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The Role of Transit Oriented Development in constructing urban environment sustainability, the case of Jabodetabek, Indonesia

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Abstract

Rapid urbanization and growing economic prosperity has brought about a higher rate of motorization in Jabodetabek, the largest metropolitan area in Indonesia. Jabodetabek is a strategic metropolitan area, consists of DKI Jakarta and the neighboring Bogor, Depok, Tangerang, and Bekasi (abbreviated as Bodetabek) cities, with more than 27 million population and Gross Regional Product in 2010 is around 22% of National Gross Product. Approximately 1,105,000 people are entering Jakarta every workday from the neighboring Bodetabek region. Degrading condition of urban mobility in Jabodetabek metropolitan area is an important policy issue. This paper discusses the potential of applicability of Transit Oriented Development (TOD) in Jabodetabek. TOD is a concept of managing urban growth in transit corridor which has characteristics of mixed land use, compact, walking-distance, and development focused around public transit area. This paper proposed ecological footprint, carbon emission, and green open space carrying capacity as sustainable urban development indicators. The simulation result reveals that the introduction of transit oriented development concept is of importance not only for restructuring urban land use growth effectively or regaining the modal share of public transport, but also improving the urban environment quality.

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Keywords: urban sustainability; green transportation; Transit Oriented Development (TOD), energy consumption, carbon emission, Jabodetabek

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1. Introduction

An urban sustainability demands a balance among economic, social, and environmental concerns. The development of urban sustainability involves several aspects, including populations (socio-ecology), land use and urban structure, and mobility behavior (transportation) [1]. The dynamic of urban is reflected in the interaction between human and environment in spatial and temporal context. With that such complex system, spatial structure strategy alone or partial strategies, such as transportation infrastructure policies, cannot be relied upon for achieving sustainability; instead, integrated land use, transportation, and environmental strategies are required.

Land use management system has a good potential in ensuring a good urban environment, particularly if the land use system could manage the people mobility. The spatial distribution for settlement areas, working places, commercial centers, and other activities contributed to the trip origin-destination patterns in urban transportation, and impacted to the trip distance and energy consumption and pollutant emission. As the statement suggest, urban spatial structure could decrease the trip distance and simultaneously increase urban environmental quality [2].

Jabodetabek is the biggest and the most strategic metropolitan in Indonesia. Jabodetabek consists of Jakarta, the capital city of Indonesia, and eight other cities including: Bogor City, Bogor Regency, Depok City, Tangerang City, South Tangerang City, Tangerang regency, Bekasi City, and Bekasi Regency. This metropolitan become central of economic activity with gross regional domestic product of Jabodetabek has around 22% of national gross domestic product. The increasing of population number in Jabodetabek is caused by the extensive growth of suburbs around Jakarta. The population number of Jabodetabek reached 27,957,194 people. This size of Jabodetabek population is 11.76% of total population of Indonesia. This number of population is predicted will still increase, due to high population growth rate, particularly in suburbs, with the rate between 2-4% annually; meanwhile the national population growth rate is 1.49% annually [3].

Population growth and dynamic has impacted urban spatial growth and expansion. In 1970s to 1990s, private developer converted about 16,600 ha of rural areas in suburbs particularly the agriculture areas into the settlements [4]. Furthermore, during 2000-2010, the conversion of agriculture areas and green open spaces into residential was 15,760 ha [5]. This urban growth structure has indicated a post-suburbanization process, which is the changing process from concentric radial into poly-centric [6].

The mobility interaction in Jabodetabek is very high, indicated by the number of commuter from suburbs Bodetabek into Jakarta. Every workday, 1,105,000 commuters come into Jakarta and the number of trips inside Jakarta reaches 20.7 trips. The private vehicle usages, including car passenger and motor cycle, dominated the share of transportation mode, with 62.2% of mode share in 2010. In contrast, the public transportation usage was only 12.9% [7]. The income rising and the convenience of having private vehicles triggered the dramatic increase of private vehicles numbers and usages in Jabodetabek. In 2010, the number of motorcycle was 7.5 million units with the growth rate of 3% per year, and the number of private cars was 2.1 million with the growth rate of 2% per year) [8].

