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# Land Ase Analysis for Surabaya Metropolitan Area Urban Transportation Planning Using Spatial Method

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**Abstract.** The East Java Province, which includes the city of Surbaya, is home to Indonesia's second-largest economic zone. It consists of the cities of Mojokerto and Surabaya as well as the five kabupaten (regencies) of Sidoarjo, Mojokerto, Lamongan, Gresik, Bangkalan, and Kota Mojokerto. There are not less than 9.115.485 peoples in SMA region, so this region categories as Megaurban. SMA is one of the practices of Mega Urban regional development concept. The development concept of SMA then widely to SMS Plus. The teritory of SMA Plus consist of Regency/Menicipality Bojonegoro, Jombang, Pasuruan, dan Tuban. That concept is supported by the acceleration of transportation development such as operational of Suramadu Bridge, Surabaya-Mojokerto Toll Road, and Trans Java Toll Road. The regional and transportation development indeed must be prepared simultaneously, and it must be supported by social, economy and land use data in detailed. The paucity of publicly available data on the geographic land usage by small zone units has made it particularly challenging to obtain this information in Asia and ASEAN countries. Base on the real condition above, the following problem statement are: How the change of land use predicted. How the change of land use will affect to the future transport demand. How the change of land use and transport demand change will affect to the future transport development. this research aims to prepare the effective solution for existing problems of the lack of public geographic land use by small zone units data that will be used for the regional and transportation development planning.

## INTRODUCTION

The Surabaya Metropolitan Area (SMA), in East Java Province, is Indonesia's second-most-important economic and metropolitan zone. The SMA Area includes the cities of Surabaya, Mojokerto, Lamongan, Gresik, Bangkalan, Mojokerto, and Surabaya as well as the adjacent regencies of Sidoarjo, Mojokerto, Lamongan, Gresik, and Mojokerto. Since the SMA region is home to more than 9 million people, it is considered a Mega-urban area and is a prime example of the Mega-urban regional growth idea.

Surabaya's metropolitan area is delineated by a combination of characteristics, including accessibility to and from the city centre, topography, and population density. The distance to the heart of Surabaya is roughly 20 km, making the trip there take about an hour. The opening of the Suramadu Bridge, which links Surabaya with Bangkalan, has undoubtedly altered the landscape, and this has significant implications for people's propensity to travel between the two cities. The opening of the new bridge has had particularly beneficial effects for Madura. People's daily routines have accelerated as they no longer need to wait for ferry services.

Japan International Cooperation Agency (JICA) created the SMA Zone regional development master plan in 1983 [1] with the following features:

i. A regional logistics hub and an ideal good distribution and an export-import gate, symbolising East Java province;
ii. A reputable economic centre for agriculture, industry, and tourism; and
iii. An outstanding and leading centre of the economic growth in Indonesia.

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At the provincial and national levels, the SMA will function as the growth centre of East Java and Eastern Indonesia, which will encourage and trigger its neighbouring areas to reach higher social and economic growth as a whole. At the local level, the SMA will create a new local demand for agricultural, industrial, commercial, tourism, and consumer activities, and trigger the economic growth as well, The Japan International Cooperation Agency (JICA), Value Planning International, Inc., Oriental Consultants Co., Ltd. and Yachiyo Engineering Co. Ltd, 2011 [2].

The increase of the SMA region's contribution to the economic development in East Java cannot be separated from the economic development performance of each district and city. The GRDP contribution to East Java Province increased by 43.67% in 2000 to 45.25% in 2015, and 44.57% in 2017. This condition indicates that this region is developing productively and very competitive compared to the other regions in East Java Province.

The preparation of regional and transit development, backed up by statistics on the local economy, population, and land use, should be done simultaneously. However, obtaining information on the geographic land usage by small zone units in Asia and ASEAN countries has been challenging due to the lack of publicly available data. Despite this, it is crucial to understand the impact of development on various indicators, such as the economy, environment, and quality of life, when considering urban policies for sustainable compact city development.

To study urban economies and assess the effectiveness of urban policies in the real world, the CUE model is used as a computational framework. The CUE model generates variables that characterize the actual urban economy, such as the distribution of locators or activities (such as households and firms), land use (such as residential, commercial, manufacturing, business, agricultural), and land price/rent (as well as other types and prices of buildings). Additionally, the CUE model outputs the distribution of passenger trips by O-D, mode, and path, and the distribution of goods cargo using transport models congruent with microeconomic theory.

