The implications of urban expansion to commuter travel behavior in the Jakarta Metropolitan Area

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Abstract. For decades, urban development is characterized by a rapid growth population and built-up expansion into the outskirts. Residential development shifted from the city center to the suburbs or the peripheral area, known as suburbanization. Jakarta Metropolitan Area (JMA) is a primate urban area in Indonesia, marked with only 0.33% of the national land area. Still, this region contributes about one-fourth of Indonesia's Gross Domestic Products (GDP) and accommodates about 12.4% of Indonesia's total population in 2017. JMA is still rapidly growing and encouraging the expansion of residents into its suburbs, and this will affect the travel behavior of daily commuting to and from home to destination. This article aims to analyze the implications of JMA expansion to its commuter's travel behavior from the perspective of the commuter's social-economic and physical psychological burden. The result of this study shows that the more expansion urban areas in metropolitan areas, the more increasingly causing problems in commuting from the suburbs to activities centers, in term of longer travel distances, longer travel times, more travel cost, and all these cause commuter stress, and more robust for the lower-income groups.

1. Introduction
Since 1990, the urban population world has increased rapidly, with an average annual rate of 57 million (1990-2000) to 77 million (2010-2015). The urban population has increased from 43% in 1990 to 54% (4 billion) in 2015 [1]. In the next decades, medium cities will grow into metropolitan areas, turning into a growth pole of economic activities within countries. The Metropolitan area is an urban networking system consisting of the urban core and several adjacent cities as its peri-urban area, which is socio-economically interrelated, forming a mega-region or megalopolis [2,3]. Over the last two decades, metropolitan areas have emerged as centers of the world, producing goods and services [1]. The Metropolitan area continues to expand due to the growing need for land for housing demand forming a large metropolitan area [4]. Urban expansion, especially in the suburbs, can be compact or fragmented human settlement growth. This urban spatial expansion can be typed as an infilling, edge-expansion, or leapfrogging [5,6].

Fragmented suburban growth, usually called urban sprawl, is defined by a natural urban expansion without following the existing spatial planning, as any settlement with scattered or leapfrog, single-use, low density or strip-like development, and poor accessibility because of lack of street and unfacilitated by public transport [5,7]. Rapid metropolitan area expansion and urban sprawl have a significantly
negative impact on the urban population's socioeconomics and human life [6,8]. Such effects can be expected to harm people's quality of life and the environment [5,9]. Various studies have shown the negative impacts of urban sprawl in many dimensions, such as sharp decreases in agriculture, increasing housing costs, commuting, long commutes, congestion, and environmental problems [10,11]. Sprawl causes a reduction in the quality of life of people living in cities, mostly residing in urban outskirts because of a lack of transportation infrastructures and facilities [5]. Even though transportation infrastructures and facilities are available, people who live on the city's outskirts will travel longer and more expensive because of the long distance between existing employment and residential centers. A dilemma occurs, people who live in the urban outskirts looking for affordable housing, but then their commuting trips get more prolonged and more expensive. This condition is called residential dissonance, a mismatch between a preferred residential neighborhood and an actual residential area [12].

There is a contradiction between this phenomenon and the urban sustainability, which is based upon decreasing of input (time, cost, and energy) while simultaneously improving its livability (health, employment, income, housing, and leisure activities) [13]. Any research pointed out that 87% of urban commuting is wasteful even though jobs follow residences [14]. Therefore, urban expansion should be regulated via a series of planning that guarantees an equal distribution of residential facilities and services [4] and directing the city's growth to be more compact.

The urban quality of life, as the primary end goal of policy of many countries, is related to residents’ satisfaction with their living conditions [15]. In the social-psychology concept, the personal satisfaction of life referred to subjective well-being (SWB). SWB, basically related to how people feel and think about their lives: stressful life and developmental life perspective. Stressful life events are all events that significantly disturb the daily routine [16]. However, there is an increasing interest in understanding how SWB on the daily routine activities such as commuting travel (e.g., travel mode, travel times, travel costs, level-of-service of public transport) [17]. The wider the city, the more the commuting trip time increases, and this will affect the physical and psychological endurance, which will ultimately reduce the commuter’s level of health. Long commutes have not been just linked to health implications, but also decrements in job performance, lifestyle choices, and stress [18].

This study aims to analyze the implications of the Jabodetabek Metropolitan Area (JMA) growth and expansion to its commuters from the perspective of the commuter’s social-economic and physical psychological burden.

