Analysis of Influence Settlement Density on the Fire Hazards Settlement at Cengkareng Subdistrict, West Jakarta

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Abstract. This study aims to determine the influence of settlement density on the fire hazard in the dense settlement area. This study location is in Cengkareng Subdistrict, West Jakarta. The population in this study was all the settlements or settlement blocks in the Cengkareng Subdistrict. This research uses the descriptive quantitative method, while data is collected using the Arc GIS Online satellite image. Technological advances in remote sensing and GIS can be used to analyze fire hazard settlements based on the variables that determined. The results showed that there was a significant influence of settlement density to increase the fire hazard in the settlement area. Therefore, the cooperation of society is still needed to participate in disaster mitigation to reduce the losses and needed to socialized to another institute in can be utilized in the planning of construction of the settlement fire response and providing fire extinguisher facilities.

1. Introduction
West Jakarta is a city while the development stage characterized by an increasing population and equipping public facilities to support community activities. The development of West Jakarta is quite rapid; this can also see from the rising number of construction of facilities and infrastructure to help the businesses of the community. Potential disasters are also found in densely settlements areas in West Jakarta, especially in Cengkareng Subdistrict, where settlement fires are possible [1].

Fire disasters do not know the time, so it cannot predict when and where these events will occur; therefore, fires can be said to be undesirable fires [9]. Fire disaster which is also explained in Law Number 24 the Year 2007 concerning Disaster Management which clarifies the definition of a fire disaster is a situation where a building in a place such as a house/settlement, factory, market, construction, and others attack by fire which causes victims and loss. The presence of an unexpected fire disaster at the time, place, and who will be the victims makes all parties must make efforts to anticipate and prevent as early as possible.

Building fire is an adverse disaster because it affects people or objects contained in the building or the surrounding environment. Fires also cause material losses and have the potential to result in a high mortality rate, thus requiring attention to the safety of building users and residents around the building area. Building fire is one of the problems in urban areas that are difficult to avoid. Typical causes of fire disasters in urban areas include the usage of wood fuel and charcoal for room heating, poverty, ignorance, waste burning around courtyards [11]; poor city infrastructure for firefighting and accessibility [8]; and insufficiencies in disaster prevention policies [29]. Frequent fire disasters are often common in crowded central business districts (CBDs) and markets [19] and are one of the major concerns for urban planners. Congestion and high density of buildings and the people increase the potential for fire risk occurrences, heightening the fire risks and rescue efforts.

Areas that are vulnerable to fire hazards characterize by dense physical building conditions, irregular building patterns, and low-quality buildings, coupled with the lack of fire extinguisher facilities. The linear distance between houses will make it difficult for firefighters' cars, and the lack of functioning of fire hydrants will facilitate fire spreading [24].

DKI Jakarta Provincial Fire Service mentions various characteristics of fire hazard areas, including narrow environmental roads, many turns that make it difficult for fire engines to turn, shoulders used to park vehicles, distances between buildings are very tight and irregular, and water sources are rare and less cooperative community behavior. These characteristics refer to the general condition of dense settlements in Jakarta, one of which located in the Cengkareng District. Seeing the losses incurred by
the fire disaster, both material and non-material losses that are not small, so it takes an effort to prevent and reduce the risk of fire hazards, namely by mapping the level of fire hazard. With the fire hazard level map, fire prevention and mitigation measures can implement effectively.

Fire hazard mapping can be done using the remote sensing approach. The remote sensing approach is advantageous and efficient in function as a source of mapping data because the information can obtain about an object, area, or phenomenon through data analysis obtained using tools without direct contact to objects, regions, or events studied [1]. The use of remote sensing data can cover some of the shortcomings in terrestrial surveys that have a relatively long measurement time, substantial activity costs, and require a lot of energy. For mapping the level of fire hazard in urban areas, we need a satellite image with high spatial resolution and temporal resolution, because the data required is in the form of data with detailed spatial information and can detect rapidly changing urban physical development.

Thus, the research topic to be proposed is identifying the level of danger of settlement fires in Cengkareng Subdistrict, West Jakarta. Cangkareng Subdistrict chooses because it is a dense residential area with the highest frequency of occurrence in the last five years (2013-2017) as well as the diversity in the incidence of fires.

