matrix Development

The survey results were expanded by other related surveys (travel speed survey, cordon line survey, and screenline survey) to get overall truck movement in the entire JABODETABEK. In the future freight demand projection, the planned development of logistics infrastructures such as Patimban port that under construction are considered. Besides, future cargo volume is estimated considering future GRDP.

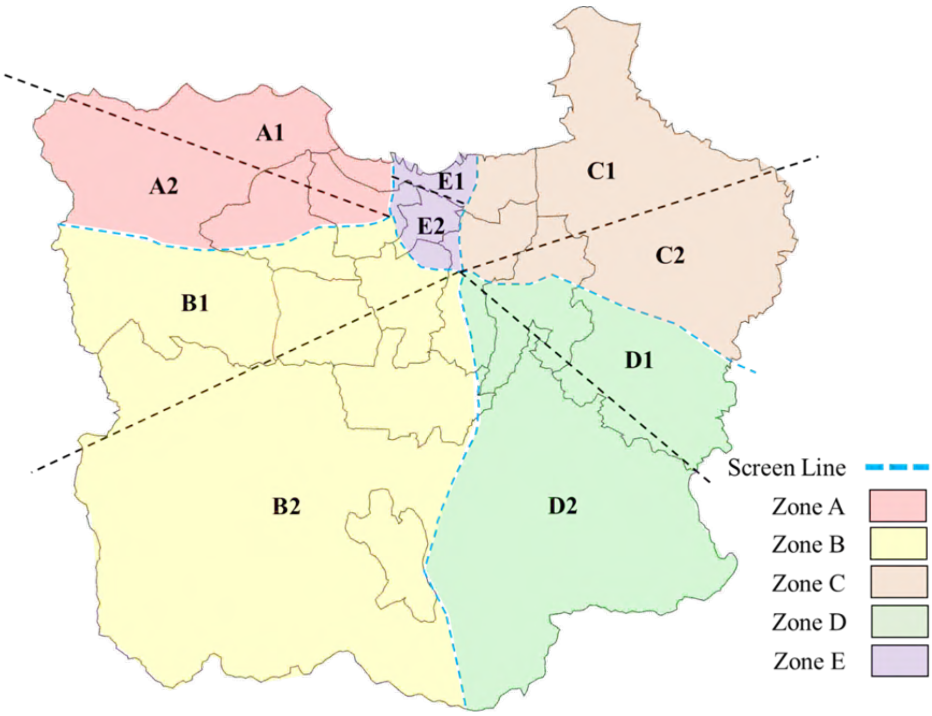
(1) Development of Present Pick-up and Small Truck OD

To develop present pickup and small truck freight OD matrices by time groups, four major data are being utilized, which are: truck OD interview survey results, OD data obtained from the GPS tracking records from travel speed survey, screenline survey results, and the cordon line survey results.

The partial OD matrices from/to the selected industrial estates within JABODETABEK of five-time groups are estimated by using expansion factors of the truck OD interview survey results.

Meanwhile, the OD matrices within JABODETABEK with approximately 337,000 trips by time groups are prepared from the GPS records of pickup and small trucks, which obtained for the travel speed survey. However, these OD matrices are biased to be sampled because the data were collected only from a GPS tracking company that cannot present overall freight movement in JABODETABEK.

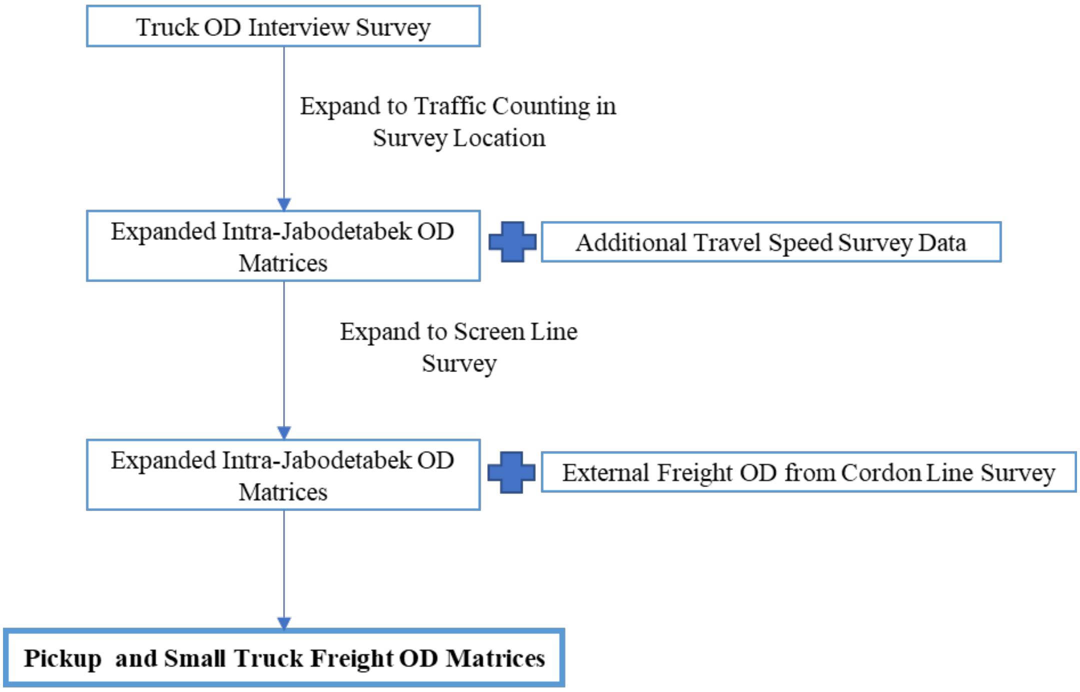
The partial OD matrices from the truck OD interview survey and the OD matrices from the travel speed survey are combined by multiplying adjustment factors for each OD matrix within JABODETABEK by 10 areas shown in Figure 64.



Source: JUTPI 2

Figure 64 Areas Utilized for Truck OD Development

The adjustment factors for ten areas are defined by the screenline and cordon line survey by five-time groups. It is estimated by using the OD matrices to match the five different zones from the screenline by using the solver function of spreadsheet software. The screenline survey results are adjusted by using the cordon line survey result to estimate trips within JABODETABEK. The differences between the screenline survey result and OD location of the cordon line survey, which are the number of external-external, external-internal, and internal-external trips crossing each screenline will generate the number of trips within JABODETABEK. Then, external freight OD data from the cordon line survey is added to the matrices to formulate pickup and small truck freight OD matrices. The method of the present OD development for pick up and small trucks is described in Figure 65.



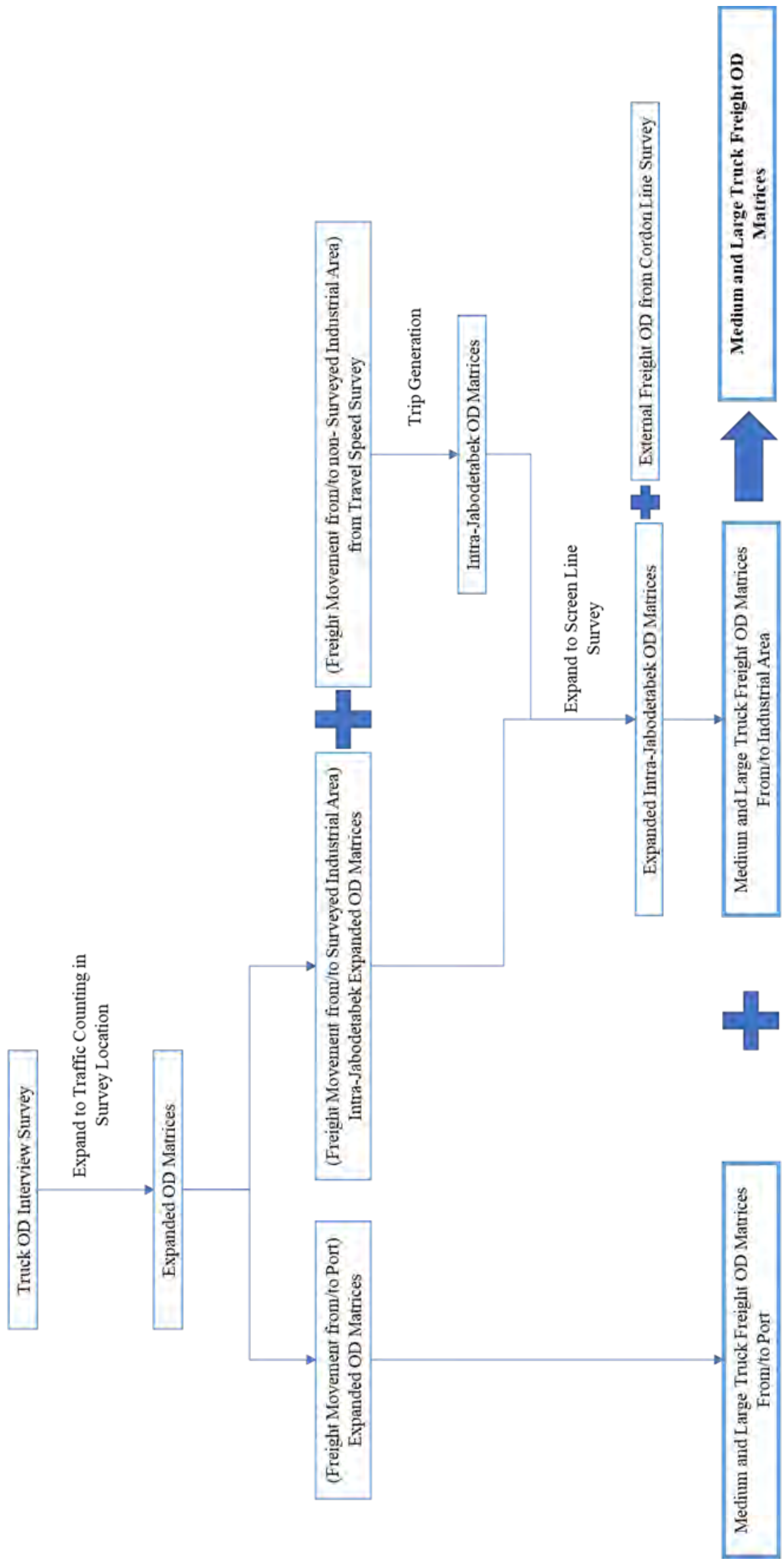
Source: JUTPI 2

Figure 65 Flow Chart of Development of Pick up and Small Truck OD

(2) Development of Present Medium and Large Truck OD

There are 374,000 large truck ODs and 267,000 medium truck ODs which obtained from the travel speed survey to be utilized in the calculation for intra JABODETABEK OD matrices. Then, the method of OD development of present medium and large truck OD related to intra JABODETABEK OD matrices is similar to pick up and small trucks.

All the trips from/to Tanjung Priok Port by medium and large trucks are counted by the truck OD interview survey, and the OD survey was conducted with a relatively high sampling rate which is 10% with random sampling. Therefore, it is acceptable to utilize the OD matrices from the truck OD interview survey for trips from/to Tanjung Priok Port. The method of the present OD development for medium and large trucks is described in Figure 66



Source: JUTPI 2

Figure 66 Flow Chart of Development of Medium and Large Truck OD

(3) Development of Future Freight Matrices

The loading and unloading activities in this chapter carried out in Tanjung Priok Port based on the sea transportation statistics book. However, the statistic book does not consider the construction of Patimban Port. Therefore, the adjustment model for unloading calculation is necessary to accommodate additional freight capacity in Patimban Port.

In principle, the present freight OD matrices are expanded utilizing GRDP growth to estimate the future freight matrices. Future freight loading is estimated based on future GRDP, while estimation of future unloading is calculate using methods. Method one is using calculation of future GRDP that is based on regression of previous year's GRDP and a variable adjusted to the previous year unloading. Method two is using future GRDP that is based on the regression of the previous year's GRDP adjusted by the exchange rate IDR to USD. In addition, future development related to freight movement such as the Patimban port that under construction is considered.

Based on historical loading and unloading volume of Tanjung Priok port and GRDP, a regression model based on the two methods mentioned above are developed. The results of the regression models can be seen below.

Model 1:

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	0	#N/A	#N/A	#N/A
GRDP (1000 trillion IDR)	21.7761	1.2962	16.7989	3.3878E-10
dummy variable	-10.5100	3.2389	-3.2448	0.0063

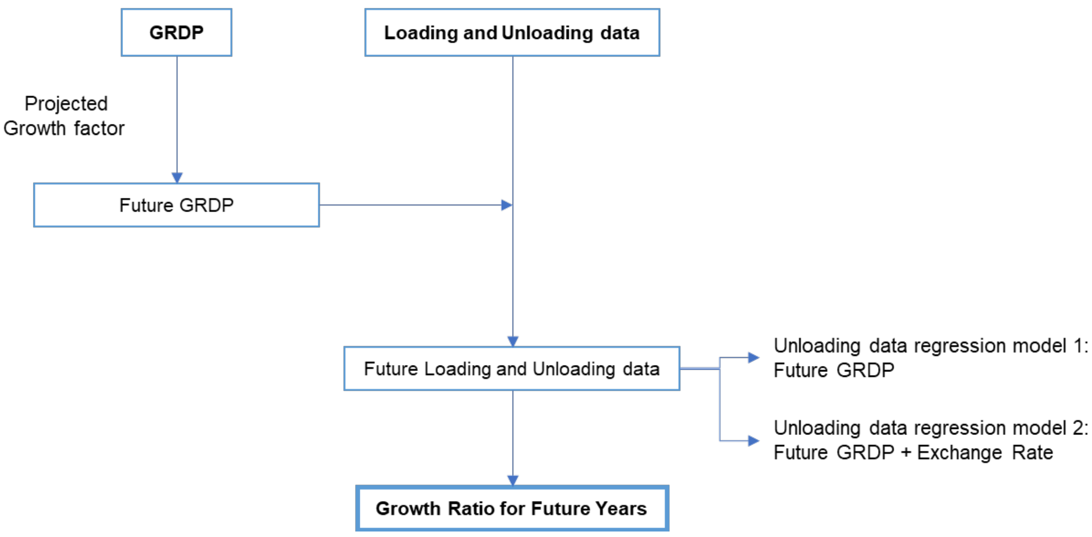
Note: R^2 adjusted = 0.8957

Model 2:

	Coefficients	Standard Error	*t Stat*	*P-value*
Intercept	-800.4036	151.8834	-5.2698	0.0001
GRDP (ln)	24.5889	4.5136	5.4477	0.0001
1 USD in 1000 IDR	-2.7816	0.6823	-4.0767	0.0015

Note: R^2 adjusted = 0.6686

By inputting future GRDP growth discussed in Chapter 2 to the regression model, the growth of freight handling volume is estimated as shown in Figure 67.



Note:
Growth ratio (unloading growth ratio) = (sum of unloading model 1 + unloading model 2) for target year / (sum of unloading model 1+ unloading model 2) for 2018
Source: JUTPI 2

Figure 67 Flow Chart of Growth Ratio

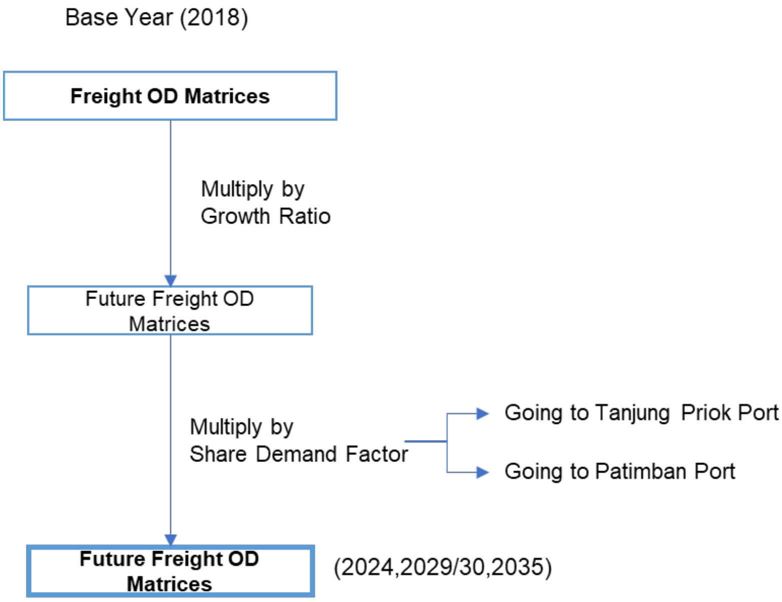
In the table below the projected GRDP cargo volume, and number of the growth ratio are shown.

Table 49 Growth Ratio of Freight

Year	GRDP (Billion IDR)	Loading (Ton)	Unloading (Ton) (Model 1)	Unloading (Ton) (Model 2)	Unloading Total (Ton)	Unloading Growth Ratio
2018	2.505	19,751,095	44,034,210	31,818,410	75,852,620	1
2019	2.639	20,293,834	46,954,076	33,100,686	80,054,762	1.06
2020	2.77	20,799,416	49,814,486	34,295,171	84,109,657	1.11
2025	3.457	23,105,104	64,774,713	39,742,588	104,517,301	1.38
2030	4.245	25,241,072	81,925,288	44,789,025	126,714,313	1.67
2035	5.147	27,246,156	101,564,586	49,526,233	151,090,819	1.99

Source: JUTPI 2

Future freight OD matrices are calculated by multiplying the present OD matrices with the growth ratio. In line with the feasibility study of Patimban port, trips to/from ports are divided into trips going to Tanjung Priok port and those of Patimban port.



Source: JUTPI 2

Figure 68 Flow Chart of Future Freight Matrices

Result of freight assignment in JABODETABEK shown in Table 50 in the form of travel distance and travel time from 2018, 2024,2029, and 2035. In 2024, there is a decreasing trend of travel time from 2018 due to massive tolls development in 2024 that supports freight movement in JABODETABEK.

Table 50 Travel Distance and Travel Time of Freight

		2018	2024	2029	2035
Travel Distance (VEH-KM)	PICKUP	9,760,000	12,860,000	16,120,000	20,890,000
	STRUCK	5,850,000	7,830,000	9,830,000	12,720,000
	MTRUCK	2,380,000	3,940,000	4,940,000	6,420,000
	LTRUCK	2,490,000	3,780,000	4,760,000	6,140,000
Travel Time (VEH-HOUR)	PICKUP	53,910,000	39,750,000	46,230,000	61,490,000
	STRUCK	79,480,000	94,860,000	123,580,000	152,700,000
	MTRUCK	9,050,000	10,480,000	13,240,000	16,850,000
	LTRUCK	8,340,000	7,980,000	10,240,000	14,000,000

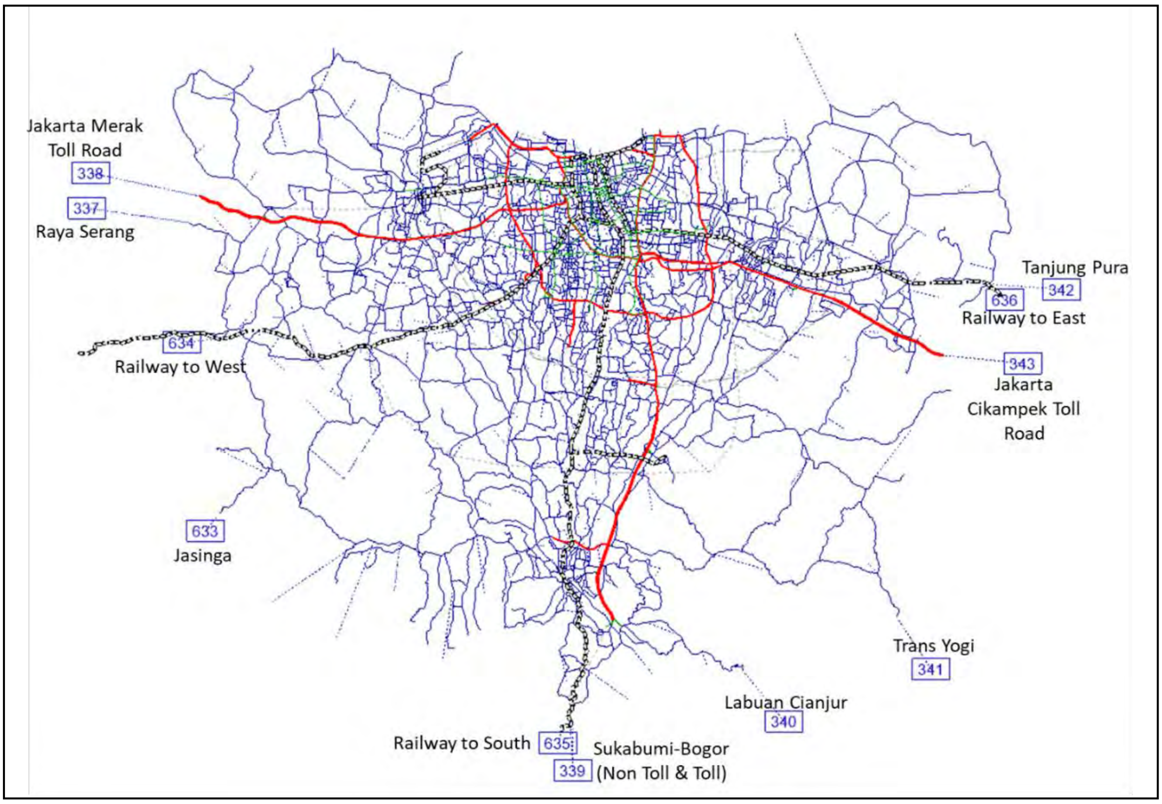
Source: JUTPI 2

6.2 External OD

6.2.1 Cordon Line Survey

The main objective of the cordon line survey is to obtain vehicle and passenger information and trip pattern data from respondents who cross the boundary of JABODETABEK using all possible modes, including private vehicle, bus, train, and airplane. Each cordon line survey was conducted and designed to survey each point before passenger or vehicle crossing JABODETABEK. This survey includes intercity bus passenger OD interview survey (survey at intercity bus terminal), intercity train passenger OD interview survey (survey at the intercity railway station), airport survey, cordon line survey on arterial road and toll road. The sampling rate for all survey sets at 20%, which is a relatively large amount of sample. Based on the data obtained, the passenger movement entering/leaving JABODETABEK using water transportation mode is relatively small. Thus, water transportation was not surveyed.

The obtained information is helpful to identify Origin Destination patterns in terms of person movements crossing JABODETABEK region..



Source: JUTPI 2

Figure 69 The External Zones

6.2.2 External OD Matrix Development

Based on the collected data, OD matrices are estimated with interview survey results expanded by passenger or vehicle flow from occupancy or passenger/traffic count survey.

Result of the surveys show that private car (arterial and toll road) has the highest modal share of external trips, followed by airplane, motor cycle, bus, railway and minibus.

Table 51 Mode Share of JABODETABEK External Trips

Mode	Gate	Passenger Flow				2 Ways	%
		Outbound		Inbound			
Bus	West Gate	34,957	101,946	31,522	117,415	219,361	21.1%
	East Gate	64,584		80,075			
	South Gate	2,405		5,818			
Minibus	West Gate	5,498	25,855	4,752	18,178	44,033	4.2%
	East Gate	7,741		390			
	South Gate	12,615		13,036			
Train	West Gate	8,295	37,589	8,295	37,589	75,179	7.2%
	East Gate	28,208		28,208			
	South Gate	1,086		1,086			
Airplane	Soekarno Hatta	103,099	114,799	102,968	113,891	228,690	22.0%
	Halim	11,700		10,923			
Private Car	West Gate	40,645	125,854	31,756	125,408	251,263	24.2%
	East Gate	63,917		74,831			
	South Gate	21,292		18,822			
Motorcycle	West Gate	26,568	111,168	24,460	110,141	221,308	21.3%
	East Gate	41,528		44,160			
	South Gate	43,071		41,520			
Total			517,211		522,623	1,039,834	100%

Source: JUTPI 2

Future external OD matrices are calculated by applying the growth ratio in existing OD matrices. Growth ratio, in this case, is population growth for each *kota/kabupaten*. The population for each target year is explained in Chapter 2.2.

Table 52 Growth Factor for External Trip

Kota/Kab.	Growth Factor (2035/2018)
Jakarta Pusat	0.982
Jakarta Timur	1.042
Jakarta Selatan	1.060
Jakarta Barat	1.147
Jakarta Utara	1.083
Kab. Bogor	1.363
Kab. Bekasi	1.758
Kota Bogor	1.199
Kota Bekasi	1.424
Kota Depok	1.638
Kota Tangerang Selatan	1.536
Kota Tangerang	1.313
Kab. Tangerang	1.526
Airport	1.870

Source: JUTPI 2

Chapter 7 NETWORK ASSIGNMENT

7.1 Key Features

The key features of the network used for the trip assignment are summarized as follows. The method used for assignment is 'multi-user class equilibrium assignment' on the generalized cost of travel. The user classes are:

- Motorcycles, by three income classes,
- Cars by three income classes,
- Public Transport (Bus Volumes as Pre-loads), PT person trips are also assigned by three income classes, and
- Trucks (Pickup, Small Truck, Medium Truck, and Large Truck).

The assignment was conducted for each five-time group and eventually combined into one result (daily). The network assignment was developed by using the software platform of traffic modeling software and additional customizable script in the platform of programming language to run the microsimulation.

7.2 Assumption

7.2.1 Value of Time (VoT), Occupancy, and PCU

Generally, VoT is divided for passenger and freight. Passenger VoT mentioned in this chapter is classified by income classes and type of mode. It is estimated using household income from survey database, by considering representative mode used (motorcycle, car, and public transport), the average number of household member for each income classes, and assuming the average monthly working hours is 160 hours (8 hours per day and 20 working days in a month).

Table 53 Weighted Average Income by Mode and Assumptions

Mode of Travel	Weighted Average Income by Mode		
	Low Income	Middle Income	High Income
Motorcycle	3,710,971	6,674,166	11,851,006
Car	3,756,030	7,409,403	14,912,267
Public Transport	3,538,189	6,684,825	11,847,848
Average Household Size	4.04	4.09	4.09
Monthly Working Hours	160 hours		

Source: JUTPI 2

Different from passenger VoT, freight VoT is estimated based on the opportunity cost of vehicle and goods, and wages of the driver. The opportunity cost of vehicle considers the price of a new vehicle for each type of truck, with 12.5% depreciation cost per year, and assumption of operation hours of a truck per year is 2,080 hours whereas the opportunity cost of goods considers the capacity of each type of truck and freight value. Results for both VoT presented in Table 54.

Table 54 Value of Time

Mode of Travel	Value of Time – VoT (IDR/Hour)		
	Low Income	Middle Income	High Income
Motorcycle	5,737	10,196	18,116
Car	5,807	11,319	22,796
Public Transport	5,470	10,212	18,111
Pickup	37,100		
Small Trucks	47,700		
Medium Trucks	72,400		
Large Trucks	103,100		

Source: JUTPI 2

With the transport modes aggregated into 7 modes for network assignment, further analysis and traffic assignment was conducted by applying the passenger car equivalent shown in the table below for each mode operated in the road network.

Table 55 PCE Factor for Aggregated Mode for Network Assignment

Aggregated Mode for Network Assignment		PCE Factor
Motorcycle		0.25
Car		1.0
Public Transport	Small Bus	1.2
	Medium Bus	1.5
	Large Bus	2.0
Pickup		1.0
Small Trucks		1.5
Medium Trucks		2.0
Large Trucks		2.5

Source: JUTPI 2

7.2.2 Tariff System and Public Transport Parameter

Cost parameters such as toll tariff and public transport fare are also considered in the network assignment. Table 56 summarizes the tariff system on the toll road in 2018 and Table 57 lists the fare system of public transport as of 2018.

Table 56 Tariff System on Toll Road, 2018

Toll / Section Name	Tariff (Rupiah)	
	Flat Tariff	Distance Proportionate
Jakarta Outer Ring Road (JORR)	15,000	
Jakarta Intra Urban Tollway (JIUT)	9,500	
Airport	7,000	
Jakarta-Serpong	3,000	
Jagorawi	6,500	
Depok - Antasari		1,293
Jakarta - Cikampek		210
Jakarta - Tangerang		260
New toll road (operated after 2018)		1,200

Source: JUTPI 2, collected from various sources

Table 57 Tariff System on Public Transport, 2018

Mode	Fare (Rupiah)
Large Bus	15,000
Medium Bus	4,000
Small Bus	4,000 – 6,000
Busway (exclusive lane)	3,500
Commuter Line (KCI)	First 25km=3,000 Additional 1,000 per each 10km
LRT	6,000
MRT	Flag fall=1,500 Additional 850 per each km

Source: JUTPI 2, collected from various sources

Since there were no detailed surveys in this study related to headway and speed of public transport survey for each mode in JABODETABEK, secondary data was utilized, and some assumptions need to be made as follows.

Table 58 Summary of Public Transport Parameter on Base Year Network

Modes	No. of Lines	Headway	Speed	Travel Time
Commuterline	6	Varies according to the existing timetable	30 km/h	
Airport Railink	1	Varies according to the existing timetable	30 km/h	
Transjakarta	115	Varies according to the secondary data (5-50 minutes)	20 km/h	
Small Bus (Angkot)	426	Varies according to the secondary data (5-30 minutes)		1.2 x Passenger Car Travel Time
Medium Bus	80	Varies according to the secondary data (10-60 minutes)		1.2 x Passenger Car Travel Time
Large Bus	144	Varies according to the secondary data (15-60 minutes)		1.2 x Passenger Car Travel Time
Walk			4 km/h	

Source: JUTPI 2, compiled from various sources

7.2.3 Capacity and Speed Relationship

When the minimum generalized cost between a specific pair of zones is searched on a network, travel time on each link of the network must be calculated in advance. In general, travel speed depends on how much traffic passes at the same time. In other words, travel speed decreases according to the increase in traffic volume. The relationship between travel speed and traffic volume is often called 'QV' function.

A QV function for this study was established by taking the following aspects into consideration:

- Free flow speed is the safe travel speed at which a vehicle would travel along a road section in the absence of other traffic. This free flow speed utilized the previous study in JABODETABEK.
- Capacity is expressed in terms of passenger car unit per day. Link capacity can be expressed in terms of possible capacity and assignment capacity. Possible capacity, which can accommodate a given condition of the road section, such as the number of lanes, operation, median, and so on, was defined based on the Indonesian Highway Capacity Manual. Assignment capacity represents the total number of daily traffic volumes which is adjusted to the possible capacity considering various factors such as functional classification of a road, encroachment, peak characteristics, and the presence of signals. This daily assignment capacity also subdivided into a five-time group for time group assignment.

The proposed capacity and speed function applied in the demand forecast is shown in Table 59.

Table 59 Capacity and Speed Function by Type of Road

No.	Link Type ID	Functional Classification	No. of Lanes	Median	Free-flow Speed (km/h)	Assignment Capacity (pcu/day)
1	12 (with MC+Truck ban) 16 (with Truck ban) 20 24 (with MC ban)	Urban Arterial	1	No	40	9,720
2	13 (with MC ban+Truck ban) 17 (with Truck ban) 21 25 (with MC ban)	Urban Arterial	2	Yes	40	24,240
3	14 (with MC ban+Truck ban) 18 (with Truck ban) 22 26 (with MC ban)	Urban Arterial	3	Yes	50	36,480
4	15 (with MC ban+Truck ban) 19 (with Truck ban) 23 27 (with MC ban)	Urban Arterial	4	Yes	60	48,600
5	30 32 (with MC ban) 34 (with Truck ban) 36 (with MC+Truck ban)	Urban Arterial with Frontage	4	Yes	60	56,760
6	31 33 (with MC ban) 35 (with Truck ban) 37 (with MC+Truck ban)	Urban Arterial with Frontage	5	Yes	70	69,960
7	40	Rural Arterial	1	No	40	12,960
8	41	Rural Arterial	2	Yes	50	32,280
9	42	Rural Arterial	3	Yes	55	48,600
10	54 (with Truck ban) 60	Urban Freeway	2	Yes	70	55,200
11	55 (with Truck ban) 61	Urban Freeway	3	Yes	80	82,800
12	56 (with Truck ban) 62	Urban Freeway	4	Yes	80	110,400
13	57 (with Truck ban) 63	Urban Freeway	5	Yes	80	138,000
14	58 (with Truck ban) 64	Rural Freeway	2	Yes	80	55,200
15	59 (with Truck ban) 65	Rural Freeway	3	Yes	90	82,800

Source: JUTPI 2

7.3 Validation

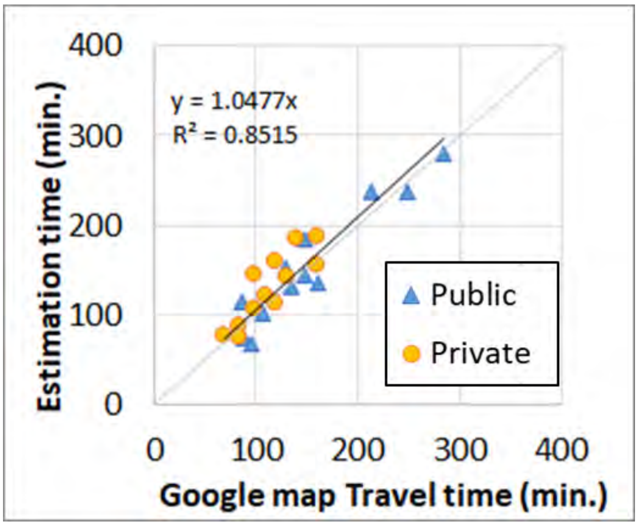
Link volumes that were estimated using an assignment result on the base year road network are compared with the traffic volumes survey observed by the transport surveys conducted by JUTPI 2 study team. Comparison to screenline survey (on major cordon line points) presented in Table 60.