Simulating land-use and transport changes together is crucial for estimating the impact of urban policies. In Japan, the CUE model has been frequently used to analyze the results of various construction projects. This model deviates from the standard Land Use and Transportation Integration Model in significant ways, as it is based on microeconomic grounding and spatial equilibrium in urban economics. Researchers in Japan have created a family of models known as the CUE model, with each model varying in how it specifies indirect utility, profit, demand, and supply to account for varying levels of interest in the potential applications of urban policy in impact analysis.

However, a general problem in Indonesia and other developing countries are limited data that will be used in long-term transportation planning. That is why the CUE model will be an alternative method for resolving the problem.



## PROBLEM STATEMENT

As the second largest and leading growth, economic zone in Indonesia and the centre of economic distribution in Eastern Indonesia, SMA region, it must be supported by the availability of transportation facilities and infrastructure that are able to support all these activities.

The development of transportation is strongly influenced by regional development where the transportation system exists. Therefore transportation planning always refers to regional development. That is why transportation planning is very dependent on the existence of regional development data.

One of the efforts to develop the SMA area was carried out through the transportation aspects planning which aimed to connect all regions in the SMA. The construction of the Suramadu Bridge as a connection between Java and Madura Island is a very strategic role on the island of Madura, will increase economic activity, distribution of goods and services and tourism activities. Fast and effective transportation flows will make the development of Madura Island immediately soar to compete with other regions in the East Java province [3-5]. The construction then began in August 2003 and the bridge was opened to the public on 10 June 2009.

The development of the Surabaya Metropolitan Area (SMA) regional and urban spatial structures relies heavily on the existence of major highway corridors, which usually take the form of radial and circular roads. To create a ring or a radial pattern, it is recommended to use primary arterial roads or toll roads. The SMA road network comprises six radial corridors, with Corridor (1) serving the Paciran-Tuban (north coast) area, Corridor (2) serving Lamongan, Corridor (4) serving Mojokerto, Corridor (5) serving Sidoarjo, and Corridor (6) serving Bangkalan. The basic ring roads and radial roads should ideally be composed of toll roads and/or major arterial highways, with secondary arterial and primary/secondary collector roads completing the primary road system.

Based on the 2015-2019 National Mid Term Development Plan (RPJMN) in the RPJMN III book, the Metropolitan Area of SMA such as Surabaya City, Sidoarjo Regency, Gresik Regency, Mojekerto Regency, Lamongan Regency, Bangkalan Regency, Mojekerto City is designated as priority locations of urban national strategic areas as a regional growth centre in the Java-Bali region. The Metropolitan SMA region as a global scale National Activity Centre (PKN) is maintained to function as a centre for national activities that support the development of Eastern Indonesia. The Spatial Plan (RTR) of the Metropolitan City of SMA is currently in the process of being determined.

Besides the Suramadu Bridge, the Surabaya-Mojokerto Toll Road was also built. The Surabaya-Mojokerto Toll Road or often abbreviated as Tol Sumo is a 36.27 kilometers toll road which will connect Surabaya to Mojokerto. This toll road is part of the Trans Java Toll Road. This toll road is connected to the Kertosono-Mojokerto Toll Road in the west. Construction of this toll road began in 2007 and has been fully operational in 2019.

The overall development carried out at this time is the result of planning ten or twenty years ago so that it is possible to deviate in estimating the developments that occur now and in the future. In addition, the overall planning process uses conventional planning methods that require a lot of primary data support, a lot of time and of course very much of a budget.

Generally, the transportation planning process has to be identified the characteristics of land use and transport demand, predicted the change of land use, the change in land use affect the future transport demand, and the change in land use and transport demand affect the future transport development.

A general problem that occurs in SMA or on a broader scale Indonesia, and other developing countries will be the limited data needed to plan transportation in the future, caused by budget and other resource limitation. Therefore, we need a method that is able to overcome the limitations of data availability in Indonesia and other developing countries.

This research will study the land use change by using a new methodology for the land use classification on a detailed spatial scale using the satellite images, the effect of the land use change against the future transport demand by using Computable Urban Economic (CUE) model, and the effect of the land use change against the future transport development.

## RESEARCH QUESTION AND GAPS

Base on the problem statements above, the following research questions are: How are the characteristics of land use and transport demand in SMA region's will be identified. How is the change in land use in SMA will be predicted. How will the change in land use affect future transport demand SMA. How will the change in land use and transport demand affect future transport development SMA.