2. Methods

This study location is in Cengkareng Subdistrict, West Jakarta (Figure 1). This research conducted in Cengkareng Subdistrict, West Jakarta, DKI Jakarta Province. Astronomically, Cengkareng Subdistrict is located at 5°19’12” SL - 6°23’54” SL and between 106°22’42” EL - 106°58’18” EL with altitude at the range of 7 m above sea level. Cengkareng Subdistrict has an area of 2,654.04 ha consisting of 6 districts, namely West Cengkareng Village with an area of 361 ha, East Cengkareng Village with an area of 452 ha, Kedaung Kaliangke Village with an area of 361 ha, East Cengkareng Village with an area of 452 ha, Kapuk Village with an area of 563 ha, Duri Kosambi Village with an area of 452 ha an area of 591 ha, and Rawa Buaya Village with an area of 407 ha [6]. Administratively, Cengkareng Subdistrict has the following boundaries:
1. Northside: River / Kali / Railway in Penjaringan District, North Jakarta
2. Southside: Railway / Ex. Gas Factory in Gambir District, Central Jakarta
3. Westside: Flood Canal / Railroad in Grogol Petamburan District, West Jakarta
4. Eastside: Krukut River / Besar River in Cengkareng District, West Jakarta

Cengkareng Subdistrict is one of the subdistricts in the West Jakarta area that have RW 84 / RT 1,017 that has a population of 514,416 people consisting of 262,093 males and 252,323 females with a population density of 19,383 people/km² in 2017 [6].

The research method that chooses in this study utilizes imagery to obtain research variable data. Image interpretation techniques use in collecting data that will use as a residential fire hazard variable, including variables that are settlement density. To determine the level of fire hazard based on the physical condition of the settlement will be done with a quantitative approach, namely, a weighted scale. This scaling is doing by giving value to variable that used, and the variable is assigned a weight or a weighing factor. The weighted tiered scaling method use in this scaling. The weighing factors function to assess the extent of the effect of variables on the assessment of residential fire hazards where the value is between one and three.

The weighting factor with a value of one indicates a small influential variable, an amount of two points a moderate effect, and a value of three has a significant influence on the level of settlement fire hazard. Research variables that have a high impact give a high value, namely three values and included in the classification of good. Variables that have not significant influence are given a moderate amount, namely the cost of two, while variables that do not affect the danger of settlement fires provide a low value that is the value of one.

The variable is utilizing the Geographic Information System processing software, Arc GIS. The research variable used is settlement density. Besides, fieldwork is needed to match the results of interpretation with the actual situation in the field. Data analysis performed with a Geographic Information System (GIS) using ArcGIS software for the processing of data interpretation.
3. Results and Discussion

3.1. Interpretation of Used Settlement and Non-Settlement
The high number and density of the population in an area will have an impact on increasing the need for land for settlements and infrastructure. A high population density requires the addition of socio-economic facilities such as increasing housing needs, increasing employment opportunities, educational facilities, and improving health facilities and services [27]. The high population in Cengkareng Subdistrict has led to an increase in the demand for settlements while the available land is narrow, resulting in more dense colonies. Policies are needed to develop for controlling the density of buildings and infrastructure facilities in the region. These are administrative maps (Figure 2) and imagery maps of Cengkareng Subdistrict (Figure 3):
Figure 2. Administrative Maps of Cengkareng Subdistrict

Figure 3. Imagery Maps of Cengkareng Subdistrict
The land use in Cengkareng Subdistrict in 2014 mostly dominated by buildings with an area of 1157.68 ha and 84.39 ha constituting parks and others. The following presented in the following table form:

### Table 1. Percentage of Land Use by Designation Use by Village in Cengkareng Subdistrict, 2014

| No | Village               | Settlement | Industry | Office Affairs/Business | Park | Others |
|----|-----------------------|------------|----------|-------------------------|------|--------|
| 1  | Duri Kosambi          | 55.67      | 20.92    | 18.00                   | 1.65 | 3.76   |
| 2  | Rawa Buaya            | 60.93      | 14.67    | 22.67                   | 0.48 | 1.25   |
| 3  | Kedaung Kaliangke     | 63.67      | 15.10    | 20.97                   | 0.00 | 0.26   |
| 4  | Kapuk                 | 72.16      | 12.72    | 13.79                   | 0.37 | 0.96   |
| 5  | East Cengkareng       | 78.53      | 10.91    | 6.00                    | 3.82 | 0.74   |
| 6  | West Cengkareng       | 80.65      | 2.62     | 10.97                   | 1.00 | 4.76   |
| 7  | Cenkareng Subdistrict | 68.60      | 12.82    | 15.40                   | 1.22 | 1.96   |

Source: Cengkareng Subdistrict in Number 2018

From the table above, it can seem that the most significant development is the construction of houses/settlements. The settlement built as a place to live or as a business place and now become increasingly narrow, and the price becomes more expensive. The village with the most significant settlement development in Cengkareng Subdistrict is West Cengkareng Village. As a result of housing developments is the increasing the number, it causes by crowded settlements while the use of land for non-settlements is minimal.

The error data during interpretation caused by the estimated number of houses in the residential block unit, the boundaries between settlements are not precise and the size, especially in areas of high density and moderate density.