Table 60 Comparison Between Model and Screenline Survey

Mode	Model	Survey	Gap (%)
Car	4,073,633	3.908,574	4
Motorcycle	8,216,273	8,309,800	-1
Public Transport	2,158,512	2,119,078	2

Source: JUTPI 2

Validation was also conducted to compare travel time and travel speed between model and survey results or other secondary data sources. A comparison of travel time between major cities and regions was conducted by comparing travel time in the model (between TAZ) and travel time in web mapping service from the same origin-destination shown in Figure 70.



Source: JUTPI 2

Figure 70 Comparison of Travel Time between Major Points

Travel time also can be validated by comparing with ADS MEILI data by calculating average travel time for each OD pair for private vehicle and public transport mode.

Table 61 Comparison of Private Vehicle Travel Speed

	Model	Survey
AM Peak	15.2 kph	16.7 kph
PM Peak	14.1 kph	15.0 kph

Source: JUTPI 2

Table 62 Comparison of Public Transport Travel Speed

	Model	Survey
AM Peak	14.6 kph	13.8 kph
PM Peak	13.4 kph	12.7 kph

Source: JUTPI 2

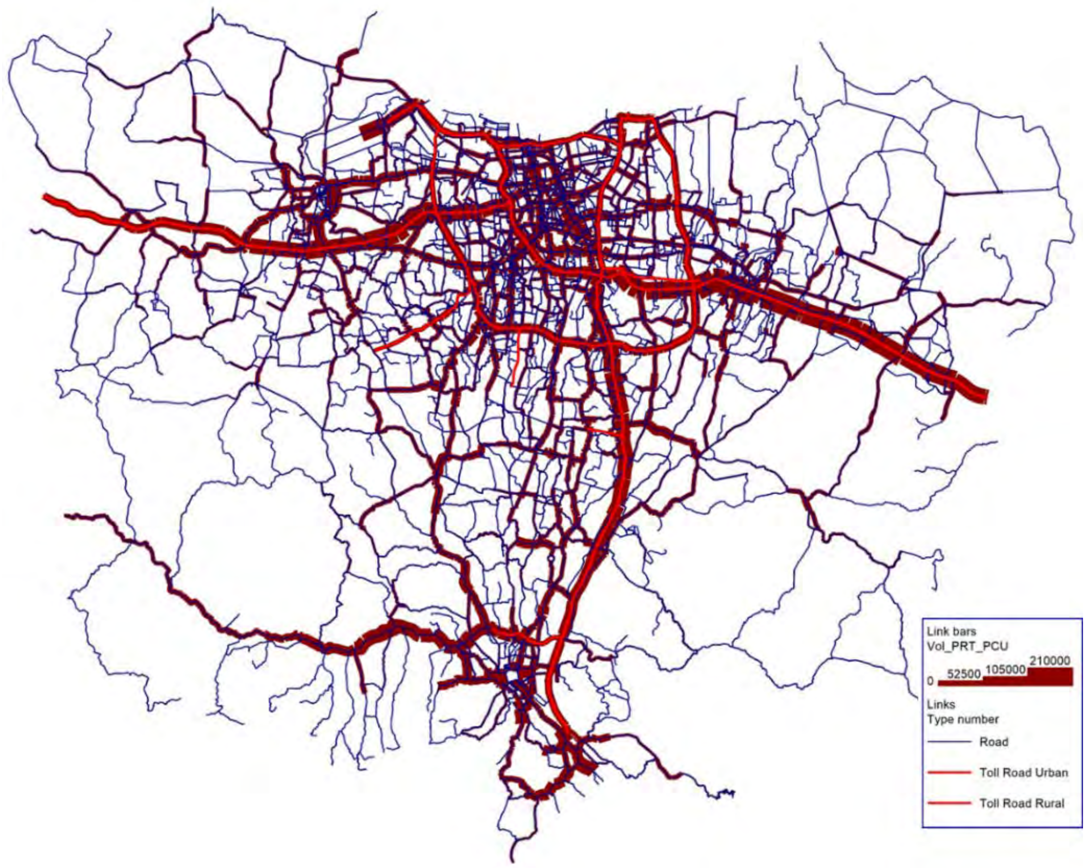
OD block matrices of the total trip that has been validated are shown in the tables below. In these tables, the non-motorized trips are excluded.

Table 63 OD Block Matrices of Total Motorized Trips

Region	DKI Jakarta	Kota Tangerang	Kota Bekasi	Kota Bogor & Kota Depok
DKI Jakarta	31,713	1,246	1,095	937
Kota Tangerang	1,258	20,733	44	558
Kota Bekasi	1,093	45	16,951	570
Kota Bogor & Kota Depok	938	554	571	28,205

Source: JUTPI 2

Network assignment results for vehicular demand on the road network and passenger demand on the public transportation network for base year network are shown in Figure 71 until Figure 74.

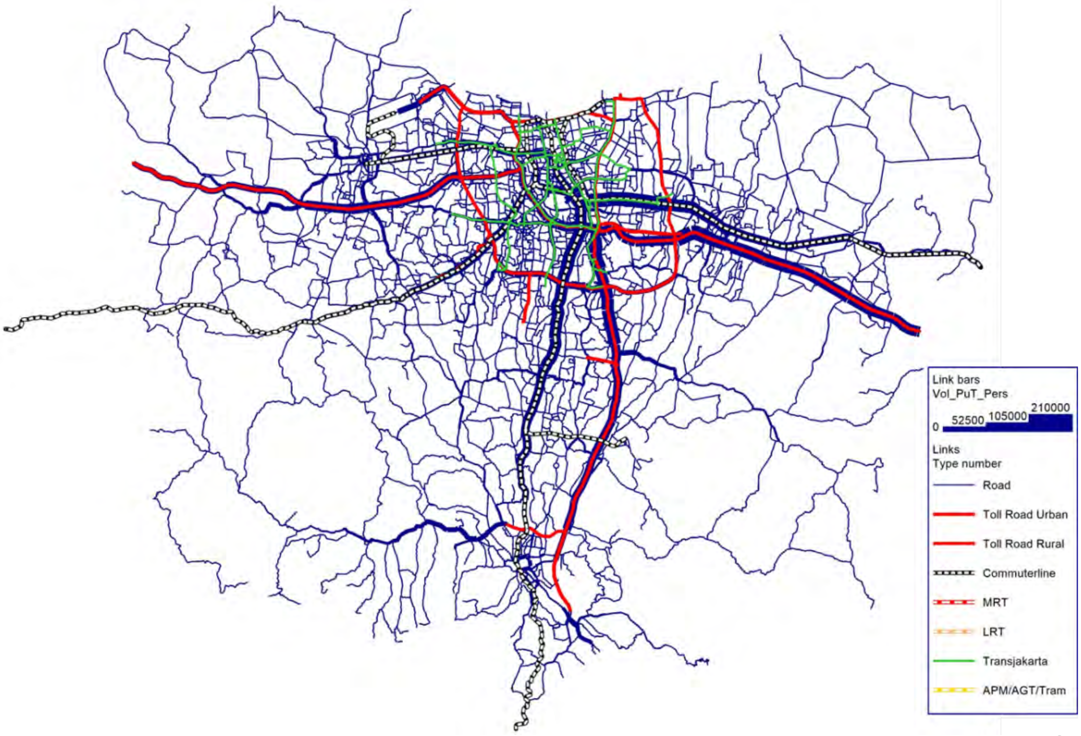


Source: JUTPI 2

Figure 71 Present Case Private Vehicle Assignment Result (JABODETABEK)

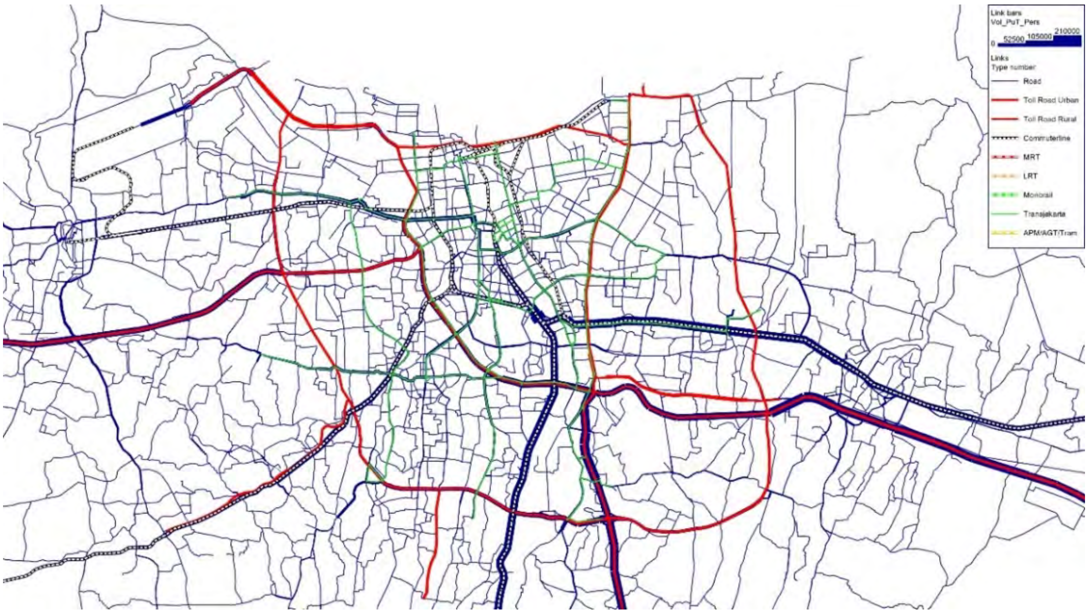
Source: JUTPI 2

Figure 72 Present Case Private Vehicle Assignment Result (JABODETABEK)



Source: JUTPI 2

Figure 73 Present Case Private Vehicle Assignment Result (JABODETABEK)



Source: JUTPI 2

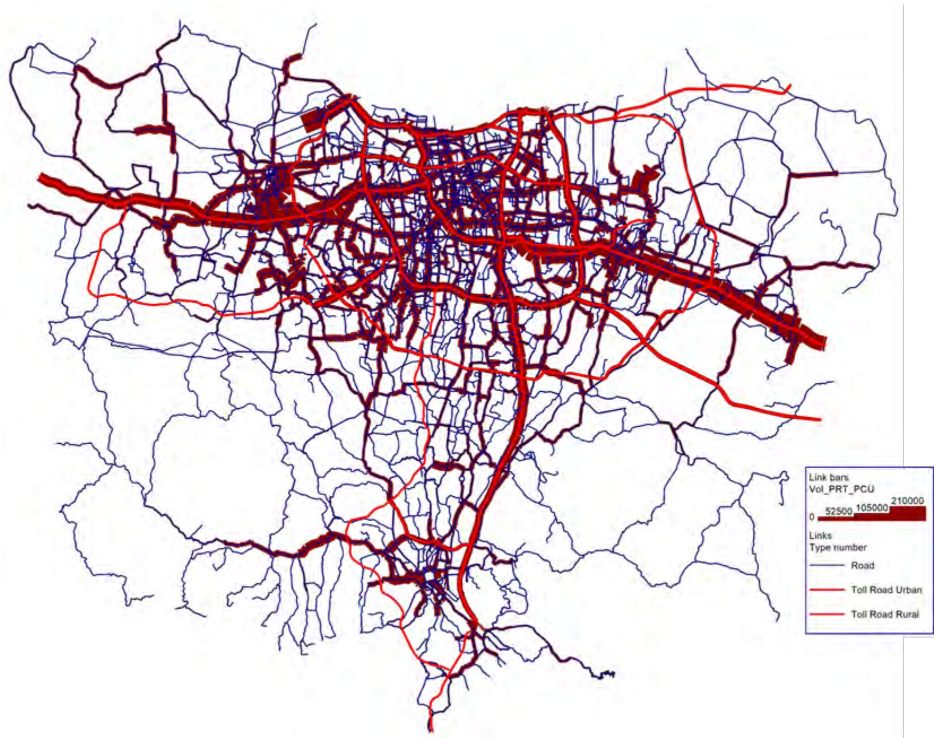
Figure 74 Present Case Public Transport Assignment Result (DKI Jakarta)

Chapter 8 TRAVEL DEMAND FORECAST

8.1 Do-Minimum and RITJ Case

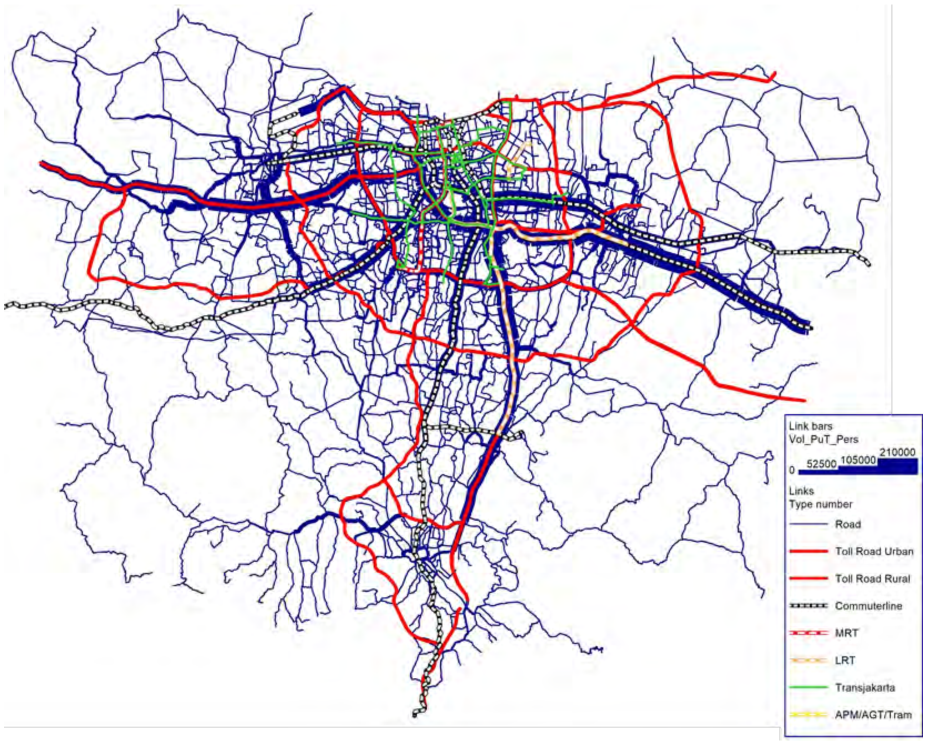
8.1.1 Do-Minimum Case

Do-Minimum case is a baseline scenario with no policy intervention after all under-construction projects have been completed (toll road and rail-based project). This scenario explains what will happen in the future if the government does nothing to improve the transportation system. This scenario is used as a benchmark to evaluate alternative development scenarios. Figure 75 until Figure 78 shows the assignment result for the year 2029 and 2035 respectively.



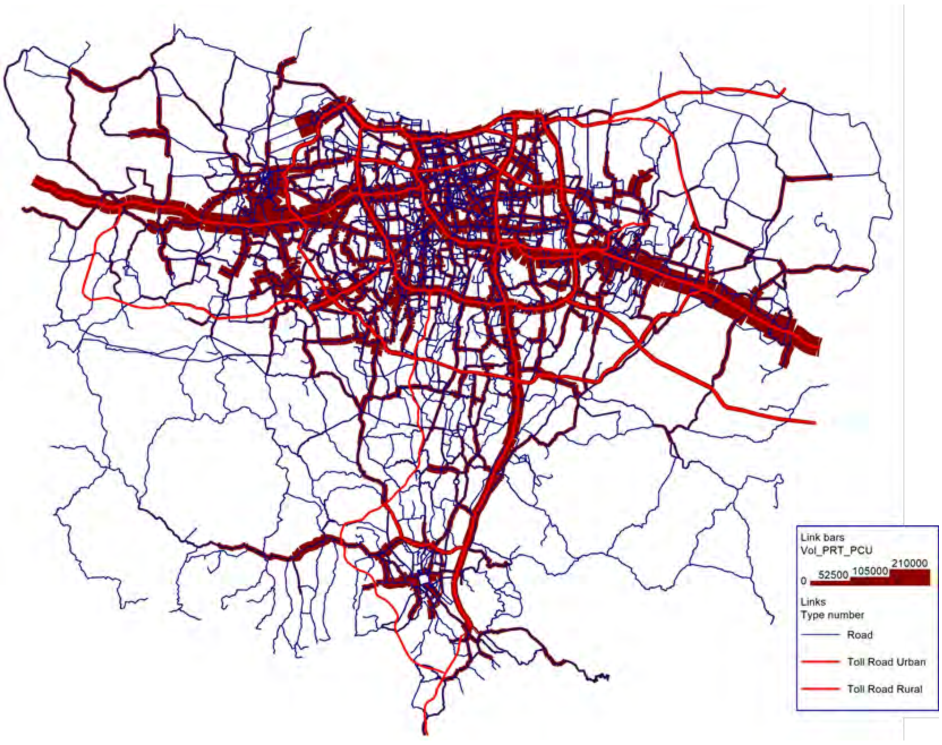
Source: JUTPI 2

Figure 75 Do-Minimum Case (2029) Private Vehicle Assignment Result



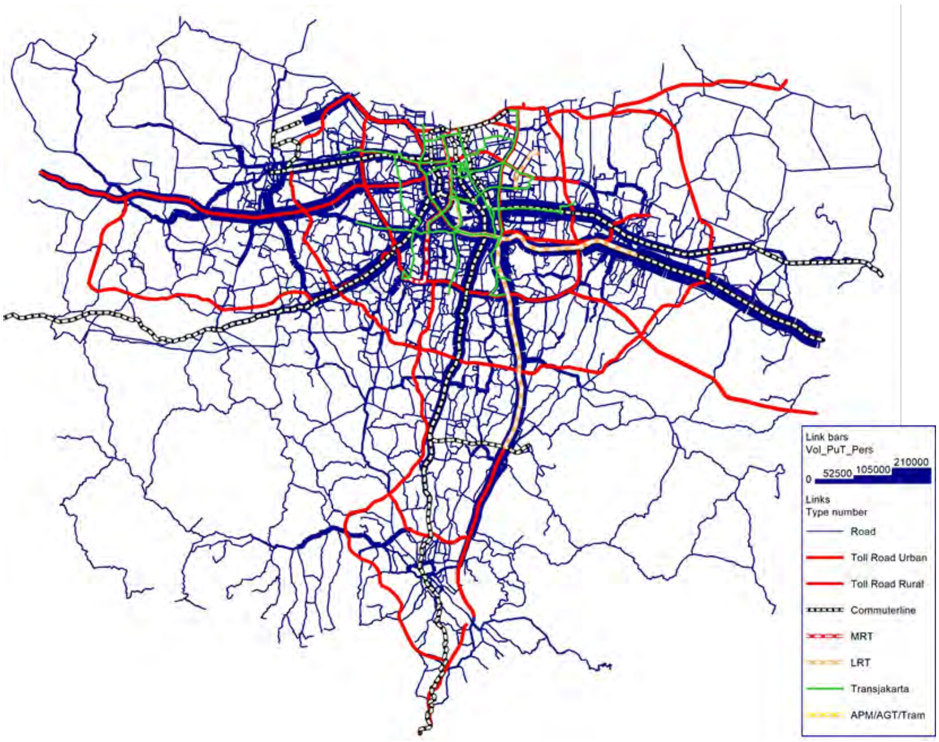
Source: JUTPI 2

Figure 76 Do-Minimum Case (2029) Public Transport Assignment Result



Source: JUTPI 2

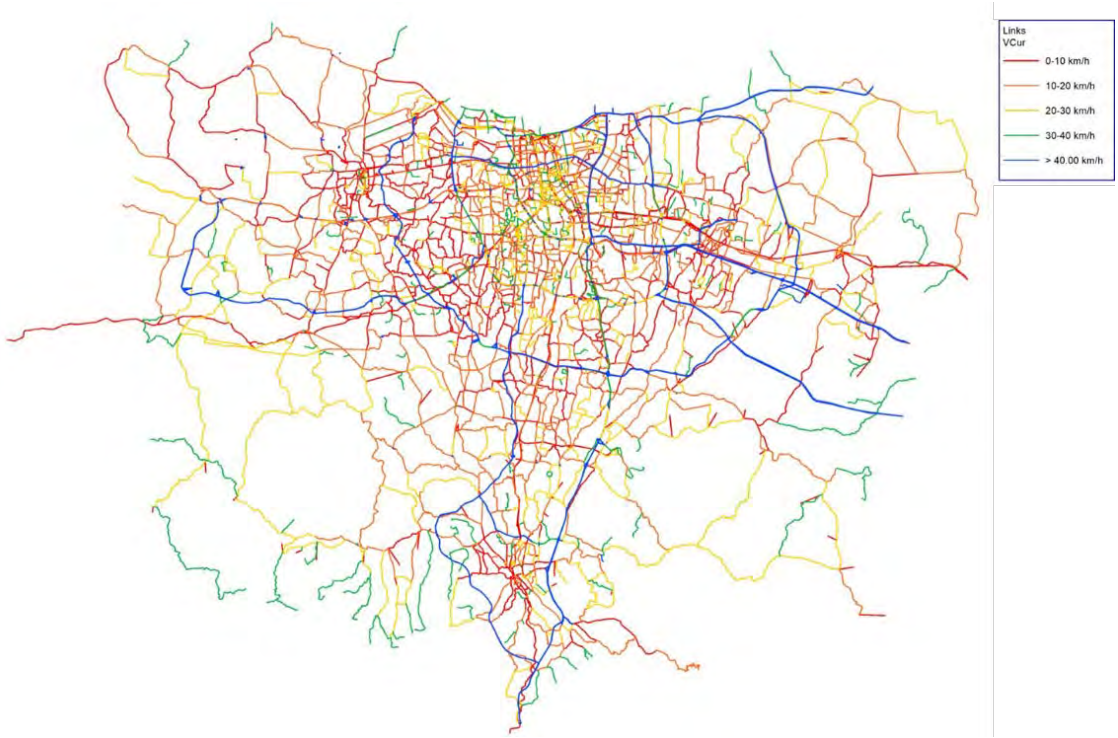
Figure 77 Do-Minimum Case (2035) Private Vehicle Assignment Result



Source: JUTPI 2

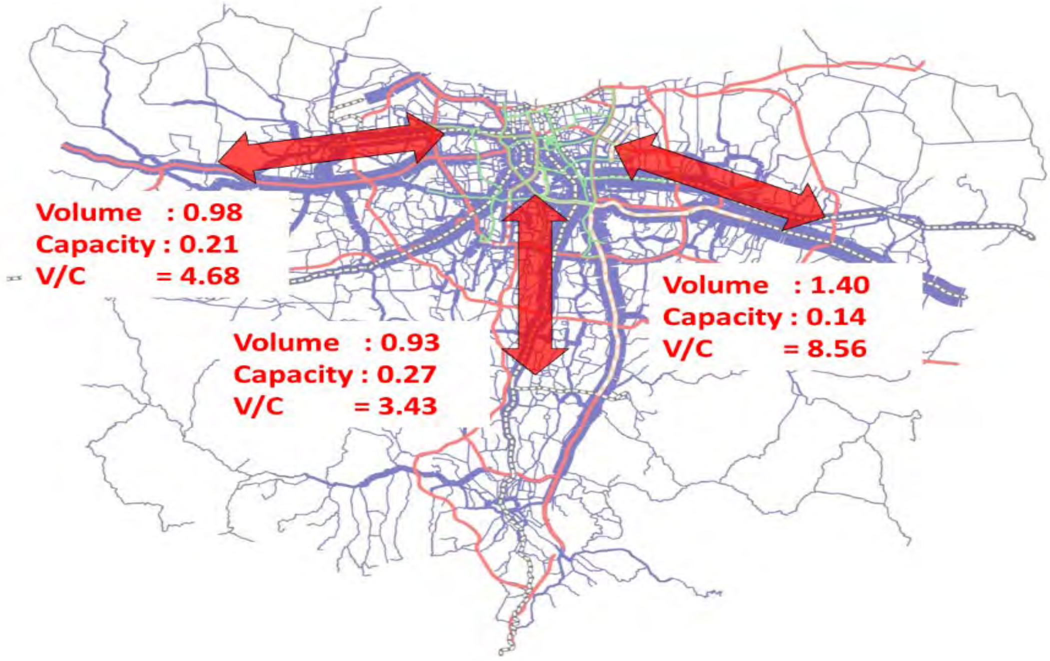
Figure 78 Do-Minimum Case (2035) Public Transport Assignment Result

Based on the assignment results, it is observed that if the government does not invest in any transport infrastructure project or any TDM, traffic congestion will become worse. Furthermore, under-construction rail-based public transport (including MRT N-S and LRT JABODEBEK) cannot accommodate the future demand of public transport passengers.



Source: JUTPI 2

Figure 79 Do-Minimum Case (2035) Travel Speed Assignment Result



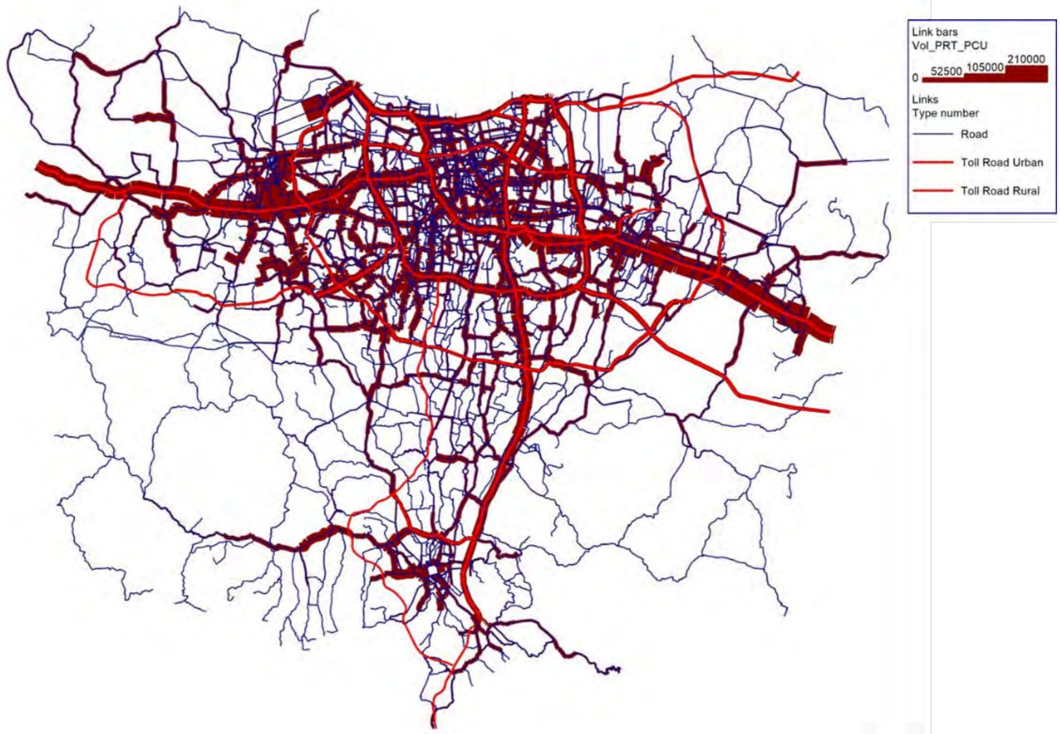
Unit: Mil. Pax/day/2 ways
Source: JUTPI 2

Figure 80 Do-Minimum Case (2035) Volume/Capacity Major Public Transport Corridors

Diagram of VCR in 2035 by applying the do-minimum case shows that all the major public transport corridors are overcapacity, especially the east line and west line. Bekasi line has the most volume while its capacity is the least. It implies that improvement and expansion of future public transport are imperative in all directions.

8.1.2 RITJ Case

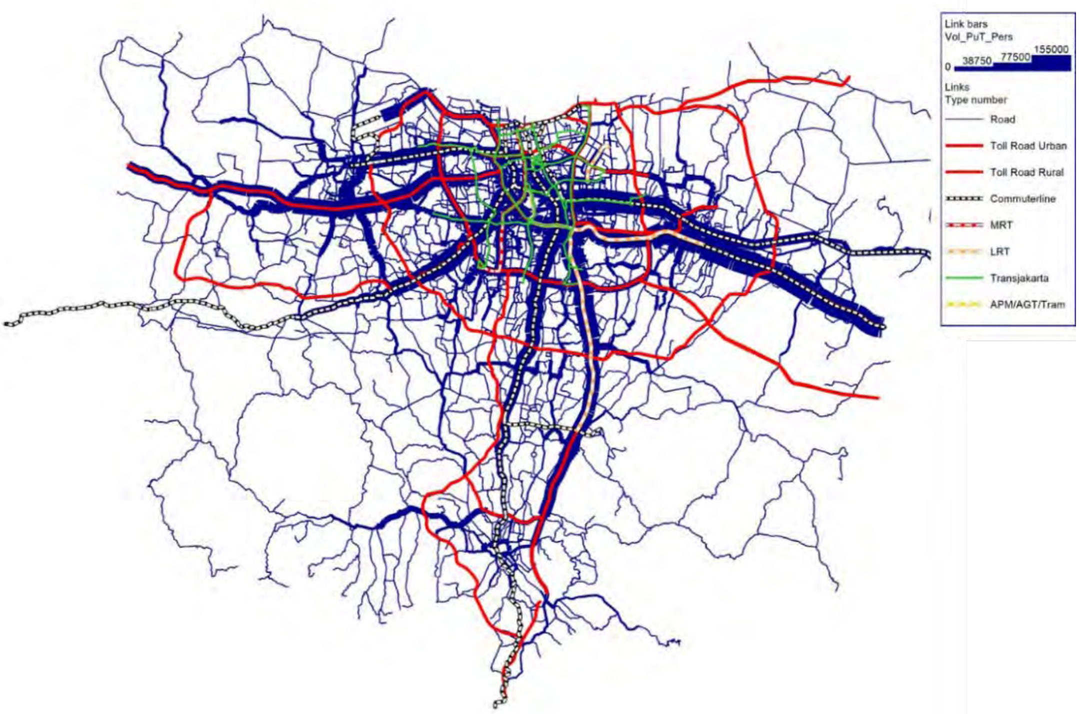
JABODETABEK Transportation Master Plan (RITJ) is a master plan based on Presidential Decree No. 55/2018. In RITJ, there are expressway corridor developments to support people's movement using private vehicles. Types of expressway development are looping, bypass, and radial support. Besides expressway development in RITJ, there are also radial MRT corridor development, radial and loop LRT corridor development



Source: JUTPI 2

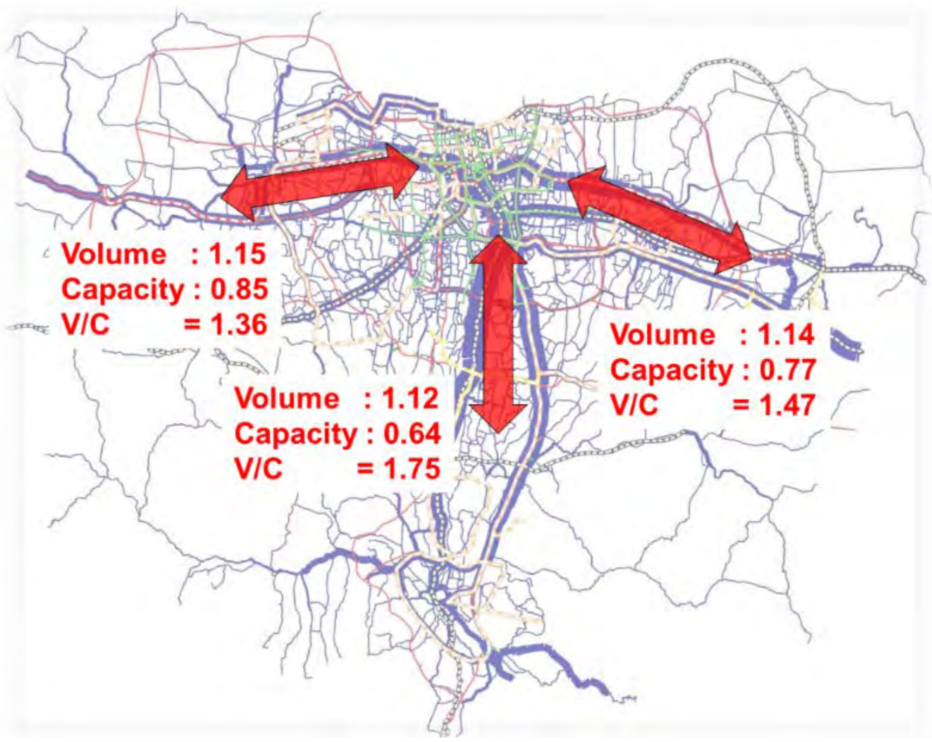
Figure 81 RITJ Case (2035) Private Vehicle Assignment Result

RITJ case is a scenario when all RITJ network plans constructed. Based on the assignment result, RITJ's comprehensive network plan is still insufficient to accommodate future demand. Therefore, additional mass transit corridors, selection of a transit mode with higher capacity (for example: from BRT to LRT and LRT to MRT), and application of TDM policies are required.