This research will study the land use change by using a new methodology for the land use classification on a detailed spatial scale using the satellite images, the effect of the land use change against the future transport demand by using Computable Urban Economic (CUE) model, and the effect of the land use change against the future transport development.

A significant amount of research has been conducted on the Computable General Equilibrium (CGE) and Computable Urban Economic (CUE) models. The CUE model is a valuable tool for analyzing city economies and evaluating urban policies in a welfare-economics compliant manner. Although the CUE model is grounded in urban economic theories and shares components with the CGE model, it differs in that it relies solely on a microeconomic basis and models market interactions as price-adjustment mechanisms or externalities. The CUE model has been utilized in Japan since the 1980s to analyze the effects of urban policies. In contrast, the CGE model has been popularly used to estimate the indirect and induced effects of transportation on the economy as a whole, and it can measure well-being while considering nth-order effects. Moreover, CGE models have been developed for transportation evaluation by different professions, each using their own theories, assumptions, and practices to reflect the connections between transportation and the economy. This paper discusses the practical and theoretical issues related to CGE modelling and its role in transport appraisal. Since each CUE model is a special case of the general form, the components of one CUE model can be interchanged with another's. A common aggregate land supply function is shared by all models in the CUE family. Therefore, based on the result above, it's concluded that many forms of the CUE models provide opportunities to be applied in other places such as Indonesia. However, it should be noted that the socioeconomic conditions in Indonesia and Japan are different, where it certainly greatly influences the characteristics of population travel in this region.

Nevertheless, the Computable General Economic as basis theory of the Computable Urban Economic Model indeed implemented for economic analysis in Indonesia. However, this theory has never been used in the transportation field, so the use of the CUE model will be the latest innovation in transportation planning.

Additionally, the application of Geographic Information System (GIS) provides a valuable means of representing economic boundaries related to highways, as it offers advanced features for managing and processing spatial data and displaying them in a visually appealing graphical format. By presenting information through different colours, thicknesses, and hatching styles, maps can provide immediate visual cues. The proposed method in this paper can be evaluated by utilising the GIS software's ability to generate precise border images. Looking ahead, the integration of land-use and transportation models is anticipated to utilise GIS technology for organising urban model data. The use of raster GIS can help with the spatial disaggregation of land-use and transportation network data. Wagner's work (1995, 1999) [6-9] highlights this point.

The simplest method for scaling down predictions is to use a proportional downscaling approach, where all components of the aggregate receive the same growth rate. However, this approach can result in irrelevant data being excluded, and unrealistic forecasts, such as a developing country having a GDP/capita twice as high as wealthy countries. Consequently, the current solution proposes the optimisation and statistical reduction of economic models' output to grid size. The review of research results related to computable general equilibrium (CGE), computable urban economics (CUE), and the relationship between land use and transportation originating from journals and textbooks is summarized. Thus, this research consists of the objectives of this study using the proposed new method Computable Urban Economic (CUE) model. It will use SMA as the case study to ensure that the CUE model is proven workable in the Indonesia environment [10-16].

## RESEARCH AIMS AND OBJECTIVES

Based on the above-mentioned background and problem statement, this research aims to prepare the effective solution for the existing problems of the lack of public geographic land use by small zone units data that will be used for the regional and transportation development planning. In order to achieve the aims of this research, the following objectives must be fulfilled:

i. To identify the parameters of land use characteristics that will be used to analyze the land use change.
ii. To estimate the change of land use by using spatial scale



## RESEARCH SCOPE

This research will be focused on SMA regional development, the land use change and its effect against the transport demand. This research scope covers the following things:

i. Analyzing the current land use activities by using MapInfo. MapInfo software will be utilized to analyze the land use activities data provided by Cities Officials. The output of this stage is the information on the type of building and the area of each land activities. The land use activities are then compared with the estimated land use development by using spatial method.
ii. Estimating Land Use Development by Using Proposed Methodology. We proposed that the methodology in this research classify the land use categories by using the satellite image from Google Earth. The area will be divided by villages administrative boundary and the types of land use are classified based on the type of the building in each zone.

## SIGNIFICANT OF STUDY

This research is expected to be able to contribute to the pursuit beneficial:

i. The difficulties of the land use data on a detailed spatial scale that will be used in the evaluation, especially in Asia and ASEAN countries (Figure 1) can be obtained by using the proposed methodology.
ii. The land use development and transportation development of the region can be estimated simultaneously in the planning phases.
iii. The result of this study will contribute to better future transport development policies.