With that spatial structure and transportation that depended on the private vehicle has led to the decreasing in urban environmental quality. Transportation sector contributed of 70% air pollution in Jakarta. Energy consumption of transportation in Jabodetabek is more than 700 million kilo liter per year. And the estimation of economic cost from traffic congestion in Jakarta reached US $68 million a year, not including the cost of health impact to human from transport pollution [9]. The challenges of Jabodetabek are how to manage the high traffic growth and to reduce traffic congestion, and the increasing demand of travel from suburbs. In term of carbon emission, Indonesian government has committed to reduce 26% greenhouse gas in 2020. Part of that emission reduction policy is 26 $MtCO_2e$ from transportation sector.

This paper examines alternative sustainable development concept for green and sustainable development in Jabodetabek, with focus on transit oriented development (TOD). Transit Oriented Development concept is spatial arrangement with locating the activity centers around the transit, particularly transit station, which has characteristics compact, mixed-use, and pedestrian-friendly within walking distance from a transit stop [10].

2. Materials and Methods

2.1. Profile of the Study Area

Jakarta, the capital of Indonesia, expanded from 180 km^2 in 1960 to a fully urbanized metropolis in the 1970s. Today, as a mega-city, Jakarta's nucleus area has spatially and economically expanded beyond its original fringes. Jakarta has increasingly been integrated with eight other proximate cities, and called as Jabodetabek Metropolitan area. Now, Jabodetabek encompasses a total land of 6,580 km^{2,} with Jakarta area is 656 km^2 and 9.6 million inhabitants.

As the important coastal city in Indonesia, Jakarta is located in the north-west of the Java Island on the shore of the Java Sea coastline (see Fig.1). According to city-level statistical yearbooks, the city has been subject to continuous urbanization level growth. Historically, Jakarta is an important port city, the main destination of immigrant from various regions in Indonesia. In our study, the city center is Jakarta City, as a concentration area of the political, economic, financial, and cultural activities. And due to geographical proximity, the periphery of the city center appears to be functionally integrated with and influenced by the city center. The peri-urban is such a zone presenting a transition or interaction zone between urban and rural areas. Therefore we took the Jabodetabek for case study that research results could enrich regular inventories of or make potential application for urban growth pattern research in such fringe zones of coastal cities in Indonesia. The actual location and range of peri-urban tend to expand out-ward from the city center at one point in time on account of topographical features and anthropogenic barriers.

