The impact of Bandung City Development to its Carrying Capacity

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ABSTRACT

The Development of Bandung City cause increase of total population. Based on statistical data revealed that the average population growth rate of Bandung was 1.8% per year. Population increment cause to land requirements. Bandung city, which has wide 16.730 hectares has already reached 2.4 million people. Data from the satellite known that the urbanized land in Bandung City has reached to 78% of the total land surface. Population growth increment followed an increase of land requirements and land uses that are inappropriate, potentially causing a decline in capability of environment.

This paper aims to find out the capability of city environment that divided into water capability, Land carrying capacity and land suitability. The results show that the ratio of land requirements compared to its availability is 2.4 which means already deficit; the ratio of water requirements than its availability is 2.4 which means the deficits, and non conformance land has been 38%. From 2003 until 2013 data shows a trend ratio continues increasing which means declining capability of environment.

Keyword: Bandung city development, carrying capacity

INTRODUCTION

Bandung is a capital city of West Java Province, Republic of Indonesia. Figure 1 shows the location of this city. Bandung initially was a small village in 1810 called Bandung village (bandung.go.id, n.d.). The Bandung village has evolved into a city in the area as well as an increase in the number of population. In 1901 wide of bandung is 900 hectares, then becomes 2.150 hectares in 1917, and finally, since 1987 become 16.730 hectares (bandung.go.id, n.d.).

The development of Bandung city, followed by population increment. When it was still formed as village, Bandung was initially inhabited only by 30 – 40 head of family (Kunto, 2008). In 1980, the Bandung City population has reached 1.461.407 population and increased become 2.424.957 inhabitants in 2011 (Bandung Central Bureau of Statistics, 2012). Even in this year, Bandung city has become the most third crowded city in Indonesia, with the level of overcrowding 14.322 population/km2 (Wikipedia, n.d.).

Increasing in population at Bandung city is followed by increasing of land demands. The developers of such a race to build new housing on paddy field and forest, also new housing was developed by many developers is an indication of the rising demand for its housing. In the Figure 2 can be seen in the area of Cisaranten from 2003 until 2013 that can be observed from satellite photos. In 2003, the land in red line limit was a paddy field land, then in 2007 began popping one-two home and end in 2013 restricted area the red lines have been turned into a crowded residential area.
Land demands increment with limited availability land will encourage people to build in the area that should be free of buildings. In Figure 3, in North Bandung area supposed to be water catchment, apparently had built homes, villas, hotels and other buildings. Based on the regulation of State Minister for the Environment no. 17 in 2009 about the determination of Environment carrying capacity Guideline in the Spatial planning, it should be regulated for harmony between the built area and population. If residential development exceeded the determined maximum limit will be decrease of Environment carrying capacity. The cause of Environment carrying capacity decrease is extremely complex, among others, caused by population, social and cultural circumstances of the community, economic, institutional, and Government policy of Bandung city increment.

Figure 2. Increasing of land for housing from 2003 Bandung city

Figure 3. Land built up in water catchment area, image from google satelite 2013

Total Population increment caused by urbanization and the high birth rate cause land requirements increment and inappropriate land use and water resources use that exceed the available volume. Social and economic conditions of Bandung society, which in terms of GDP, total of unemployment and total of social ills one of the important sectors which can cause Environment carrying capacity decrease, because poverty is potentially causing environmental degradation (Biel, 2006). The Government policy of Bandung City which is pro-environment required to maintain carrying capacity. Its related to this issue is the completeness of the environmental regulations, regulations concerning urbanization, land use supervision and regulatory restrictions on the population. Thus, the formulations of the problem in this research are: the development of Bandung City with indications of economy, infrastructure, the social culture development can cause increment of population and prohibited land undue decrease of Bandung City carrying capacity. Hence the title of this research is the impact of Bandung City development to its carrying capacity.

Research Objectives

1. Calculate the environmental carrying capacity of Bandung.
2. Analyze the environmental carrying capacity of the city of Bandung in the last 10 years associated with the development of the city in terms of economic development and social culture.
3. Analyzing the sustainable development of Bandung city.

RESEARCH METHOD

The Data in this study are obtained based on observations of the field and secondary data. Environment carrying capacity determined using calculation method specified in the regulation of the
State Minister for the environment no. 17 in 2009 about Environment carrying capacity Guidline in the Spatial planning.