**FIGURE 1**. Research location, SMA Region, East Java, Indonesia

# METHOD

Research approach consists of the steps of broad assumptions to detailed methods of data collection, analysis and interpretation. It is, therefore, based on the nature of the research problem being addressed, the research approach is divided into two categories:

i. Approach of data collection and
ii. Approach of data analysis or reasoning.

In this study the data used were qualitative data and quantitative data. Qualitative data relates to the characteristics of land use and population, while the quantitative data relate to the amount of activity in land use, population and traffic. For the purposes of modeling, secondary data will be used, while the primary data will be used during the validation process of the modeling results. While the data analysis of land use characteristics using MapInfo then continued using spatials method in predicting changes in land use.

The land-use activities are presented by current land activity such as residential, commercial, industry, population, employment, and density of each zone. While the travel demand characteristics are presented by the number of trips and time of travel. and cost of travel.

Figure 2 shows the land activities map of the SMA region in 2018 published by Badan Informasi Geospatial (Geospatial Information Agency). The land activities data will be obtained and interpreted by using land-use maps for the SMA region. It will show the type and information about the activities of each location, such as residential, industry, open space, and so on. The type of land use activities is represented by different colours as shown in Table 1.




**FIGURE 2**. Land use activity maps of GKS Region, (source: Geospatial Information Agency/Badan Informasi Geospasial, BIG, 2018)

**TABLE 1**. Legend for land use activity map

| Color | Symbols | Land Activities |
|---|---|---|
| | PD | Commercial/Offices |
| | RD | Resident |
| | OS | Open Space |
| | IND | Industrial |

## Marking The Location by Opening the File on Land Use Map Software

As the land use map provided is the current land use data (Figure 3), the location of the boundary of the SMA region does not exist. Hence, it needs to mark the boundary by using Google Earth maps. Before that, the exact boundary must be obtained from previous planning. This research will estimate the land use development within the existing SMA region to give clear information.


**FIGURE 3.** Land use activities map showed by land use map software

## Creating Placemark and Line by Using Google Earth

The SMA region will be marked that represents the boundary of the SMA region. There is consist of Surabaya city, some areas of the district of Sidoarjo, Gresik, Bangkalan, Mojokerto, and Lamongan.

## Import The Files to Land Use Map Software

The placemark of the SMA region data created by using Google Earth will be imported to the land use map software in the appropriate format, which is a useful way to work with geographic data. First, it needs to specify the format and the dataset sources to import the file into land use map software as shown in Figure 4. After that, the location of the SMA region marked automatically on the land use map software as shown in Figure 5.

**FIGURE 4.** Data maps created from the geospatial information agency imported to land use map software in appropriate format

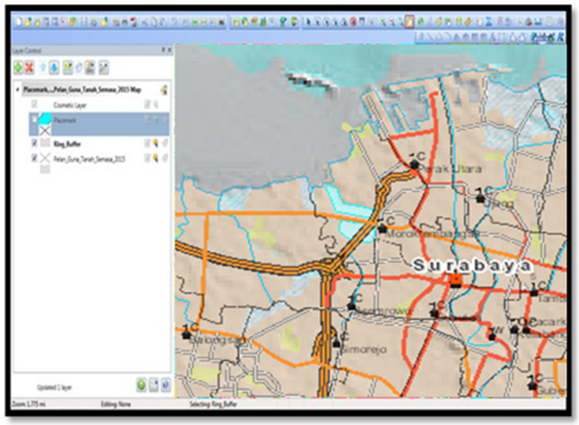


**FIGURE 5.** The location of SMA region traced by land use map software

## Creating Detail Zones

SMA region, then divided into smaller areas or detail to obtain more detailed and accurate land-use characteristics. The entire SMA area will be divided into the zones of the Village for Surabaya city and the zones of the district for the other Regencies. SMA is divided into 154 villages in Surabaya City as internal zones and 6 regencies as external/peripheral zones (Figure 6).

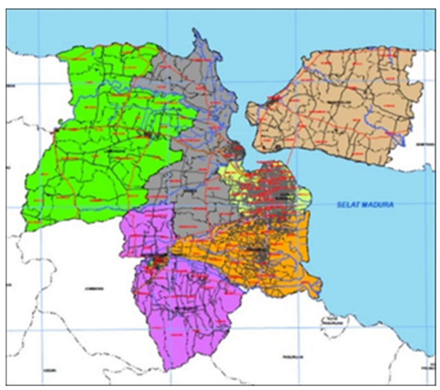


**FIGURE 6.** The location of SMA region traced by land use map software

## Land-Use Data Output

Land-use map will give the information about the land use activities of the SMA region as shown in Figure 7 and Table 2 shows the land activities symbols and categories. More detailed information on the land use activities of the area as well as the area it's occupied.