2. Materials and methods

This study's methodology is based on the concept of polycentricity with the dimensions of functional relations, namely that urban centers become commuter travel destinations for metropolitan residents. JMA consists of some urban center, i.e., Jakarta as the capital of Indonesia and eight other local government, each of which is autonomous, namely three kabupatens (districts or rural governments): Kabupaten Bogor, Kabupaten Tangerang, Kabupaten Bekasi, and five kotas (municipalities or urban government): Kota Bogor, Kota Depok, Kota Tangerang, Kota Tangerang Selatan, and Kota Bekasi (Figure 1). In the JMA concept, Jakarta is in a position as the core area; on the other hand, three kabupatens and five kotas as peri-urban of JMA. There is a relation between a core area and its peri-urban area in the functional one, characterized by a commuting flow from the core area to the peri-urban area and vice versa [19]. In the concept of polycentric, JMA has some centers as attraction zones of the commuters. The function of those attraction zones can be as a destination for the commuter mainly for work. Those zones, especially in the form of services, trades, and industrial area, located in some of the central business districts (CBD) of Jakarta as the core of JMA and in several activities centers in the peri-urban of JMA. Interrelated amongst attraction zones show that the CBD of Jakarta is still dominated as a destination area of commuters from the peri-urban of JMA. This travel pattern can be seen from person trips distribution, mostly directed to Jakarta CBDs from the peri-urban of JMA [20] (Figure 2).
The development of the metropolitan area is marked by the expansion of residential areas, especially on the metropolitan area's outskirts. Then, this increasingly gigantic residential will change in commuter travel behavior and influence to its subjective well-being (SWB). SWB can be used as an indicator of public transportation services, such as trip length, distance, purpose, and mode, and all these are related to fatigue and pleasantness. SWB is related to individuals' cognitive and emotional well-being. The trip can make the commuter mentally and physically tiring, pleasant, or unpleasant [17,21]. SWB also depends on experiences during travel, when the trip is taking place, and the existing transportation infrastructures or systems [22]. The travel satisfaction can be assessed by utility-maximum theory, e.g., in the context of cost-benefit analyses [17]. In this study, assessment is focused on the "cost" factors that burden the commuters consisting of travel distance, travel time, travel cost, and travel satisfaction, and cumulative all these factors will determine they are physically and mentally healthy. To a certain extent, travel behavior has a maximum limit tolerant of being borne by commuters.

The analysis used is a comparative analysis of dual-temporal JMA statistical commuter travel behavior data 2014 and 2019. The data processed refers to the primary source, that is the JMA Commuter Survey conducted by the Indonesian Central Bureau of Statistics (Badan Pusat Statistik/BPS) in 2014, which covered 13,120 sample households from 1,312 census blocks, and in 2019, which included 12,960 sample households from 1,296 blocks. The amount of Relative Standard Error (RSE) ≤ 25%, then the estimate is considered accurate. These data will be analyzed in terms of travel behavior of the commuter consisting of travel modes, travel distance, travel time, travel cost, and commuter health.

3. Results and discussion

3.1. Travel modes
Commuting in 2010 reached around 53 million, with motorbikes accounting for almost 28.1 million (53%), cars 10.5 million (20%), and all modes of public transportation 14.4 million (27%) of the total. It shows a relatively high level of dependence on public transportation [23]. The mode share of commuting by income groups shows that the percentage of public transport demand is below 36% for low & middle-income groups, and reduced to 14% for the high-income groups. It can then be seen that the use of car modes increases with an increase in income by more than 5½ times (from 8% to 44%) of low-income to high-income groups. The motorcycle is the most dominant mode in 56% of all trips [23]. Private car users consider that public transport services, in general, are still not satisfactory. They judge
it mainly from the inconvenience factor, long-distance, long travel time, and long waiting times. Most of these respondents came from car users in Jakarta. Based on this assessment, they are not interested in switching to using public transportation.

3.2. Travel distance

The travel distance is the distance of one-way from departure from residence to the place of activity. The average JMA commuter travel distance is not much different between 2014 and 2019. Commuters travel distance dominated almost the same between ranges < 10km, 11 - 19 km, and 20 - 29 km with a total number of JMA commuters 750,000 – 975,000 person a day. Commuters who live on the outskirts and go to the city center of JMA will take a trip 30 - 50 km one way or about 60 – 100 km round trip a day (Figure 3).

![Figure 3. Travel distance of commuter Jabodetabek, 2014 and 2019.](Source: Indonesian Central Bureau of Statistics).

3.3. Travel times

The travel times are the trip length of the departure from residence to the activity location, including the waiting time for public transportation for those using it. In this context, travel times are related to travel time reliability, which is an essential component of the commuter’s behavior to the choice route [24]. Average commuting travel times are 10 – 40 minutes in one trip and reach about 35 – 40 % commuters. Commuters living in Jakarta, Kota Tangerang, Kota Tangerang Selatan, and Kota Bekasi relatively have travel times longer than others. Commuters who live on the outskirts and go to the city center of JMA will take about 40 – 60 minutes in one trip (Figure 4), or about 80 – 120 minutes round trip. They will spend about 10 hours outside the home. They go to work in the morning and get back home in the evening or at night.
3.4. Travel costs

There are differences between travel cost for the car private and public transport passengers. For private car transport, the costs include the fuel costs and maintenance costs, repairs, depreciation, and public transport passengers only, including public transport fares [25]. Commuters who live on the outskirts and go to the city center of JMA will pay more than 25.000 rupiahs one trip or 50.000 rupiahs round trip, or about 1,2 million rupiahs a month (Figure 5). It spends almost 80% of his total income a month or 20% for the medium income groups for the low-income groups.

3.5. Subjective well-being of the commuters

Subjective well-being (SWB) is strongly related to commuter’s satisfaction with travel, with their average experience, whether positive or negative, whether more or less pleasant during trips [26]. The negative emotions and unpleasant during trips in a long period probably will cause stress to the commuters. The number of commuters who feel stress reaches 1 million more people. Of the total stressed commuters, about 8% of them intend to stop working because they can no longer bear to commute. Most of them survived, did not intend to stop working even though they felt stress on the trip.
4. Conclusions
The urban expansion areas in metropolitan areas cause increasing problems in commuting from the suburbs to activities centers. This commuter trip is not productive because of the longer travel time, which almost 2 hours round trip a day, and of course, it affects decreased physical and mental endurance. The decreased subjective tolerance of commuters is shown by the stress they feel, and of course, this automatically disrupts work productivity and social life and their household. They spend most of the day outside the home. The problem of commuting trips is getting tough for lower-income groups because the transportation costs they pay almost 20% of their salary. Improving public transport services does not seem to help too much. Distance, travel time, and travel costs are already impossible to reduce.

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