Source: JUTPI 2

Figure 82 RITJ Case (2035) Public Transport Assignment Result



Unit: Mil. Pax/day/2 ways
Source: JUTPI 2

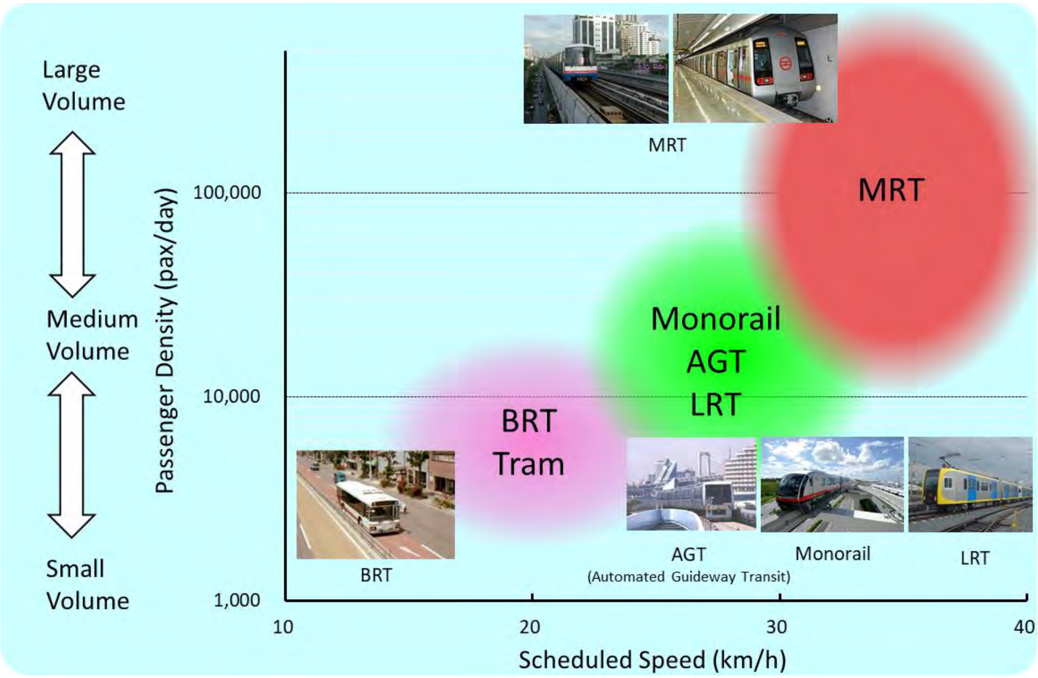
Figure 83 RITJ Case (2035) Volume/Capacity Major Public Transport Corridors

8.2 Scenario Development

8.2.1 Basic Directions to Propose Mass Transit Network

To solve the existing problems in public transport and the anticipation of a growing number of trips in the future, the development of a mass transit network is proposed with the following considerations:

1. To propose new lines and set the alignment of public transport based on scientific analysis through the travel demand forecast model;
2. To maximize the efficiency of the public transport network;
3. To select proper public transport mode which can accommodate the travel demand from a neutral viewpoint. It is important to introduce optimum transportation systems in each place, with due consideration for city size, future passenger demand, conditions of use, and topographical conditions;



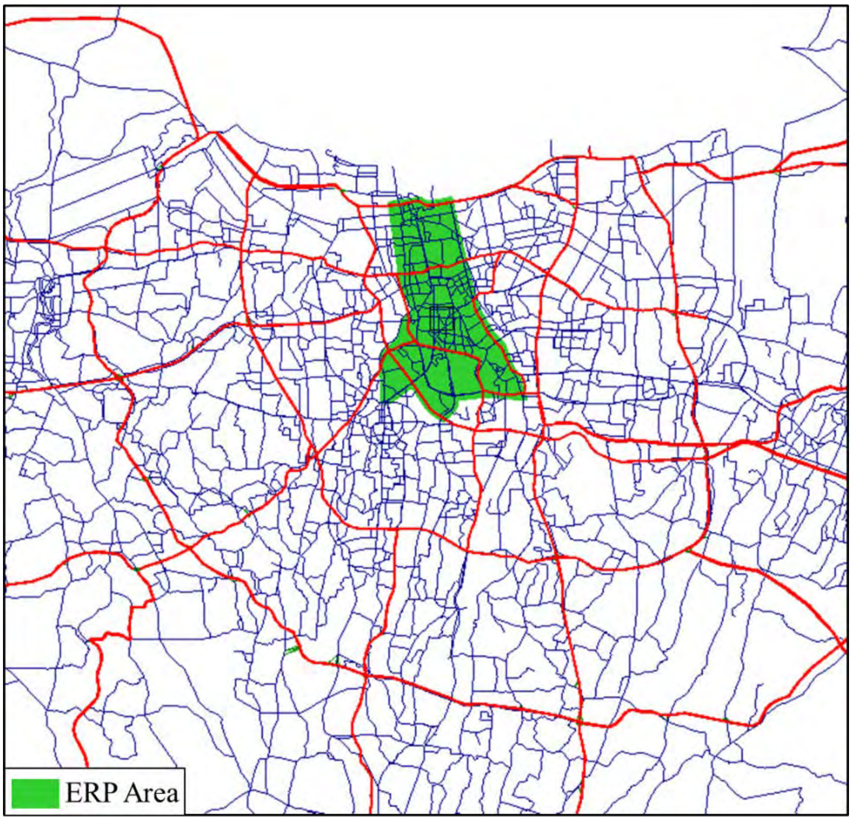
Source: JUTPI 2 from various references

Figure 84 Planned Platform of Mass Transit Corridors

4. To avoid overlapping of many corridors of different public transport modes;
5. To cover 30 activity centers of DKI Jakarta and TOD locations which generate traffic demand;
6. To consider the staging of 2024, 2029/2030, and 2035 (and after) in accordance with the demand growth.

8.2.2 Transportation Demand Management (TDM)

Traffic Demand Management (TDM) measures were designed for the alleviation of severe vehicular traffic congestion in JABODETABEK, especially in DKI Jakarta. Such congested road segments are observed in the major business and commercial activity cores in the city. Based on the analysis and also others plan in RTRW DKI Jakarta, the figure below shows the proposed Electronic Road Pricing (ERP) area starting from year 2024.



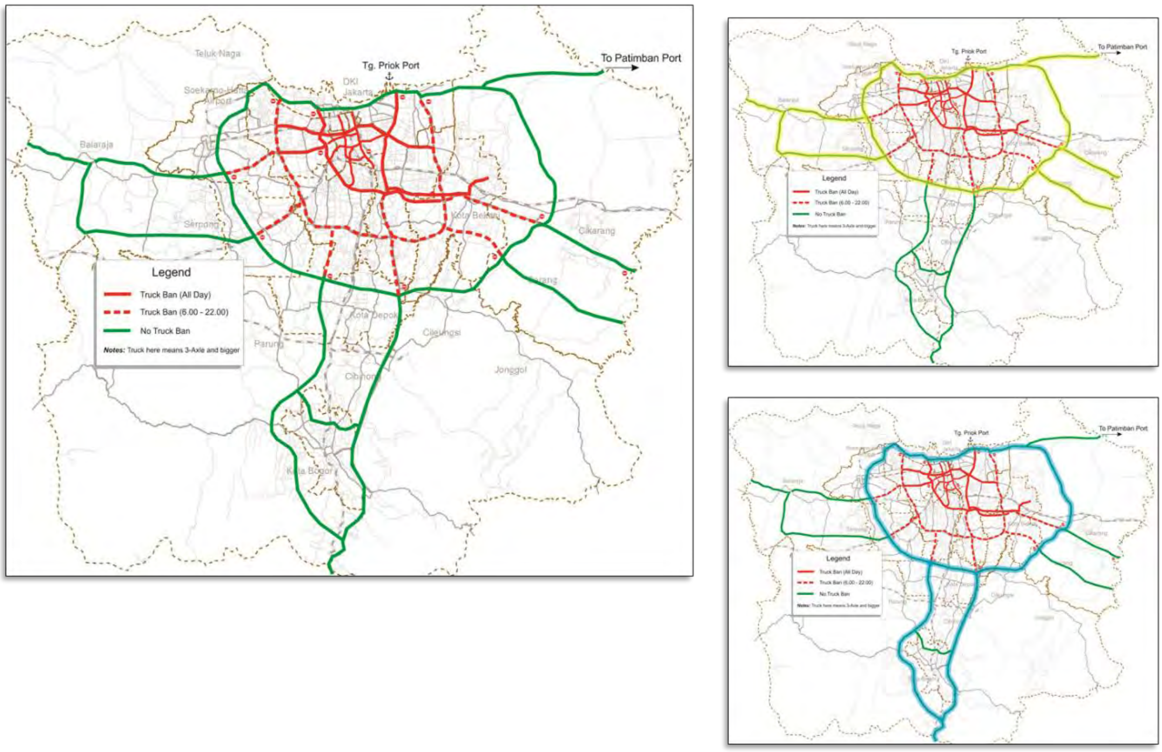
Source: JUTPI 2

Figure 85 Proposed ERP Area (Roads)

TDM was applied to the car, motorcycle, and truck trips on a network level. The measure and assumptions employed in this impact analysis are as follows:

- All car, motorcycle, and truck trips that going from/to ERP area will be charged IDR 100,000 (IDR 50,000 for going in and IDR 50,000 for going out) from 6 AM to 8 PM.
- All car, motorcycle, and truck trips generated/attracted in the ERP area will be charged maximum IDR100,000 for maximum parking fee per day from 6 AM to 8 PM.
- Attributing motorcycle ban along MRT corridors.
- Integrated public transport fare with base fare IDR 1,500 and incremental IDR 1,000/km.
- Expanded road with the truck ban as follows:

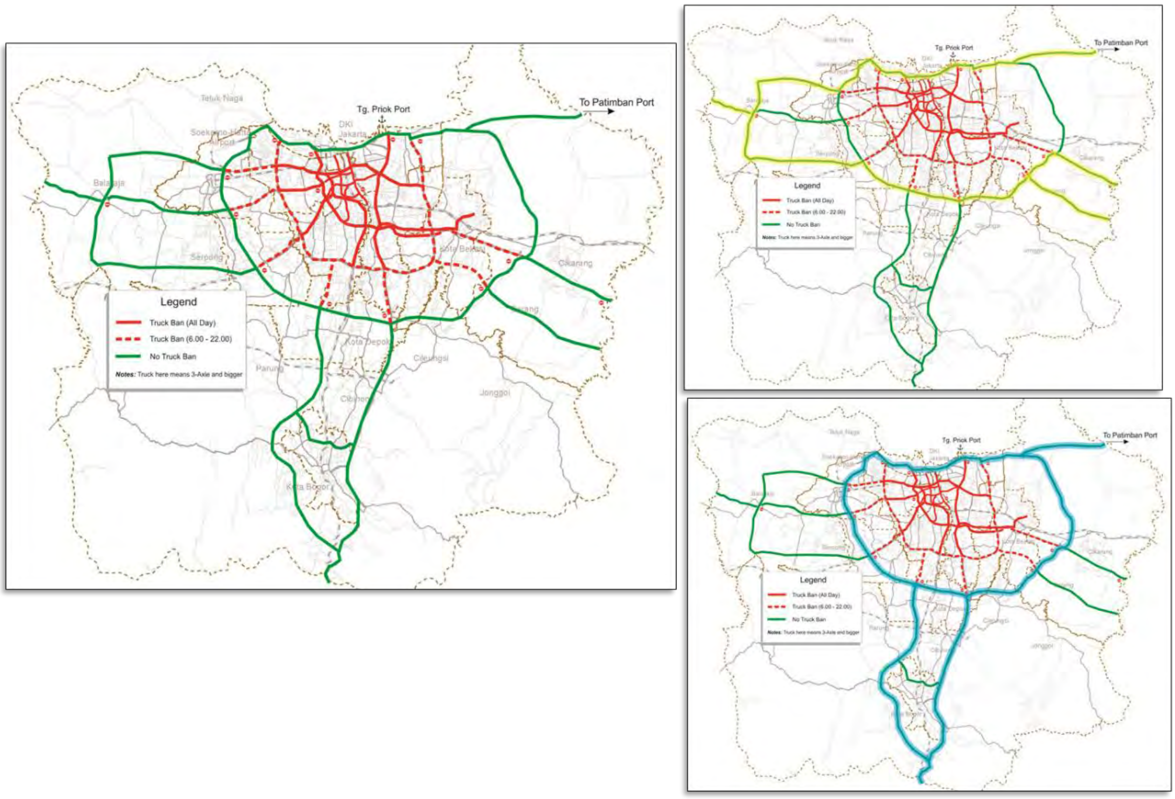
a. Trucks and commercial vehicles in 2024 are prohibited to enter the downtown areas in JABODETABEK either for all day or at least from 6 AM - 10 PM.



Source: JUTPI 2

Figure 86 Map of Truck Ban in 2024

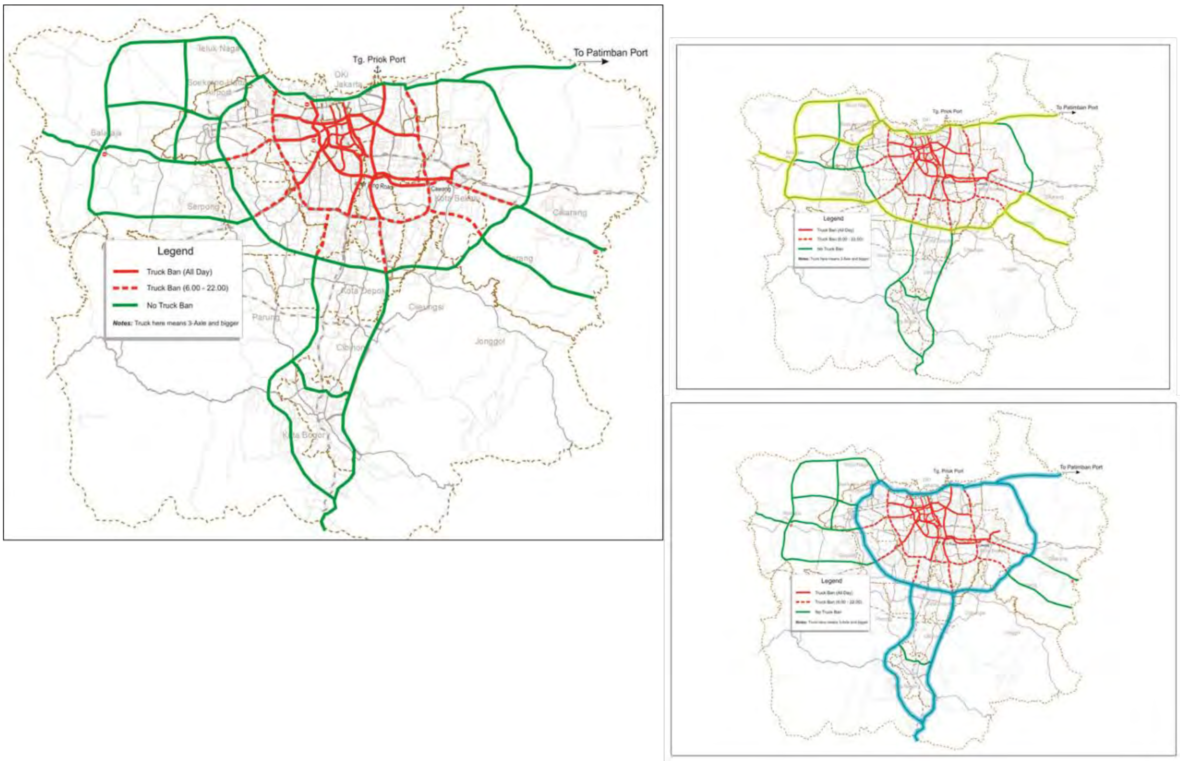
b. Trucks and commercial vehicles in 2029 are prohibited to enter the downtown areas in JABODETABEK either for all day or at least from 6 AM to 10 PM. In addition to what was implemented in 2024, toll road sections inside Jakarta are prohibited while the new toll road outside DKI Jakarta has no truck ban.



Source: JUTPI 2

Figure 87 Map of Truck Ban in 2029

c. Trucks and commercial vehicles in 2035 are prohibited to enter the downtown areas in JABODETABEK either for all day or at least from 6 AM - 10 PM. In addition to what was implemented in 2024 and 2029, toll road sections inside Jakarta are prohibited while the new toll road outside DKI Jakarta has no truck ban.



Source: JUTPI 2

Figure 88 Map of Truck Ban in 2035

8.2.3 Selecting Optimal Scenario

The future networks were developed for the target year 2035, the with intermediate years 2024 and 2029 by including various development plans of the transportation network.

These 2035 networks are computerized networks originating from JUTPI 1 and have been revised to complement the RITJ network, with improvement, adjustment, and recommendation to the network based on demand and network connectivity as mentioned in the Section 8.2.1. Meanwhile, the 2029 network was created by considering the demand for each planned road network and public transport network. Whereas the 2024 network is formed based on the on-going or under construction project.

This network scenario along with the TDM described in Section 8.2.2, will be explained as a JUTPI 2 Master Plan scenario.

There is a 3-staging year in the master plan arrangement, 2024, 2029, and 2035. In each year, some priority projects are set considering the urgency and readiness towards the whole plan which consists of the toll road network and public transportation network.

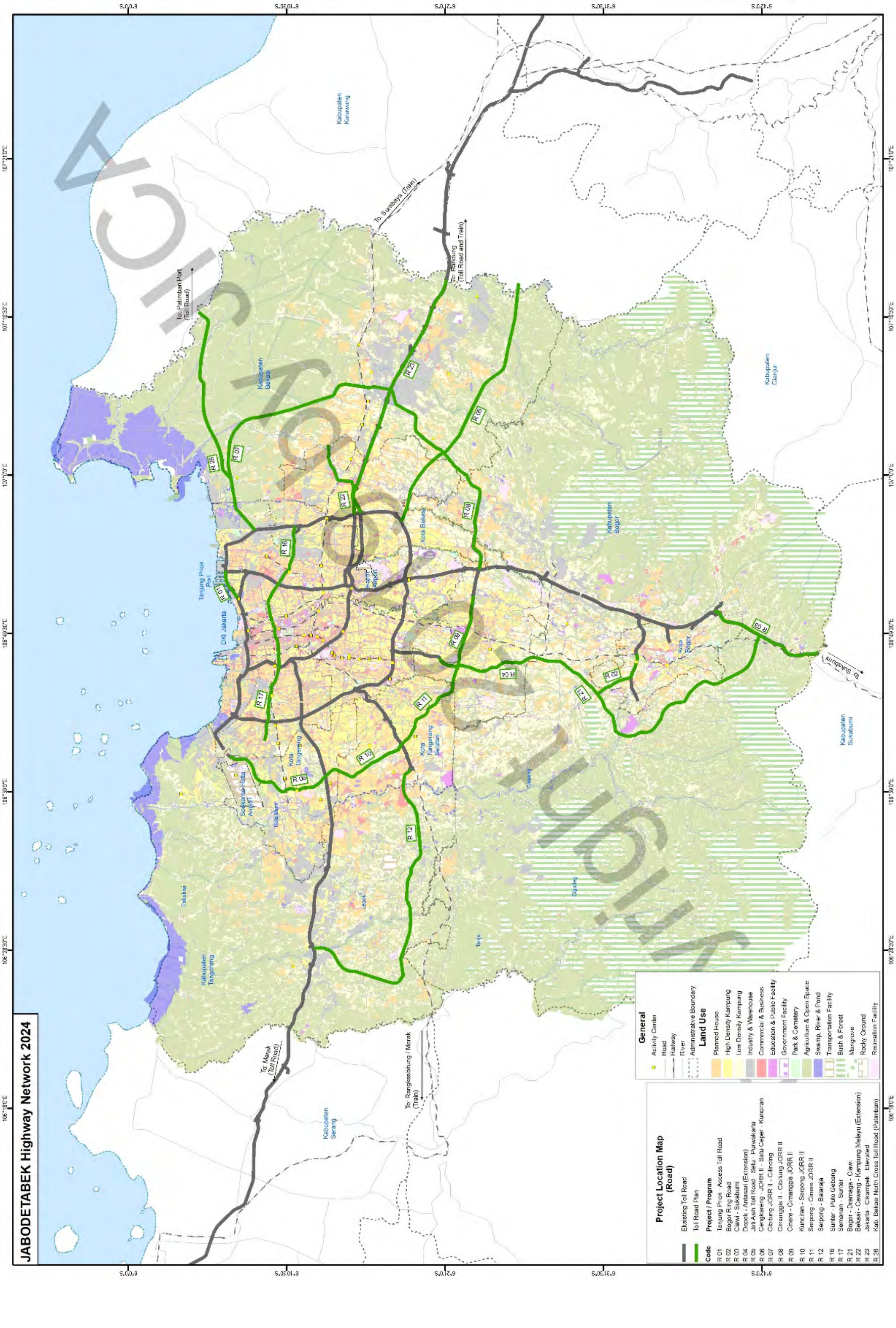


Figure 89 JABODETABEK Highway Network in 2024

Source: JUTPI 2

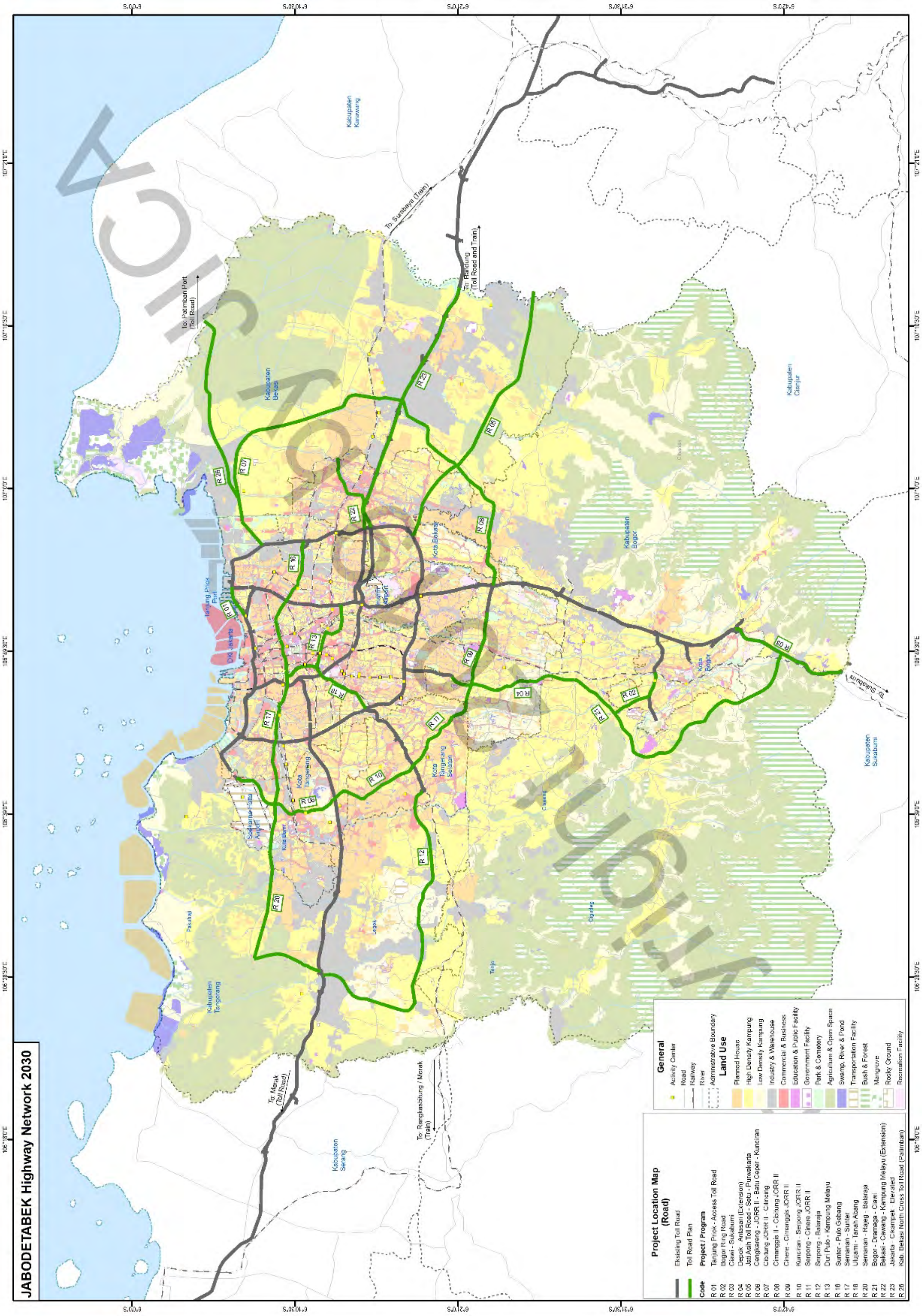


Figure 90 JABODETABEK Highway Network in 2029/30

Source: JUTPI 2

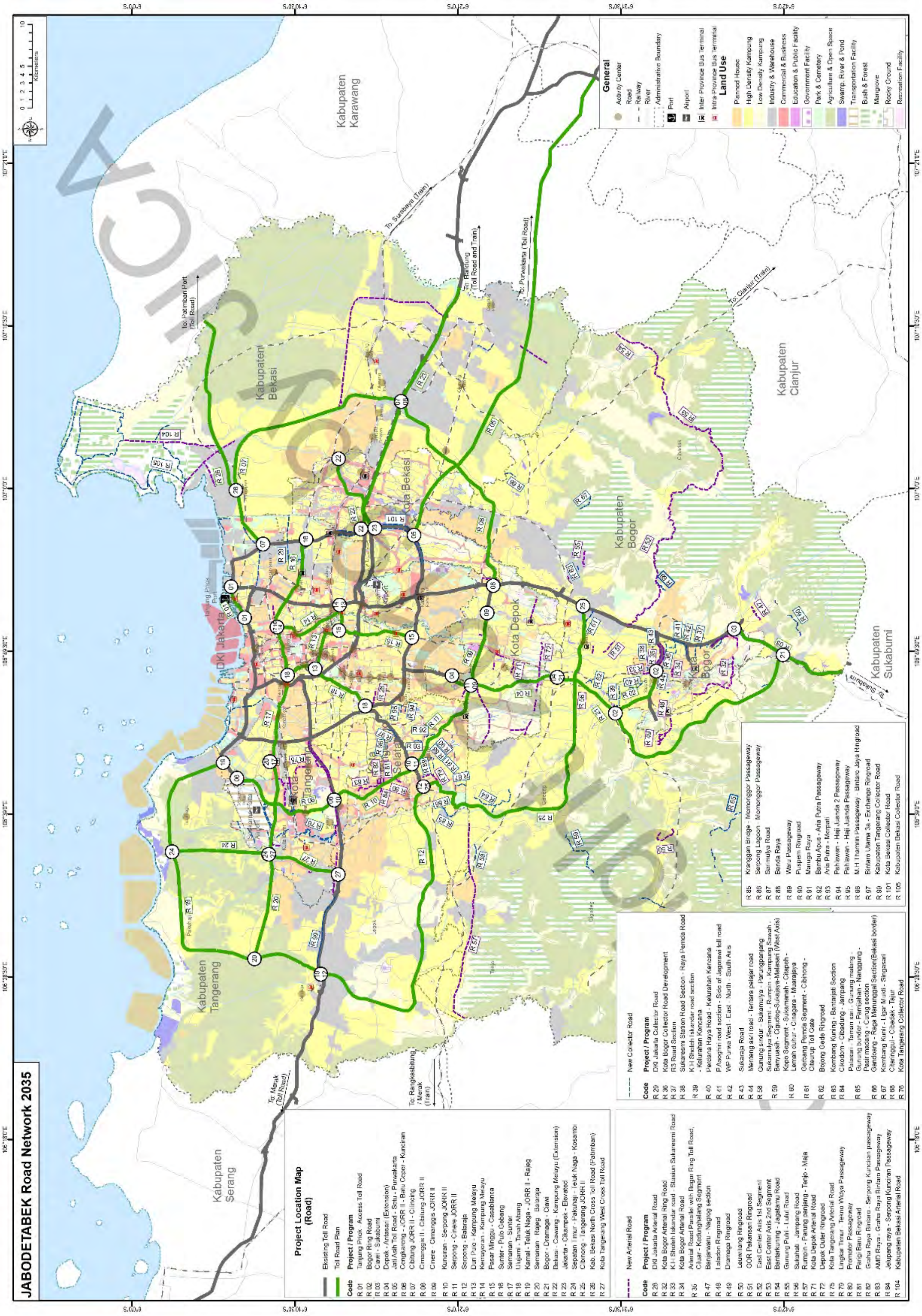
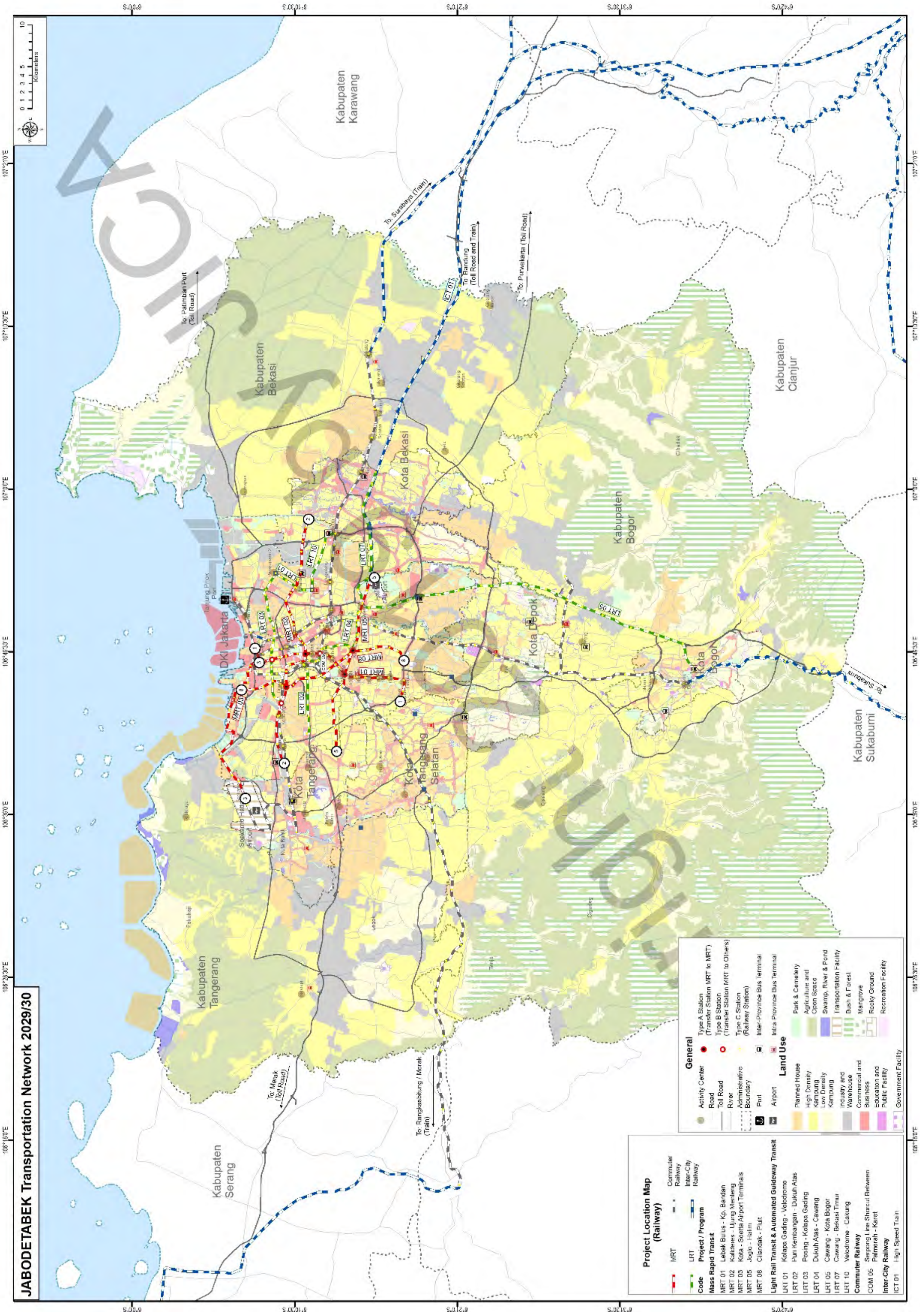


Figure 91 JABODETABEK Highway Network in 2035

Source: JUTPI 2

Figure 92 JABODETABEK Transportation Network in 2024

Source: JUTPI 2



Source: JUTPI 2

Figure 93 JABODETABEK Transportation Network in 2029/30

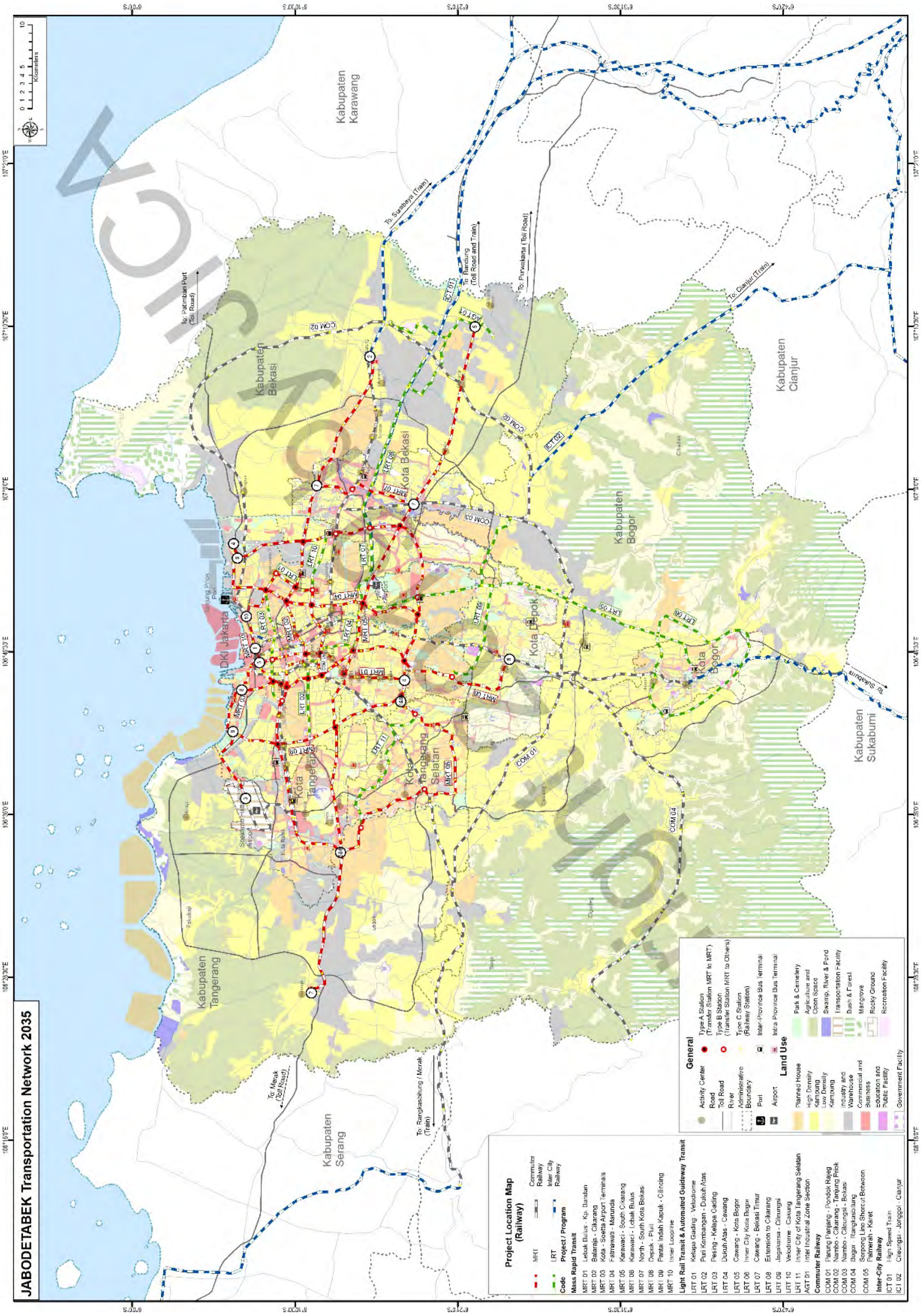


Figure 94 JABODETABEK Transportation Network in 2035

Source: JUTPI 2

In 2024, there are 18 corridors proposed for the toll road network. Some networks are the extension of the existing toll road such as Depok – Antasari and Bekasi – Cawang – Kampung Melayu toll road. In terms of public transportation network, 2 MRT lines and 5 LRT lines are assumed to be operated.