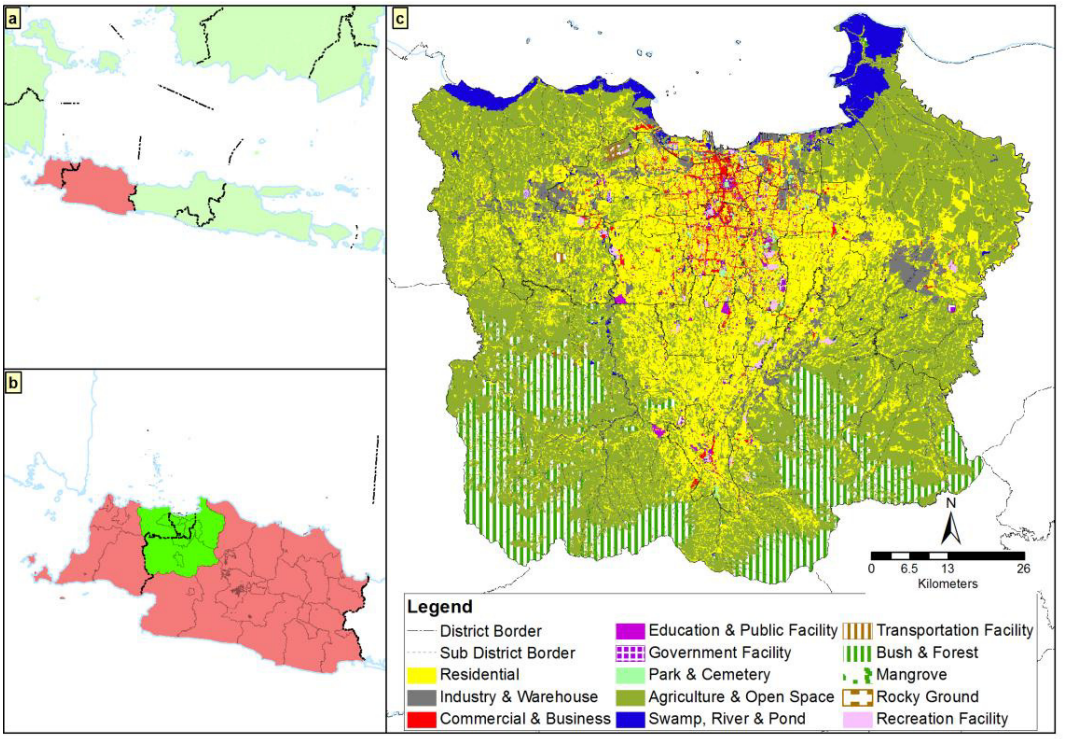

Fig. 1. (a) orientation map of Jawa Island; (b) orientation map of Jabodetabek; (c) land use map of Jabodetabek, 2010

As the concentration of economic activities, the Gross Regional Product (GRP) of the study area was about 22% of GDP share to national economy and the average annual GRP per capita is approximately 3,267 USD per person [3]. Referred from the GRP statistic from 2000-2010, the average GRP growth was 7.7%. The number of the vehicle

registered in the end of 2010 was 10.5 million vehicles; 71.6% of it were motorcycles. The statistic data of the study area are summarized in Table 1.

Table 1 General Data of the Jabodetabek Metropolitan area, 2010

Regions	Area hectare	Population Persons	Urban Population (%)	GDP per capita USD*	Road area hectare	Commuter** Persons/day
Jakarta	65,600	9,607,787	99.8	8,992	3,903.58	
Bogor City	11,850	950,334	100	1,481	421.45	101,400
Bogor Regency	298,838	4,771,932	79.01	1,547	4,389.62	67,600
Depok City	20,504	1,738,570	100	837	718.04	169,000
Tangerang City	16,4543	1,798,601	100	3,167	830.38	196,080
South Tangerang City	14,719	1,290,322	100	785	879.08	147,920
Tangerang Regency	110,838	2,834,376	82.0	1,142	980.04	69,730
Bekasi City	21,049	2,334,871	100	1,540	1,222.93	359,550
Bekasi Regency	127,388	2,630,401	80.14	3,554	1,539.48	63,450

Source: Indonesian Bureau Statistical Report, 2011. *USD= 10,000 IDR, **commuting to Jakarta every workday

The transportation infrastructure in this study area, the total length of road network is around 29,698 kilometers. Railway length is around 166 km with 95 stations. Some of the stations planned as transit oriented development, based on the Ministry of Communication and Government of Provincial Jakarta, are followings: Dukuh Atas, Kampung Bandan, Manggarai, Kampung Melayu, Duri Pulo, Senen, and Tanah Abang, all are inside Jakarta. Beside the rail stations some bus terminals also planned as transit oriented development, those are: Blok M, Harmoni, and Kramat Jati.

2.2. Data processing

The initial step of this study was the construction of the first detailed land use map produced for this area. It is based on map of Rupa Bumi Indonesia (1:550,000) produced by National Agency of Land Survey (Bakosurtanal), Iconos image year of 2000 and 2010, and analysis with ESRI ArcGIS system, year 2013, and field surveys. Structure and spatial growth analysis here include: types of growth (expansion) urban form, density, diversity (heterogeneity), and connectivity. This study also classified lands based on its suitability to support TODs within the Jabodetabek Metropolitan area using GIS to investigate the pattern of growth of urban structure, the conversion of land use, and the density changes in some areas focused around transit area.

