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The Use of Mobile Positioning Data (MPD) to Delineate Metropolitan Area in Indonesia: Case Study in Cekungan Bandung

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Abstract:

Metropolitan area as the economic growth center has a major effect on the economic development of the surrounding hinterlands. Appropriate delineation of metropolitan areas becomes important as an effort in boosting economic growth and ensuring equitable development. Surrounding hinterlands that are socioeconomically tied to the urban core are typically measured by commuting patterns. Therefore, commuting patterns can be used to identify commuting zones. Surrounding hinterlands that fall within the commuting zone can be included in the metropolitan area.

Mobile Positioning Data (MPD) as one of big data sources can be used to determine commuter patterns and therefore can be considered as a basis for delineating the metropolitan area. MPD contains location information records from the subscribers of mobile network operator (MNO) from time to time. This feature can be employed to produce commuting flow statistics even to area level lower than municipality. The result obtained from processing MPD data to produce commuting statistics make it possible to delineate the metropolitan area by sub-district level. This study aims to describe how MPD has been utilized to produce delineation of Cekungan Bandung metropolitan area in Indonesia. The delineation was conducted using the Functional Urban Area (FUA) approach. In addition, this study also implements the travel diary survey to validate the result of MPD in order to ensure the quality of statistics.

Keywords: Surrounding Hinterlands; Commuting Zone; Functional Urban Area

1. Introduction:

Urban development in Indonesia is still concentrated on Java Island and several cities out of Java (Java-Centric). Four out of ten metropolitan areas are on Java (Government of Indonesia, 2017), as well as most of big cities and medium-sized cities. As the economic growth center, metropolitan areas have a major effect in economic development. All metropolitan areas in Java contribute more than one-third Indonesia's Gross Domestic Product (GDP) with the Greater Jakarta (Jabodetabek) as the biggest contributor. Jakarta itself contributes 17,31 percent of Indonesia's GDP (BPS-Statistics Indonesia, 2019).

Within the equitable development framework, the role of metropolitan areas outside Java – as the economic growth center – needs to be increased. In this regard, proper methods to delineate metropolitan area are urgently needed. It is expected that in the future, metropolitan areas in Indonesia can be delineated properly. Thus, national spatial and budgeting planning can be conducted appropriately. The United States is one country that had used a metropolitan approach in budget planning. The US Office of Management and Budget (2010) used the term of Metropolitan Statistical Area (MSA) to provide standard statistical area delineations in the country.

The general concept of MSA is associated with the urbanized large population area. The area consists of urban core plus surrounding hinterlands that have a high degree of integration with the urban core. One aspect that can be used to measure the degree of integration is the commuting pattern. The

high percentage of outlying area's residents who commute to the urban core for work may indicate the high degree of social and economic integration between areas.

BPS-Statistics Indonesia has already produced commuting statistics using a conventional survey since 2014. However, due to the budget constraints on conducting survey, the commuting statistics can only be produced every 2 years in 5 metropolitan areas consecutively. The statistics is also limited to regency/municipality level. In addition, it takes a long time to conduct conventional survey, from designing to disseminating the result. These limitations drive BPS-Statistics Indonesia to begin exploring another source of data to produce official statistics. MPD has been employed to support tourism statistics since 2016 and commuting statistics since 2018. From experience working with MPD, it is possible to produce statistics in a shorter time lag and lower level of administration area without increasing the budget.

This study explored the use of MPD to delineate metropolitan area, with a case study in Cekungan Bandung, one of the metropolitan areas that have been delineated. The data itself was obtained from Telkomsel, one of the largest Mobile Network Operator (MNO) in Indonesia. To analyze commuter patterns using MPD, BPS-Statistics Indonesia has established some algorithms to identify commuters and to estimate commuting flows at sub-district level. The commuting flows were used to measure the integration between the urban core and surrounding hinterlands in Cekungan Bandung. In order to verify the result of MPD algorithms, the validation process was carried out using 907 volunteers. The volunteers verified or annotated their movement through a travel diary survey. The algorithm result on MPD were then compared with the result of the volunteers' annotation.

2. Methodology:

Commuter Identification Using MPD

MPD is a large-scale location data of MNO subscribers. MPD can produce intertemporal location of subscribers approached by the location of their mobile devices (using Mobile Station International Subscriber Directory Number/MSISDN). The location data recorded in MPD comes from the Base Transceiver Station (BTS) coordinate, which is recorded for every transaction conducted by the subscriber, such as call activities, sending and receiving SMS, signal searching, or activities that require internet connection. Thereafter, the subscriber's location is obtained from the location aggregation of BTS.

