Urban Sprawl Development in Eastern Bandung Region

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Abstract. Eastern Bandung Region including Cileunyi, Jatinangor and Rancaekek is a suburb area of Bandung, which has gone through many changes in land use from agrarian to non- agrarian, also the population density and urban growth rate have increased. This phenomenon can lead to urban sprawl and potentially lead to a negative spatial transformation and inefficient resource allocation. This research objectives are to identify the characteristics of urban sprawl development and the pattern of urban sprawl in Eastern Bandung area in 2002, 2010 and 2017. This study uses quantitative approach with descriptive method also spatial analysis technique, scoring, and descriptive analysis. The spatial data that was used are Google Earth image data in 2002, 2010 and 2017. The results of this study show that the characteristics of urban sprawl development that consist of physical and social dimension is high with a score of 2.46. The pattern of urban sprawl can be identified as the combination of ribbon and leap frog development. Ribbon development can be seen in Cileunyi and Jatinangor, meanwhile leap frog development occurs in Rancaekek. The results of this study hopefully can help improve the understanding about urban sprawl and encourage the policy makers in controlling the spatial transformation wisely.

1. Introduction
Urban areas in major cities in Indonesia such as Jakarta, Bandung, Yogyakarta and Surabaya have a rapid increase of urban activities. It is caused by the increasing number of people in urban area. The increasing number of population will increase the need for land to settle and other need in socio-economic and culture life [1].

The growing activities in urban area trigger the use of space (land) inside the city to increase. In addition, the land inside the city have experienced space compaction so that the land availability will be limited. Besides, land in suburban area (peri-urban) have been dominated by agricultural land so that the availability of land for urban activities are relatively adequate.

The land that is still adequate in suburban areas most likely to lead to the emergence of new built-up land. The new built-up land can be built for settlement, industry, trade and services with various aspects of activities in it. The activities that take place on that built-up land may attract many people because in there, they can meet all the needs that can support their activities, such as easy to access the facilities and infrastructure [2].

The emergence of a wide variety of activities in rural area will eventually experience symptoms of urban sprawl. Urban sprawl is the spread of activities from urban area and surrounding area to the suburbs and if it happens continuously, it will also cause the conversion of open space into built-up area [3].
From spatial perspective, it can explain that the urban sprawl phenomenon that occurred in rural area will always show the physical appearance of urbanity outwards, also many conversion of land use happened that change the countrified into urbanity. These symptoms were indicate the appearance of urban sprawl in suburban areas, including in the eastern part of Bandung City.

There are three districts in the eastern suburban area of Bandung namely Cileunyi sub-district, Rancaekek (Bandung Regency) and Jatinangor (Sumedang Regency), which have indicate the symptoms of urban sprawl. Therefore, those three districts in this study called as Eastern Bandung Region.

Based on the spatial problems described above, a way to analyze the problems of urban sprawl can be identified by using Geographic Information Systems (GIS) and remote sensing data. Each of these technologies has advantages in studying the area accurately and efficiently. In order to plan and manage an area, needed a tool that can provide information which can cover a large area fast, consistent and up-to-date, the tools such as GIS and remote sensing data [4].

Therefore, to determine and analyze the level of development of urban sprawl that occurred in peri-urban area of Bandung, it used GIS and remote sensing data (image). Thus, the title of this study is: “The development of Urban Sprawl Eastern Bandung Region” The research question in this study is how is the characteristics and patterns of urban sprawl development that occurred in the Eastern Bandung Region in 2002 and 2017.

2. Methods
This study uses a quantitative approach with descriptive method and spatial analysis technique, scoring, and descriptive analysis. The sampling method in this study uses probability sampling with cluster area sampling. This technique is used when the population is not consist of individual people but rather consists of a group of individuals or an area. Samples taken in this study represent the population in Cileunyi, Rancaekek, and Jatinangor, then take one spot as representative and in total there are 32 villages as samples.