The travel data used in this paper were derived from a commuter interview survey conducted in several selected transit areas in suburbs in 2013. The respondents were requested to provide information of their personal and household characteristics, their workplaces, and their preferences concerning the transit oriented development concept. They were also asked about their travel mode for the journey to work and their average one-way commuting time and fuel consumption as well as the travel cost.

The environment indicators estimated were fuel consumption and carbon emission production. After gaining the estimation, the fuel consumption and carbon emission production results were used to estimate the transport ecological footprint. The transport ecological footprint method basically refers to the ecological footprint method developed by Rees [11], with the modification to the calculating the carbon emission from transport activity. In this study, the transport ecological footprint method is the sum of the physical footprint of the roadway network on the basis of the surface area added with the energy footprint which is referred as the area of green open space required to sequester carbon emissions produced [12]. Furthermore, this study forecast the energy consumption and carbon emission from the road transportation and to evaluate the policies in urban and transportation management during the planning period, until the end of Jabodetabek spatial planning period, year of 2030.

3. Results

3.1. Demographic and land use system of Jabodetabek Metropolitan

In this section, first of all, we present the results of the analysis of urban spatial structure development of Jabodetabek. From 2000 to 2010, there was a marked upward trend in the replacement of peri-urban by urban areas. Urban land expanded from 219,028 ha in 2000 to 241,783 in 2010, with 3.32% increase during that period, an average expansion rate of 2,275 ha/year. The dominant urban growth type was determined for the study periods as the expansion of settlement areas in suburbs of the edge of Jakarta, such as in South Tangerang City in the western side, Depok City in the southern side, and Bekasi City in the eastern side. Meanwhile, the expansion of the industrial areas predominantly occurred in the suburbs in the outlying of Jakarta.

The settlement model corresponds to the population dynamics. Growth population is still remaining high in the Jabodetabek region. From 1970 to 2010 the trend of population number is growth both for Jakarta, as main urban, as well as for Bodetabek region as suburban areas. It can be noted that rate of urban population growth in Jakarta city, substantially declined from 3.1 per cent over the period of 1980-1990 to only 0.16 per cent over the period 1990-2000 (Central Bureau of Statistics, 1991 and 2001). This might reflect the rapid spill-over of the Jakarta City to the surrounding areas. The cities having highest population growth in the Jabodetabek over the period 2000-2005 were Depok (3.82%), Bekasi (3.72%), and Tangerang (2.03%). This might suggest that while Jakarta City experienced low population growth, the Bodetabek area, as an extended metropolitan area, is growing rapidly. But still, the concentration of population in Jakarta is the highest among the regions in Jabodetabek (see Fig. 2).

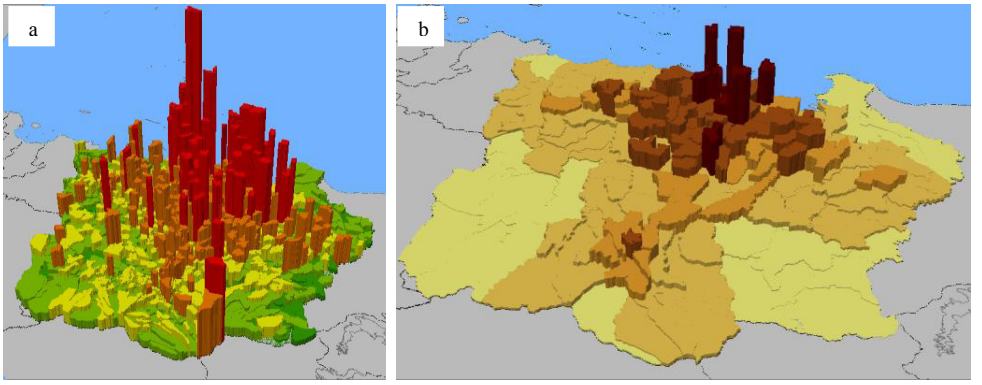

Fig. 2. (a) Population distribution in Jabodetabek; (b) Population density in Jabodetabek