Based on the definition used by BPS-Statistics Indonesia, the term commuter refers to someone who routinely does a round-trip within 24 hours to work/school/course outside his administrative area of residence. There are two aspects to consider: spatial aspect and routine aspect. When using MPD, the location of someone's residence and the location of his/her main activity (work/school/course), or their round-trip routine can't be determined directly by interviewing respondents as in conventional survey. Therefore, it is necessary to adjust those two aspects to determine commuters using MPD.

The location of residence and the location of main activity in MPD can be described using the Usual Environment scheme (Putra et al., 2019). The residence location (*home*) is a subscriber location in the nighttime, while the main activity location (*work*) is the subscriber location in the daytime. The highest aggregate time duration of *home* and *work* in sub-district level (kecamatan) will be chosen. If the chosen *home* and *work* of a subscriber are in different kecamatan, the subscriber fulfills the spatial aspect of a commuter. Subsequently, the subscriber fulfills the routine aspect of commuter when he/she made a round-trip from *home* to *work* at least once a week in two different weeks on a one-month observation period. If the subscriber fulfills spatial and routine aspects, he/she is classified as a commuter. The commuting flows were then identified for every subscriber from origin/*home* to destination/*work*.

Metropolitan Area Delineation

According to the Ministry of Public Works of Indonesia (2012), the establishment of metropolitan area delineation considers various aspects; one of them is the high rate of commuter mobility between the urban core and surrounding hinterlands. The metropolitan area delineation based on commuter patterns is carried out in various countries, including European countries, the United States, and Japan. According to Eurostat (2017), European countries determine surrounding hinterlands

that included in a metropolitan area by using the Functional Urban Area (FUA). FUA consists of the city and its commuting zone. In this approach, a commuting zone can be identified based on commuter patterns using the following steps:

1. Define the urban core.
2. Identify all surrounding hinterlands with a certain threshold percentage of its worker residents commute to the urban core.
3. Surrounding hinterlands that share at least 100 percent of its land border by FUA are included and non-contiguous surrounding hinterlands are dropped.

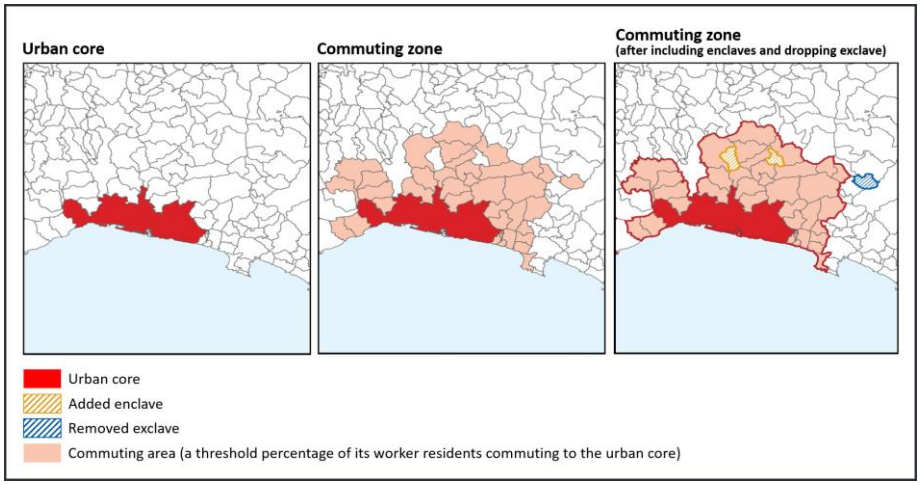

Figure 1. Functional Urban Area (Genova)

Every country has different thresholds in determining the surrounding hinterlands that fall within the commuting zone. European countries use at least 15 percent (Eurostat, 2017), while the United States uses at least 25 percent (US Office of Management and Budget, 2010). Meanwhile, Japan determines at least 5 percent of worker and student residents (Kurahashi, 2012). The percentage was obtained by dividing the number of commuting workers with the total workers in each hinterland. However, in MPD, the subscribers can't be classified as workers or students. According to the commuter survey result in Cekungan Bandung (BPS-Statistics Indonesia, 2017), 69.19 percent of commuters in surrounding hinterlands were commuting for work purposes. Hence, in this study, most subscribers were assumed to be workers so that the percentage of commuters used was the number of commuting subscribers divided by total subscribers. In addition, based on Indonesian Labor Force Survey (Sakernas), 8.91 percent of surrounding hinterlands workers in Cekungan Bandung commuted to its urban core. Therefore, this study used 5 percent threshold with FUA approach.

