Identifying city park accessibility using geographic information system

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Abstract. Bandung has about 2.5 million people that reside in 9.267 ha urban area. Bandung city has only about 189 hectares of urban park, which is not enough to serve all the settlements area. This study analyzed the level of accessibility of residents to the park services, in term of how far and wide the city park can serve the surrounding community. This research used Network Analysis in Geographic Information System (GIS) method to calculate the Services Area. The method used assumption that one park can be reached by residents walking in radius 1.250 km around their house. The result show that the existing of the park in Bandung City can only serve about 6.942 Ha of urban area, which is only serve 2/3 urban area in Bandung City. City parks in Bandung City have not been distributed well, especially in the eastern and western part of Bandung City, which have blank spot areas in which the residents are unable to reach to a city park. The result of this research can serve as an input to the local government in the planning of building new city parks, which will be beneficial for the residents of eastern and southern area of Bandung City.

1. Introduction
Bandung City, the capital of West Java Province of Indonesia, has about 2.5 million people that stayed in 9.267 Ha of urban area. Bandung City has had many city parks with 189 ha of city parks total area. Unfortunately, their locations are not well distributed in every district and have caused several settlement areas having no park. Therefore, the benefit of city park existence in Bandung City is not optimal. One of important factor in utilization of city park by the citizen is about distance and accessibility of the city park from the settlements [1]. Accessibility factor in Bandung City has not been used in the planning of city parks locations so a couple of city parks are far from the settlement, leading people to be lazy in utilizing city parks.

On several previous researches, some researchers measured the accessibility of the city park from the settlement with several methods, like cumulative opportunities measure, the minimum distance measure, and the travel cost measure [2]. Those studies showed that when accessibility of city park is measured using cumulative opportunities method, the result is more representative and logical, compared with the result of using least cost distance method and minimum distance method.

In another research, accessibility of city park from the settlement in Seoul (South Korea) was measured using network analysis method. The research concluded that only half of the service area covered compared with the service area that was generated by simple buffer. This result was supported by the fact that the travel route to the city park was not straight but had to follow the streets network.
This fact made the service area of the city park to the settlement smaller [3]. This result was in line with another research stating that the service area of urban park was influenced by the accessibility, spatial distribution, and the city park area [4].

From several method that had mention before, there are some drawbacks to the method, one of the drawbacks is when determine service area and choose where the most priority location that must build the city park, the analysis is not included the factor of population. There is several of the settlement that not had covered by the service area of city park, but when we see the population in that location, the total population and the density population is low, this resulted not accurate of the recommendation for the location that will be build the city park. This research is try to create the service area of the park from the settlement and recommend the which location that suitable for building the new city park with include the population factor, with this research we expected that the result of study can be input to the government for the management of urban parks in the city of Bandung.

2. Methods
Many methodology that can measure the service area of the accessibility of the urban park, like buffering method [5], time distance weighted technique [6], or network analysis method [3,7]. This research using network analysis to measure the accessibility of the urban park.

2.1. Network analysis
Network analysis is the method that can solve problem regarding network. This method usually finds the closest route between two locations [8], with the purpose of efficiency to save more money and time. Network analysis has been used in many researches, like bicycle facilities planning [9], tourism management [10,11], or the community evacuation process in disaster situation [12]. An example of network analysis in service area is showed in figure 1(a). The area from network analysis is built by the road network, so the result is more different with the area that is built by the buffer method that is showed in figure 1(b). The service area generated from buffer method is only in round or circle form, because human walk to the park follow the road network so the result of service area when using the network analysis, will get results that are close to the condition on the field.

![Service Area form network analysis](image1)
![Service Area form buffering](image2)

Figure 1. (a) Service Area form network analysis (b) Service Area form buffering.

2.2. Maximum traveled distance
In city park planning, many standards that can be used to measure maximum walking distance of the citizen from their home to the city park. In National Recreation and Park Association (NRPA) of the North America, the maximum distance that recommended is 800 m [13], while in Turkey the maximum walking distance is 500 m [4]. In this research, the maximum walking distance is estimated from the normal speed human which is 0.5 km / hour and the human duration can be walk is 15 minutes, from that we calculate that the maximum travelled distance in walking to the city park from the settlement area is 1.250 m.
2.3. Data

The population data of Bandung City in 2018 obtain from the book of Bandung Municipality in Figure 2019, which is illustrated with map in figure 2, was used in this research. As it is shown in figure 2(a), main crowded population areas are Sukajadi District, Coblong District, Bandung Kulon District, Babakan Ciparay District, Cibeunying Kidul District, Batu Nunggal District, and Kiaracondong District (showed in red color), and the densest population of Bandung City is in Bojongloa District. From those data, it can be concluded that the high total population in Bandung City does not have a straight correlation with the population density.