The intensity of urban development in urban areas varies from high to low degrees. The most densely inhabited is in Jakarta, recorded at 146 persons per hectare in 2010. On the other hand, the sub-urban areas located in the second ring of Jabodetabek areas, recorded very low density, only 16-26 persons per hectare. The classified of population density in Jabodetabek is divided into four categories, such as following: (a) high density (over 200 persons per hectare), most of the lands are distributed within Jakarta, about 50 percent of the Jakarta territory is densely inhabited by low buildings such as urban kampongs or multi-storey development; (b) medium density (100-200 persons per hectare), low building developments are seen in the area; (c) low density (50-100 persons per hectare), this area is characterized by spacious residential land or underdeveloped land for further land use intensity; (d) very low density (20-50 persons per hectare), most of the very low-density are located far from Jakarta. The aggregated area is huge enough to encompass Jakarta twice.

The net population density which is population in one region divided with the residential area was found in Jabodetabek such as presented in Table 2.

Table 2 Net population density in Jabodetabek Metropolitan area

Regions	Population (people)	Residential area (ha)	Net population density (people/ha)
Jakarta	9.607.787	36.007,24	267
Sub-urban areas in the first ring of concentric-zone (Depok City, Bekasi City, Tangerang City, South Tangerang City)	8.112.698	58.495,37	141
Sub-urban areas in the second ring of concentric zone (Bogor City, Bogor Regency, Tangerang Regency, Bekasi Regency)	10.236.709	101.611,67	100

This pattern of net population density suggests that the concentration of population correlated with the distance of region to the core of CBD, which is Jakarta City. This data also show us that the expansion of population from the city-center is still continuing, which indicated urbanization will continue to expand, and more prominently in the peri-urban.

3.2. The urban mobility pattern

The variables of density, job-housing distance, and transport accessibility have significantly influenced the commuter's travel mode for journey to work. For commuters live within a radius of 1 km from station node with a lower degree of job-housing balance or population density and with poor access to the station and to work place destinations there is a higher likelihood that they will choose to commute by motorcycle and car rather than choosing to commute by public transport. In areas with a higher density, workers tend to choose public transport rather than the private motor-cycle or car as their mode of travel to work. The possibility of worker choosing to commute by bicycle and or other transport mode will become higher when the worker resides in n area with higher density or higher job-housing balance.

The analysis of commuter growth during 1985, 2002, and 2010 shows that the rate of commuter growth is very high, 5.7% per year. This growth was contributed mostly from the edge-suburbs, with 6.2% from the eastern suburbs, 5.7% from the western suburbs, and 4.5% from the southern suburbs. Not only the number of commuter that increasing, but also the travel distance, due to the expansion of built-up areas into the suburbs. The average of travel length of commuter is about 22 kilometers. The addition of travel distance during the time period of analysis from 2000-2010 was around 2-3 kilometers in average.

The increasing of income along with the more easily having the private car and motorcycle triggered the dramatic surge of private vehicles. In 2010, the motorcycles number reached 7,517,000 (with the growth rate of 3.07% annually) and cars were 2,116,000 fleets (with the growth rate of 2% annually). The analysis of commuter mode share from the respondent analysis show that the public transport estimated contribute about 16.7% of Jabodetabek traffic, cars and motorcycle take about 17.4% and 62.9% respectively, and others 3%.

Based on the report from Indonesia energy outlook, 2010, fuel consumption of transport sector was about 27% of the total energy consumption in Indonesia. Total fuel consumption of transportation sector in Jakarta in 2010 is 3.046.603 kiloliter; it is about 57.8% of total energy consumption. And the total fuel consumption of transportation sector in Jabodetabek in 2010 was 4.5 million kiloliters. The worst congestion prevails in the almost all of the roads inside Jakarta and the connecting roads between Jakarta and suburbs with the traffic only moves below 20 km/hour in average. So that average time consumption for workers commuting from suburbs to Jakarta in one-way is 1-2 hours. While land-use pattern is concentric, then the traffic dominated by radial movement from residential areas (along Jakarta boundary) to the business center at CBD. Those land-use related mobility inefficiency has led to high increase in transport energy consumption. In Jakarta, the growing rate of transport energy consumption was 50% during 2008-2010.