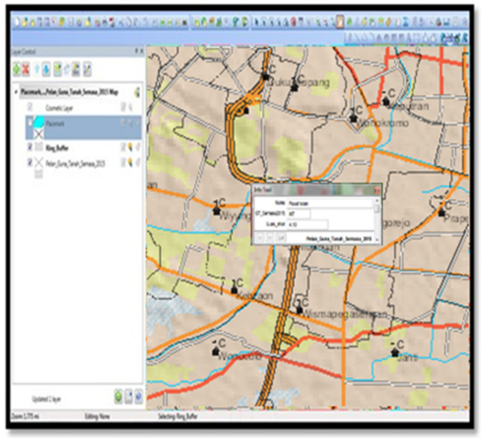

**FIGURE 7.** Information on the Land-Use can be Obtained by Clicking on the Selected Point

The output of the Land-use map Software will give information about the type of building and the area of each land use activity occupied. Hence, it is very useful as it gives the current percentage for each activity. This method produces the existing conditions of land use in the study area, which will be used in the analysis of the estimated conditions of future land-use.

**TABLE 2.** Legend for land-use activity map

| Colour | Symbols | Land Activities |
|---|---|---|
| | PD | Commercial/Office |
| | RD | Residence |
| | OS | Open Space |
| | IND | Industrial |



## Data Set Sources and Method of Land Use Data

It is important and necessary to set up a zone in which zero or the existing conditions of land use and road networks, it's because will be used to analyze the changes of land use characteristics due to changes of the road network by CUE model.

In this research, it proposes a methodology for estimating the land use area by using satellite image (google earth). It enables the land use classification on a detailed spatial scale. Table 3. shows the setting sources and methods of each zona.

**TABLE 3.** Dataset sources and method of land use data

| List of Land Use data | Large Zone (Prefecture and City Level) | Small Zone (Administrative village) |
|---|---|---|
| The population of each zone | Central Bureau of Statistics | An estimate by a new methodology |
| Employee | Central Bureau of Statistics | An estimate by a new methodology |
| Land Value (residential/commercial) | District revenue offices | An estimate by a new methodology |
| Building Lot Area (residential/commercial) | District revenue offices | An estimate by a new methodology |
| Land Area Available to supply (residential/commercial) | District revenue offices | An estimate by a new methodology |

## Zoning The Land Use Area By Using Satelite Image (Google Earth)

The proposed approach of estimating land use by using satellite image (Figure 8) is as follows:

i. The SMA region is divided villages. The reason in adopting the villages area is that the administrative village area's as the smallest zone and that is enough to keep accurate for the land use classification decision making.

ii. By using the proposed methodology of land use estimating method, the area divided by villages creating a total 160 number of zones and then each zone classified by categories.


**FIGURE 8.** Zoning the part of the city area of surabaya from satellite image

## Land Use Classification, Population and Employee Density

The categorization of land use in each zone will be determined based on the composition of the buildings observed in the Google Earth satellite imagery. The land use classification will be assigned from one of the four categories presented in Table 4, utilizing the decision tree shown in Figure 9. The primary decision factor in the flowchart is the area occupied by each zone. By comparing the land use area data at a larger area scale (city or prefecture level) with the area data calculated for each small zone from public sources, the land use data for each zone can be estimated. However, any variation in land use area due to building type will be disregarded.

1. Analysis of land use and transportation behavior will be done by using CUE (computable urban economic) model.
2. The CUE model will produce a set of variables which describe a real urban economy, a distribution of activities, a distribution of land use and distribution of land value.
   a. A proposed new methodology for estimating the land use by satellite Image [Google Earth]
   b. Zoning the land use area by using satellite image
   c. Land use classification based on the type of building
   d. There are three agents, namely "Household", "Firms" and "Absentee landowners". All the agents attempt to maximize their utility or revenues by their relocation behavior.