#### 3.2. Variable: Settlement Density

Settlement density variables divided into three classes, namely high density, moderate density, and low density. High-density settlements easily identified through imagery because of the condition of the settlements that are close together between residential buildings. Moderate-density determined from the sparse distance between houses; between one building and another, there are still trees which side yards. Low-density concluded the settlement location is far from each other due to the existence of separators such as yards [27]. More clearly can be seen the comparison of the appearance of the image with the presence in the field in the table below:

### Table 2. Result of Interpretation of Settlement Density Variable

| No. | Object Appearance on Imagery | Object Appearance on Ground | Class        |
|-----|-------------------------------|-----------------------------|--------------|
| 1   | ![High Density Image](image1) | ![High Density Image](image2) | High Density |
| 2   | ![Moderate Density Image](image3) | ![Moderate Density Image](image4) | Moderate Density |
The value that gives to the density of settlements by limiting zoning and interpreting the number of roofs in each residential house then comparing with the area of settlement zoning. Each settlement zoning is defined by road units, making it easy to provide boundaries and assess settlement densities [27]. The distribution of settlement zoning based on settlement density in Cengkareng Subdistrict can seem in the following map of settlement density (Figure 4):

![Figure 4](image_url)

**Figure 4.** Maps of Settlement Density of Cengkareng Subdistrict

Based on the map of settlement density, it can seem the level and percentage of settlement density in each village in the Cengkareng Subdistrict. The following presented in the table:

**Table 3.** Area and Percentage of Settlement Density Variables in Cengkareng Subdistrict

| No | Class           | Large (ha) | Percentage |
|----|-----------------|------------|------------|
| 1  | High Density    | 955.22     | 35.99%     |
| 2  | Moderate Density| 580.60     | 21.87%     |
| 3  | Low Density     | 17.83      | 0.67%      |
| 4  | Non-Settlement  | 1100.40    | 41.46%     |
|    | **Total**       | **2654.04**| **100%**   |

Source: Result of Data Analysis, 2019
Based on the analysis results in the table above, 955.22 ha or 35.99% of the total area of Cengkareng Subdistrict can obtain. The upper-middle class is the most significant settlement by the West Cengkareng Village, with an area of 136.81 ha or 21.87% of the total area of the Cengkareng Subdistrict. Kedaung Kaliangke Village is the region with the lowest density class in Cengkareng Subdistrict, with an area of 15.33 ha or 0.67% of the total area of Cengkareng Subdistrict.

Duri Kosambi Village has the highest area of zoning, with the most significant city, which is 183.14 ha, and more buildings built, usually used residential houses such as boarding houses, rented houses, apartments, or used for businesses such as shops and others. Besides, Duri Kosambi Village located in Rawa Buaya Station, which is crossed by class three/small trains. Low-density settlements are 204.37 ha, and low-density settlements are 1.81 ha.

Rawa Buaya Village has a residential area with a high-class field, which of 142 ha, a middle class of 64.12 ha, and no low class. The relationship Rawa Buaya Village is very crowded. There are still many settlements on the banks of the Angke River. Cengkareng Subdistrict has a high hazard of fire settlement. Many numbers of areas that are potential for fires, especially areas with high settlement densities, and the lack of fire extinguisher facilities makes Cengkareng Subdistrict dangerous to fire settlement [27].

The addition of buildings for houses in Rawa Buaya Village is near and becomes a crossing point for industrial and trade areas in the Kamal Cengkareng area. Besides, overcrowding and high building density, fire can start and spread easily in such locations due to a number of factors, including: cooking on open fires or unstable stoves, use of combustible fuels (for cooking, heating, and lighting), unsafe electrical connections, ignorance of safe practices, alcohol intoxication, arson, flammable building materials, lack of fire hydrants and water supplies, and the inability of fire services to bring fire-fighting equipment through narrow lanes and alleys [28].

4. Conclusions
1. The danger level of residential fires in the Cengkareng Subdistrict dominated by high-class.
2. The danger of settlement fires in Cengkareng Subdistrict with a high-class amounted to settlement zoning (35.99% of total area) with the most dominant distribution being in the East Cengkareng Village, the number of settlements namely zoning with an area of ha. Moderate-class in Cengkareng Subdistrict is settlement zoning (21.87%), with the most dominant distribution being in the Duri Kosambi Village, West Cengkareng Village, Rawabuaya Village. Low-class in Cengkareng Subdistrict amounted to the zoning of settlements (0.67%), with the most dominant distribution being in the Kedaung Kaliangke Village.

The results of this study need to disseminate to various agencies related to disasters, especially settlements fire so it can use for planning the construction of fire response settlements and providing fire disaster fighting facilities cause the fires that occurred in Cengkareng Subdistrict mostly originated from the lack of public awareness of the dangers of fire disaster and the still lack of fire extinguisher facilities near community settlements. Communities should participate in disaster mitigation, especially settlement fires to reduce the losses incurred in the event of settlement fires.

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