Steps to analyze the data in this study includes: (1) spatial analysis by using the imagery interpretation of Google Earth year 2002, 2010 and 2017 to identify land cover (2) scoring and matching data, scoring was used to score the parameters, then compare the measured parameters such as settlements characteristic data, building function, accessibility, population density and the livelihoods in the study site. Table 1 and Table 2 are the urban sprawl parameters based on any variables.

| Table 1. Urban sprawl Parameter and Variable Weight Based on Physical Dimensions [5] |
|-----------------------------|-----------------------------|-----------------------------|-----------------------------|
| Variables                   | Criteria                   | Class                      | Score  |
| Land Use                    | <4 km                      | Low                        | 3     |
|                             | 4-8 km                     | moderate                   | 2     |
|                             | > 8 km                     | High                       | 1     |
| Characteristics of Settlement | <30%                       | Low                        | 3     |
|                             | 30-75%                     | moderate                   | 2     |
|                             | > 75%                      | High                       | 1     |
| Building functions          | Undeveloped Land           | null                       | 0     |
|                             | ≤ 2 Functions              | Less                       | 1     |
|                             | 3-4 Functions              | moderate                   | 2     |
|                             | ≥ 5 Functions              | Complete                   | 3     |
| Accessibility               | Undeveloped Land           | null                       | 0     |
|                             | ≤ 1500 meters              | Bad                        | 1     |
|                             | 1500 - 3000 meters         | moderate                   | 2     |
|                             | ≥ 3000 meters              | Well                       | 3     |
|                             | 1 Type of transportation   | Low                        | 1     |
|                             | 2 Type of transportations  | moderate                   | 2     |
### Variables

| Variables                  | Criteria       | Class   | Score |
|----------------------------|----------------|---------|-------|
| 3 Types of transport       | High           | 3       |
| Poor Quality               | Low            | 1       |
| Moderate Quality           | moderate       | 2       |
| Good Quality               | High           | 3       |
| Difficult access           | Low            | 1       |
| Enough access              | moderate       | 2       |
| Easy access                | High           | 3       |

**Table 2. Urban sprawl Parameter and Variable Weight Based on Non-Physical Dimensions [5]**

| Variables                  | Criteria       | Class   | Score |
|----------------------------|----------------|---------|-------|
| Population density         | ≤ 1500 meters  | Low     | 1     |
|                           | 1500 - 3000    | moderate | 2     |
|                           | ≥ 3000 meters  | High    | 3     |
| Livelihood Population      | ≤ 30%          | Low     | 1     |
|                           | 30-75%         | moderate | 2     |
|                           | ≥ 75%          | High    | 3     |

### 3. Results and Discussion

This study was located in 3 sub-districts in the eastern Bandung, such as Cileunyi and Rancaekek sub-districts that administratively in Bandung Regency and Jatinangor sub-district in Sumedang Regency. These three sub-districts are directly adjacent to these following regions, North: Sumedang Regency, West: Bandung City, South: Bandung Regency (Majalaya and Cikancung sub-districts). East: Bandung Regency and Sumedang Regency.

#### 3.1 The Characteristics of Urban Sprawl Development in Eastern Bandung Region

The characteristics of urban sprawl development in terms of physical dimensions which includes land use, settlement characteristics, building functional and accessibility. Table 3 shows land use conversion occurs from agricultural land into non-agricultural.

**Table 3. The Development of Land Use in East Bandung from 2002-2017 [6, 7, 8]**

| Locations/ Sub-district | Agriculture | Land Use (km²) | Non-Agriculture |
|-------------------------|-------------|----------------|-----------------|
|                         | 2002        | 2010           | 2017            | 2002        | 2010           | 2017            |
| Cileunyi                | 21.45       | 34.11          | 17.25           | 8.69        | 11.61          | 12.25           |
| Rancaekek               | 37.57       | 35.99          | 34.11           | 6.29        | 9.60           | 11.20           |
| Jatinangor              | 18.89       | 14.64          | 13.98           | 6.96        | 9.47           | 11.88           |
| Total                   | 77.91       | 69.16          | 65.34           | 21.95       | 30.69          | 35.33           |

The characteristics of settlements in Eastern Bandung Region on the Table 4 show that 22.6% are rural settlements and 77.3 are urban settlements.

**Table 4. Settlements Characteristics [6, 7, 8]**

| Sub-district | Rural (%) | Urban (%) |
|--------------|-----------|-----------|
| Cileunyi     | 0         | 6         | 100       |
| Rancaekek    | 6         | 43        | 8         | 57         |
| Jatinangor   | 3         | 25        | 9         | 75         |

The building function in every sub-districts in this study has a diverse variety of functions, especially in Jatinangor sub-district. The building in Jatinangor has been functioning for business, social and...
cultural and residential. The building function that has a significant development is occupancy function (occupancy vertical and horizontal) and business function. In Cileunyi sub-district, the building has been functioning for residential, business, social and cultural function, and religious functions. In Rancaekek sub-district, the building function that has a significant development is horizontal residential function.