Determination of Environment carrying capacity on that guidline based on three approaches:
1. Ability to use of allocation spatial planning
2. Comparison between the land availability (land supply) and land needs (land demands)
3. Comparison between the water resources availability (water supply) and water needs (water demands)

Land carrying capacity for Land Use Allocation
This method described in how to know the proper use of space allocation based on the ability of land zoned in the form of classes and subclasses. Sub classes category divided into management unit based on restricting intensity factors on subclasses category. Thus, in the management unit category has indicated similarities potential and barriers/risks it used to determine the type of management or conservation techniques required.
Land suitability evaluation done by comparing the ability land with existing land at this time. Results of the evaluation is: fit or not fit.

Comparison Between Land Supply and Land Demands
This method used to find an overview of Land carrying capacity state in surplus or deficit. Surplus shows that the availability of local land still fulfill the requirement for biological production in that region, while deficit means that the availability of local land unable to fulfill biological production need in that region.
Calculation of Land availability and land Needs according to the regulation of the State Minister for the environment no. 17 in 2009 about the determination of the Environment carrying capacity Guidline in the Spatial planning as follows :

1. Calculation of land (supply) availability
Calculation using formula as follows:

\[ S_L = \sum \left( \frac{P_i x H_i}{H_b} \right) \times \frac{1}{P_{tvb}} \]  
--- (1)

Descriptions :
\( S_L \) = Availability (supply) of land (ha)
\( P_i \) = The actual production of each type of commodity (unit depends on the type of commodities). calculated commodities include agriculture, plantations, forestry, animal husbandry and fisheries.
\( H_i \) = Unit price each type of commodity (Rp/unit) at the level of producers
\( H_b \) = Unit price of rice (Rp/kg) at the level of the manufacturers
\( P_{tvb} \) = Rice Productivity (kg/ha)

In this calculation, the conversion factor that used for equalize product of non rice with rice is the price.

2. Calculation of land Needs (Demand)
Calculation using formula as follows:

\[ D_L = N \times KHLL \]  
-- (2)

Descriptions :
\( D_L \) = Total land requirement equivalent of rice (ha)
\( N \) = Population (people)
\( KHLL \) = Land area required for the necessities of life are worth per resident that needs decent per population is assumed to be the magnitude of 1 ton of rice/capita/year in for the productivity of rice.
3. The determination of Land carrying capacity Status
The status of land carrying capacity obtained from comparing between the land availability (SL) and land demands (DL). If SL > DL, means that land carrying capacity of area is surplus, whereas if SL < DL, means deficits.

Comparison between Water Resources and Water demands
According to the guidelines for calculate the carrying capacity of the environment, this method shows how the calculation of the carrying capacity of water in the region, taking into account the availability and demand of water resources for the people who live in the region. With this method, it is known in general whether the water resources in a region in a state of surplus or deficit. Circumstances indicate that the availability of surplus water in the region is fulfilled, while the deficit situation suggests that the region can not meet the need for water. To meet the needs of water, environmental functions associated with the water system must be preserved.

Water Availability and Requirements Calculation according to Regulation of the Minister of Environment Number 17 Year 2009 on Guidelines for Determining Environmental Carrying Capacity in Regional Spatial Planning are as follows:

1. Calculation of water resources (Water Supply)
Formula:
\[ C = \frac{\sum (Ci \times Ai)}{\sum Ai} \]  
\[ R = \frac{\sum Ri}{m} \]  
\[ SA = 10 \times C \times R \times A \]

Descriptions:
SA = Water supply (m3/year), C = Runoff coefficients, Ci = runoff coefficients of land use -i, Ai = area of land use -i (ha), R = annual rainfall of bandung city (mm/year), Ri = annual rainfall at stasion i, m = number of observation stasion, A = area (ha), 10 = conversion factor from dari mm.ha to m3

2. Calculation of water demand
Formula:
\[ DA = N \times KHLA \]

Descriptions:
DA = Total of water demands (m3/year), N = population (person), KHLA = minimum demand of water = 1600 m3 water/capita/year

3. Status of water carrying capacity
Status of water carrying capacity is identified from comparison between water supply (SA) and water demands (DA). If SA > DA, means that water carrying capacity is surplus, whereas if SA < DA, means deficit.

