The relationship between night time light and population in 2000 and 2015 in The Java Island

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Abstract. Night time light may indicate that a region is well developed. The phenomena can DNB satellite imagery. The amount of reflected light can be attributed to many population activities and indicates the number of inhabitants in a region. Based on the purpose of this research is to analyze the dynamics of population growth in Java in 2000 and 2015 based on the brightness level of light at night. The method be seen from the sheer reflection of light at night that is received by the VIIRS- used is by a classification method of K-Means and a descriptive analysis. The results showed that as intensity level higher, the number of population is also higher. High-intensity categories generally occur in the provincial capital, and there are new cities that are developing and entering the high-intensity category as well.

1. Introduction

Night time light is one of the indicators of determining the extent of progress in the region [1]. Night time light comes from various lighting used to illuminate housing, roads, and various other facilities. Night time light gives a unique picture of dwelling place, density, and population distribution [2], that makes the light at night an indication that a region is developing well.

A large population generally denotes Well-developed cities in comparison with the surrounding towns. The large population is affected not only by birth and death but also by urbanization. Urbanization tends to motivated by the desire for better housing. The large population will also affect an increase in territory for activity, whether for housing or the industry[3]. note that night time light directly give a relatively accurate picture of how to identify human activity and its spatial characteristics.

Satellite imagery of VIIRS-DNB (Visible Infrared Imaging Radiometer Suite-Day/Night Band) is a night satellite image managed by the Earth Observation Group, National Oceanic and Atmospheric Administration (NOAA), this satellite image measures radiation of night time lighting emitted upward from the surface and transformed by the atmosphere [4, 5]. The VIIRS-DNB satellite imagery provides cloud imagery during the day and also provides some of the imagery data in the infrared channel for cloud imaging applications during the day and night. Also, the VIIRS-DNB imagery data is also used to measure weak light radiation for the study of Energy estimation exposure [6]. One of the advantages of using VIIRS-DNB satellite imagery is that the data is consistently consistent and continuously repeated annually.

Night time light can be used to examine various kinds of things, such as predicting urban expansion [7], the development of an area [1], and many others. The utilization of light data in the evening can also be used to see the dynamics of the population, based on this research aims to analyze the
dynamics of population growth in the island of Java in 2000 and 2015 based on a Brightness level of light at night.

2. Method

2.1 Study Area
The location of this research located in Java Island, which consists of 6 provinces, namely Banten, DKI Jakarta, West Java, Special Region of Yogyakarta, Central Java, and East Java. Figure 1 is an illustration of research location.

![Figure 1. The Study Area](image)

2.2 Data
The research uses VIIRS-DNB night satellite imagery data from 2000 and 2015 (figure 2), managed by the Earth Observation Group, National Oceanic and Atmospheric Administration (NOAA) and then cut using RBI 1:500,000 Maps for island area Java, and uses a population data of 2000 and a projected population of 2015 downloaded from the Central Statistic Agency website (https://www.bps.go.id). The population data of 2015 uses projection data due to unavailability of the census of Population data for the year on the BPS website. The specifications for the VIIRS-DNB satellite imagery can be seen in Table 1, while for the population between 2000 and 2015, it can be seen in Table 2.

![Figure 2. VIIRS-DNB Satellite Imagery in Java Island (a) 2000 (b) 2015](image)

Each satellite image has different specifications both from spectral, temporal, or spatial resolution. The specifications for the VIIRS-DNB satellite imagery can be seen in Table 1. Then for the population for the years 2000 and 2015, it can be seen in Table 2.
Table 1. VIIRS-DNB Satellite Imagery Specifications

| Specification          | Description                                      |
|------------------------|--------------------------------------------------|
| Spectral Channels      |                                                  |
| a. Visual Channels/near-infrared | Recording 9 times per day/night                  |
| b. Medium Infrared     | 8 times/day                                      |
| c. Far Infrared        | 4 times/day                                      |
| Satellite Mass         | 275 kg                                           |
| The average power of satellites in orbiting | 200 Watt                                       |
| Data acquisition parameters |                                              |
| a. Spatial resolution  | 0.742 km x 0.742 km                              |
| b. Speed data          | 10.5 Mbps (maximum)                              |
| c. Quantization data   | 12 bit-14 bit with A/D converter for low noise   |
| d. Stroke length       | ± 56°, 3.000 km                                  |

Table 2. Java Island Population Data

| Province          | 2000   | 2015 (Projection) |
|-------------------|--------|-------------------|
| DKI Jakarta       | 8.389.443 | 10.177.900       |
| Jawa Barat        | 35.729.537 | 46.709.600       |
| Jawa Tengah       | 31.228.940 | 33.774.100       |
| DI Yogyakarta     | 3.122.268  | 3.679.200         |
| Jawa Timur        | 34.783.640 | 38.847.600       |
| Banten            | 8.098.780  | 11.955.200       |

2.3 Data Processing
The process of data processing in this research consists of three phases: data collection, image cropping, and analysis of the resulting data. The flowchart for the process is presented in Figure 3, while for explanations regarding the three processes are as follows.

a. Data collection
The research uses five data which is the image of VIIRS-DNB in 2000 and 2015 obtained from NOAA (National Oceanic and Atmospheric Administration); Map of RBI Province 1:500,000 obtained from BIG (Geospatial Information Agency); Population data of 2000 and the projected data of the population of 2015 obtained from the BPS (Central Statistic Agency).

b. Image cropping
Cropping of imagery is done using ArcGIS software. Image of VIIRS-DNB cut with map RBI Province 1:500,000 located in Java Island. The two images of VIIRS-DNB that were cut will result in the image of the VIIRS-DNB Java Island in 2000 and VIIRS-DNB image of Java in 2015.
c. Analysis
This research analyzes the image of the VIIRS-DNB Java Island in 2000 and 2015, which is correlated with population data of 2000 and population projection data in 2015. The analysis will produce and a map of the night time light intensity distribution in Java in 2000 and 2015 based on K-means classification method, and the table of city growth in Java in 2000 and 2015.