The highest level of accessibility in Eastern Bandung Region is Cileunyi sub-district with a score of 2.08, while the Rancaekek and Jatinangor sub-districts are classified as moderate. The accessibility value in Cileunyi sub-district reaches a score of 2 because it is easy to access public transportation.

The addition of new road network in the three subdistricts happen when there is a new housing development. If there is a building compaction on some research sites, it shows that there is no additional road network. Therefore, in areas that experience building compaction, they only use the existing road network.

The characteristics of urban sprawl development based on social dimension which includes population density and livelihoods. Table 5 shows the highest population density is in Cileunyi sub-district with people population 7,049 people/km$^2$. It is because this area is directly adjacent to Bandung City. Rancaekek sub-district has the lowest population density of all three with 3,948 people/km$^2$. It is because Rancaekek sub-district has a large area and the land use still dominated by agricultural use. While Jatinangor sub-district has population density of 4,298 people/km$^2$.

| Table 5. Population Density [6, 7, 8] |
|--------------------------------------|
| **Sub-district** | Population Density (people / km$^2$) |
|  | 2002 | 2017 |
| Cileunyi | 2,949 | 7,049 |
| Rancaekek | 2,997 | 3,948 |
| Jatinangor | 2,610 | 4,298 |

The livelihood of residents in the Eastern Bandung Region, especially in Cileunyi, Rancaekek, and Jatinangor, which was rural areas in 2002, is still dominated by agricultural land use. Then as time goes by, there is a conversion of agricultural land into non-agricultural which will have an impact on people's livelihoods as shown in Table 6.

| Table 6. Livelihood Population [6, 7, 8] |
|----------------------------------------|
| **Sub-district** | **Livelihood** | **Total agrarian livelihood (%)** |
|  | Agriculture | Non-Agriculture |  |
| Cileunyi | 5902 | 56 055 | 10.52 |
| Rancaekek | 13 019 | 59 006 | 22.06 |
| Jatinangor | 5,365 | 56 883 | 9.43 |

Furthermore, in order to obtain the measurement result of urban sprawl development on the physical and social dimensions, scoring was carried on each district. Then these results are classified based on the following criteria on the Table 7.

| Table 7. Urban Sprawl Development Criteria |
|-------------------------------------------|
| **Information** | **Score** |
| High | > 2 |
| Moderate | 1-2 |
| Low | <1 |

The following table 8 is the final score of Urban Sprawl in Eastern Bandung Region based on physical dimension and a social dimension.
Table 8. Scores Urban Sprawl in East Bandung Region

| Variables               | Score by district | Final Score |
|-------------------------|-------------------|-------------|
|                         | C     | R     | J     |        |
| Land Use                | 1.8   | 2.3   | 2.3   | 2.13   |
| Settlement characteristics| 3     | 2     | 3     | 2.66   |
| Building functions      | 2.16  | 2.14  | 2.25  | 2.18   |
| Accessibility           | 2.08  | 1.55  | 1.64  | 1.75   |
| Population density      | 3     | 3     | 3     | 3      |
| Non-Agriculture Livelihood | 3   | 3     | 3     | 3      |
| Score                   | 2.51  | 2.16  | 2.54  | 2.46   |

Information:
C = Cileunyi R = Rancaekek J = Jatinangor

3.2 The Pattern of Urban Sprawl Development in Eastern Bandung Region

Based on the results of Google Earth imagery data processing year 2002, 2010, and 2017, it showed a combination ribbon development and leap frog development pattern in Eastern Bandung Region. Ribbon development pattern occurs in Cileunyi and Jatinangor sub-district. This pattern happened to follow the main road network that crosses in both sub-districts, such as in Cileunyi sub-district namely Cibiru-Cileunyi highway, while in Jatinangor, there are Jatinangor highway with Bandung-Sumedang lane and Rancaekek highway with Bandung-Cicalengka lane.

Rancaekek sub-district shows that the sprawl in leap frog pattern, even though there is a small part in ribbon pattern. This leap frog pattern happened because Rancaekek has the widest administrative area compared with the two other sub-districts. The land use in this area is still dominated by wetland which causes the physical development of Rancaekek to spread like leapfrog pattern. The ribbon development pattern can be identified only for small part along the river.