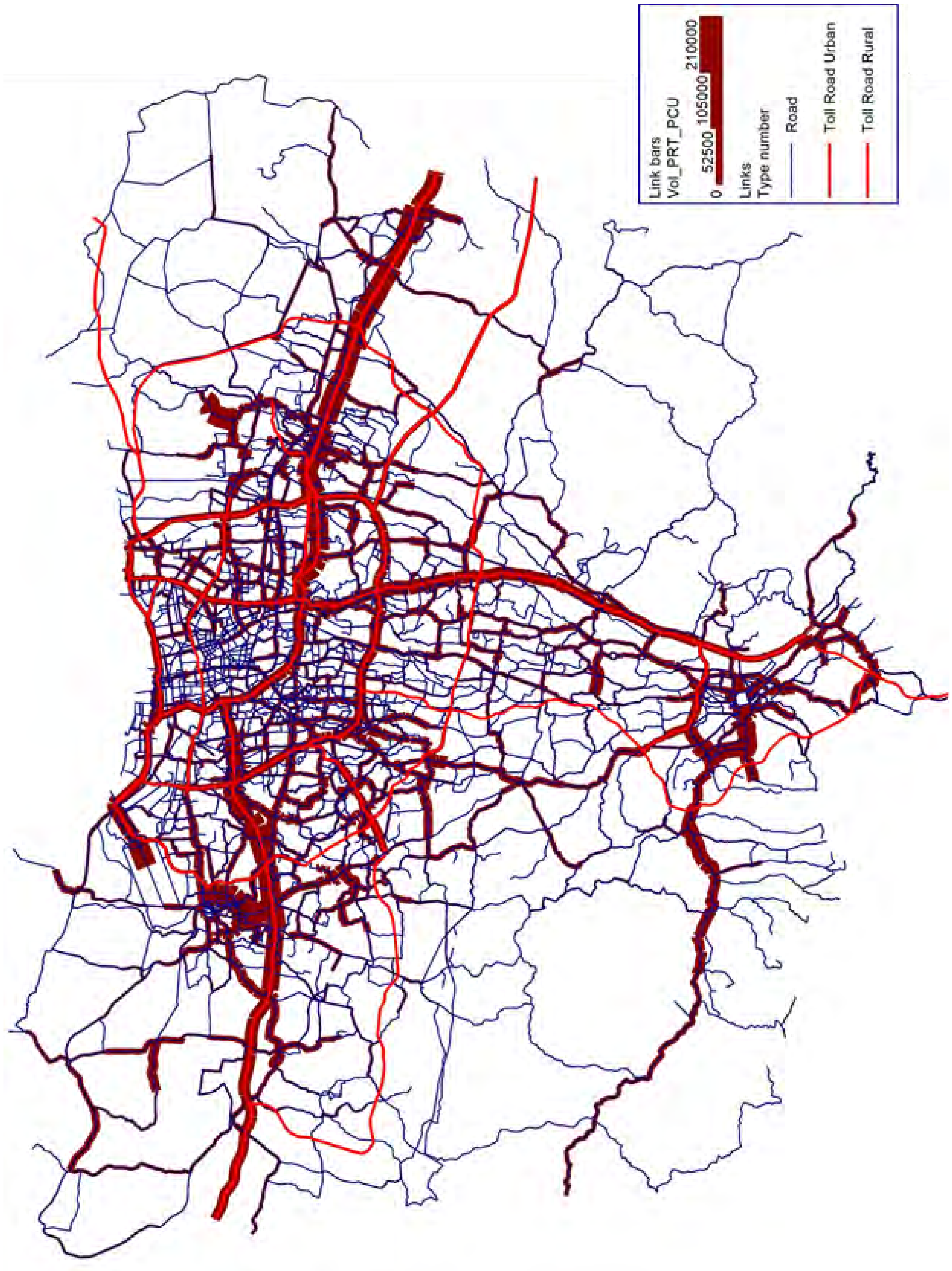
Moving to 2029, the same toll road corridors are proposed in line with the 2024 proposal with the addition of toll road from Duri Pulo to Kampung Melayu, Ulujami to Tanah Abang and Semanan to Balaraja. 8 MRT lines and 9 LRT lines are assumed to be operated.

Finally, in year 2035 as an accumulation of the previous plan, it is expected that the proposed 18 roads from the previous period have been developed. In addition, there are 3 corridors from year 2029/30 and 6 corridors from year 2035 which comprises Kemayoran – Kampung Melayu, Pasar Minggu – Casablanca, Kamal – Teluk Naga – JORR II – Rajeg, Sepatan Timur – Pakuhaji – Teluk Naga – Kosambi, Cibinong – Tangerang JORR III, and Kota Tangerang West Cross Toll Road.

In the case of the public transport network, there are four main transits to serve people’s trips, namely LRT, BRT, commuter line, and MRT. MRT is the backbone of the regional transportation system proposed in 10 lines in 2035, followed by 11 lines of LRT and improvement of 5 routes commuter line. In addition, BRT will be placed as a feeder to access mass transit.

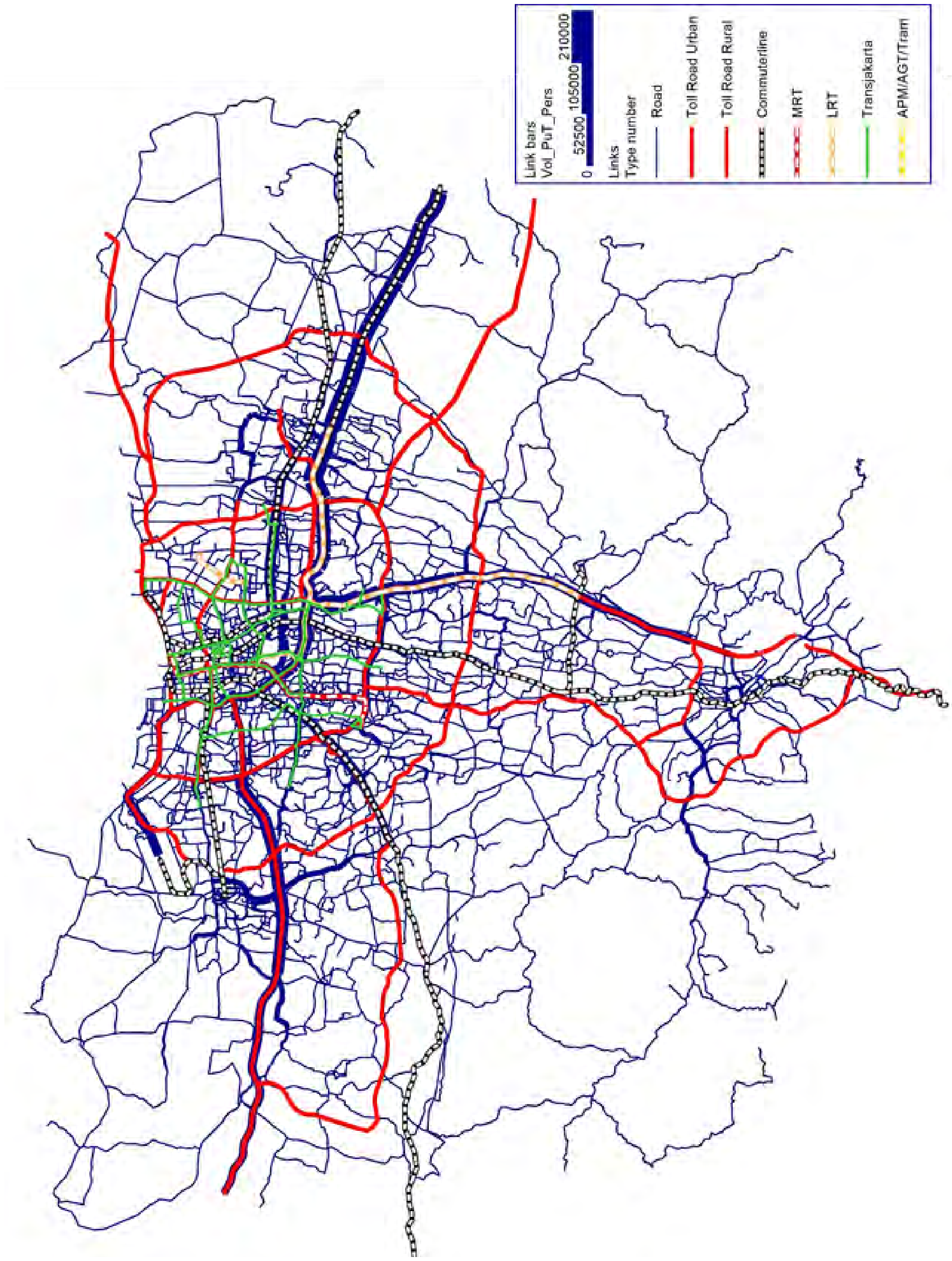
8.2.4 Projected Future Demand on MP Network

Passenger demand on the planned public transportation network and vehicular demand on the planned road network has been forecasted by the transportation development scenario for the year 2024, 2029, and 2035 respectively. The estimated passenger demand and vehicular demand are depicted from the figures below.



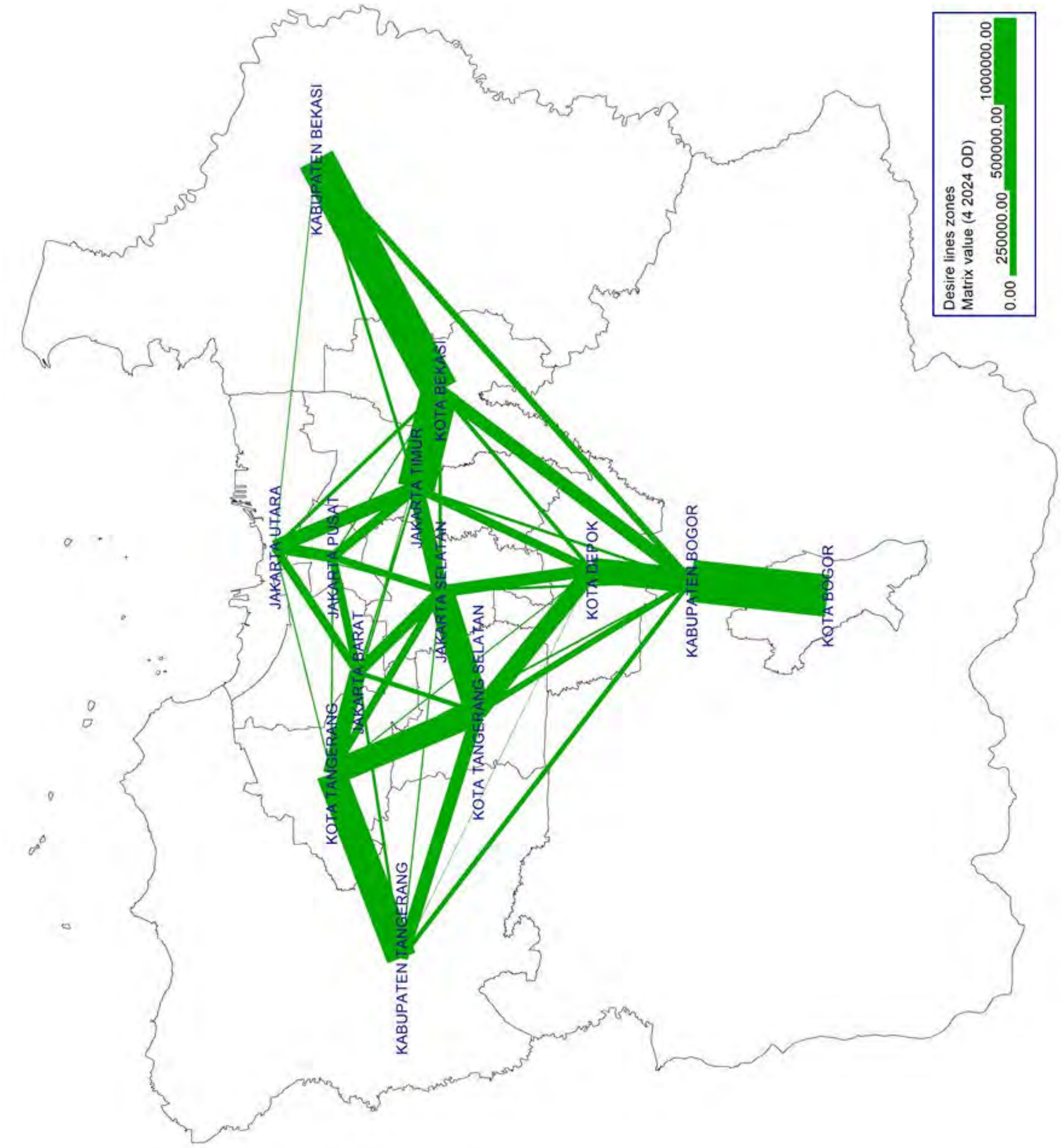
Source: JUTPI 2

Figure 95 Private Vehicle Assignment Result in 2024



Source: JUTPI 2

Figure 96 Public Transport Assignment Result in 2024



Source: JUTPI 2

Figure 97 Desire Line in 2024

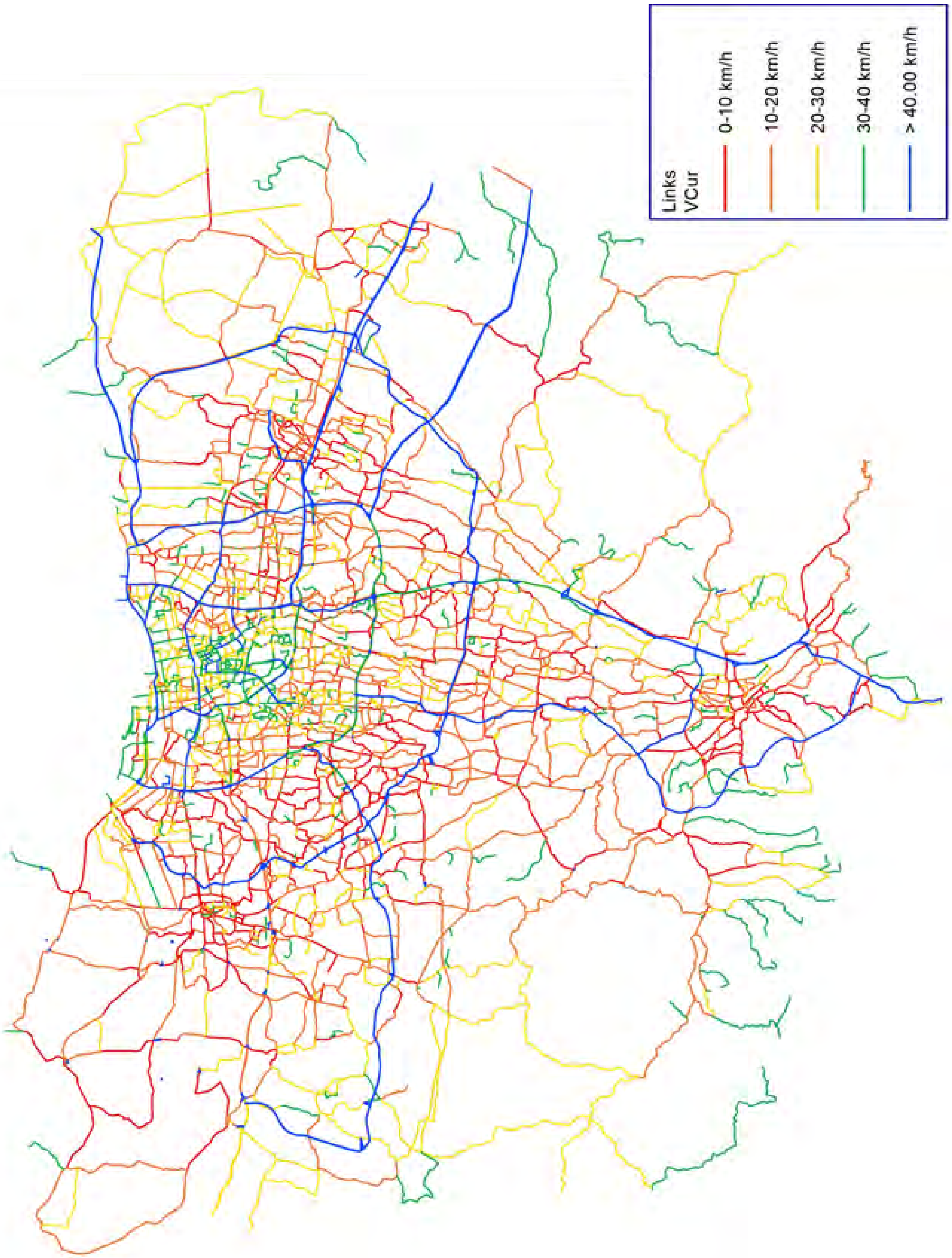
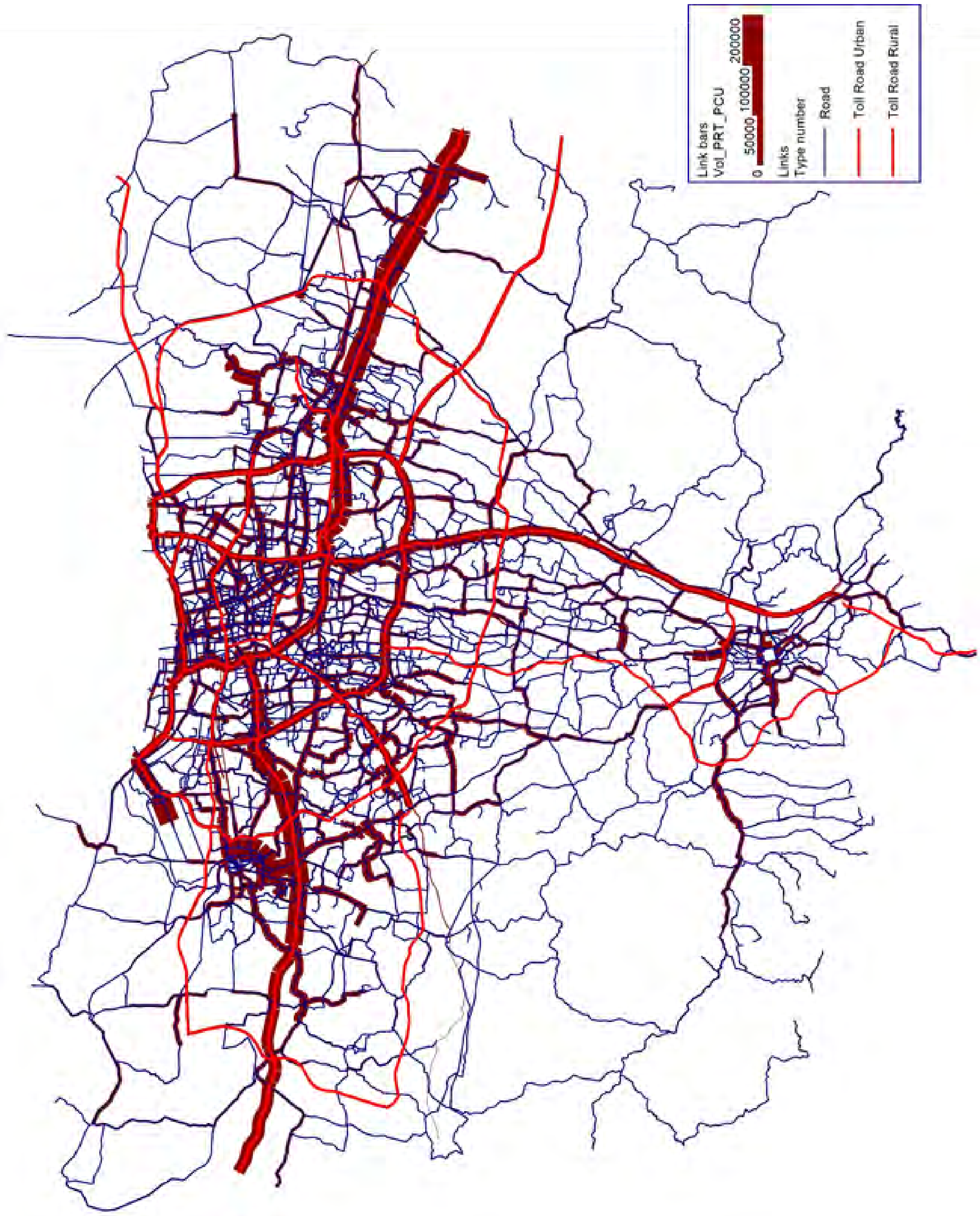


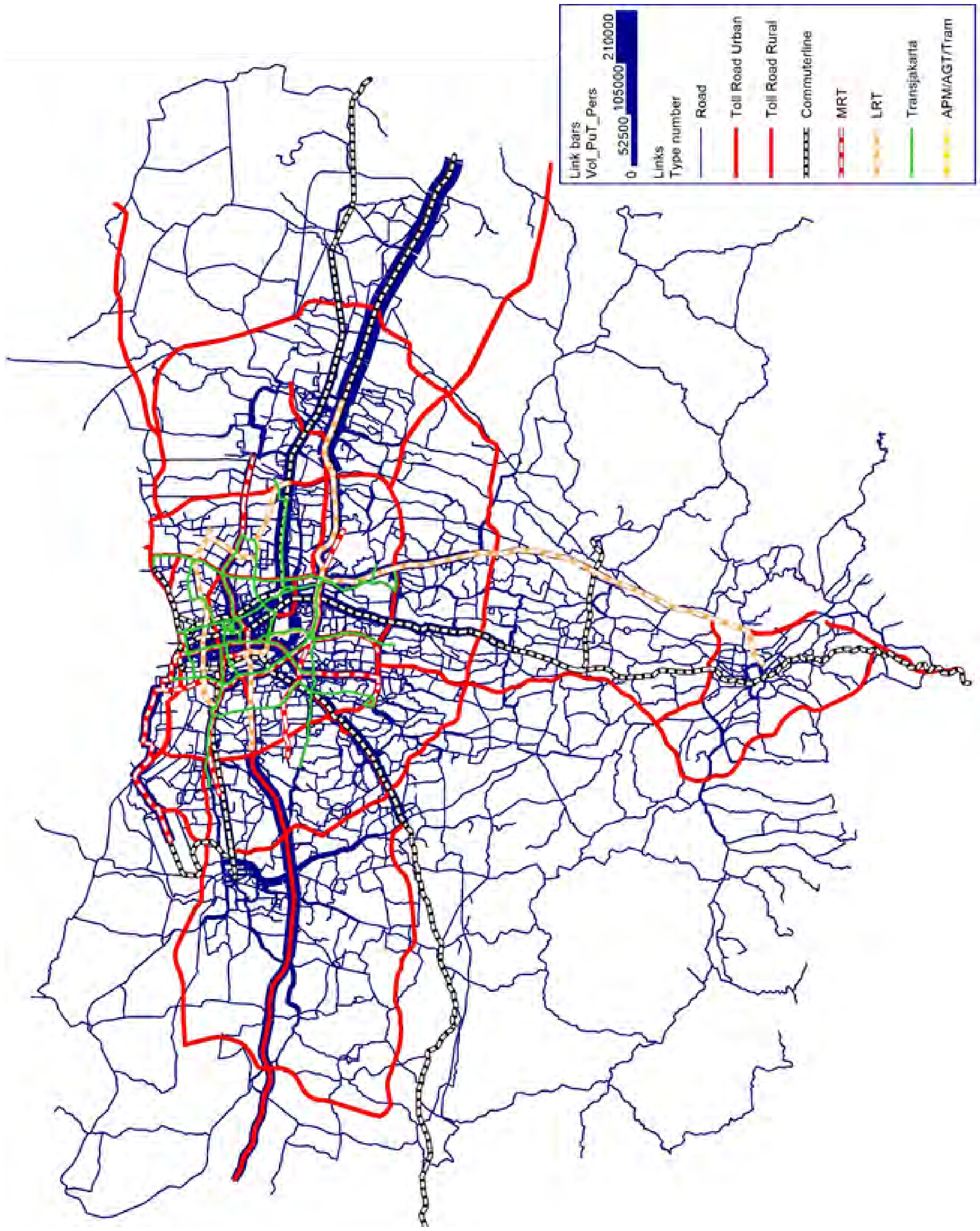
Figure 98 Travel Speed Assignment Result in 2024