New proposed methodology for estimation detailed spatial scale are as follows,

i. Building more than 50% categories to the Urban Area
ii. Building less than 50% categories to the Green Space unused area
iii. In an urban area that transportation infrastructure more than 50 % categories to the land for transportation infrastructure
iv. In an urban area that transportation infrastructure less 50 % and large scale building more than 50% categories to the land for the non-resident area
v. In an urban area that transportation infrastructure less 50 % and large scale building less than 50% categories to the land for the resident area

**TABLE 4.** Land use categories

| Categories of Land Use | | Item |
|---|---|---|
| Green Space, Unused Land | | Green Space, Unused Land, River, pond, etc |
| Urban Area | Land for Residence | Residential House, Apartement Building |
| | Land for non Residence | Commercials, Factory, Commercial Services |
| | Land for Transportation Infrastructure | Riadway, Railway, Terminals, Airport, Port, etc |

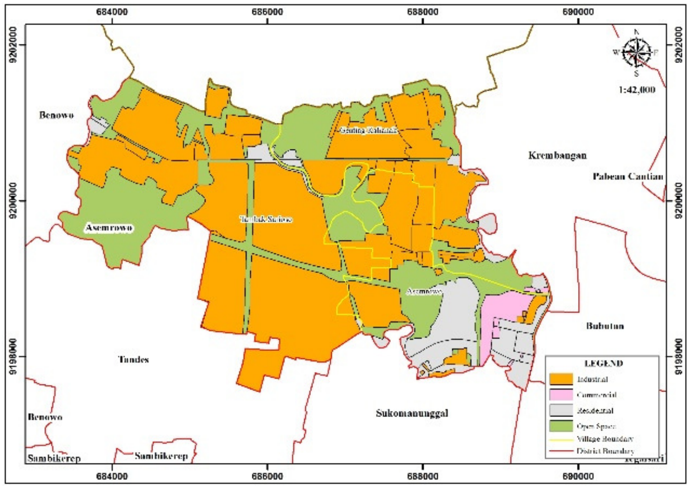


**FIGURE 9.** Land use classification result

The dataset of population density and employee density will be obtained from the Centre Statistic Office in each District and Province. The data source will give land use data such as employee density by large zone units (original scale), the proposed methodology for estimating the land use area by satellite image can show land use data by small zone units (down scale).

## EXPECTED RESULT

This research will be developed the future regional and the transportation system by using the proposed new methodology of analyzing the existing land use characteristic and the future land use development. The spatial method will be simplifying the land use data analysis by using satellite image (google earth). Therefore, this research will be expected as following:

i. The land use data on a detailed spatial scale which is difficult to evaluate especially in Asia and ASEAN countries can be obtained by using the proposed methodology. It enables to develop the land use classification on a scale by using satellite image such as Google Earth.
ii. The change of land use will be predicted by using a new methodology for land use classification on a detailed spatial scale using satellite images.
iii. Current land use activities of the area will be obtained by using MapInfo Software and will be compared with the estimated land use development to evaluate the land use changes.
iv. The effect of the land use change in the future transport development will be predicted
v. The land use development and transportation development can be estimated simultaneously
vi. The travel demand for SMA Region will be obtained to evaluate the outcome of the road network service

The four-stage transportation model is commonly used for simulating individual vacation travel plans, although it has been criticized for its reliance on a transportation-based approach rather than an activity-based one. McNally and Recker (1986) have highlighted the problems with this modelling strategy, but it remains widely used. The current 4-stage approach can be thought of as a 2-stage model that generates measures of travel demand in the first step, and then incorporates this request into the transport network in the second step. Although the approach has been effective overall, it has not disseminated the results of the most important demand- and supply-side policy experiments.

Transportation modelling began in the United States after World War II, and Mitchell and Rapkin's 1954 research established links between mobility and physiological processes. The four-step system model was first applied in its entirety in the Chicago Area Transportation Study in the early 1950s, and with the passage of federal law in the 1960s, the four-stage process was firmly established. Although some type of locating approach is always necessary, it is rarely formally integrated into the four-stage model used for basic calibration, and there is a severe lack of formal supply procedures. Different geographical degrees of demand and performance procedures must be resolved during the calibrating process.

## STUDY AREA DEFINITION

After identifying the problem, a cordon line can be utilized to delineate the survey area. Traffic analysis zones within this boundary are modeled with precision, while external stations are used to establish contact with the outside world and act as entry/exit points for the research zone. Different models are used to represent interactions within and outside the survey area, with less complex growth factor models commonly used for external traffic. Socioeconomic, demographic, and land use data sets are used to depict the internal activity system within useful spatial units such as traffic analysis zones. The total number of traffic analysis zones is determined based on the model's goal and data availability. The unit of study varies between individuals, families, traffic analysis zones, or larger groups depending on the stage of the model. To illustrate the transportation system, network graphs are used, which connect nodes (such as intersections) with edges (homogenous stretches of transportation infrastructure or service). These graphs include attributes such as link length, speed, capacity, and node-specific restrictions. Centroid connectors serve as the interface between the activity system and the transportation system by connecting traffic analysis zone centroids to practical access points on the physical network.