Figure 2. (a) Total population Bandung City in 2018 (b) Density population Bandung City in 2018.

Other data that were used in this research are park location that was obtained from field survey and settlements distribution in Bandung City was obtained by digitizing the aerial photography of Bandung city year 2015, the park location which is illustrated in figure 3(a). The distribution of existing city parks is one of the main data of this research. Using city park location data and accessibility from the road network in figure 3(b), which settlements are being served with park can be calculated.

Figure 3. (a) Distribution map of settlements and parks (b) Map of road network.

3. Result and discussion

3.1. Result

3.1.1. Service area. The service area was generated using two methods, the network analysis method and the buffer method. Using buffer method, the total service area of city park to the settlements is 8,786 Ha or about 94% from all settlements in Bandung City, which is illustrated in figure 4(a), whereas using network analysis method, the total service area of city park to the settlements is 6,942 ha or 74% from all settlements in Bandung City, which is illustrated in figure 4(b). The result is in coherence with the
result of previous research which states that the service area generated from network analysis is smaller when compared with the service area generated from the buffer method [3]. If the result from the network analysis method is used, the government of Bandung City will have to build new city parks that will serve about 25% of settlements that have not been served with city park.

The result of service area of city park using network analysis in the form of settlements distribution district which has and does not have access to city park is shown in table 1. There are 3 districts of settlements which are served with city park, i.e. Bandung Wetan District, Lengkong District, and Sumur Bandung District. Meanwhile from the table it can be seen that there are 3 districts of settlements which have lowest percentage served with city park, i.e. Mandalajati District (67,83%), Ujung Berung District (63,56%), and Antapani District (63,5%). However, when seen from the total area that has not been served with park, the districts are different from the districts that have the lowest percentage, i.e. Bandung Kulon District (247.48 Ha), Ujung Berung District (257.66 Ha) and Arcamanik District (279.34 Ha). From the map of the service area, it can be seen that the distribution of city parks in Bandung City is not balanced, especially in eastern part (Antapani District, Arcamanik District, Mandalajati District, and Ujung Berung District) and Western part (Bandung Kulon District) of Bandung City, which have a low level of city park service area.

![Figure 4.](image)

*Figure 4. (a) Service area from the buffering method (b)Service area from the network analysis method.*

| No | District              | Settlement Does Not Have Access to Park | Settlement Have Access to Park |
|----|----------------------|----------------------------------------|-------------------------------|
|    | Area (Ha)            | %                                      | Area (Ha)                     | %                                      |
| 1  | Andir                | 9.75                                   | 219.08                        | 95.74                                   |
| 2  | Antapani             | 238.26                                 | 136.97                        | 36.50                                   |
| 3  | Arcamanik            | 279.34                                 | 271.75                        | 49.31                                   |
| 4  | Astana Anyar         | 71.58                                  | 120.82                        | 62.80                                   |
| 5  | Babakan Ciparay      | 148.11                                 | 237.81                        | 61.62                                   |
| 6  | Bandung Kidul        | 12.31                                  | 194.13                        | 49.40                                   |
| 7  | Bandung Kulon        | 247.48                                 | 225.04                        | 47.63                                   |
| 8  | Bandung Wetan        | 0.00                                   | 150.70                        | 100.00                                  |
| 9  | Batununggal          | 2.01                                   | 272.35                        | 99.27                                   |
| 10 | Bojongloa Kaler      | 75.28                                  | 167.81                        | 69.03                                   |
| 11 | Bojongloa Kidul      | 75.93                                  | 220.34                        | 74.37                                   |
| 12 | Buahbatu             | 21.82                                  | 445.33                        | 95.33                                   |
| 13 | Cibeunying Kaler     | 13.83                                  | 232.57                        | 94.39                                   |
| 14 | Cibeunying Kidul     | 48.04                                  | 222.19                        | 82.22                                   |
| 15 | Cibiru               | 210.48                                 | 181.79                        | 46.34                                   |
Table 1. Cont.