RESULTS
Can be seen at figure 4., trend of appropriate land use in Bandung city is increase. Environment carrying capacity of Bandung city in terms of land carrying capacity
(LCC) and water carrying capacity (WCC). LCC is a comparison between demand of land (DL) and the availability of land (SL), while the WCC is a comparison between water needs (DA) and water availability (SA). In 2013, the value = 2.4 DL/SL which means land needs 2.4 greater than the availability of land, and DA/SA = 2.25, which means water demands is 2.25 of water availability. This result shows that environment carrying capacity of Bandung City is **deficits**.

In the last 10 years from 2003-2013, this value trend shows up from LCC 1.7 in 2003 to 2.4 in 2013. WCC value also indicates the inclination up from 1.94 in 2003 to 2.25 in 2013. This shows that there has been a decreasing in Bandung City environment because of population increment.

**DISCUSSION**

Bandung city has a very attractive natural conditions for residence. Rock Quarter as a constituent of rocks which close to the surface composed of sedimentary rocks of the Lake and the volcano, and about 75% of the land area of Bandung is the inceptisol. The rocks and soil that exists in Bandung city is the type of rock and soil fertility that could potentially lead to plants that grow on it.

Bandung is also located at the elevation of 675-1050 meters. At this altitude the air feels cooler and fresh so that eventually Bandung famous as *Paris van Java*. With this good natural conditions make it became the choice of many people to become homeless. This may be causing the population of Bandung keeps growing. In 1810 a population of approximately 30-40 head of family (KK) (Kunto, 2008), in 2010 become 2,424,957 populations (BPS, 2012).

The impact of the continuous population increases land needs for resettlement, food production, industry, Commerce and entertainment. The use of natural resources to fulfill livelihood population’s life also increase.

Statistic data shows that Bandung land area when specified as the autonomous region in 1906 was 1,922 hectares, and then in 1917 was expanded into 2,871 hectares, in 1945 expanded again to 5,413, in 1949 it became the 8,098 hectares, and finally in 1987 set a 16,730 hectares (Bureau of Statistic, 2012).

The expansion of Bandung city area shows land needs increment cause of population growth always accommodated by Indonesia Government because on that day still available land for development of urban areas. But at the moment all regions are growing and require land as their capability, finally land for each areas inevitably should be restricted.

In a book titled *Essay on the Principle of Population* (1798) Robert Malthus argued that population, if not controlled, will increase according to the ratio of geometry, and livelihoods of human their rising according to series arithmetic (Malthus, 1798, p. 6). Increased according of geometric ratio means increased compliance according to series multiplication, for example 1, 2, 4, 8, 16, 32, etc, while increasing in accordance arithmetic sequence that is appropriate for the increase of computational sequence eg 1, 2, 3, 4, 5, 6, 7 etc.

With the model mentioned by Malthus (1798) the population growth will increase dramatically compared the need for subsistence or food supply. As a consequence will happen lack of food because the food before it can be used by seven million people for example, then at any given time must be divided to eight million people. The poor will live worse, much reduced labor, while prices tend to rise (Malthus, 1798, p. 9). This condition will control the birth because a lot of people put off marriage and will reduce the number of children. In addition, there will be starvation so that adds to the mortality rate, and as a result is a decline in population.

In line with the theory advanced by Malthus on population is a Minimum Legal Theory advanced by Liebig expert bio-chemistry, Justus Liebig, Germany in the 1840s. The legal Minimum of Liebig argued that in a State of steady (steady state), the size of the population of a species get a constraint of resources that supply most minimum (Chapman, Peterson, Smith-Moran, 2007 p. 90). For the human population, the barriers are the supply of food and water.

Food and water depending on the amount of land. Therefore as a limiting factor on the growth of population is water, food and land. So it can be said that by law a minimum of Liebig then this can be
the limiting factor controlling population growth. Both of these theories agree that if food, water and land are reduced then it will decline in population.

Based on the research result, Bandung Environment carrying capacity has deficit. That is, the population already exceeds the availability of land and water that becomes one of the factor of its capability. Based on the calculations, the land needs of the Bandung City population in 2012 is 2.4 times of the land availability, its included deficits category. Then its water needs, water availability is 2.25 which also means deficits category.