The analysis to the transit stations was conducted, inside Jakarta and in suburbs. The focus of analysis was the land use in the area of transit stations in a radius of 1 km from the station stop, and the mobility characteristics of commuters in those transit areas. Those transits observed by GIS tool to get the detailed land uses data. The researchers set a typology based on four factors that can be measured and analysed, then compared of ranks between those observed transit areas. Those four factors are: mixed-land uses, compactness, density and pedestrian friendly.

The mixed land use identified from the proportion of detailed land uses inside transit areas, between residential, work places, commercials, and others. And the compactness associated with the spatial design inside the transit areas. The density identified from the proportion of residents living in transit areas, or residential density. And the pedestrian friendly identified from the accessibility of the street network of the transit stops. Each of these factors was categorized into four: very low, low, moderate, and high, derived from the comparison of ranks between those observed transit areas (see Table 3).

Table 3. The Typology of transit stations in Jabodetabek

Region	Mixed-Land use	Compactness	Density	Pedestrian-friendly
Jakarta	Moderate	Moderate	High	Low
Suburbs in the first ring	Low (domination of residential)	Low	Moderate	Low
Suburbs in the second ring	Low (domination of residential)	Low	Very low	low

The result of study found that the transit stations in Jakarta have characteristics of moderate mixed-land use, means the proportion of residential and work places is quite similar, ranging from 30%-40% each of residential and work places. The compactness of transit areas in Jakarta are moderate, means that the spatial design of allocating residential-work places is not efficient enough to access by walking or cycling, without dependency on car using. This mixed land-use and compactiveness in suburbs both in first ring and in the second ring are low, due to the predominantly of settlement land uses and the sprawl of spatial design. For the pedestrian friendly factor, the study found from the street network design combine with the results of commuter survey that in all areas of transit stations in Jabodetabek, whether in Jakarta and suburbs are in low category.

There are totally 11 of 95 stations of both primary and subsequent networks, they were classified and sampled for the empirical research, based on which the questionnaire and survey are designed. The study classified the stations into four types according to the transportation feature: (1) transfer station, refers to the junction of two or more railway lines, (2) terminal station, refers to the terminal of a railway line, they are located near the outskirts, (3) interchange station, refers to the station with plenty of bus lines nearby which facilitates the interchange, and (4) regular station, refers to the station without above features.

3.3. The Environment Impact Analysis

The spatial structure within the urban affects transport demand by conditioning the number and lenght of trips as well as the modal split. The current trend of urban growth expansion as well as the soci-cultural aspect has led to longer trips and an increasing dependence on cars, causing pressure on the environment, social and economic. In the environmental context, the pressures caused are in terms of energy consumption, carbon emissions, and the availability of green open space to sequester the carbon emission. In this strudy, the analysis of environment impact conducted with estimating carbon emission production and transport ecological footprint. The ecological footprint of transportation has been calculated as a sustainability indicator. The approach taken here is a component-based footprinting, which is based on the calculation of the eco-print for certain activities using data appropriate to the region under consideration [13].

The results of analysis show that carbon emission production in Jakarta is much higher rather than in suburbs of Bodetabek due to the transport and socio-economic centralistic activities in Jakarta. And the carbon emission production in suburbs in the first ring is almost twice of carbon emission production in suburbs in the second ring. The environment indicators presented in Table 4 shows that there is a high relation between transport activities driven by urban structure to the quality of environment.

Table 4. The environment indicators in Jabodetabek

Region	Carbon Emissions (tCO_2)	Transport ecological footprint (hectare)	Transport ecological footprint per capita (hectare/capita)
Jakarta	7.140.635	17.265,05	0.00179
Suburbs in the first ring	2.525.200	10/709,15	0.00132
Suburbs in the second ring	1.243.755	7.223,32	0.00071
Jabodetabek	10.909.591	35.197,52	0.00090

The carrying capacity of green open space for sequestrating carbon emission reduced, with decreasing of green open space areas. The green open space area decreased during 2000-2010 period of 22.364 hectare, with the declining rate of 4.7% per year. The highest rate of green open space declining mainly occurred in the boundary cities, the suburbs in the first ring. The transportation ecological footprint of Jabodetabek is 5% of total urban area. The biggest contribution is from Jakarta, with the transportation ecological footprint 26% of total city area.