| No | District     | Settlement Does Not Have Access to Park | Settlement Have Access to Park |
|----|--------------|---------------------------------------|-------------------------------|
|    |              | Area (Ha) | % | Area (Ha) | % |
| 16 | Cicendo      | 14.63    | 3.88 | 362.70 | 96.12 |
| 17 | Cidadap      | 8.11     | 4.12 | 188.97 | 95.88 |
| 18 | Cinambo      | 54.49    | 27.64 | 142.67 | 72.36 |
| 19 | Coblong      | 9.67     | 2.21 | 427.27 | 97.79 |
| 20 | Godehage     | 30.44    | 17.03 | 148.37 | 82.97 |
| 21 | Kiaracondong | 62.83    | 17.38 | 298.70 | 82.62 |
| 22 | Lengkong     | 0.00     | 0.00 | 269.74 | 100.00 |
| 23 | Mandalajati  | 243.23   | 67.83 | 115.37 | 32.17 |
| 24 | Panyileukan  | 70.09    | 28.39 | 176.79 | 71.61 |
| 25 | Rancasari    | 41.18    | 10.08 | 367.44 | 89.92 |
| 26 | Regol        | 9.25     | 3.38 | 264.31 | 96.62 |
| 27 | Sukajadi     | 69.10    | 18.31 | 308.32 | 81.69 |
| 28 | Sukasari     | 0.03     | 0.01 | 288.35 | 99.99 |
| 29 | Samurbandung | 0.00     | 0.00 | 136.89 | 100.00 |
| 30 | Ujungberung  | 257.76   | 63.56 | 147.81 | 36.44 |
|    | Total        | 2,882.35 | 6,385.05 |

3.1.2. Insufficient areas of neighborhood park service area. City park existence has a great role in determining the convenience of residents that live in surrounding area. Figure 5(b) shows the area of settlements which have not been served with city park. In order to get more accurate location of districts that have not been served with city park, the result is compared with total population and density population in each district. From table 1, it can be concluded that there are 5 districts that have not been served with city park, i.e. Antapani District, Arcamanik District, Bandung Kulon District, Mandalajati District, and Ujung Berung District.

These 5 districts are weighed to calculate which district is the most unserved with park. The weight factors that were used in this research are the total area that has not been served with city park factor, percentage of area that has not been served with city park factor, total population factor, and density factor which can be seen in table 2. The result shows that Bandung Kulon district and Ujung Berung District have the biggest total weight compared with other districts. Hence, this means that Bandung Kulon District and Ujung Berung District are in main priority if the government of Bandung City has plan to build new city parks.

Table 2. Weighting sub-districts in service by city parks.

| No | District      | Area (Large Area) | Weight (Large Area) | Population | Weight (Total Population) | Populati Density | Weight (Population Density) | Total Weight |
|----|---------------|--------------------|---------------------|------------|--------------------------|-----------------|----------------------------|--------------|
| 1  | Antapani      | 238.26             | 1                   | 63.50      | 3                        | 75.460          | 3                          | 19.91        | 4            | 11           |
| 2  | Arcamanik     | 279.34             | 5                   | 50.69      | 1                        | 68.550          | 2                          | 11.68        | 2            | 10           |
| 3  | Bandung Kulon | 247.48             | 3                   | 52.37      | 2                        | 144.890         | 5                          | 22.43        | 5            | 15           |
| 4  | Mandalajati   | 243.23             | 2                   | 67.83      | 5                        | 63.500          | 1                          | 9.52         | 1            | 9            |
| 5  | Ujungberung   | 257.76             | 4                   | 63.56      | 4                        | 75.570          | 4                          | 11.81        | 3            | 15           |

4. Conclusion
This research shows that when service area of city park is calculated using network analysis method, the result is more relevant compared with the one using buffer method. The result concludes that the government of Bandung City must serve 25.1% of settlement area regarding city park provision. The distribution of city parks in Bandung City is not balanced yet since there is a lack of city parks in eastern and western part of Bandung City. From the analysis when we only calculate the area have the lowest access to the park, we find that Arcamanik District is the most priority district is the most recommended
district to build city park, but when we insert the population facto, the most recommended districts for the government to build new city parks are in Bandung Kulon District and Ujung Berung District.

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