If it refers to a theory introduced by Malthus (1798), Liebig (1840) and Meadow et.al (2005), because of the environment capacity has been exceeded, the Bandung city population growth model should have been experiencing a downturn.

On the theory advanced by Malthus (1798), Liebig (1840) and Meadow et.al (2005) human beings are regarded as ordinary population growth so that it can be controlled by nature. In the regular population such as Tiger-deer-grass, the food chain is going to control the population growth. The deer population will be controlled by the amount of grass, and the tiger population will be controlled by the amount of deer.

These environments capacity theory also applies to a closed environment. In fact, there is rarely an environment limited/closed, so the population depends greatly on the limits of the minimum required. In the concept of human community, is a population that has a high degree of dominance (Odum, 1971). The ability to reason that high cause humans are capable of controlling and predominantly affects the environment from all the other types. Whatever the high ability as well as the urgent needs can inspire humans to modify the environment in such a way so that people can continue to maintain the sustainability of life. For example, at the time the weather is getting hot, for instance, people thus creating air room (Air-conditioning) which can be installed in home, Commerce as well as in the car.

Humans do not equal the population of tigers or reindeer that will become extinct when the amount of the food is depleted. Furthermore, based on the progress of his mind then Environment carrying capacity does not become a limiting factor.

Shortage of land in Bandung city, for example, it does not cause the population of the city of Bandung. Bandung population in 2010 is 2.424.957 inhabitants (BPS, 2012), means the land area which can accommodate the population as much as it should be 21.189 hectares. But Bandung City area apparently 16.730 hectares. For now it may be difficult if done by expanding the city of Bandung as in the 1900s. Bandung is the administrative boundary, while the ecology is not limited by the administration. Therefore, although Bandung City has an area of only administratively 16.730 hectares, but since the use of technology, transport and communication, to fulfill the Bandung City population needs, their food got from out of town like Garut, Cianjur, Ciwidey village, Lembang, and more. So, even though it has deficit Environment carrying capacity, Bandung population keeps increasing.

Bandung population growth Model is a terrible about the conditions on earth that humans continue to grow although deficit capability continues. All of the warning given by nature will be answered by a human being with the invention of new technologies to address the warning.

Who will be able to stop the deterioration of the natural environment? The answer is the man himself. Humans, not environment that can control so that the population did not hold up, humans also can control the use of other natural resources, and it is people who can remind other human beings to control so as not to damage nature in a big way.

Thus so that the State of the environment can be maintained then required the addition of a number of insightful environment, the addition of environmental experts, the addition of environmental institutions and pro-environment policies. These would be a means of controlling the development of human life so that people can grow in harmony with nature.

The existence of sustainable development concept, the establishment of Environmental Laws in various countries is realization that the only indication of people who can control the damage to the environment.

Bandung Population growth, probably caused by the old development model applied to i.e only development-oriented economic growth, so that the economy is growing nicely but not yet fully
controlled environment. Regional gross domestic product (GDP) of Bandung city on the basis of constant prices for the year 2010 the amount is Rp 31,697,282 million in 2011, and then increased to Rp 34,463,631 million or increased production of 8.73%. The rate of economic growth in 2011 of 8.73% (BPS, 2012).

GDP is the calculation of the value for money of the final goods and services produced by an area in any given year. GDP has yet to reflect the actual state of the economy due to the calculation of GDP not reduced the value of natural capital depreciation (Ratnaningsih, et.al., 2013). Because environmental degradation factors not listed then the GDP can only seen in economic growth. The environmental value of the depreciation factor occurs because the production process cannot be known. Thereby, in development planning, the economic became the focus of attention. As a result, there is the occurrence of environmental degradation.

The development of urban areas is also not in accordance with Law No. 26 of 2007 about the arrangement of the space. The Law (Act) are hereby expressly mentioned that the drafting spatial plans of counties should pay attention to capability and environmental capacity.

Based on the above mentioned Act, maximum built land area is 60% and 40% of open land. As a comparison between reality and the ideal State built land area in Bandung, can be seen in table 1.

Table 1 Comparison of Bandung city land between reality and should be referred to the law No. 26 of 2007 Concerning Spatial (source: research results).