4. Discussions

Urban growth structure in Jabodetabek from the 2000-2010 is characterized by an extensive growth of built-areas which radiates from city center and extends beyond city boundary. This expansion of Jabodetabek can be seen from the direction of residential and socio-economic spatial growth to accommodate the dynamics of population in this urban area. This urban growth pattern is a continuum, which began from the center of Jakarta, then expanded into the suburbs in the edge of city center. Furthermore, the expansion reached the distant suburbs. This process is referred to as the phenomenon of Extended Metropolitan Region (EMR), which is the continuity of urban activity that includes urban agglomeration and satellite towns networking formed along corridors [14]. Based on urban growth phase theory, spatial urban evolution can be a general temporal oscillation between phases of diffusion and coalescence. Diffusion is defined as the dispersion of patches, while coalescence is the diffusion of patches into one patch. Outlying growth corresponds with diffusion, and edge-expansion and infilling represent coalescence [15]. Edge-expansion took the predominant role in urban growth in the study area from 2000 to 2010.

The urban growth pattern in the study area is not leapfrog or sprawl, like usually occurs in many large American or European cities with the trend towards population and employment decentralization. The urban growth pattern in the study area is divided into three concentric zones, such as followings: the first ring, inner circle, the center of CBD, Jakarta, the place of concentration of economic, public services, and governance activities. The second ring, the peri-urban, in the borders of Jakarta, which predominantly as dormitory towns with the services economic activity. And the third ring is the distant suburbs which are still semi-rural area with the growing economic activity is manufacturing industry. This transformation in distant suburbs generally fit ‘desakota’ theory of urbanization developed by McGee, a pattern characterized by the rapid development of mixed industrial, residential, and commercial land-uses. And based on the study of accessibility model in ‘desa-kota’ region, the study found the dissimilarity in relative accessibility between travel distance and time, and its relationships with the the land settlement, this implies the estimations of travel time take greatly account of accessibility to employment compared to those of travel distance [16].

In addition, it is clearer that agriculture lands suffer conversion to urban sites in suburbs of Jabodetabek. The land use change maps generated in our study from the 2000-2010 periods showed that 8% of newly developed urban areas were formerly agriculture land. Outlying growth, particularly in the suburbs, resulted in the loss of a large tract of arable land. Due to shortages of space and the high cost of construction in city center, investments in peri-urban with flexible options for land use conversions have become economically attractive. Furthermore, the industrialization pushed forward the expansion of settlements and the pollution of local environment.

Environmentally, this urban structure represents the unbalancing of resource consumption rates between the core city and the peripherals. The urban activity concentrated in core areas and the high density of jobs in the urban centre, make majority of urban people spend their life time in the urban centre. The approach of urban and transport planning should be shifted from business as usual to the integrated land-transport-environment planning. The smart growth idea is designated as a compact form of urban growth pattern in the long-term interest of existing suburbs, small towns, and rural communities. With the TOD scenario the travel demand, energy consumption, emission, and transport ecological footprint can be reduced. The sustainable transport city is one of the important characteristics of

green urban [17]. The relationship between urban form and travel patterns has been widely studied. Some previous empirical research suggests that land use factors have influences on travel behavior with other factors, such as income. In particular, market forces tend to be the dominant factors influencing individual firms and homes location and then travel patterns. Since the mutual location adjustments between households and firms that occur in the urban expansion process can optimize travel duration and distance.