Source: JUTPI 2



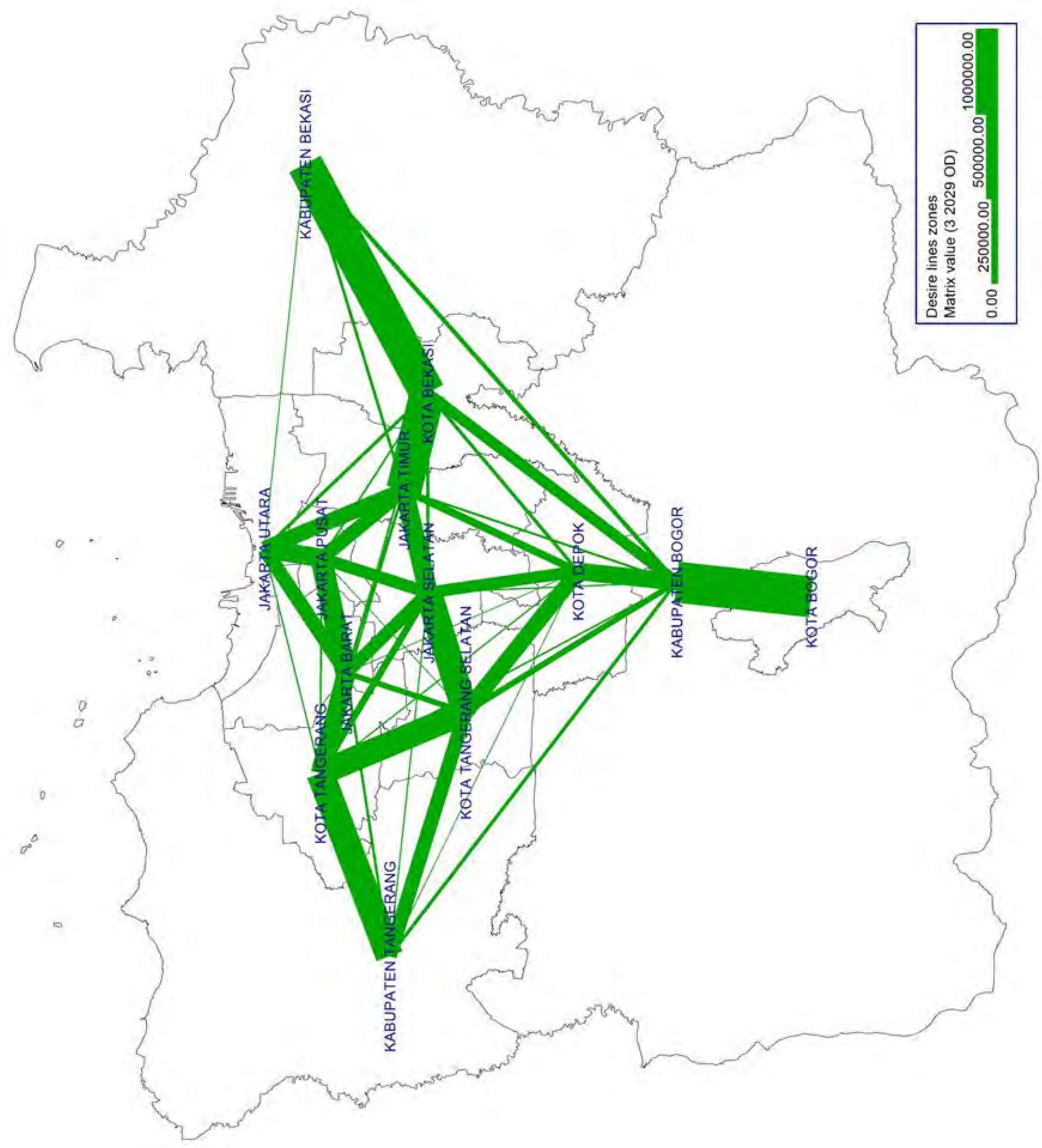
Source: JUTPI 2

Figure 99 Private Vehicle Assignment Result in 2029



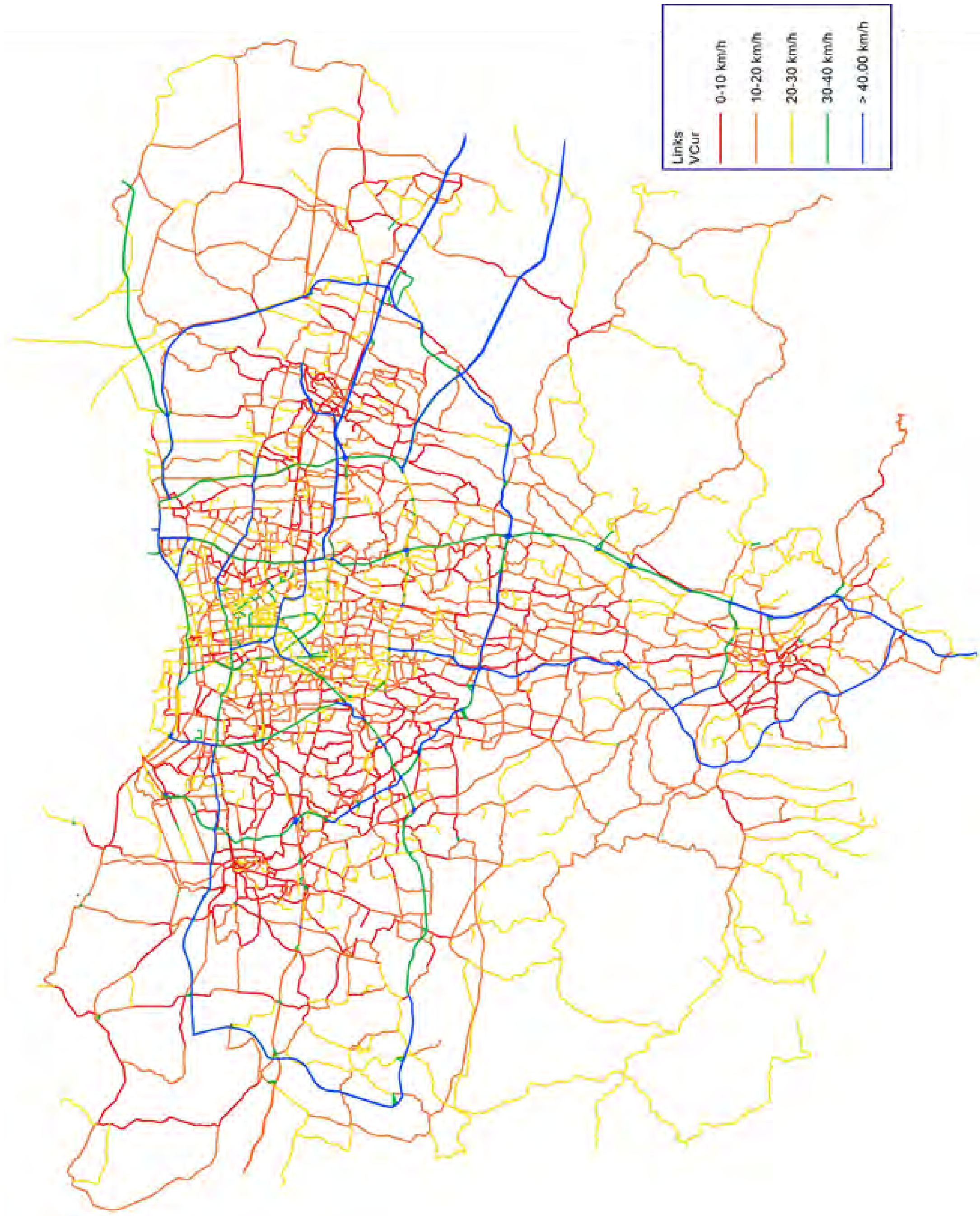
Source: JUTPI 2

Figure 100 Public Transport Assignment Result in 2029



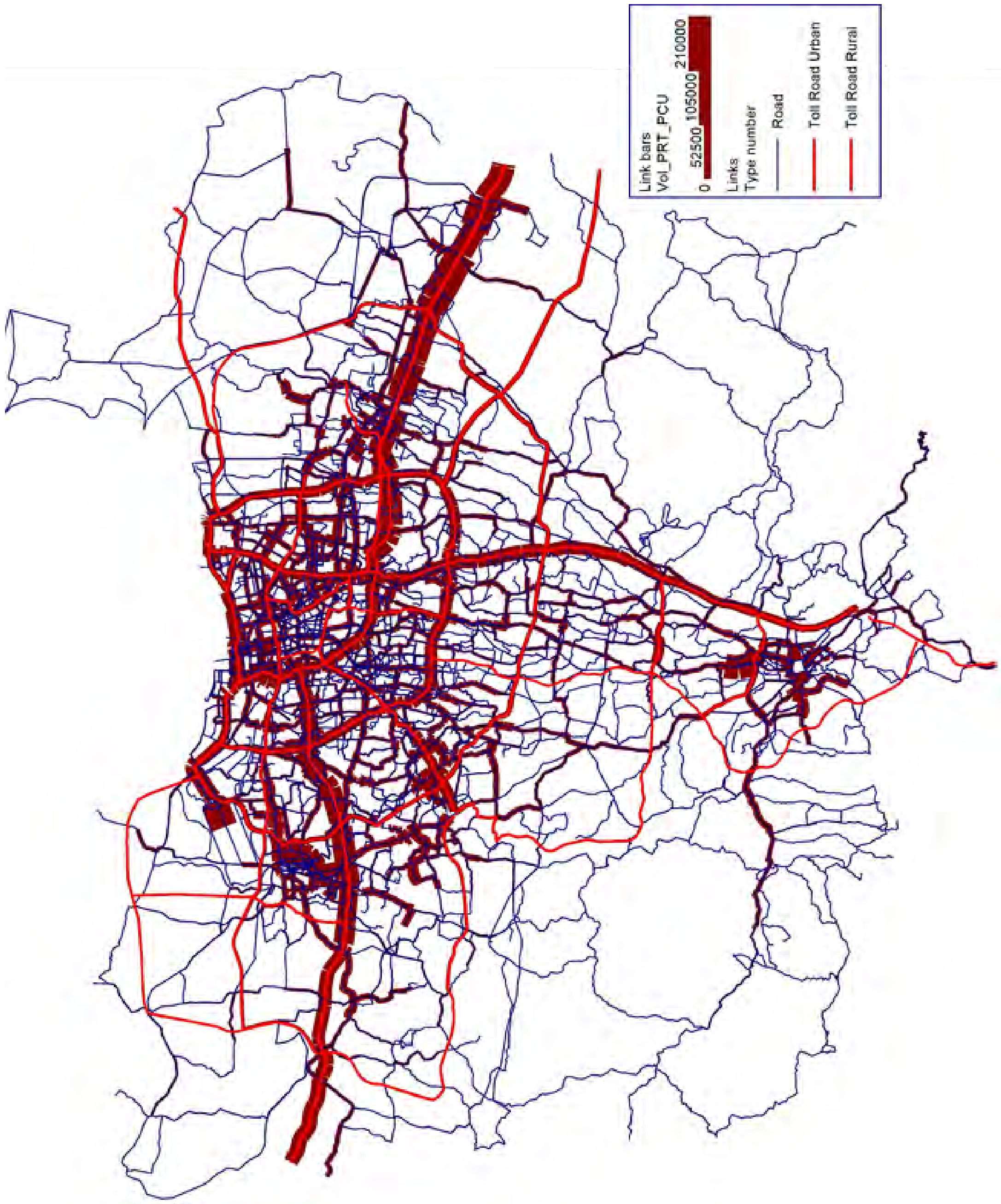
Source: JUTPI 2

Figure 101 Desire Line in 2029



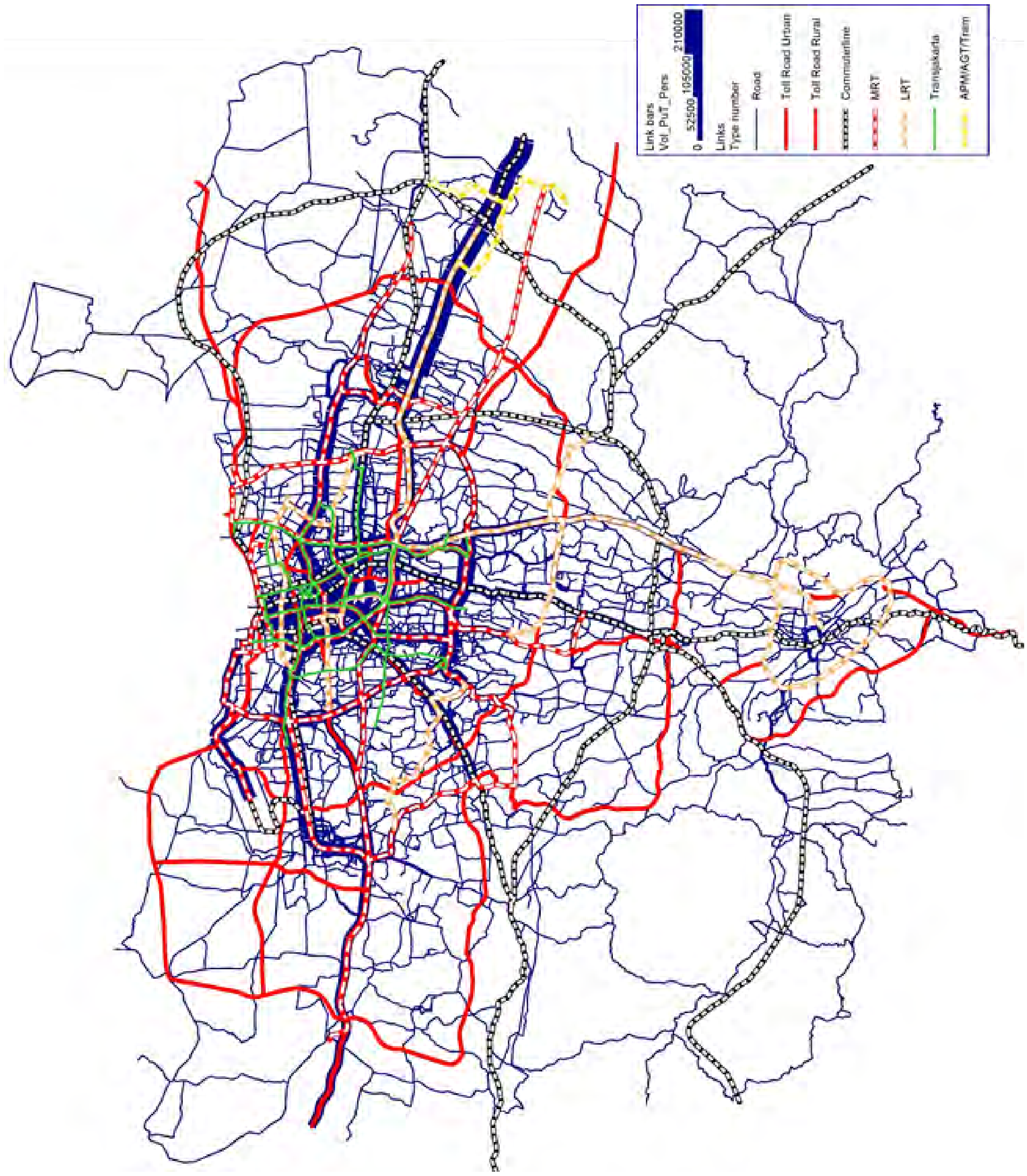
Source: JUTPI 2

Figure 102 Travel Speed Assignment Result in 2029



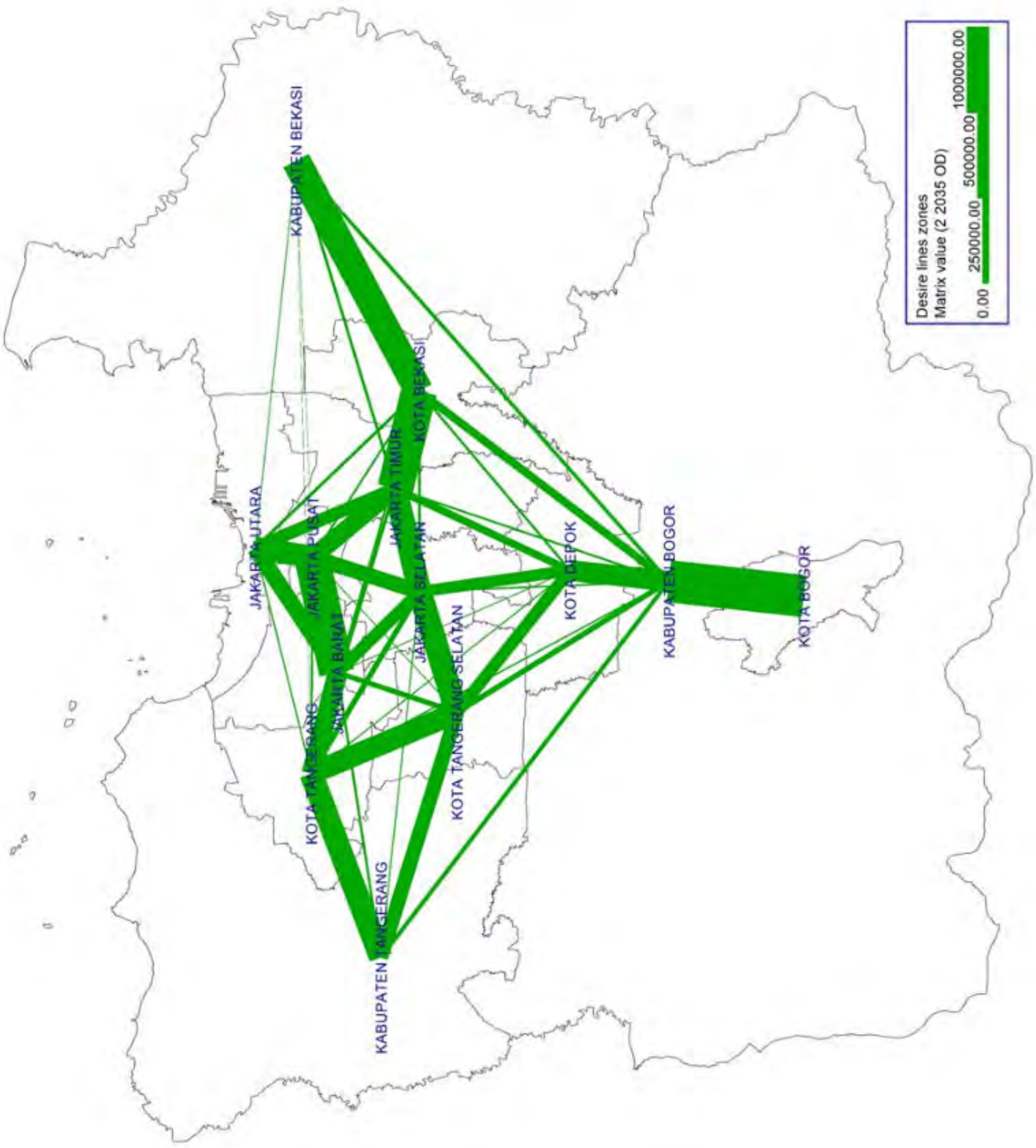
Source: JUTPI 2

Figure 103 Private Vehicle Assignment Result in 2035



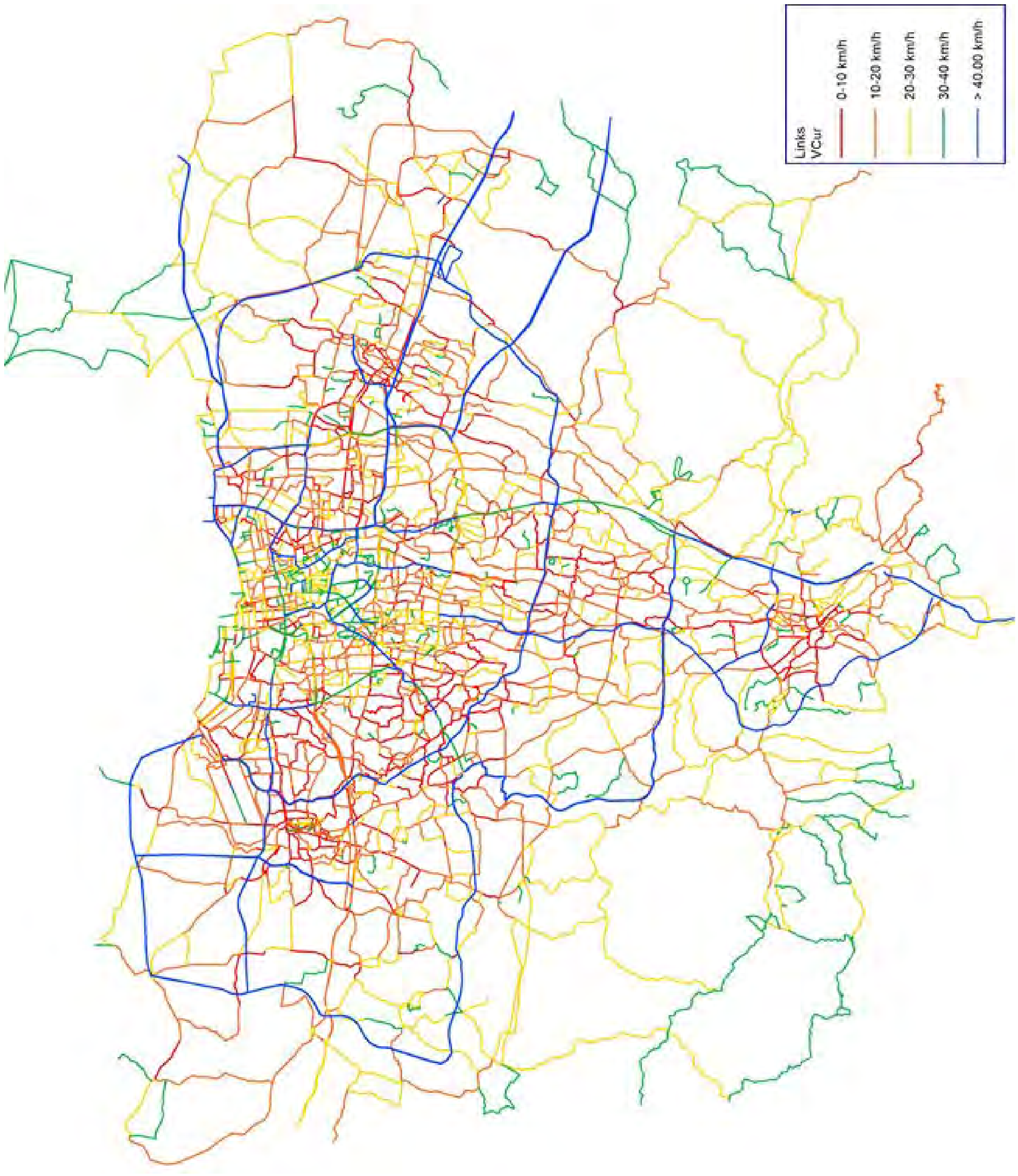
Source: JUTPI 2

Figure 104 Public Transport Assignment Result in 2035



Source: JUTPI 2

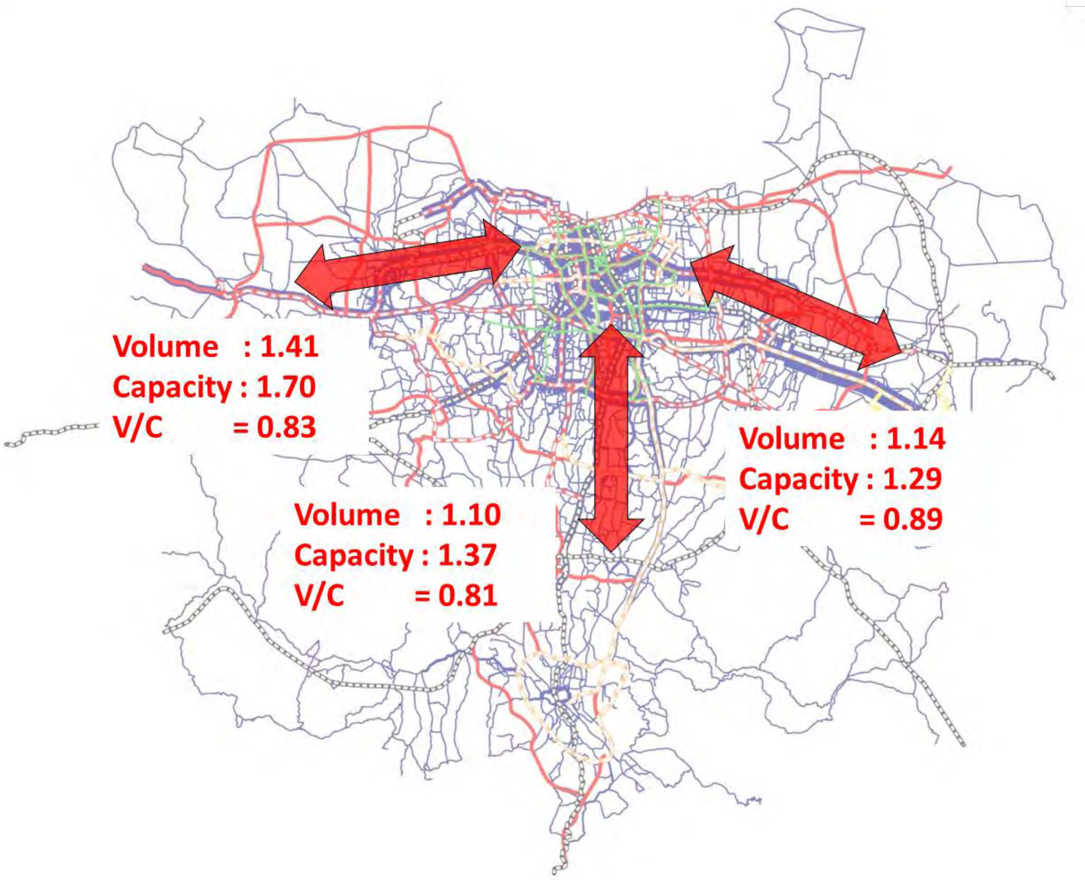
Figure 105 Desire Line in 2035



Source: JUTPI 2

Figure 106 Travel Speed Assignment Result in 2035

Based on the assignment result, it is observed that although congestion is still occurrs, volume capacity ratio is below 1.0 for all directions as shown in Figure 107. This means that JUTPI 2's comprehensive network plan can accommodate future public transport demand.



Unit: Mil. Pax/day/2 ways
Source: JUTPI 2

Figure 107 JUTPI 2 Master Plan Case (2035) Volume/Capacity Major Public Transport Corridors

Passenger demand calculated in passenger density /day is distinguished for JABODETABEK, DKI Jakarta, and BODETABEK. Some lines are crossing within DKI Jakarta and others lie across the cities. Planned lines that across in internal Jakarta are LRT 01, 02, 03, 04, and 10 while LRT 05, 07, 09 lies cross-boundary, and lines 06, 08, and 11 proposed for BODETABEK area in Bogor, Bekasi, and Tangerang Selatan.

Passenger demand for LRT shows that some corridors will have more than 50,000 passengers in density. Among the proposed lines, the highest demand is projected coming from LRT 07 section Cawang – Bekasi Timur with 79,700 pax/day, followed by LRT 03 from Pesing to Kelapa Gading via Kemayoran. In general, it is inferred that cross-boundary lines will attract more passengers for commuting rather than inner-city lines.

Table 64 Passenger Demand on LRT - JUTPI 2 Master Plan Case (2035)

Line Name	Length (km)	PAX-Density* (PAX/day) JABODETABEK	PAX-Density* (PAX/day) in JAKARTA	PAX-Density* (PAX/day) in BODETABEK	PAX (PAX/day)	Section
Planned LRT 01	6	11,200	11,200	-	30,300	Kelapa Gading - Velodrome
Planned LRT 02	12	21,000	21,000	-	63,800	Puri Kembangan - Tanah Abang - Dukuh Atas
Planned LRT 03	17	65,600	65,600	-	369,100	Pesing - Kelapa Gading via Kemayoran
Planned LRT 04	10	37,300	37,300	-	94,900	Cawang - Kuningan - Dukuh Atas
Planned LRT 05	44	61,300	76,900	54,100	161,600	Cawang - Cibubur - Kota Bogor
Planned LRT 06	40	16,800	-	16,800	89,800	Inner City of Kota Bogor/Kab. Bogor (Sentul City - Tanah Baru - Kedung Halang - Sukaresmi - Bubulak - Laladon - Rancamaya - Cibanon - Sentul City)
Planned LRT 07	19	79,700	77,500	80,100	210,200	Cawang - Bekasi Timur
Planned LRT 08	15	21,000	-	21,000	42,700	Route up to Cikarang integrated with automated people mover (APM) and High-Speed Train (HST)
Planned LRT 09	25	34,300	32,100	34,300	141,100	Jagakarsa - Cibubur - Cileungsi
Planned LRT 10	8	31,700	31,700	-	54,400	Velodrome - JIEP – Cakung
Planned LRT 11	20	27,600	-	27,600	106,700	Inner City Kota Tangerang Selatan

Note: * PAX Density = PAX-km / Route length
Source: JUTPI 2

10 MRT lines were proposed. 3 out of 10 MRT lines lie in the inner city of DKI Jakarta and others lie across the boundary and outside of DKI Jakarta. Inner-city MRT lines are proposed in 3 sections in DKI Jakarta and 1 section in Kota Bekasi, namely MRT 01, 04, 10, and 07 respectively. The longest MRT line is MRT 02 from Cikarang to Balaraja with 87 km and the shortest line is MRT 07 that serves South of Kota Bekasi to North of Kota Bekasi. The highest demand is projected on MRT 02 section Cikarang – Balaraja, followed by MRT 01 from Kampung Bandan to Lebak Bulus. Similar to LRT, cross-boundary MRT lines

will attract more passengers rather than inner-city lines with the average number of passengers are exceeding those of LRT.

Table 65 Passenger Demand on MRT - JUTPI 2 Master Plan Case (2035)

Line Name	Length (km)	PAX-Density* (PAX/day) JABODETABEK	PAX-Density* (PAX/day) in JAKARTA	PAX-Density* (PAX/day) in BODETABEK	PAX (PAX/day)	Section
Planned MRT 01	23	150,200	150,200	-	791,000	Kp. Bandan - Lebak Bulus
Planned MRT 02	87	114,500	164,500	87,200	816,100	Cikarang – Balaraja
Planned MRT 03	23	103,300	108,100	97,100	213,800	Bandara –Kp. Bandan
Planned MRT 04	38	67,100	67,100	-	363,600	Cilincing – Cawang – Lebak Bulus
Planned MRT 05	67	54,500	76,900	43,500	348,800	Karawaci – Senayan – Cawang –South Cikarang
Planned MRT 06	34	65,500	-	65,500	288,200	Lebak Bulus – Rawa Buntu – Karawaci
Planned MRT 07	13	75,800	-	75,800	177,700	South Bekasi City – North Bekasi City
Planned MRT 08	39	72,100	82,200	51,700	347,000	Pluit – Grogol – Kuningan – Depok
Planned MRT 09	63	80,100	80,700	72,000	507,500	Outer Loopline
Planned MRT 10	38	72,800	72,800	-	536,200	Inner Loopline

Note: * PAX Density = PAX-km / Route length
Source: JUTPI 2

8.2.5 Traffic and Public Transport Indicator

Comparison between existing condition (2018), 2035 with the do-minimum, and 2035 with the master plan are comparatively evaluated on the basis of the following indicators.

Table 66 Traffic and Public Transport Indicators

Indicator	Scenario		
	2018	2035 Do Minimum	2035 Master Plan
Public transportation mode share in ERP area during ERP operation time	6%	7%	50%
Average person travel time in public transport modes at peak hour	81’	63’	45’
Average number of transfers for public transport passenger	1.0	0.9	0.8
Passenger-Hours (‘000 Person hr)	5,183	7,199	4,512
Vehicle-Km (‘000 PCU km)	151,113	169,142	149,659

Source: JUTPI 2

- Public transportation mode share in ERP area during ERP operation time
  People movement using urban public transport divided by total movement of people inside of ERP area during ERP operation. This movement included all motorized person trips in normal business day.
- Average person travel time in public transport modes at peak hour
  Average person travel time in public transport vehicle at peak hour from origin to destination. This value calculated from weighted average from OD Matrix and travel time Skim Matrix for all public transport at morning peak (6-10) or evening peak (16-20) in normal business day.
- Average number of transfers for public transport passenger
  Average number of transfers for public transport passenger in a single trip (from origin to destination). This value calculated from weighted average from OD Matrix and number of transfer skim matrix (excluding walking). Transfer from same system with different line routes considered as transfer.
- Passenger-Hours
  Passenger-hours is time which the passengers spend in public transportation vehicle. Passenger-hours = Volume x Duration. Calculation for table above excluded intra-zonal trip.
- Road Traffic Vehicle-Km
  Vehicle-kilometers traveled is the total kilometers traveled by vehicles on the network during a given period of time. Calculation for table above excluded intra-zonal trip.

Coordinating Ministry for Economic Affairs
Republic of Indonesia

JABODETABEK Urban Transportation Policy Integration Project Phase 2 in the Republic of Indonesia

Annex 06: Travel Demand Forecast

Appendix A:

Verification Synthesized Population

October 2019

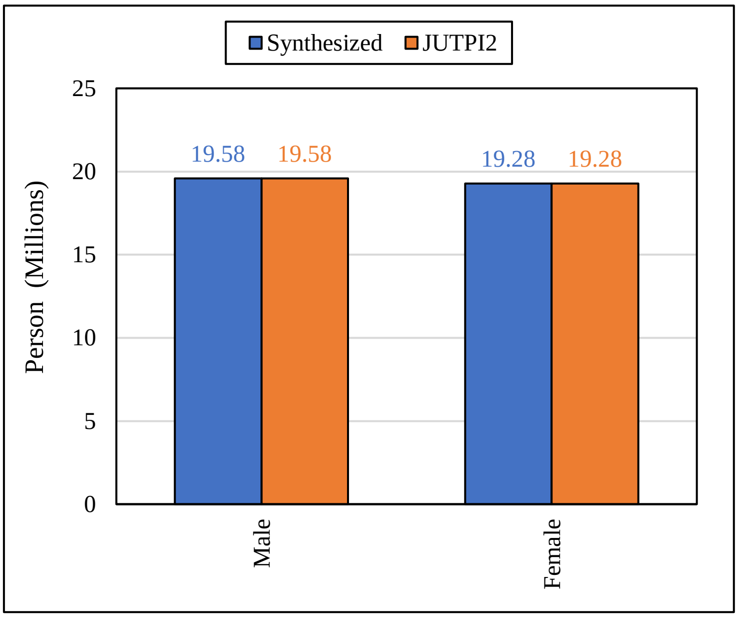
Japan International Cooperation Agency (JICA)