Furthermore, based on the buffering analysis of urban sprawl development pattern in 2002-2017 in Eastern Bandung Region, it identified the urban sprawl ring zone (shows in Figure 1). The sprawl pattern appears on the 3rd Ring within 9 km from the City Service Center Gedebage. On the 3rd ring shows a significant sprawl of 9.9 km². In the 4th ring, the sprawl area is 12.5 km². The 3rd and 4th ring are in the center part of Jatinangor and Rancaekek sub-district. Also, the 5th ring which is the farthest side on the delineation of study area shows that the sprawl has declined with 6.8 km².

Figure 1. The Development of Urban Sprawl Based on Buffering Analysis
3.3 The Development of Urban Sprawl in Eastern Bandung Region

The area in Eastern Bandung Region including District Cileunyi, Rancaekek and Jatinangor continue to experience growth, both physical and social development. The physical development in this study is related to spatial transformation, one of them is urban sprawl. Also, the social dimension development is related to population. The population growth rate the three sub-districts are constantly increasing.

The phenomenon of urban sprawl that happened in the Eastern Bandung is caused by the population growth and is also a major factor in urban spatial problems [4, 9, 10]. It means that urban sprawl is identified by unplanned and uneven growth also driven by a lot of process and lead to inefficiency of resources utilization [11].

Urban sprawl and the increasing of population growth rate that occurred in Eastern Bandung Region resulted in land use change. In 2002 to 2017 the land use change is the utilization of agricultural land into non-agricultural. Such conditions aligned with the understanding that urban sprawl and its relations with the population growth is one of the main driving factor for land use or land cover change [12, 13].

Figure 2 shows the development of urban sprawl on the physical dimensions such as land use, settlements characteristics, building function and accessibility is consider in the moderate level of development. Besides that, on the social dimensions such as population density and non-agricultural livelihoods is relatively in high level of development. These two dimensions were then combined in scoring analysis that resulting a high-level of urban sprawl development with a score of 2.46. The high-level of urban sprawl developments is in line with the phenomenon of urbanization. The process of urbanization is a complex phenomenon that transform rural areas into urban land [13].

Figure 2. Urban Sprawl Map in Eastern Bandung Region

Based on the explanation before, urban sprawl and urbanization are a phenomenon that interrelated and influence each other. Rapid urbanization led to the spread of urban development around urban areas,
leading to urban sprawl phenomenon [14]. Thus it can be concluded that the high-level of urban sprawl
development in Eastern Bandung Region is not only affected by physical and social dimensions but it
can be widely influenced by the process of urbanization.

The pattern of urban sprawl development in Eastern Bandung Region is a combination of ribbon
development leap frog development. The ribbon development pattern occurred in the Cileunyi and
Jatinangor while leapfrog development pattern happened in Rancaekek.

The ribbon development pattern occurred because of the existing of national and provincial road
network that crosses the two sub-districts. The road network are the primary collector and primary
arterial road that have a high accessibility so that the movement of people and goods will be easy and it
became the pull factor urban sprawl.

The spatial interaction such as people, goods and information movement create a real connection
between the urban core and the rural area so that it led suburban area to growth (urban sprawl) [10, 15].

The leapfrog development pattern is caused by the existing physical constraints like in Rancaekek,
where the territory is dominated by agricultural land. The sprawl phenomenon is caused by unsuitable
physical terrain such as steep terrain, wetlands or bodies of water so that it created leapfrog development
pattern [16, 17].

4. Conclusion

The characteristics of urban sprawl in Eastern Bandung Region is consider high with a final score of
2.46. Jatinangor sub-district has the most sprawling urban area with a score of 2.54. It is because
Jatinangor is an education area so there are many physical development. The overall impact of this
phenomenon is the increasing of road network availability in good condition, an adequate level of
accessibility, also various activities are concentrated in it so that the potential for the occurrence of urban
sprawl in Eastern Bandung Region is bigger.

Based on the results of Google Earth imagery data processing year 2002, 2010, and 2017, it showed
a combination ribbon development and leap frog development pattern in Eastern Bandung Region.
Ribbon development pattern occur along the main road network that cross Cileunyi and Jatinangor sub-
district, while the leapfrog development happened in the center of Rancaekek sub-district and there is a
small part of ribbon development pattern along the river. The result of buffering analysis show a
significant sprawl on the 3rd ring shows with an area of 9.9 km² and in the 4th ring, the sprawl area is
12.5 km².

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