The alternatives of measures are simulated in this study, including (1) do-nothing or business-as-usual, (2) the mixed of extensive road building with the increasing of bus mode share scenario, and (3) transit oriented development (TOD), with development concentrating around the transit nodes and increasing the train ridership. Alternative (1) Do-nothing is the base-case scenario as the benchmark to measure the performance of other scenarios. The do-nothing assume was no intervention to the transport network along the time horizon of 2013-2030; with the same of mode-share in travel to work. Alternative (2) adapted the Jabodetabek related planning document based on the plans of inner toll road study and non-toll road inside Jakarta and outer ring roads and increasing of bus mode share. Alternative (3) transit-oriented development is the proposed concept by this study.

It can be said that the most-preferable option to mitigate transport problem for Jabodetabek was the road development, due to the large-scale addition of capacity from the road development. However, the expansion of road development will induce and generate the expansion of the urban growth and more traffic, in turn can bring more congestion. The land-use planning alone could not reduce the environment indicators significantly, but this option can reduce travel time and travel demand, but not for the length. The most reasonable option is the Alternative (3) transit oriented development. With the introduction of TOD the modal split is predicted to increase the train modal share of 30%. The effectiveness showed by the reduction of fuel consumption and carbon emission that could reach up to 20% and 26% respectively. With the TOD strategy the expansion of built-up areas can be reduced, with the development of high density and mixed land use in transit. Furthermore, the trip distance and number trips of commuters could be reduced and could maintain the green open space areas for sequestering carbon emission produced by the transport activities. With an estimated reduction of 3.5 million tCO_2 carbon emission through transit-oriented development, the green open space required for sequestrating is about 29.9% of total area.

This result simulation is in line with the agenda for large cities now is to have more sustainable transport options so as to reduce traffic whilst reducing greenhouse gases by 50 per cent by at least 2050, in line with the global agenda set through the Intergovernmental Panel on Climate Change.

It is concluded that an urban restructuring of land and transport through transit-oriented development measure is required to sustain Jabodetabek development. Development of urban center-suburbs areas needs to be coordinated to improve land use and transportation efficiency and to minimize destruction to the regional ecosystem. This reorientation and restructuring of land use and transportation should meet the need to create urban that appropriately adapt to changing times, finding harmony between the transit services and urban landscapes. With this TOD, we manage three dimensions of transit-supportive cities and suburbs: density, diversity, and design [18]. Ultimately, managing urban growth through transit-oriented development not only changes the orientation of built up areas development and increasing transit ridership, but also to maintain the natural ecosystems with efficiency of energy and land resources consumption but also in reducing carbon emission in urban area.

5. Conclusions

The pattern of urban land use and transport is responsible for energy and land resources consumption, which has major global environmental consequences. The challenge at the Metropolitan level is to plan, design, and manage urban growth in moderate ways that contribute to sustainable development. In order to contain the impact of urban structure and transport system on carbon emissions and the consumption of resources associated to the transport sector, this study proposes transit-oriented development (TOD) concept to be implemented in Jabodetabek Metropolitan area. The transit-oriented development is designated to environmental protection, ecological balance and increasing the accessibility of commuting. The transit-oriented development concept is found in many cities around the world and it is a viable land-use planning concept from planning in peri-urban of Jabodetabek Metropolitan. Policy interventions in urban form, considered with an emphasis on accessibility, would have a significant effect on individual travel patterns by giving shape to a proposed land-transport system.

Considering the simulation result presented in the Section 4, it is highly recommended that the most effective strategy to mitigate land use, transport and environment problems for the future urban sustainability in Jabodetabek were the strategy of adapting the transit oriented development alternative. This study uses some indicators as control

and assesses the urban sustainability. The study found that TOD's role in constructing the Jabodetabek urban environment sustainability is on reducing the fuel consumption and carbon emission, and maintaining the availability of green open space area for the urban ecosystem.

Future research is required to delineate a suitable development management plan to sustain a baseline for urban growth. The transit-oriented development should be implemented in major stations with high mobility and accessibility services and quality of mixed land use. Subsequently, the TOD serves several important roles, including but not limited to ecosystem conservation. The establishment of the carrying capacity of urban green open space methodology is also recommended to forecast mid and long-term urban growth trends, and the potential impacts on surrounding ecosystems.

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