ALMEC Corporation

IN
JR
20-004

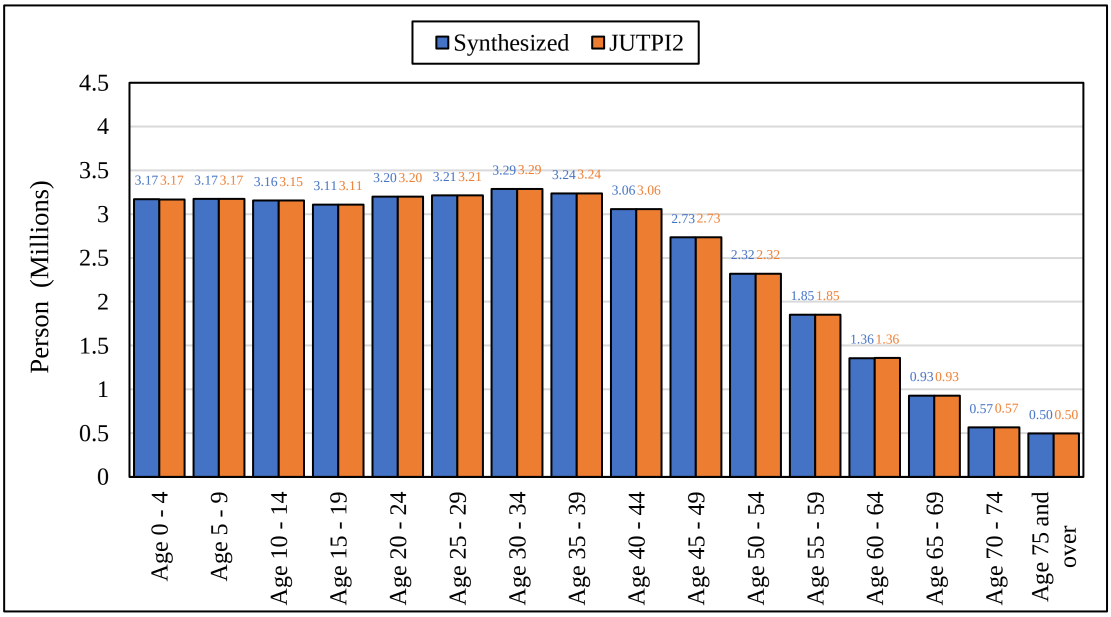
A. Master Plan Case in 2024

Person Synthetic Data



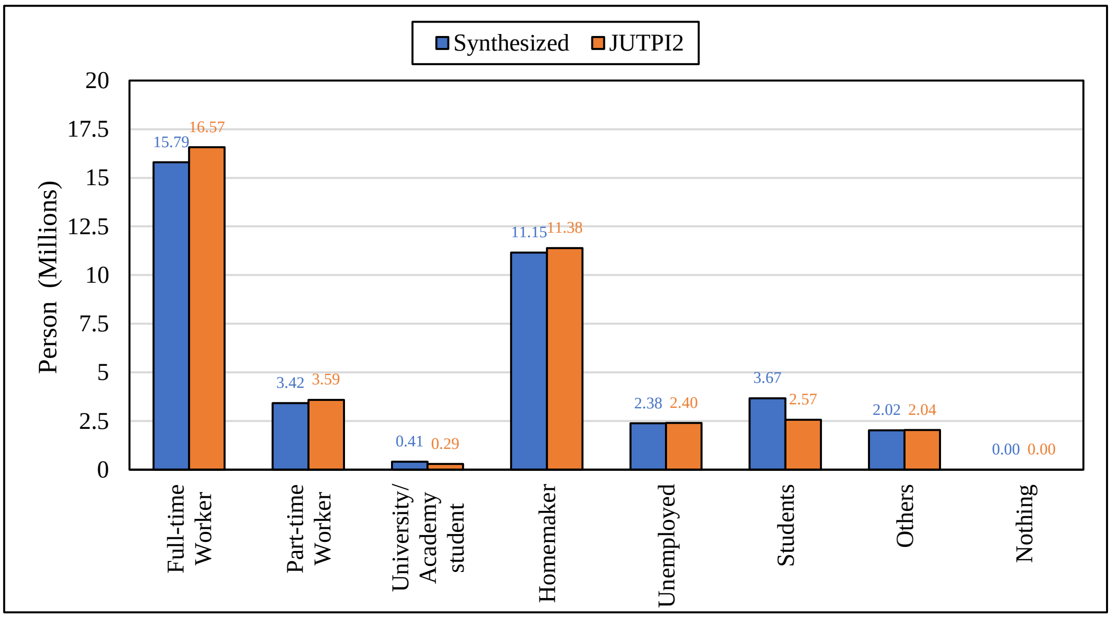
Source: JUTPI 2

A1 Estimation of Population by Gender at TAZ Level in 2024



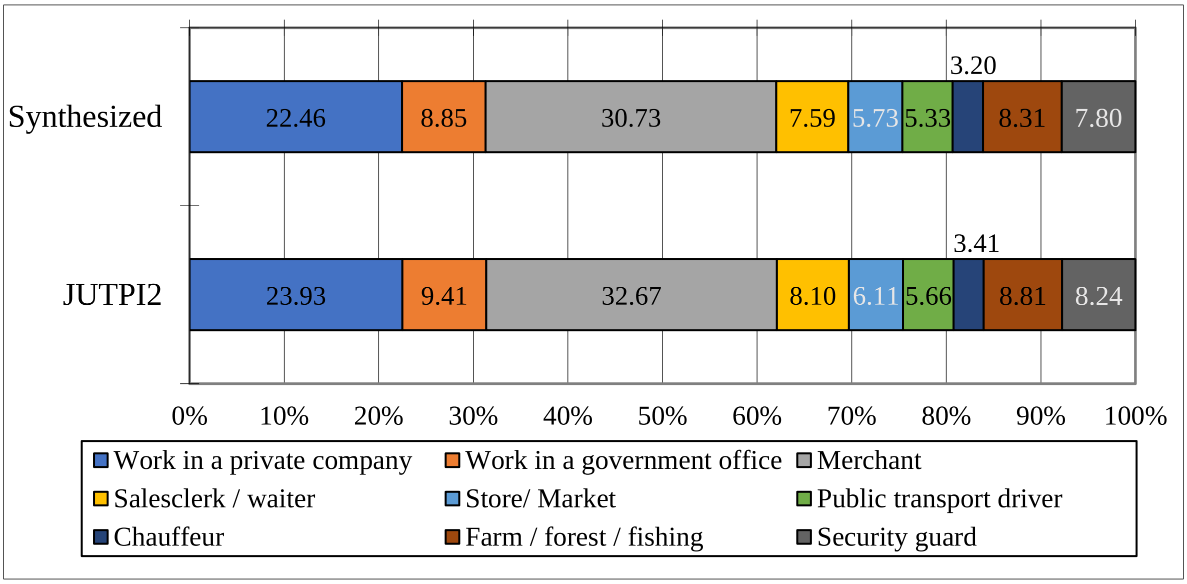
Source: JUTPI 2

A2 Estimation of Population by Age Group at TAZ Level in 2024



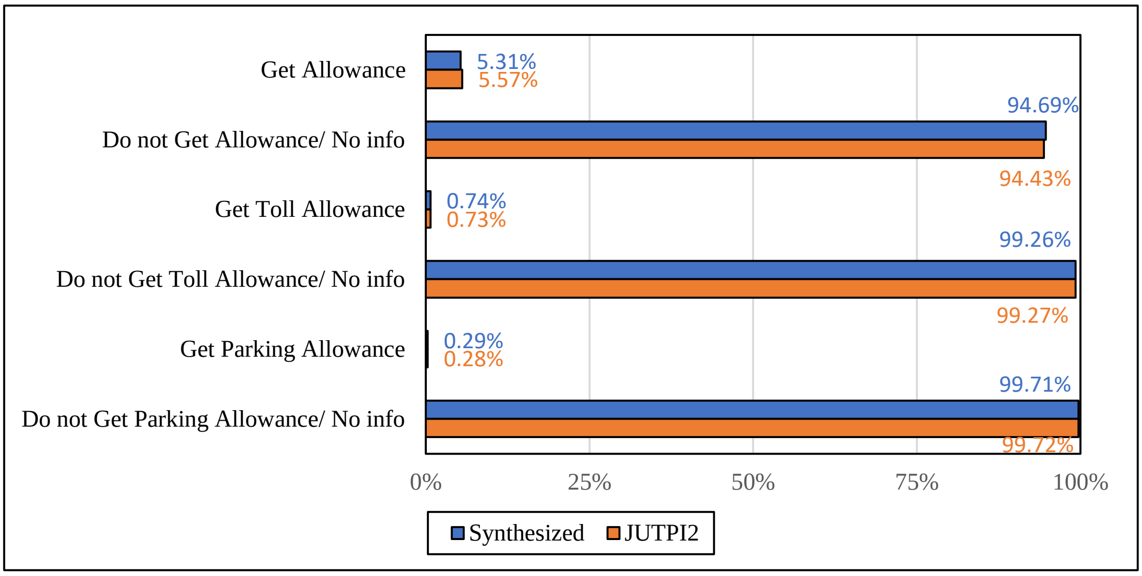
Source: JUTPI 2

A3 Estimation of Population by Main Activity at TAZ Level in 2024



Source: JUTPI 2

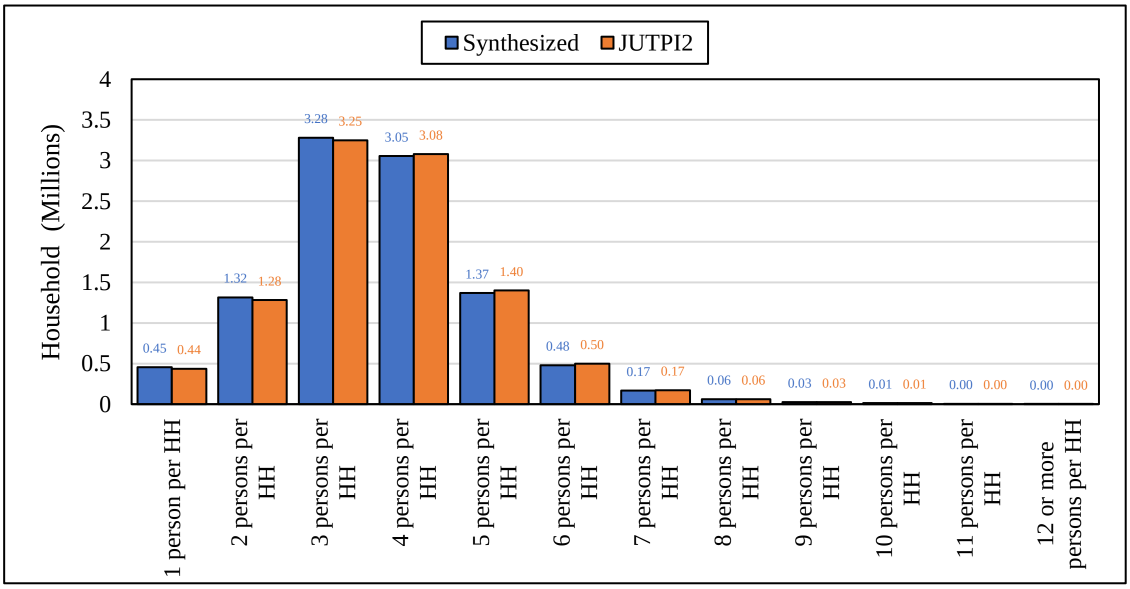
A4 Estimation of Worker by Type of Work at TAZ Level in 2024



Source: JUTPI 2

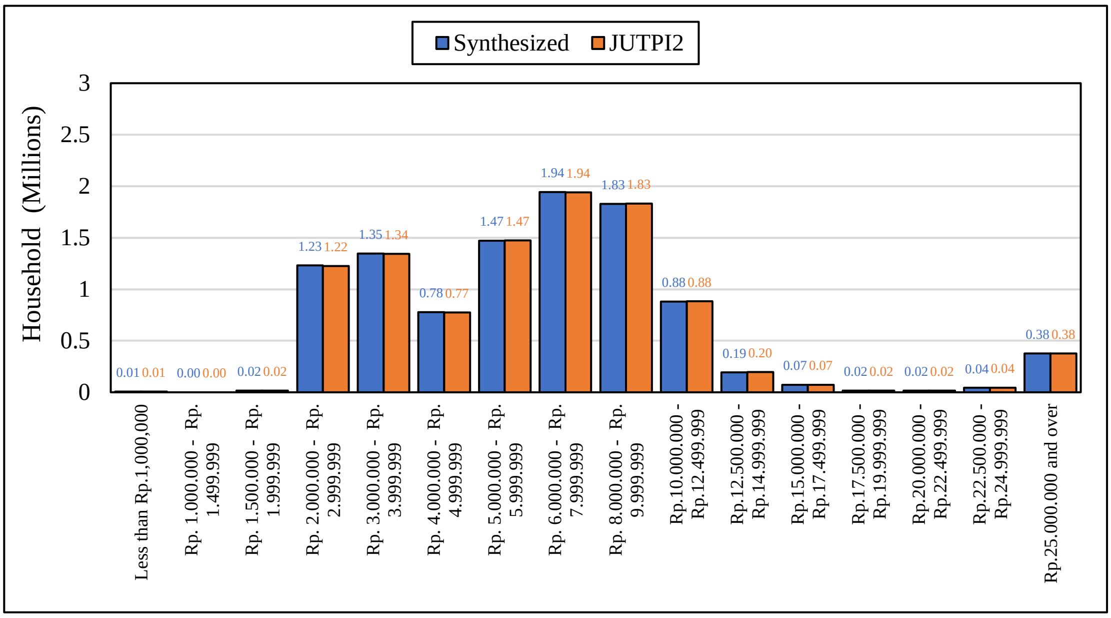
A5 Estimation of Worker's Allowance at TAZ Level in 2024

<u>Housing Synthetic Data</u>



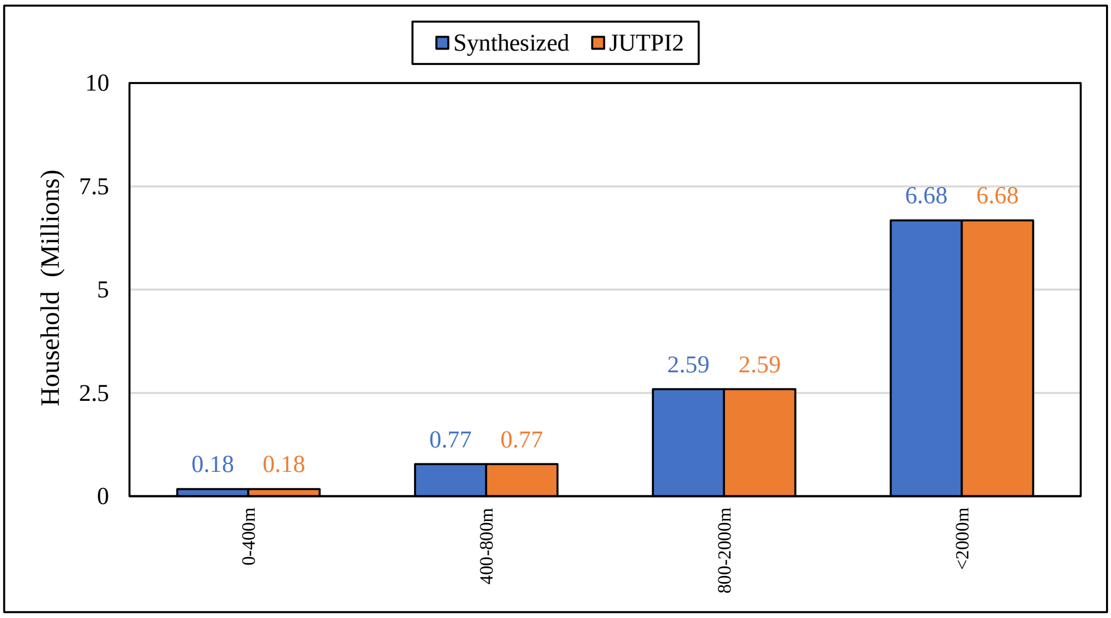
Source: JUTPI 2

A6 Estimation of Household Size at TAZ Level in 2024



Source: JUTPI 2

A7 Estimation of Household Income at TAZ Level in 2024

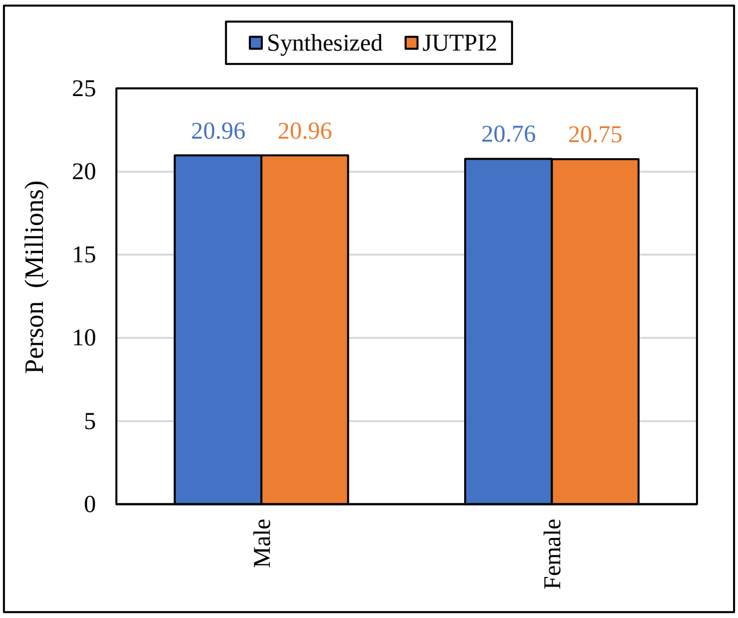


Source: JUTPI 2

A8 Estimation of Household Distance from the Nearest Railway Station at TAZ Level in 2024

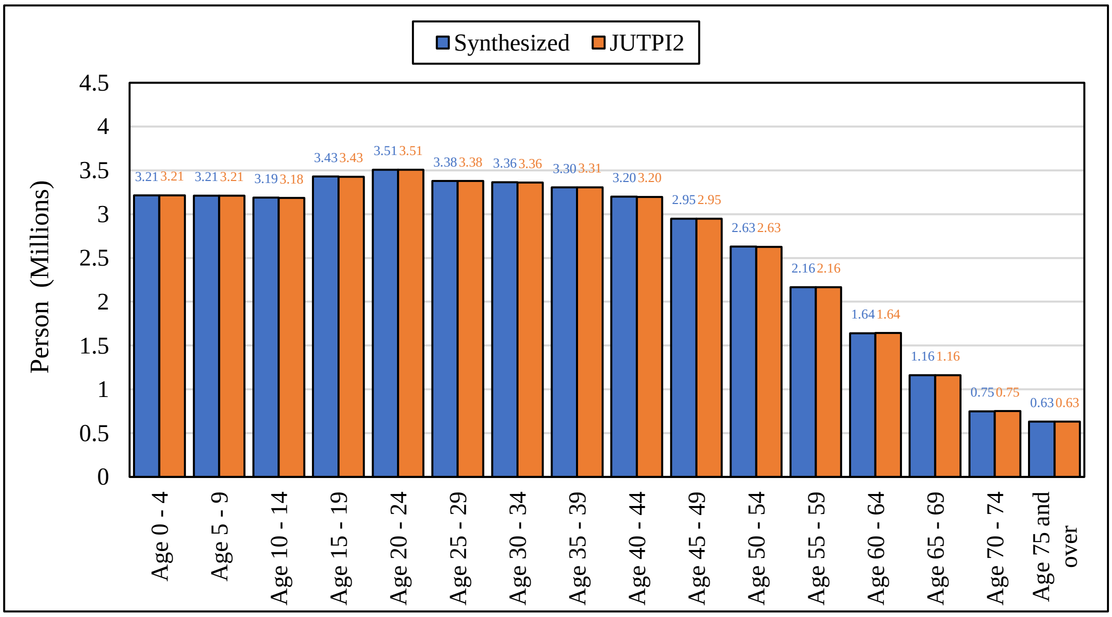
B. Master Plan Case in 2029

<u>Person Synthetic Data</u>



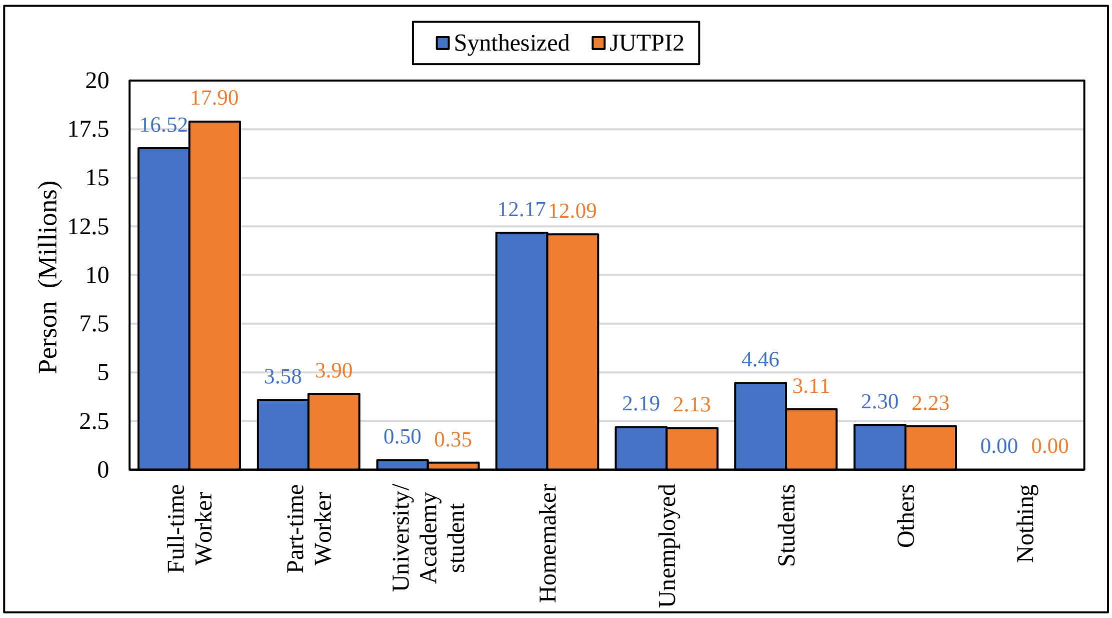
Source: JUTPI 2

A9 Estimation of Population by Gender at TAZ Level in 2029



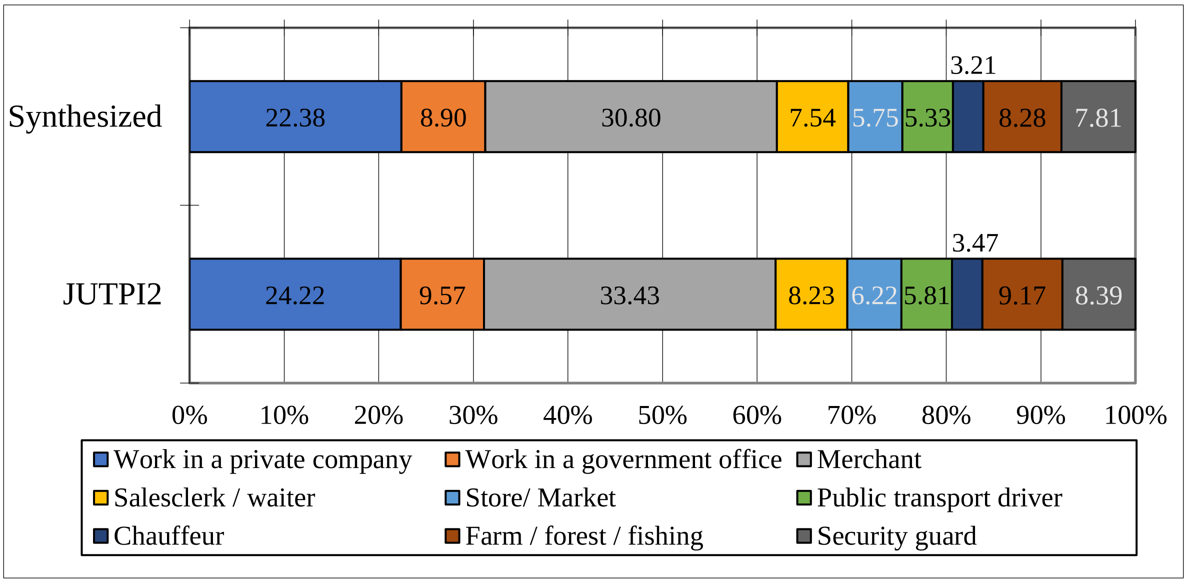
Source: JUTPI 2

A10 Estimation of Population by Age Group at TAZ Level in 2029



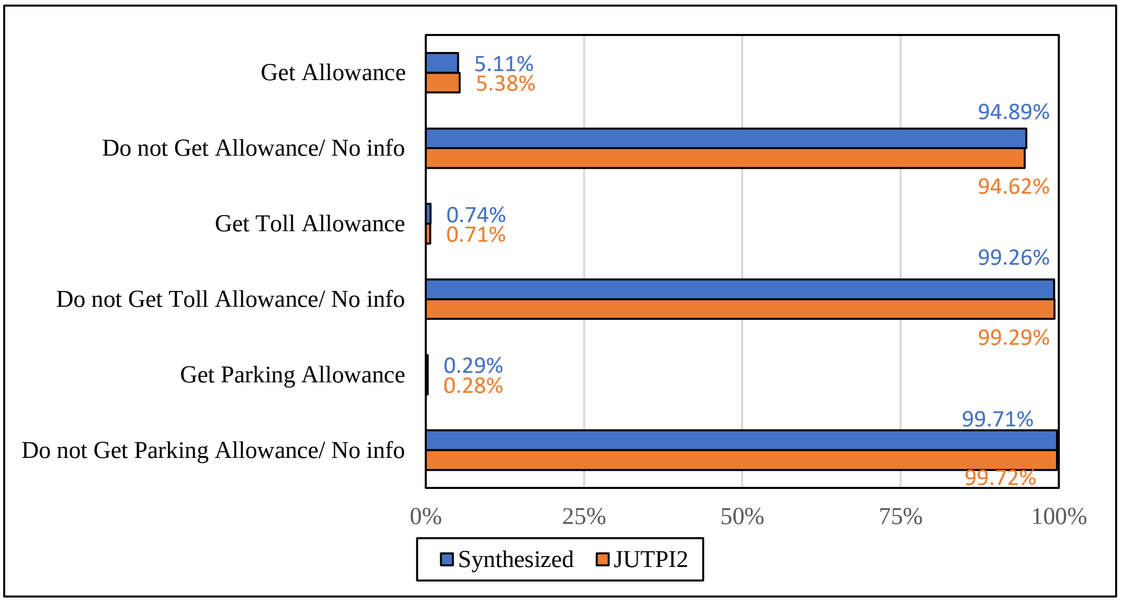
Source: JUTPI 2

A11 Estimation of Population by Main Activity at TAZ Level in 2029



Source: JUTPI 2

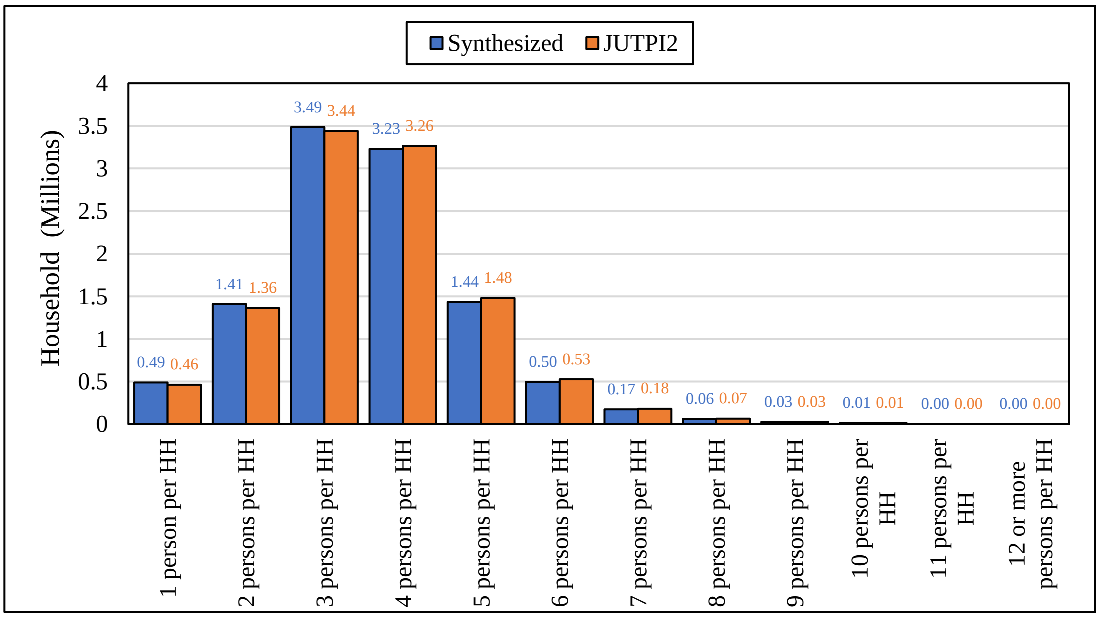
A12 Estimation of Worker by Type of Work at TAZ Level in 2029



Source: JUTPI 2

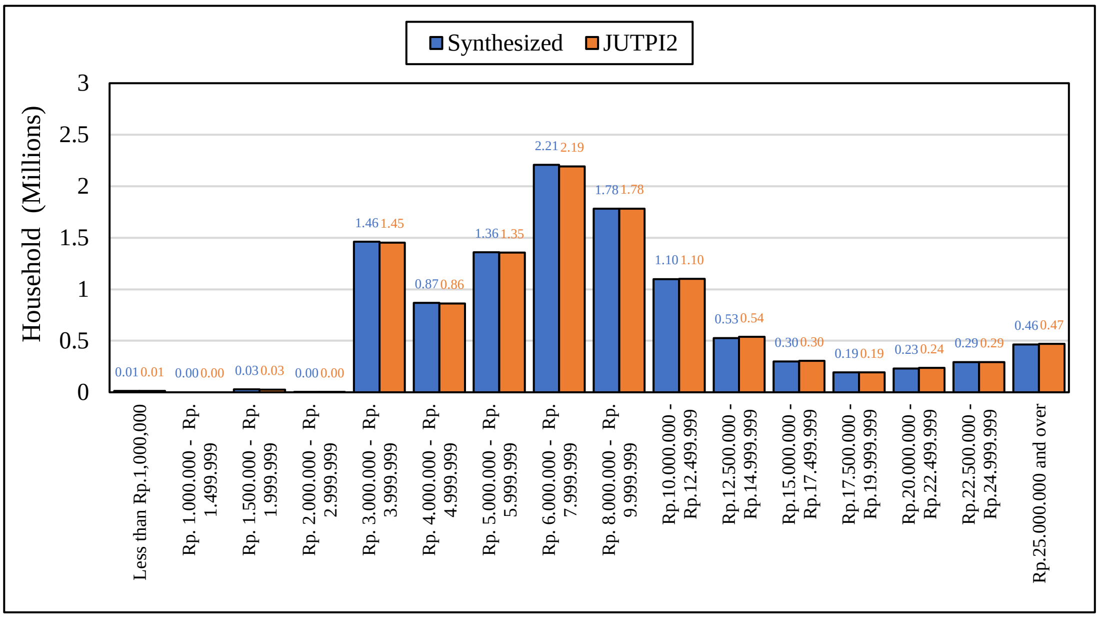
A13 Estimation of Worker's Allowance at TAZ Level in 2029

<u>Housing Synthetic Data</u>



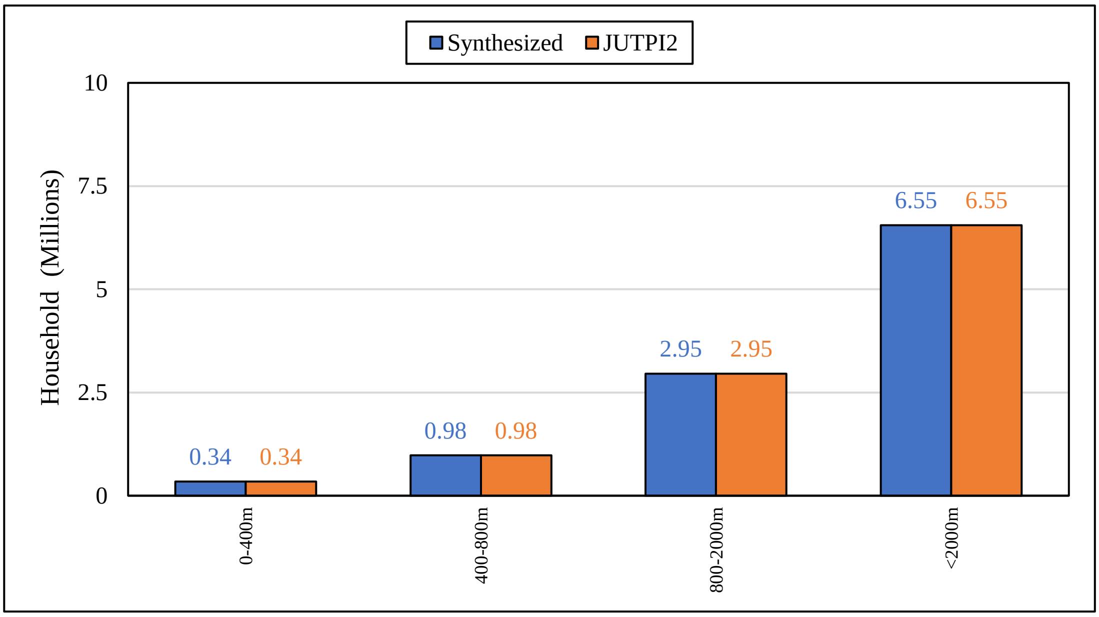
Source: JUTPI 2

A14 Estimation of Household Size at TAZ Level in 2029



Source: JUTPI 2

A15 Estimation of Household Income at TAZ Level in 2029

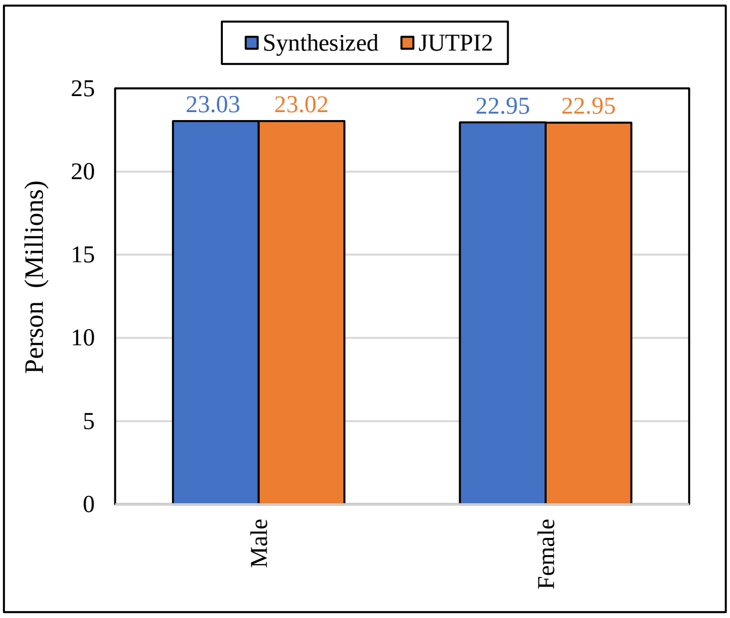


Source: JUTPI 2

A16 Estimation of Household Distance from The Nearest Railway Station at TAZ Level in 2029