Figure 3. Flow Chart

3. Data Analysis
The method used to analyze the results obtained is by using descriptive analysis. This analysis is used to describe the dynamics of nighttime light scattered throughout the province in Java Island.

4. Result and Discussion
Distribution of nighttime light in Java Island spreads unevenly both in 2000 and 2015. The dominating category in both years was a moderate category of 86% in 2000 and 84% in 2015. The high category generally dominated by major cities such as DKI Jakarta, Surabaya, Bandung, Semarang, Yogyakarta. Low category for the years 2000 and 2015 in dominance in the southern part of Java Island. That can be attributed to the status of the area in the form of forest. The map illustration is in Figure 4.

Provinces that do not change and remain in the high category is DKI Jakarta. The factor that encourages this is the high population activity in DKI Jakarta province and a significant increase in 2015 that affects high category distribution in surrounding areas such as Bekasi City, Bogor, Depok, Tangerang, and Karawang. The high category is dominated by provincial capital areas, such as Serang, DKI Jakarta, Bandung, Yogyakarta, Semarang, and Surabaya. The city of Serang in 2000 was in the
category of moderate, in the same year that city was also appointed as the capital of Banten province. As that city grew in 2015, there was a change in category status to high category.

![Map of The Distribution of Night Light Intensity](image1)

**Figure 4.** Map of The Distribution of Night Light Intensity (a) 2000, (b) 2015

The development of an area can be seen from a better category change than before. Became evident in the number of new cities that entered the high category in 2015. The provinces of the newest cities are Central Java province as many as 25 cities, while the least province is Yogyakarta as much as one city. The number of cities developing in Central Java can be connected with the existence of these cities, which is the main route of land transportation in the island of Java.
### Table 3. New City on the high category in 2015

| Province      | City     | Province      | City     | Province      | City     |
|---------------|----------|---------------|----------|---------------|----------|
| Banten        | Cangkuwu | Cepu          | Cimah    | Karangasem    |
|               | Ceplak   | Ciamis        | Demak    | Kepanjen      |
|               | Cimas    | Demak         | Jepara   | Krian         |
|               | Dukun    | Kendal        | Kedungwuni| Lamongan      |
|               | Rajeg    | Kendal        | Sangkat  | Mojoseangun   |
|               | Serang   | Mojokerto     | Nganjuk  | Mojokerto     |
| West Java     | Babakan  | Klaten        | Ngawi    | Ngawi         |
|               | Batujajar| Magelang      | Nganjuk  | Pare           |
|               | Cianjur  | Maranggen     | Prambanan| Prambon       |
|               | Cobanusa | Pasu          | Purbolinggo| Purworejo    |
|               | Cicalengka| Pramaling     | Purwodadi | Samrang       |
|               | Cisarua  | Pernalang     | Rejubang  | Singapuran    |
|               | Cisolok  | Purwodadi     | Salariga  | Singapuran    |
|               | Cisoklo  | Slawi         | Serang    | Singapuran    |
|               | Cimlang  | Telegomulyo   | Tegal     | Singapuran    |
|               | Majalaya | Villu         | Tulangan  |                |
|               | Sawo     | Central Java  |          |                |
|               | Sindanglaut| Surakarta    |          |                |
|               | Subang   |              |          |                |
|               | Sumber   |              |          |                |
|               | Tasikmalaya|              |          |                |
| DI Yogyakarta | Sleman   |              |          |                |
| Central Java  | Ambarawa | East Java     | Bangil   |                |
|               | Bae      |              | Bangkalan|                |
|               | Batang   |              | Batu     |                |
|               | Blera    |              | Bondowoso|                |
|               | Boyolali |              | Cerme    |                |

The area of night light intensity display in Figure 5 in each province for the low average category decreased in 2015 compared to 2000; the most significant decline occurred in West Java is 6659 km². The area of night light intensity in each province for moderate category also decreased in 2015 compared to 2000; the most significant decline occurred in West Java is 59439 km². The reason is due to the geographical location adjacent to DKI Jakarta so that it is experiencing faster development than other provinces.

Bustos states that there is a relationship between night light and economic activity in both areas of high and local light intensity in GDP development [1]. In comparison to the widespread changes in night time light intensity to high categories, in high category there is an increase in the intensity of night light at every province in 2015 compared to 2000, the most significant improvement is in Banten amounted to 1553 km².

The result explains that if the high category has increased, it will directly affect the decreasing of moderate and low categories. The encouraging factor is the rate of increasing population in each province that can be seen in Table 2.

BPS’s data showed that there was an increase in population in each province of Java from 2000 to 2015. The highest population increase in West Java amounted to 10,980,063. The development of a region is indeed not separated from the availability of social, economic facilities, and infrastructure within the region. Areas with rapid development will undoubtedly be influenced by several factors such as population factors, which is growing, the rapid growth of populations will follow a region. Population growth causes increasing demands on the availability of various facilities and infrastructures such as housing, shopping centres, health, education, city transportation, and other public facilities [8].
5. **Conclusion**

The night light intensity level in Java island directly shows the relationship with the increasing number of inhabitants in each province. The higher the intensity, the more the number of inhabitants. High-intensity categories generally occur in the provincial capital, and there are new cities that are developing and entering the high-intensity category as well. The increased development of these cities influences the decline in moderate and low categories.

6. **Reference**

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