MPD Validation Method

To validate the result of MPD algorithm, this study employed MEILI, an open-source mobile application that can records the location of multiple users over a period-of-time and can be annotated to verify each trip. Basically, MEILI is a travel diary survey that uses mobile phone as a data collection mode. While MPD uses passive geo-positioning to determine someone's location (aggregate BTS location), MEILI uses GPS, an active geo-positioning to determine the location of the mobile phone. Thus, location information resulting from MEILI is more accurate compared to location information from MPD. However, there are some disadvantages of MEILI. This application needs to be installed on a mobile phone with certain specifications, consumes high amount of battery, and requires user's permission to activate the GPS feature.

Through the MEILI application installed on mobile phone, volunteers annotated their locations, trips, and the purpose of each trip. Thus, the location of volunteers' *home/work* can be known by looking at the trip purpose. The location was identified as *home* when the trip purpose annotation is "my house" or "my family/friend house", the stay location in the nighttime, or the stay location in days off. On the other hand, the location was identified as *work* when the trip purpose annotation is "my office" or "my

school/course place", or the stay location on working hours. The identification of *home* and *work* locations result from MEILI were then compared to the MPD result. Therefore, the higher the similarity level of *home* and *work* identification between MPD and MEILI, indicate the better commuting flows produced from MPD.

The Scope of Study

MPD records in this study was obtained from Telkomsel, one of the largest MNO covered all of 514 regencies/municipalities in Indonesia. Telkomsel has the largest number of subscribers, 167,8 million subscribers in Semester I 2019. For this study purposes, there were 50,907 Telkomsel subscribers used as the sample within November 2019, which 907 of them were the volunteers of MEILI. The location focus of this study was in Cekungan Bandung metropolitan area. Based on Government of Indonesia (2018), the Cekungan Bandung consists 85 kecamatans in five regencies/municipalities in West Java province. More specifically, there are 31 kecamatans in Bandung Regency, 5 kecamatans in Sumedang Regency, 16 kecamatans in West Bandung Regency, 30 kecamatans in Bandung Municipality, and 3 kecamatans in Cimahi Municipality.

3. Result:

Metropolitan Area Delineation

Based on Government of Indonesia (2018), Bandung Municipality and Cimahi Municipality are the urban core in Cekungan Bandung metropolitan area. There are 52 kecamatans that become surrounding hinterlands. The result of MPD in Cekungan Bandung shows that on average, 19.1 percent of residents in surrounding hinterlands commuted into the urban core. Kertasari Kecamatan in Bandung Regency and Rongga Kecamatan in West Bandung Regency have almost no commuters (into the urban core). On the other hand, Cimenyan Kecamatan in Bandung Regency recorded the highest proportion of commuters with 70,3 percent. Only 23 and 16 kecamatans have the proportion of commuters more than 15 and 25 percent, respectively. Also, there were more residents from surrounding hinterlands commute to Bandung Municipality rather than to Cimahi Municipality.