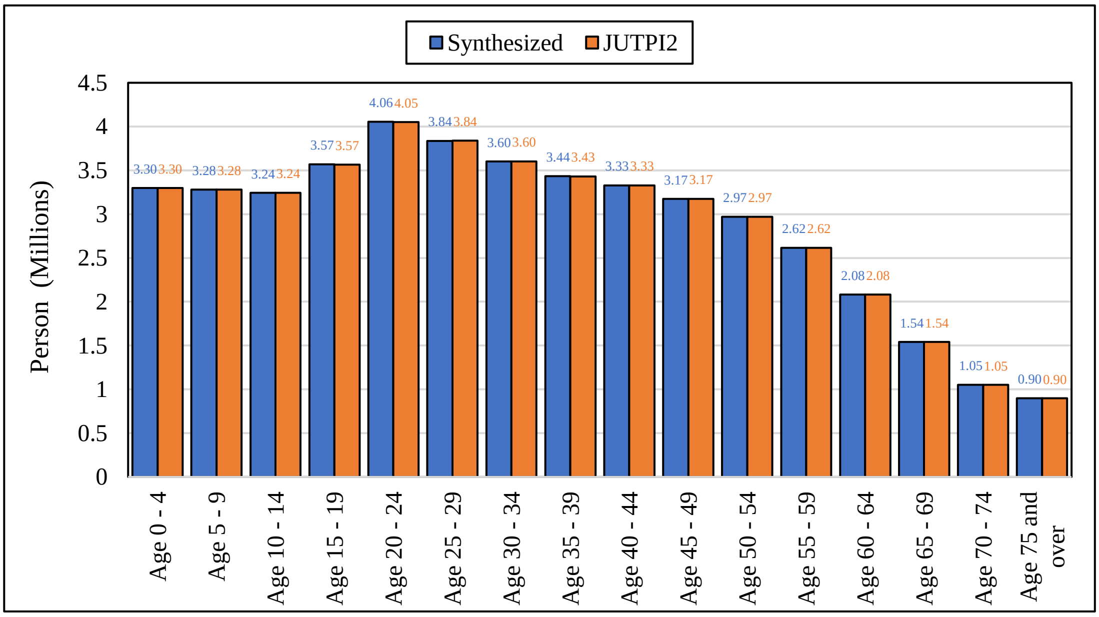
C. Master Plan Case in 2035

Person Synthetic Data



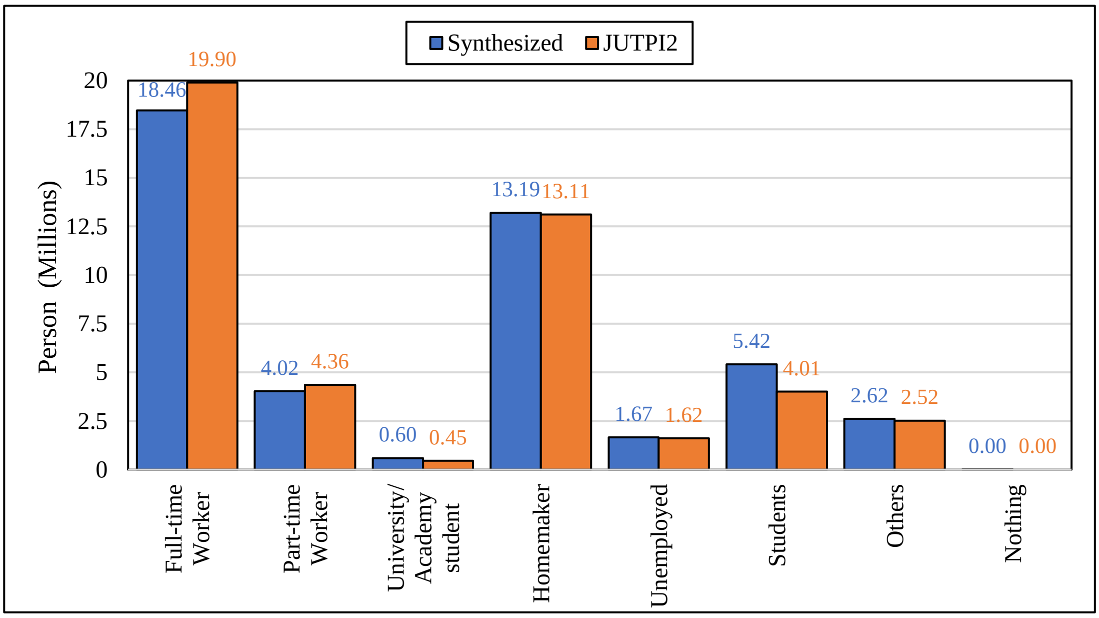
Source: JUTPI 2

A17 Estimation of Population by Gender at TAZ Level in 2035



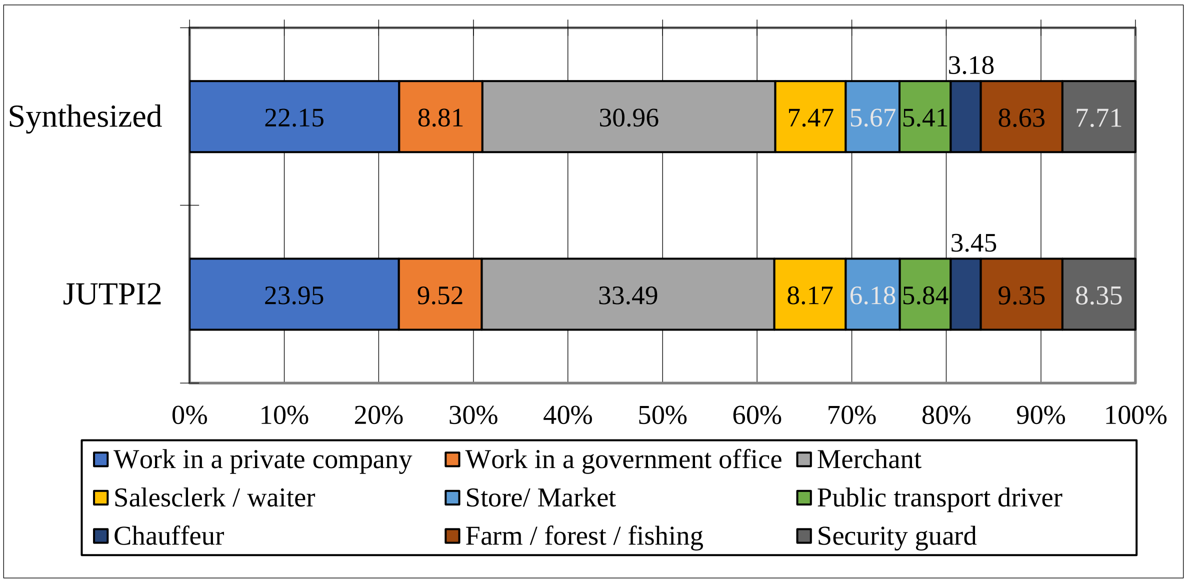
Source: JUTPI 2

A18 Estimation of Population by Age Group at TAZ Level in 2035



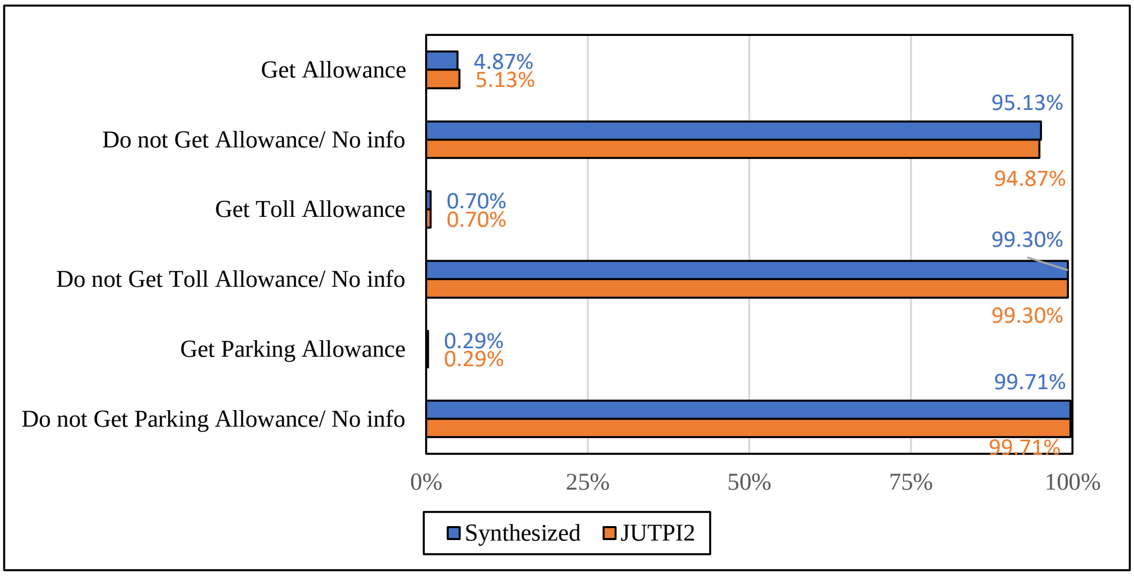
Source: JUTPI 2

A19 Estimation of Population by Main Activity at TAZ Level in 2035



Source: JUTPI 2

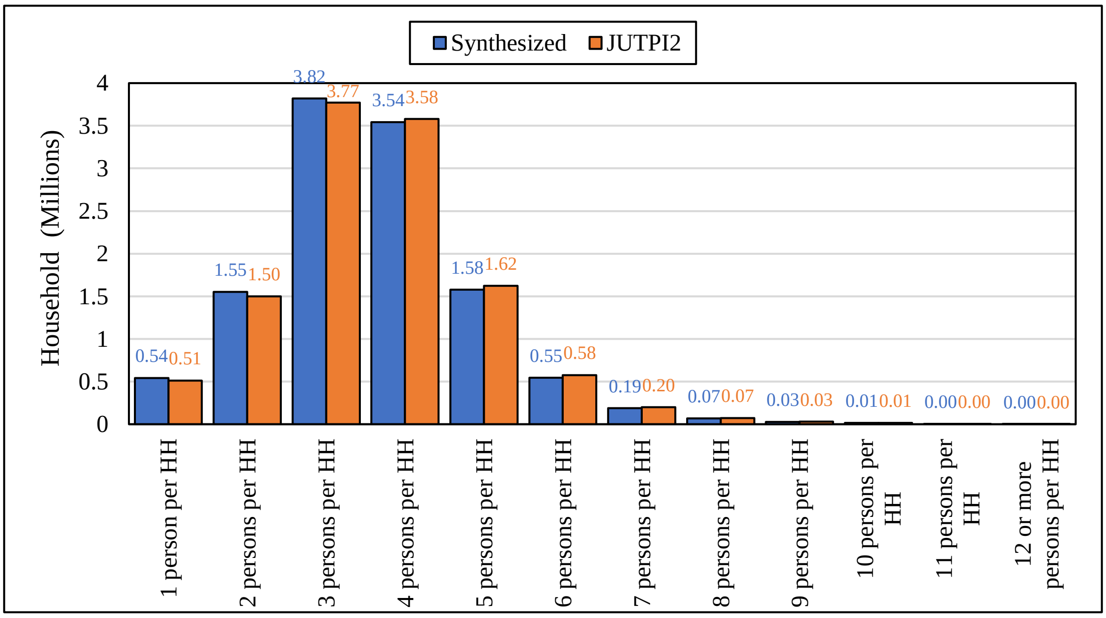
A20 Estimation of Worker by Type of Work at TAZ Level in 2035



Source: JUTPI 2

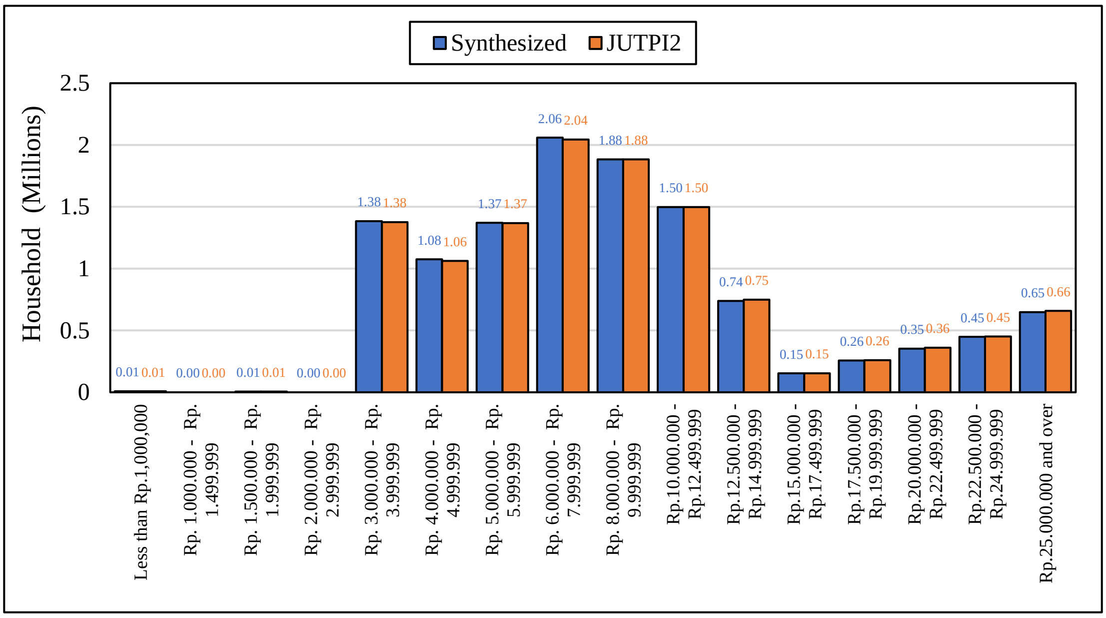
A21 Estimation of Worker's Allowance at TAZ Level in 2035

Housing Synthetic Data



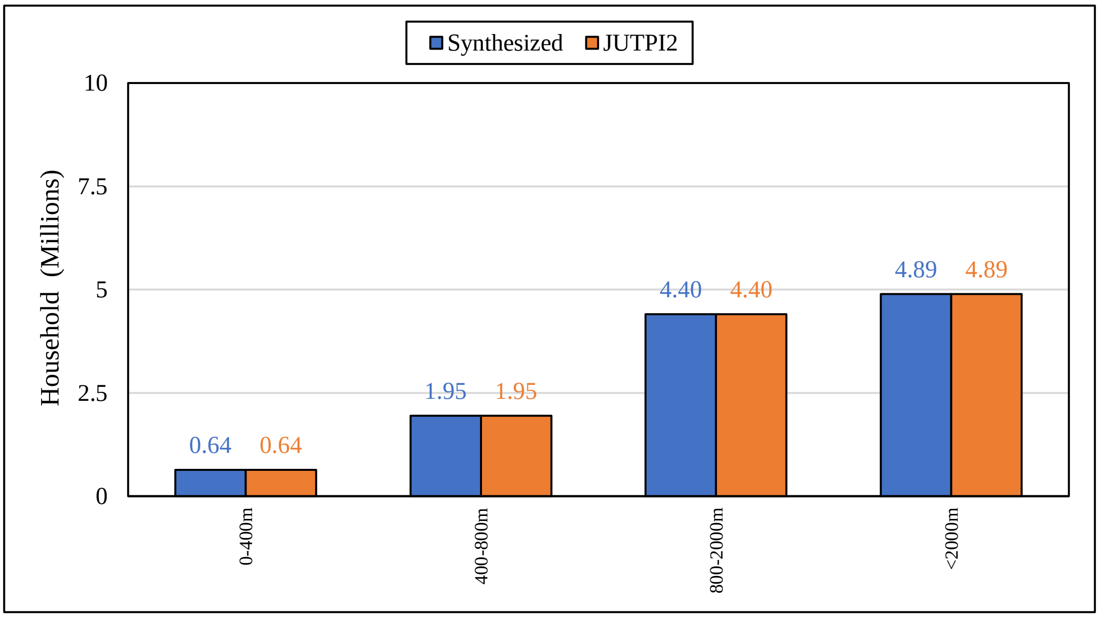
Source: JUTPI 2

A22 Estimation of Household Size at TAZ Level in 2035



Source: JUTPI 2

A23 Estimation of Household Income at TAZ Level in 2035

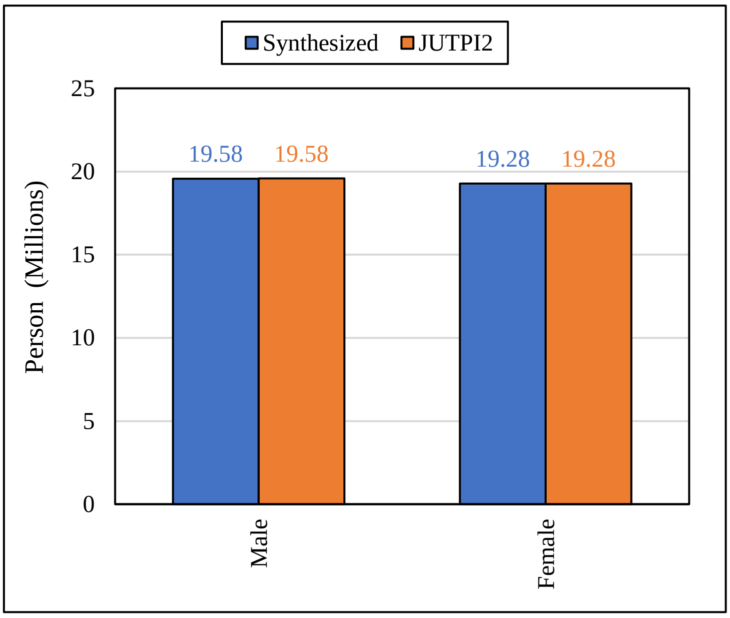


Source: JUTPI 2

A24 Estimation of Household Distance from The Nearest Railway Station at TAZ Level in 2035

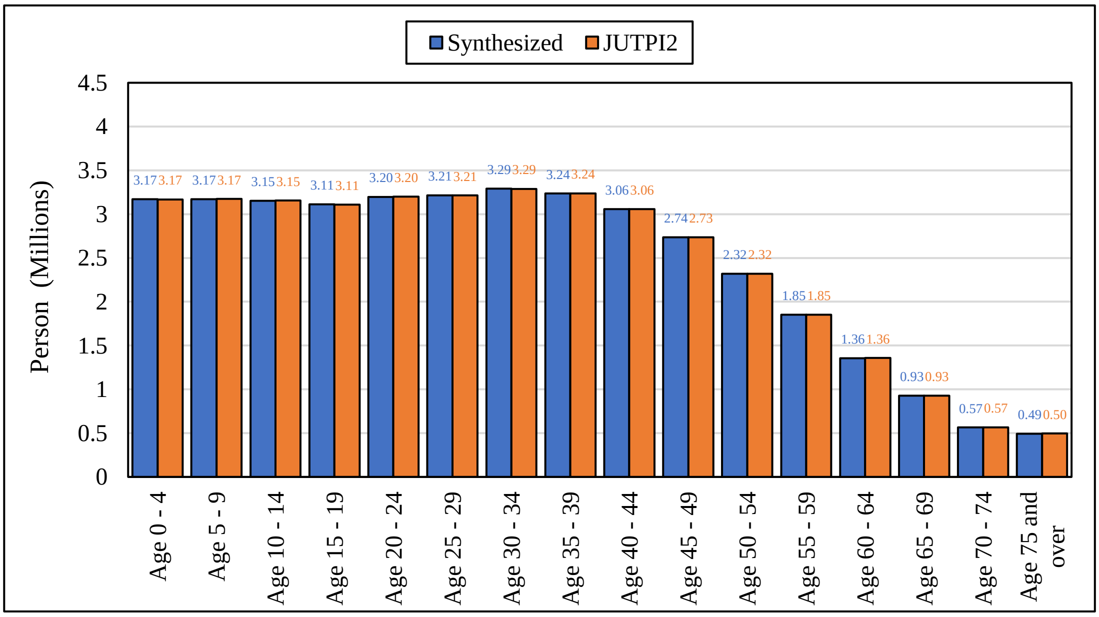
D. Do Minimum Case in 2024

Person Synthetic Data



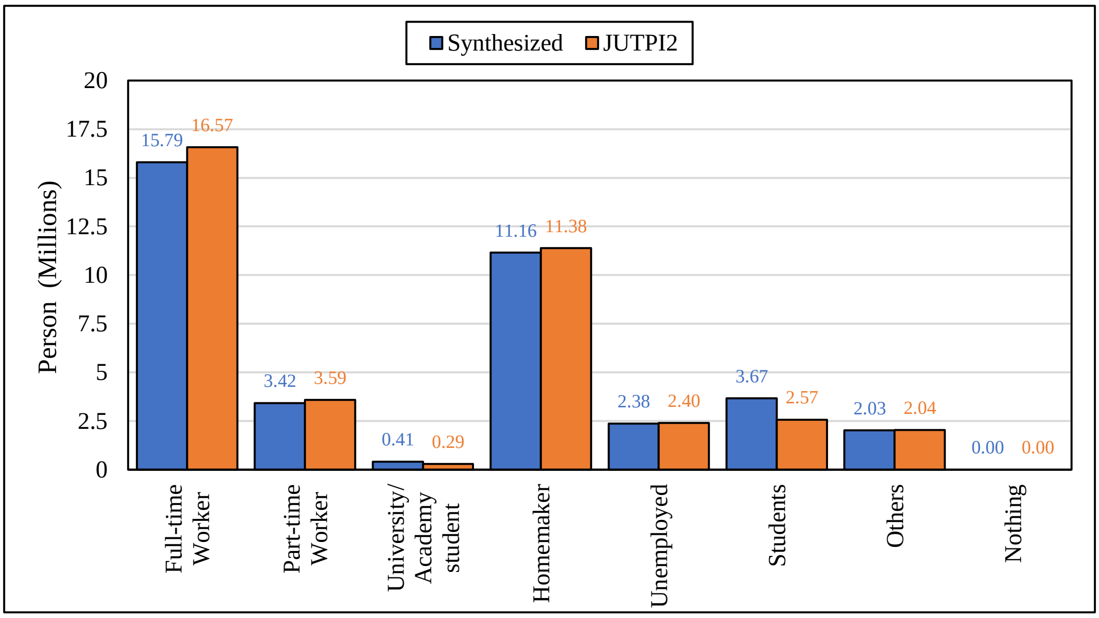
Source: JUTPI 2

A25 Estimation of Population by Gender at TAZ Level for Do Minimum Case in 2024



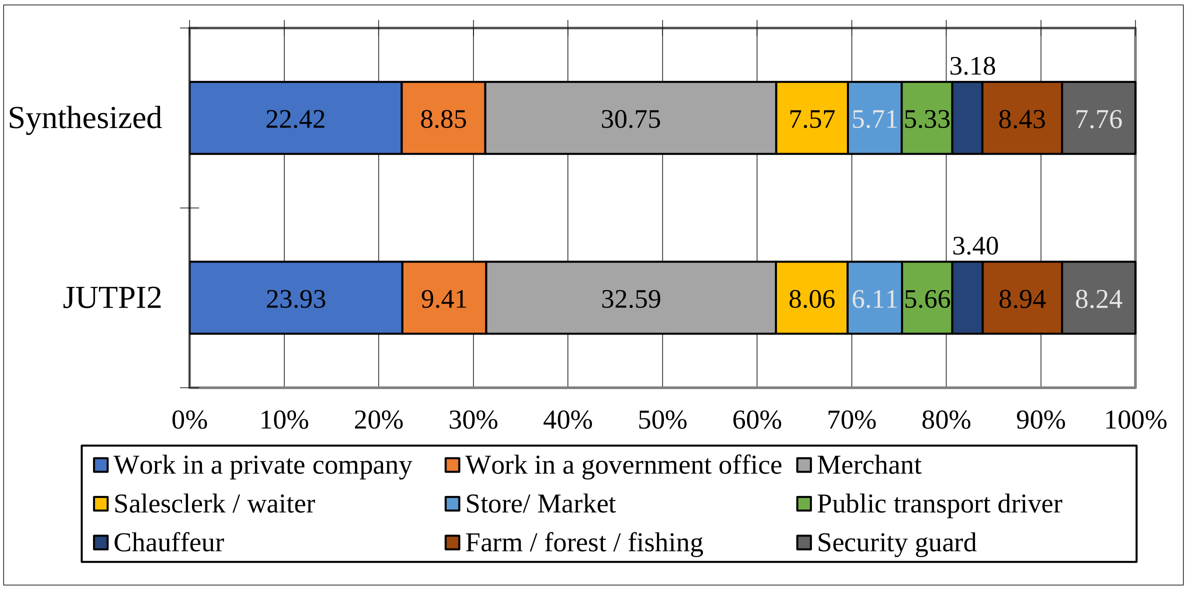
Source: JUTPI 2

A26 Estimation of Population by Age Group at TAZ Level for Do minimum Case in 2024



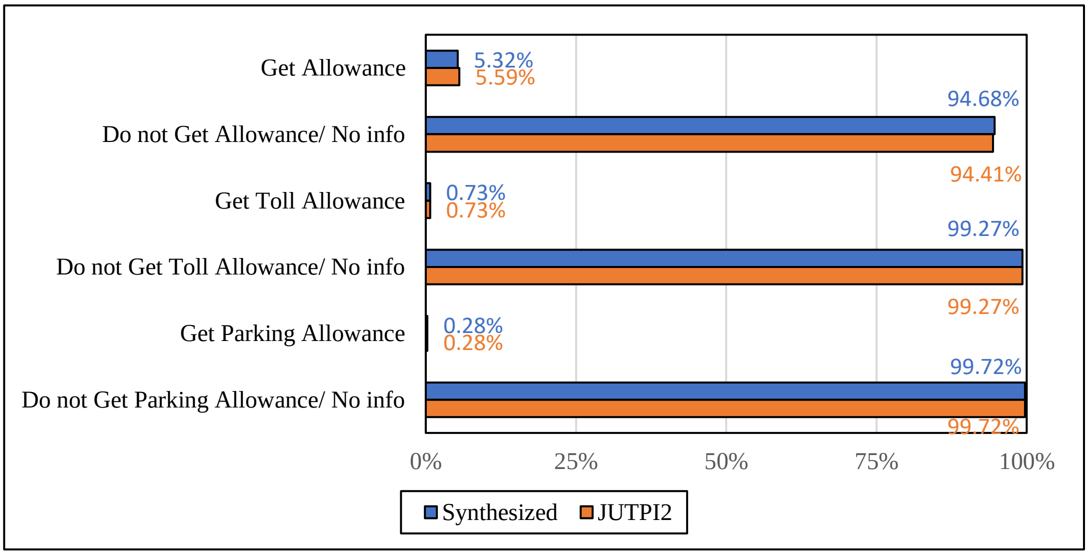
Source: JUTPI 2

A27 Estimation of Population by Main Activity at TAZ Level for Do Minimum Case in 2024



Source: JUTPI 2

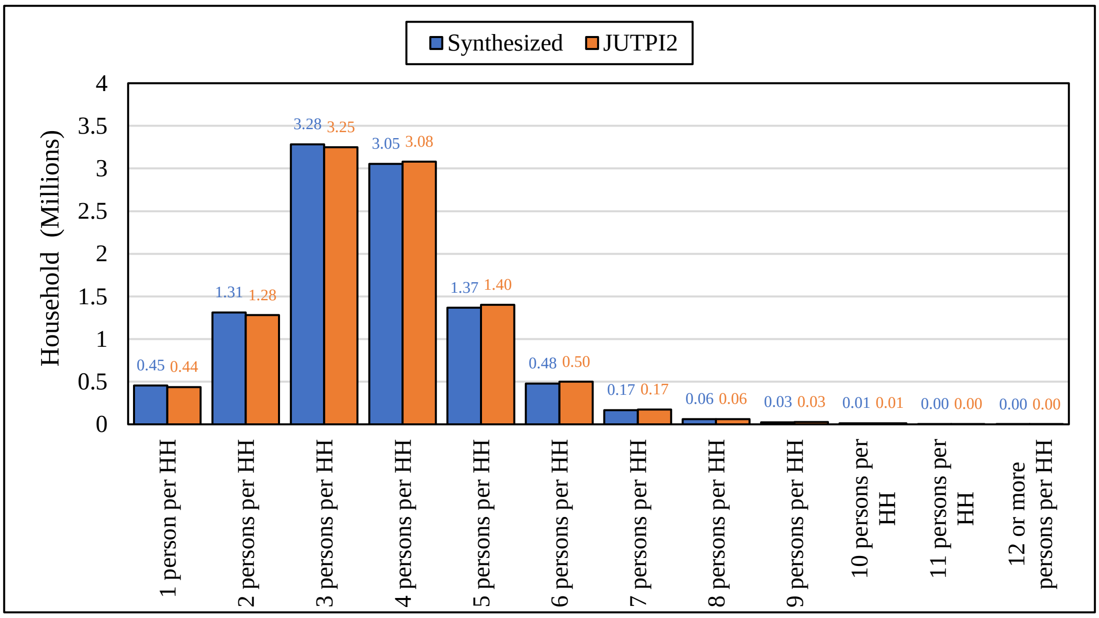
A28 Estimation of Workers by Type of Work at TAZ Level for Do Minimum Case in 2024



Source: JUTPI 2

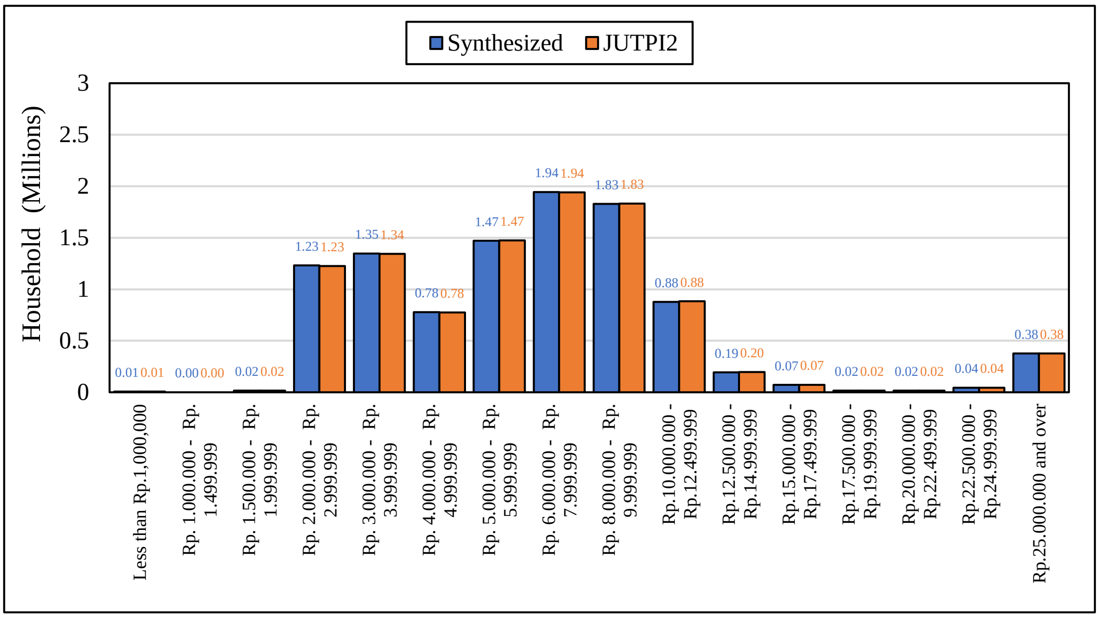
A29 Estimation of Worker's Allowance at TAZ level for Do Minimum Case in 2024

Housing Synthetic Data



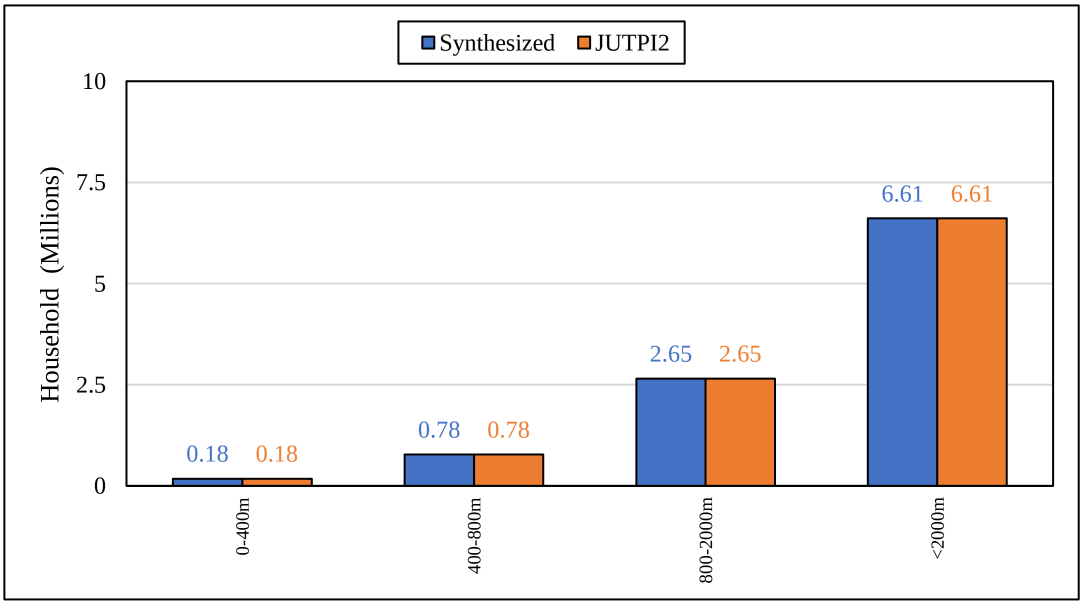
Source: JUTPI 2

A30 Estimation of Household Size at TAZ Level for Do Minimum Case in 2024



Source: JUTPI 2

A31 Estimation of Household Income at TAZ Level for Do Minimum Case in 2024

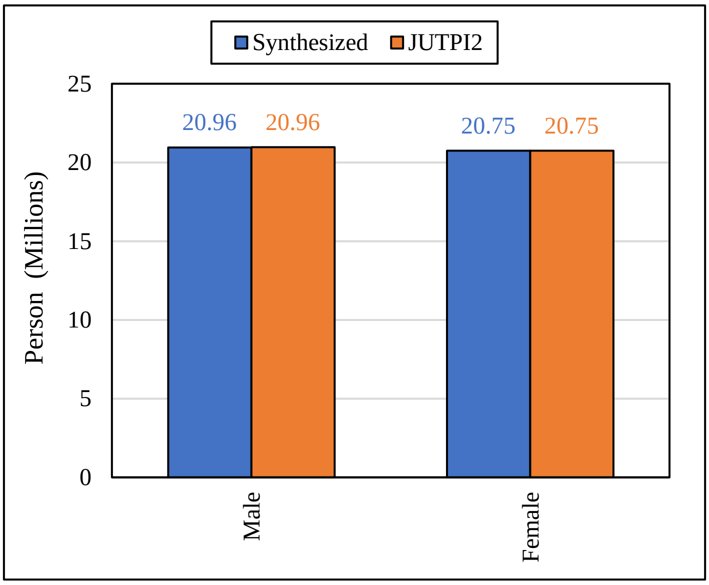


Source: JUTPI 2

A32 Estimation of Household Distance from The Nearest Railway Station at TAZ Level for Do Minimum Case in 2024