<table>
<thead>
<tr>
<th></th>
<th>2003</th>
<th>2007</th>
<th>2010</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Real land up</td>
<td>12,240</td>
<td>12,517</td>
<td>12,588</td>
<td>13,118</td>
</tr>
<tr>
<td>Ideal land up</td>
<td>10,038</td>
<td>10,038</td>
<td>10,038</td>
<td>10,038</td>
</tr>
<tr>
<td>Difference (%)</td>
<td>18</td>
<td>20</td>
<td>20</td>
<td>23</td>
</tr>
</tbody>
</table>

The population in 2010 is 2,424,957 person (BPS, 2012), means the land area which can accommodate the population as much as it is with land composition 21.189 hectares built and open areas may can be seen at Table 2. But if the land area can not be changed anymore i.e. 16.730 hectares, the population is 1,914,670 person.

Table 2 Population and land area of Bandung city to match with environment carrying capacity

<table>
<thead>
<tr>
<th></th>
<th>IDEAL</th>
<th>IDEAL</th>
<th>REAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population (person)</td>
<td>2,424,957</td>
<td>1,914,670</td>
<td>2,424,957</td>
</tr>
<tr>
<td>Land up</td>
<td>12,713 (60%)</td>
<td>10038 (60%)</td>
<td>12,588 (75%)</td>
</tr>
<tr>
<td>Unbuilt land</td>
<td>8,476 (40%)</td>
<td>6,692 (40%)</td>
<td>4141 (25%)</td>
</tr>
<tr>
<td>Total land (hectare)</td>
<td>21.189</td>
<td>16.730</td>
<td>16.730</td>
</tr>
</tbody>
</table>

The population in 2010 is 2,424,957 person (BPS, 2012), means the land area which can accommodate the population as much as it is with land composition 21.189 hectares built and open areas may can be seen at Table 2. But if the land area can not be changed anymore i.e. 16.730 hectares, the population is 1,914,670 person.

Sustainable development aims to the development undertaken by human beings at this time not destroy the environment so that future generations can still enjoy a good quality of the environment. Given that the people who can control of environment quality is the man himself so that the concept of sustainable development can be put in place, people must learn and understand population growth form, determine the optimum size of quantitatively and configuration of a human population in relation to a particular area of support resources and are ready to accept the cultural setting where nature control not running (Odum, 1971).

To make development of Bandung City is sustain, then the reliance of population toward environment carrying capacity must be reduced by implementing appropriate technologies, such as food processing technologies that apply to land that can be generated good food.

Improved transportation facilities so that people who want to enjoy the facilities, infrastructure and economic growth of Bandung City does not have to reside in the territory of the city of Bandung. They
can work in the city of Bandung, but resides in surrounding area such as Cimahi, Padalarang, etc. This can be realized if the transportation between area keep at cheap prices, fast and secure. The use of the railway infrastructure either conventional or monorail is one of the best alternatives to current traffic conditions. The idea for the megapolitan Jakarta is one example of extending the Land carrying capacity to support Jakarta. With the concept of a megapolitan, then capability Jakarta increase land area without having to expand the boundaries of his administration. For Bandung city, this idea needs to be realized because of Land carrying capacity currently espouses deficit. Repairment of transport and communication will make easy inhabitants of Bandung city to fulfill food needs. Housing developments and commercial means at this time, its time to apply the vertical development of the system (multi-storey apartments, malls, and more), thus reducing land needs. Furthermore, it mentioned before that who can control the behavior is a man himself, then it should be improved, the number of private institutions, Government or non-profit pro-environment in order to control the development plan area. The Government should be pressured to always control the rate of population growth and land use, so that does not occur in population explosion and the explosion of land use needs.

CONCLUSIONS

Bandung environment carrying capacity can be reviewed from the value of Land carrying capacity (LCC) and water capability (WCC).
LCC is a comparison between the land needs (DL) and the availability of land (SL), while the DDA is a comparison between water needs (DA) and water availability (SA). In 2013, the value = 2.4 DL SL which means land needs 2.4 greater than the availability of land, and DA/SL = 2.25 which means water needs is 2.25 from its availability.
From these values the Bandung City environment carrying capacity in deficit category. In the last 10 years from 2003-2013, value trend shows up from DDL 1.7 in 2003 to 2.4 in 2013. DDA value also indicates the increment from 1.94 in 2003 to 2.25 in 2013. This shows that there has been a decline of Bandung Environment carrying capacity as impact of the population increase.

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