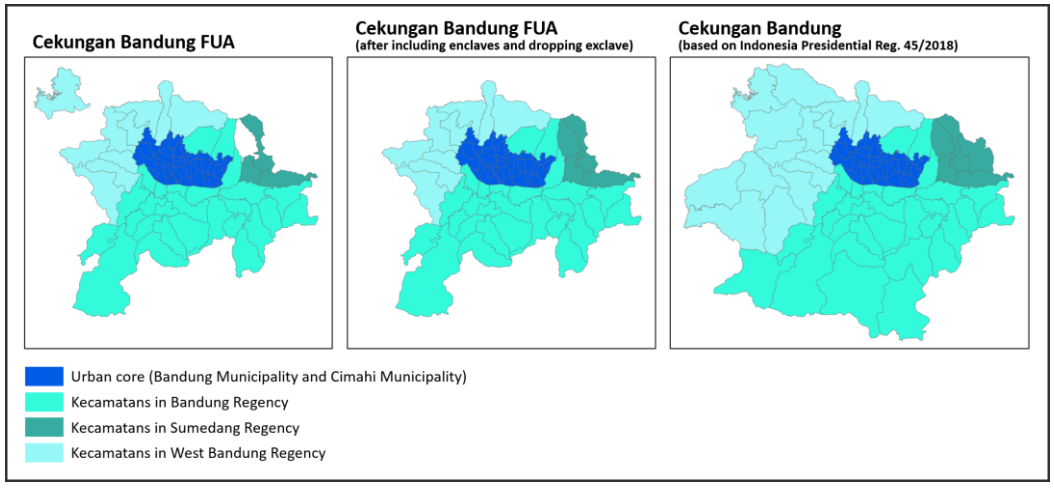

Figure 2. Cekungan Bandung Delineation

Figure 2 shows the comparation of Cekungan Bandung delineation between the result based on FUA approach and Indonesian Government (2018). The result from MPD shows that most kecamatans with higher percentage of commuters have a shorter distance to the urban core. From 13 kecamatans which directly adjacent to the urban core, 9 of them are top ten kecamatans with the highest proportion of commuters. Furthermore, with the 5 percent threshold, there were 40 kecamatans that fall within the commuting zone compared to 52 kecamatans determined by the government. There were one exclaved kecamatan removed (Cipendeuy Kecamatan in West Bandung Regency), and one kecamatan added (Sukasari Kecamatan in Sumedang Regency) in the result of MPD based on their location to other kecamatans.

The difference between MPD result and the delineation establish by the Government of Indonesia was due to the different methods used. Up until now, the government uses ecoregion and urban sprawl aspects, people and goods movement patterns to the urban core within 40 km radius or equivalents to one-hour travel time, and stakeholder aspiration in delineating metropolitan areas. All 40 kecamatans – which fulfill the 5 percent threshold from MPD result – were the same kecamatans within 52 kecamatans determined by the government.

MPD Accuracy

As explained in the previous section, MEILI result was used to validate the MPD result. The higher similarity level of *home* and *work* identification between MPD and MEILI, the better commuting flows produced from MPD. From 907 volunteers, there were 738 of them whose *home* and *work* can be identified. Table 1 shows the number of volunteers based on match and mismatch *home* and/or *work* location identifications between the result from MPD and MEILI.

Table 1. The number of MEILI volunteers by Identification and Similarity of MPD and MEILI results

Identification	Similarity of MPD and MEILI results	
	Match	Mismatch
(1)	(2)	(3)
home	518	220
work	424	314
home and *work*	313	425

The result shows that 313 of 738 volunteers (42,41 percent) have the same *home* and *work* identification between MPD and MEILI results in kecamatan level. The similarity level of *home* location identification (70,19 percent) is higher compared to *work* location identification (57,45 percent). The lower percentage of the similarity of *work* location identification was due to the share of volunteers who are mobile workers or have not fixed office location (i.e. public transport or taxi driver, courier expedition, and peddler).

4. Discussion and Conclusion:

MPD can be used to delineate metropolitan area, by calculating the intensity of commuting flows as a measurement of integration between the surrounding hinterlands and the urban core. MPD also can provided the delineation in a lower level of administration area. From the study conducted for Cekungan Bandung, by using a 5 percent threshold, there were 40 kecamatans identified as the commuting zone using MPD. Those kecamatans were part of 52 kecamatans of the government delineation. However, there were 12 other kecamatans not included as commuting zone in MPD result. The result indicate that the government did not use commuting flows intensity or used a lower threshold to determine the integration between the surrounding hinterlands and its urban core. Therefore, it is important to identify the best threshold to delineate metropolitan areas in Indonesia.

Since the analysis using MPD has little or no possibility to interact with subscribers, therefore, it is important to ensure the validity of the analysis. With the help of volunteers and MEILI application, this study tried to measure the accuracy of the result of MPD algorithms. The identification of *home* location has a higher accuracy than *work* location identification. Keeping in mind that there were significant number of volunteers who frequently mobile during work. On the other hand, the large number of mismatch *home*/*work* location of volunteer between MEILI and MPD must be taken into consideration. To have better result from MPD analysis, the algorithms regarding commuters' identification including *home*/*work* identification needs to be improved by using the result of this study.

Nevertheless, the utilization of MPD for metropolitan area delineation is an innovation worth to be further developed. The analysis using MPD can reduce operational time and costs. Therefore, it is important to establish a sustainable collaboration with not only one MNO. Other than that, regardless the data privacy issue, if MPD can be integrated with the Administration Record, the analysis will be able to identify demographic and labor characteristics of subscribers in addition to commuting flows.

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