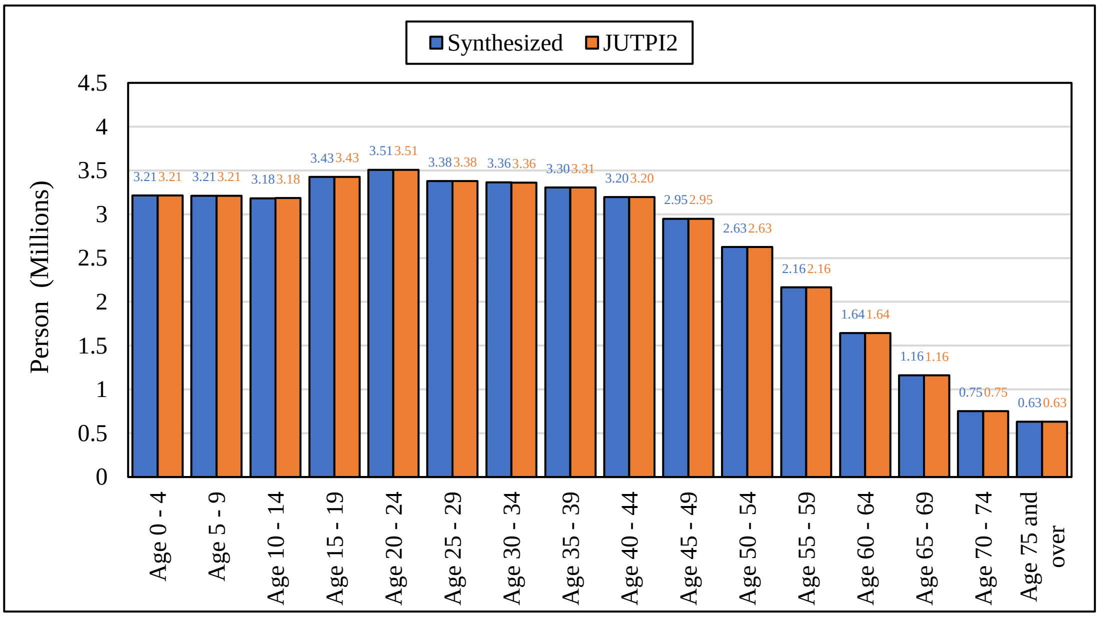
E. Do Minimum Case in 2029

Person Synthetic Data



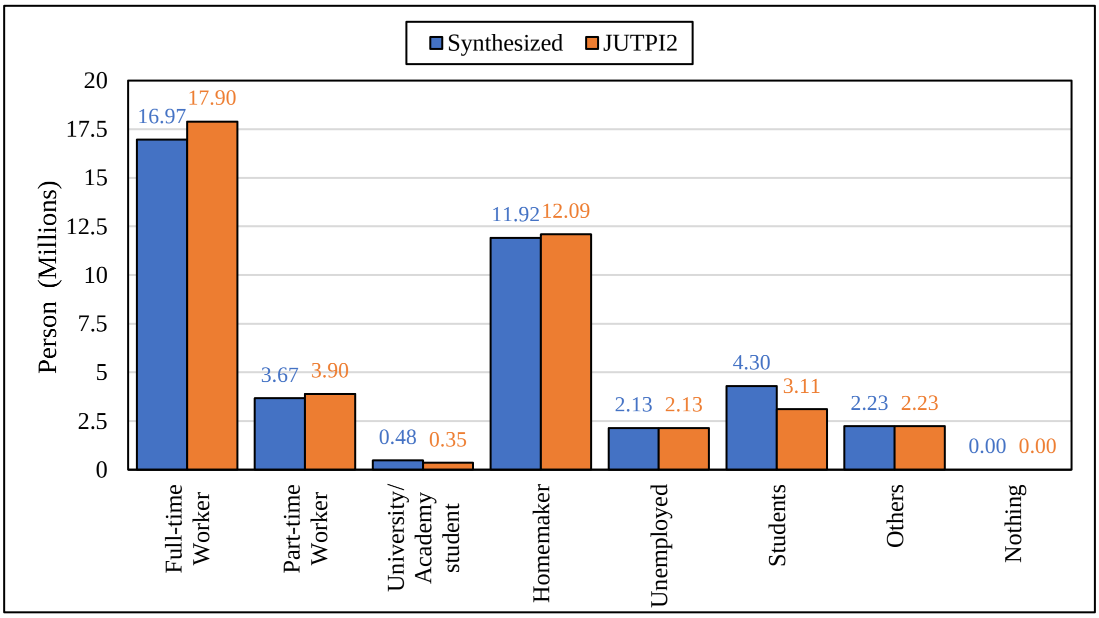
Source: JUTPI 2

A33 Estimation of Population by Gender at TAZ Level for Do Minimum Case in 2029



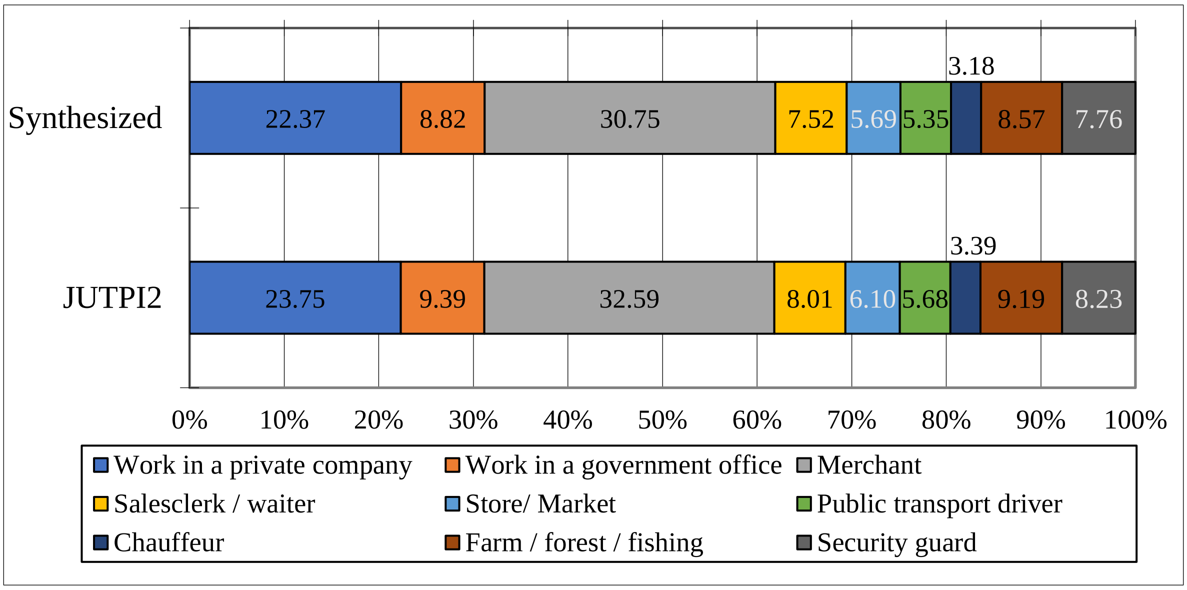
Source: JUTPI 2

A34 Estimation of Population by Age Group at TAZ Level for Do Minimum Case in 2029



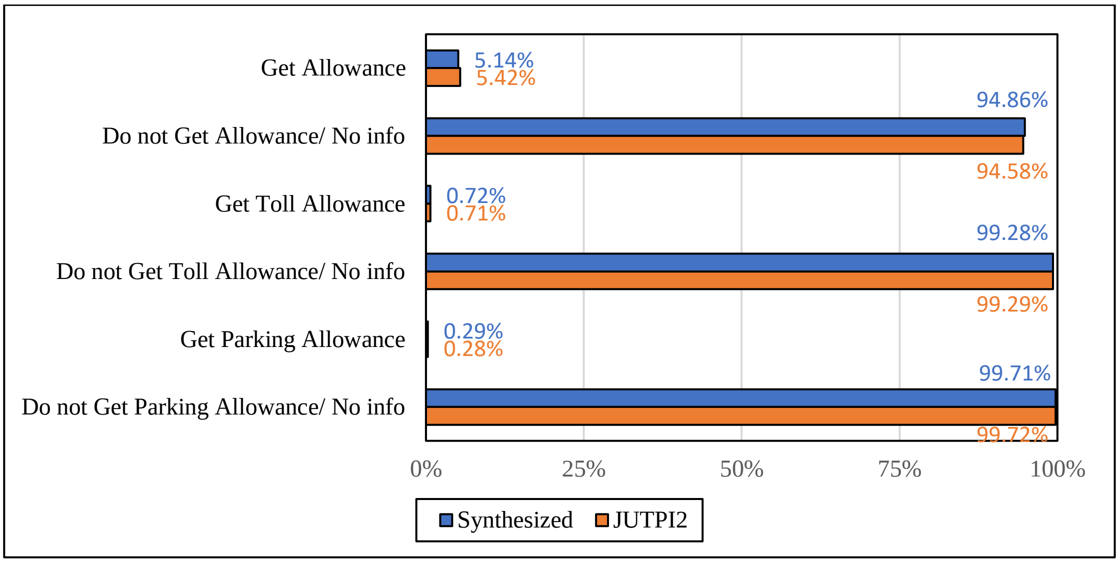
Source: JUTPI 2

A35 Estimation of Population by Main Activity at TAZ Level for Do Minimum Case in 2024



Source: JUTPI 2

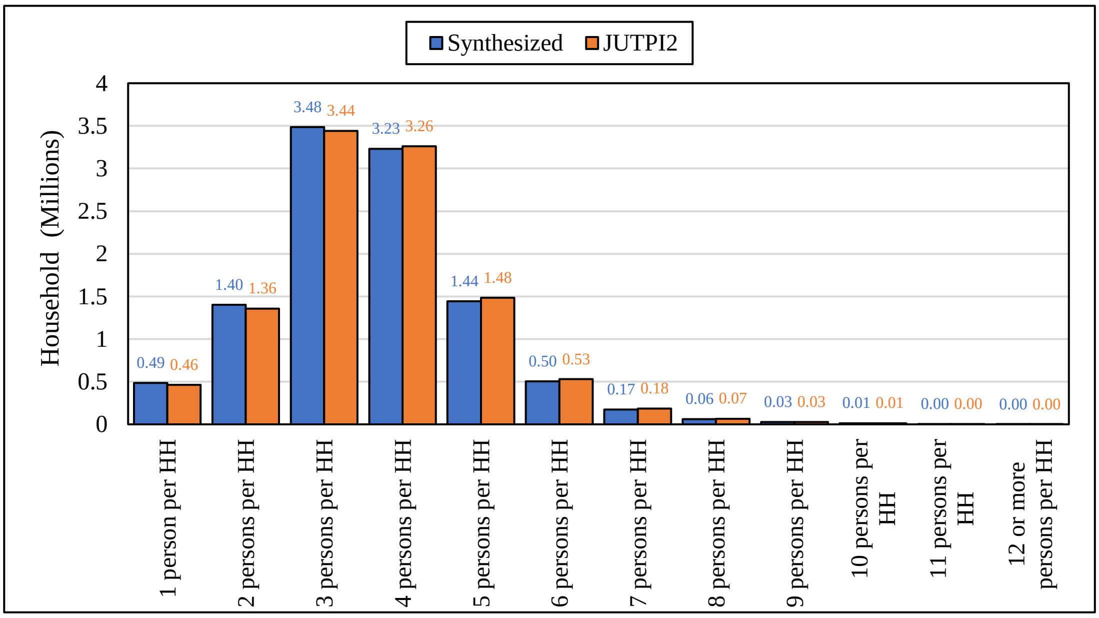
A36 Estimation of Worker by Type of Work at TAZ Level for Do Minimum Case in 2029



Source: JUTPI 2

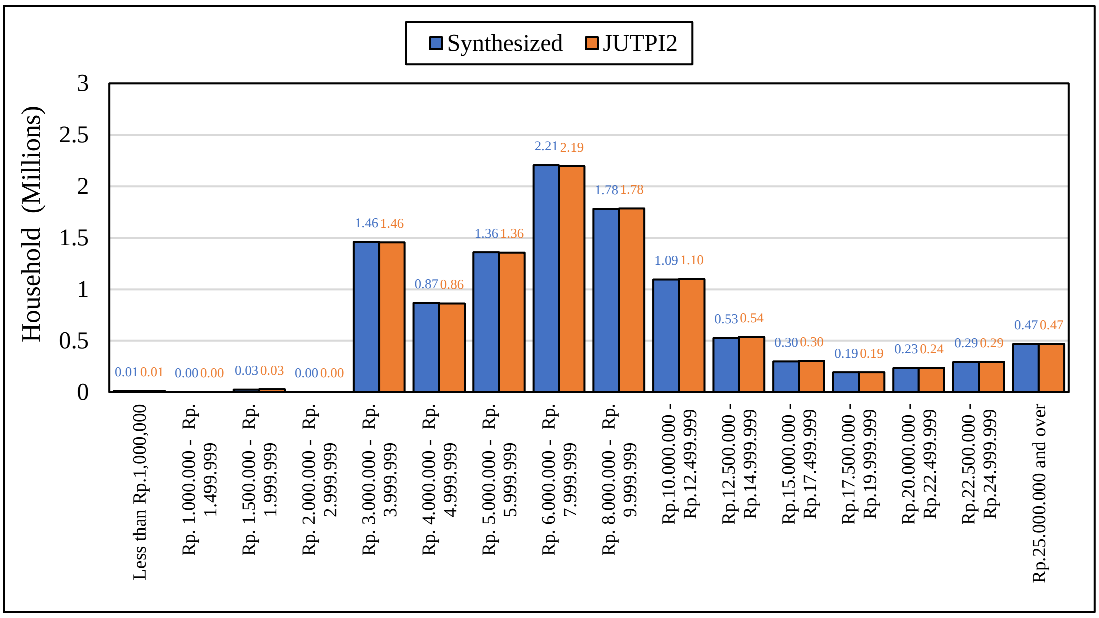
A37 Estimation of Worker's Allowance at TAZ Level for Do Minimum Case in 2029

Housing Synthetic Data



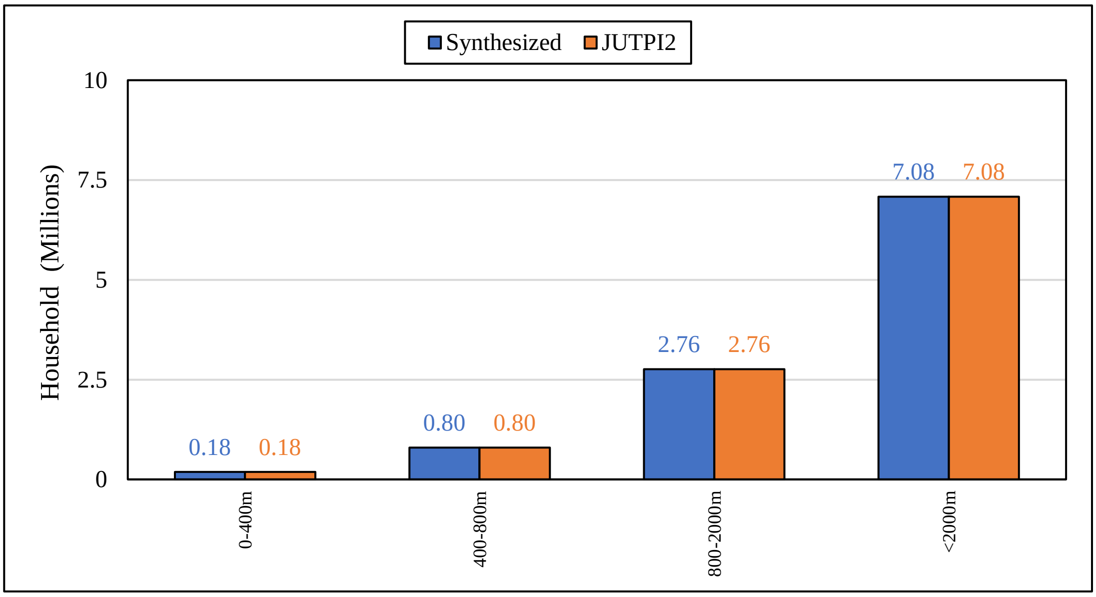
Source: JUTPI 2

A38 Estimation of Household Size at TAZ Level for Do Minimum Case in 2029



Source: JUTPI 2

A39 Estimation of Household Income at TAZ Level for Do Minimum Case in 2029

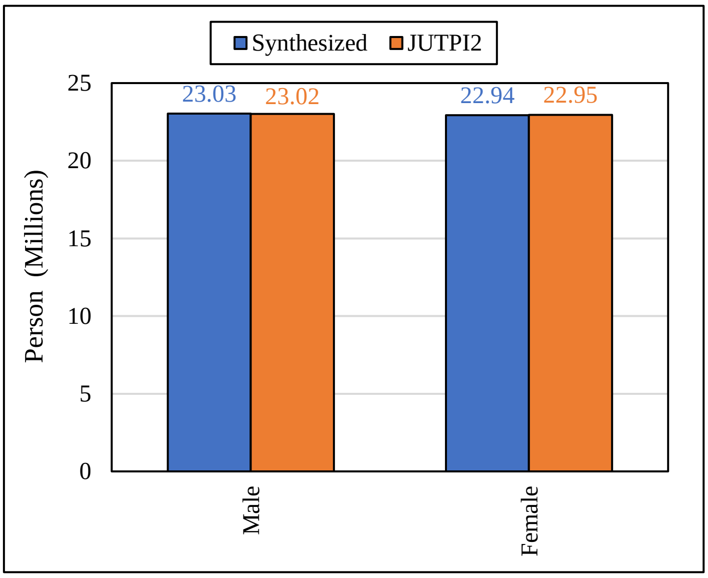


Source: JUTPI 2

A40 Estimation of Household Distance from The Nearest Railway Station at TAZ Level for Do Minimum Case in 2029

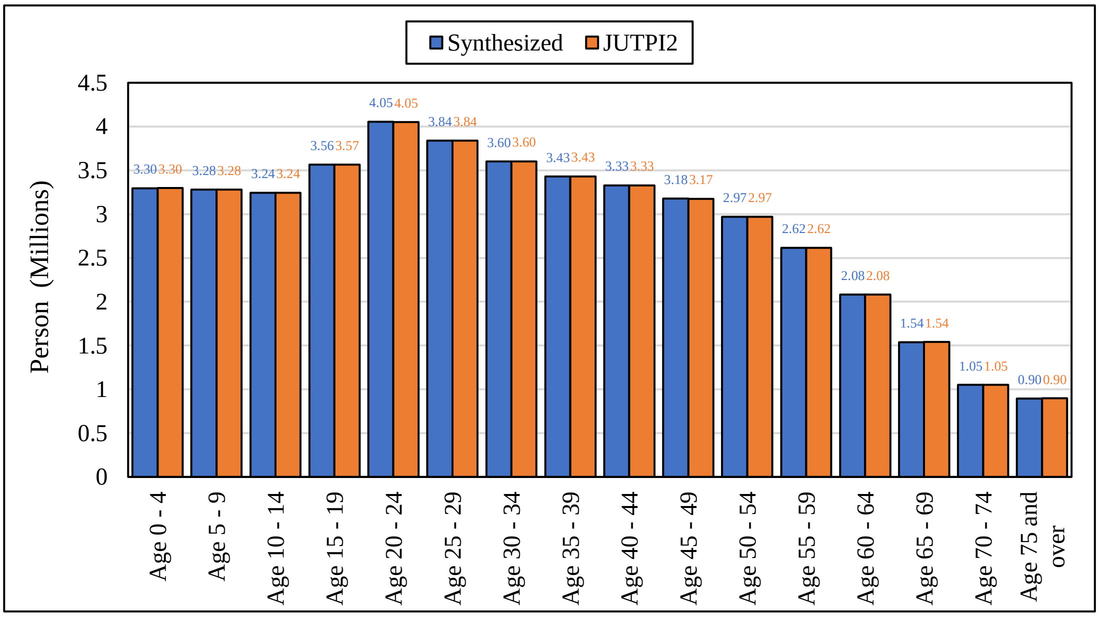
F. Do Minimum Case in 2035

Person Synthetic Data



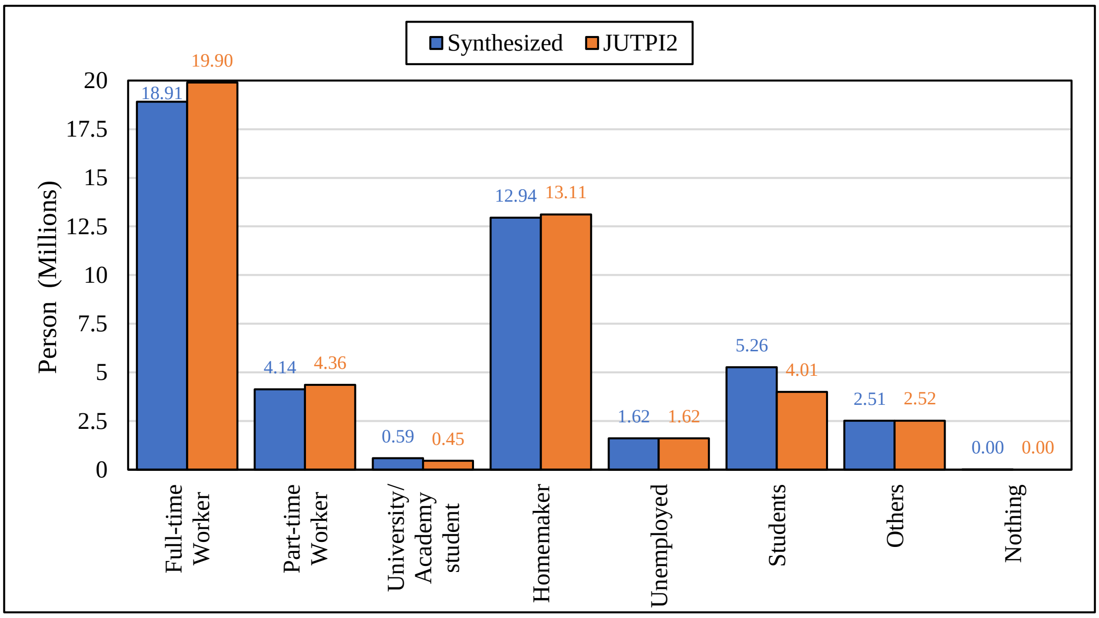
Source: JUTPI 2

A41 Estimation of Population by Gender at TAZ Level for Do Minimum Case in 2035



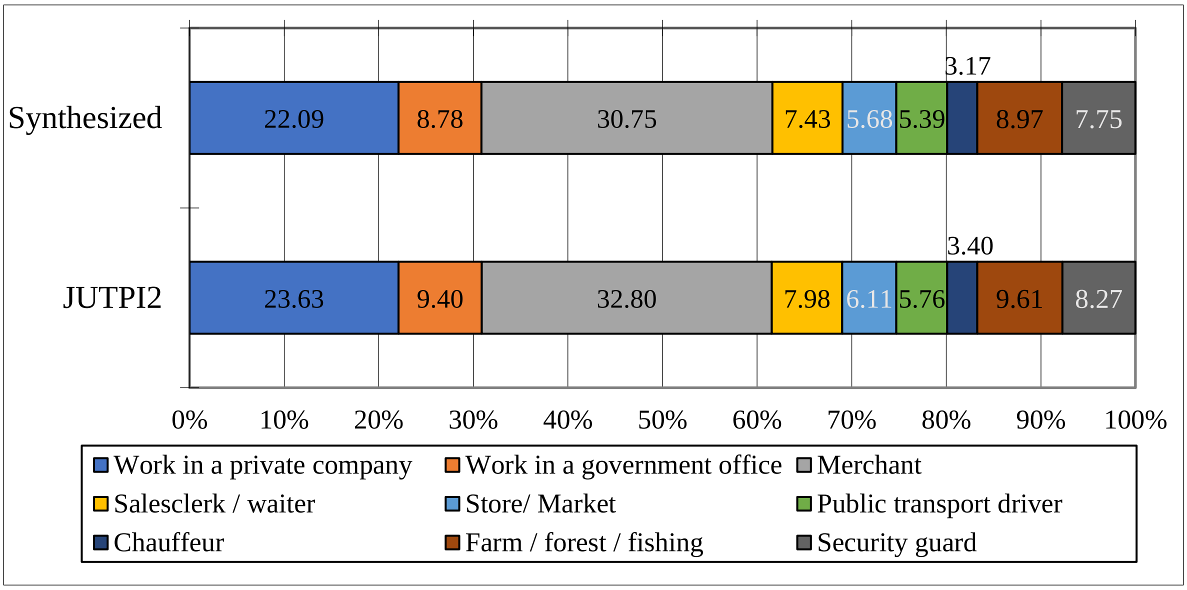
Source: JUTPI 2

A42 Estimation of Population by Age Group at TAZ Level for Do Minimum Case in 2035



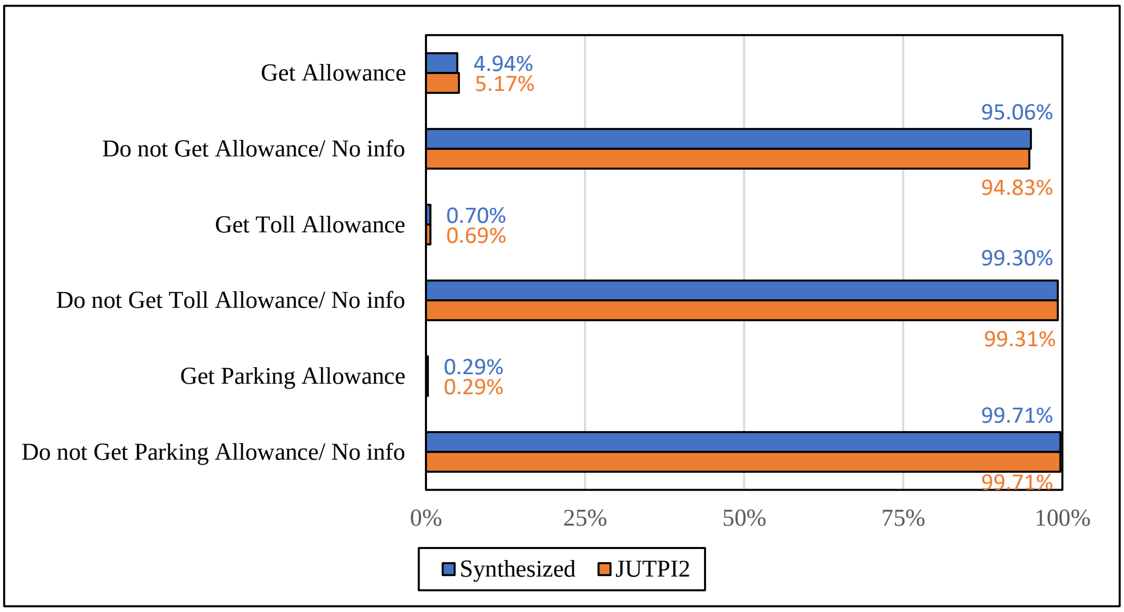
Source: JUTPI 2

A43 Estimation of Population by Main Activity at TAZ Level for Do Minimum Case in 2035



Source: JUTPI 2

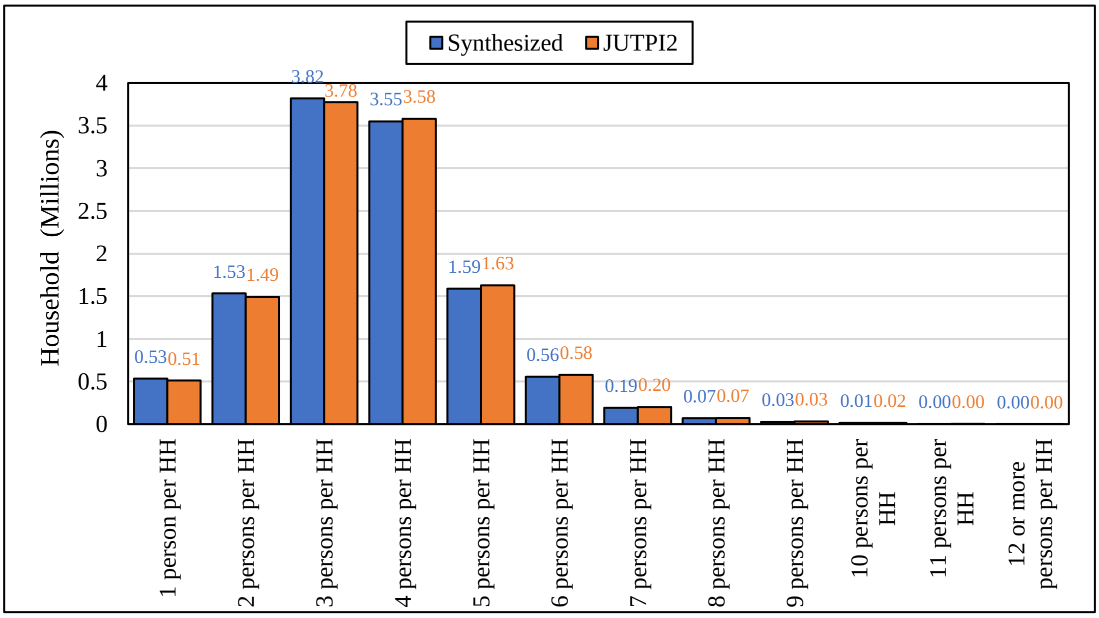
A44 Estimation of Worker by Type of Work at TAZ Level for Do Minimum Case in 2035



Source: JUTPI 2

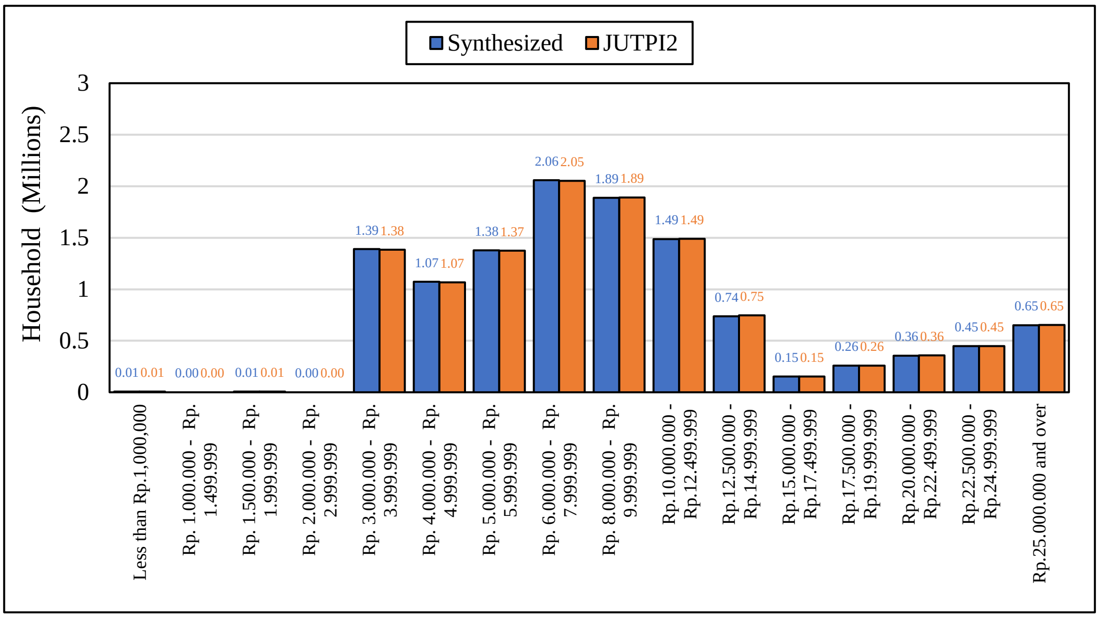
A45 Estimation of Worker's Allowance at TAZ Level for Do Minimum Case in 2035

Housing Synthetic Data



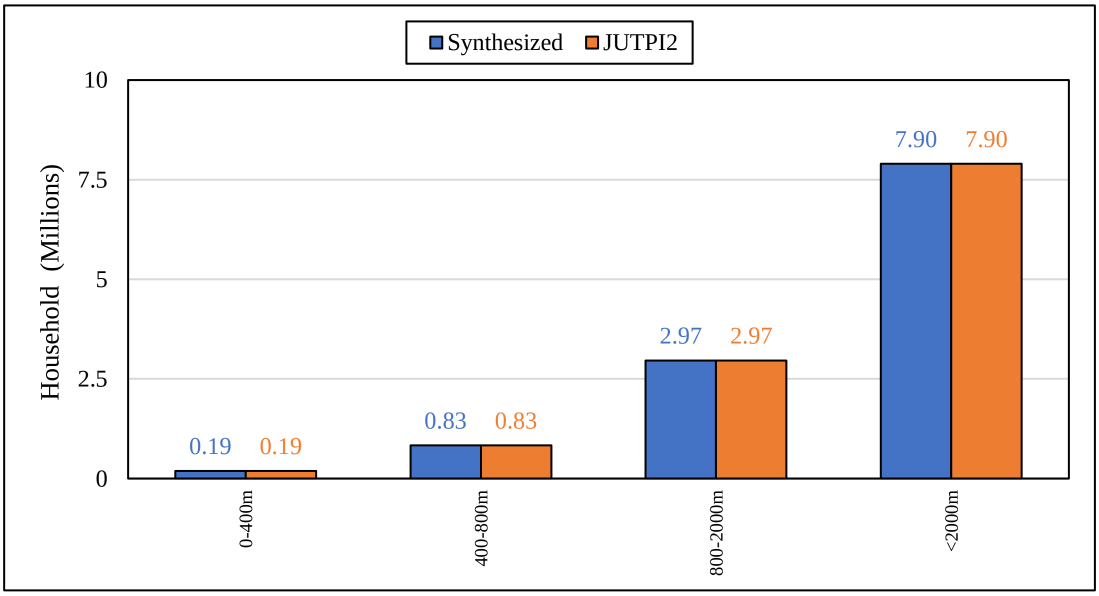
Source: JUTPI 2

A46 Estimation of Household Size at TAZ level for Do Minimum Case in 2035



Source: JUTPI 2

A47 Estimation of Household Income at TAZ Level for Do Minimum Case in 2035



Source: JUTPI 2

A48 Estimation of Household Distance from The Nearest Railway Station at TAZ Level for Do Minimum Case in 2035