## RESULT AND DISCUSSIONS

### Trip Generation

In the term of the transportation planning process, the travel generation planning stage is the future estimation of the number of the trip of the residents, the vehicles and the logistics from a specific tip generation zone. The travel generation is mostly affected by two following factors: the land uses and developments, and the socioeconomic characteristics of the residents in the particular region.

The next important factor is to know the essential affecting factors that are commonly used to determine the trip generation in the specific region, i.e socioeconomic characteristics. The socioeconomic characteristics of the origin and the destination zone that generally affect the trip generation are:

i. Number of Population
ii. Number of families
iii. Number of Income
iv. Number of Vehicles owned

Meanwhile, the trip attraction is generally affected by:

i. Industrial activities
ii. Commercial activities
iii. Office and Service activities
iv. High school and university activities

Besides determining the variables that affect the trip generation of each zone or the whole city, the other important factor is specifying the growth factors that are used to estimate the number of a future trip.

The models of the trip generation that are generally used for practical planning purposes are the Growth Factor Model (GFM) and the regression analysis. The Growth Factor Model is used to estimate the number of the trip generation of a particular zone based on the current trip generation. The GFM is explained by the following Equation 1:

$$Ti = Fi \times ti \qquad (1)$$

Where Ti and ti are the number of the future and the current trip respectively, and Fi is the growth factor. Furthermore, the growth factor is generally correlated with certain variables such as the economic growth, the number of population, the number of families, the income and the vehicle ownership.

The next one is the regression method that is generally used in the numerous studies about either the trip planning or the generation to obtain the trip generation formulas. This method can be defined as a statistical approach to determine the correlation between a restricted variable and one or several independent variables. The multiple linear regression can be expressed as Equation 2:

$$Y = a + b1X1 + b2X2 + \ldots\ldots\ldots + bnXn \qquad (2)$$

Where,

Y = dependent variable;
X1, X2 … Xn = independent variables;
b1, b2 … bn = partial regression cofficients
a = a constant

Furthermore, the regression analysis method is based on the following basic assumptions:

i. The deviation magnitude of Y in the regression line is uniform for all independent variables
ii. The standard deviation of Y in the regression line is independent one another and normally distributed
iii. The magnitude of X is the result of the measurement without errors
i. The regression of the independent variables to the restricted variable is linear

The above data are then processed by using the calculation software to obtain the fast and accurate results.

## Trip Generation

The characteristics of the original and the destination zones are needed to determine the generation and the attraction models for each administrative area of the village in Surabaya. The socioeconomic aspects of the above particular zones mostly affect both the travel generation, such as the population, the number of families, the income and the vehicle ownership and the travel attraction like the industrial activities (the number or the size of the areas), the commercial activities, the offices and the service activities and the number of highschools or universities

Based on the household interview results, the socioeconomic characteristics data of the travelling residents of the origin and the destination zones are compiled and shown by the following. Referring to the analysis results, it can be explained that most of the travelers at the family levels are the children who go to school (50,5%) and the husbands who go to work (34,20%). Meanwhile, the education background of the travelers is mostly a senior high school-graduated (53,56%), followed by the university and junior high school-graduated with 18,75% and 16,18% respectively

The above characteristics are also linearly matched with the income profile of the majority of the citizens (± 53%) which are below 2 million monthly, meaning that it is close to the minimum wage (UMR). The second-largest income portion is between 2-3 million (28%), followed by a portion of 3-4 million (19 %).



## The Travel Characteristic Based on The Household Interview

The travel characteristic consists of the travel purpose, the origin and the destination place, and the transportation modes. It can be seen that the biggest purpose of travelling is to work, to start and to finish at home. The type of the transportation modes that are mostly used by the travelers in the SMA is motorcycle (73%), followed by the public transportation such as the taxis, the city buses, the microbuses and the multi-purpose public car in Surabaya (9 %) with the microbuses usage as the most (8 %). The trends above show that the usage of private vehicles is still very dominant for travelling citizens in SMA.

## The Travel Characteristic Based on The Household Interview

The travel characteristics that consist of the origin city, the travel destination, the travel purpose, and the basis of the itinerary is shown that majority of the travels to Surabaya (49%) are originated from Sidoarjo city corridor, followed by Gresik city (28%), Madura island (14%) and Mojokerto and the other surrounding city (9%).

Based on the destination city of the four corridors outside Surabaya, the majority of the travel activities (95%) head to the destination within Surabaya itself with only a small portion (5%) that continuously travels outside. This indicates that the road users entering Surabaya city aim to carry out the activities within the city. Meanwhile, the road users that travel outside Surabaya prefer to use the toll or the other roads in the corridors outside Surabaya city.

On the travel destination basis, it can be reviewed that the majority of the destination places (69%) are the places that are related to the economic motives such as the offices, the factories, and the warehouses, followed by the schools (5%), the airports (1,5%) and the harbors (1,5%). In addition to that, it can be seen that many Surabaya residents have daily activities outside Surabaya, indicated by the travel-to-home basis that is relatively high (23%).

The next one is the travel purpose. The results show that most of the trips are for work and business activities (52%), followed by the travel-to-home activities (22%), the shopping activities (7 %), the school activities (5%), the social activities (1,75%), and the others (12,25%). Besides that, the travel-to-home as the travel purpose basis shows almost the same magnitude as the travel destination one (22 % and 24 % respectively) which means that the home acts as the travel destination and the travel purpose for Surabaya residents.

## The Origin-Destination Matrix Formulation

The origin-destination matrix of Surabaya city is formulated based on the household interview for the trips within the region (Internal to Internal) and out of the region (Internal to External) whereas, the data of the trip from the outside is obtained from the roadside interview.

Furthermore, the matrix of the survey compilations data is the matrix of the total trips of the samples. So the expansion factors are obtained from the ratio of the total samples and the populations are needed.

The expansion factor of the household interview matrix is defined as:

FE = Number of village residents/number of village samples

The expansion factor of the roadside interview is explained as:

FE = traffic volume / number of vehicle samples

The origin-destination matrix based on the household and the roadside interviews is then combined by summing the travel origin-destination pair after the expansion process.

Based on the above matrixes formulation, the following aspects can be obtained:

i. Number of trips between villages inside Surabaya city
ii. Number of trips from the village inside to outside Surabaya city
iii. Number of trips from outside to Surabaya city

## CONCLUSIONS

The research results indicate that the metropolitan area of Surabaya in the East Java Province of Indonesia is the second largest economic region in the country, accommodating a population of approximately nine million individuals. To determine the boundaries of the Surabaya Metropolitan Area, various factors such as travel distance and time to the city center, natural elements, and urbanization trends were taken into account. The city center of Surabaya is approximately 20 km away, with a one-hour travel time. However, the opening of the Suramadu Bridge connecting Surabaya and Bangkalan has likely affected travel patterns and behavior. The presence of the new bridge has brought tremendous positive impacts, especially for Madura. The activities of people have been much faster same they will no longer depend on the ferry services.

Based on the result of the study, we can also conclude that the travel characteristic consists of the travel purpose, the origin and the destination place, and the transportation modes. It can be seen that the biggest purpose of travelling is to work, to start and to finish at home. The type of the transportation modes that are mostly used by the travelers in the SMA is the motorcycle (73%), followed by the public transportation such as the taxis, the city buses, the microbuses and the multi-purpose public car in Surabaya (9 %) with the microbuses usage as the most (8 %). The trends above show that the usage of private vehicles is still very dominant for travelling citizens in SMA.

Based on the trip generation regression equations above, it can be observed that the variable X1 is the number of family members, X2, the number of family members who work and X3, the number of family members who go to school or college is a variable that always appears in the equation with a relatively large partial regression coefficient, while the other variables, namely X4, total family income and X5, the number of vehicle ownership, appear alternately in the generated regression equation even though the partial regression coefficient is relatively smaller.

So it can be concluded that the most determining variables for trip generation are the number of family members and the number of working family members. This illustrates that the daily trips of residents of the city of Surabaya are for work or activities related to the economy and attending school or college for their children.

The travel growth of the Surabaya metropolitan area residents, for the next 10 years, based on the economic growth of Surabaya city and East Java province, can be estimated to reach 6,36 % and 5,5 % respectively in 2018, while the average economic growth of Surabaya during the 2011 to 2018 period reached 6,5% per year. Furthermore, the average population growth of Surabaya was 1.045% per year during 2011-2018, inspite of the in-depth study about certain variables such as the vehicle ownerships, the spatial growths, and the others will still be needed to determine the travel growth rate of the Surabaya residents.

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