Environmental Carrying Capacity Assessment of an Industrial Estate (Study of Cikupa Mas Industrial Estate Tangerang Regency)

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Abstract. Complete facilities and good infrastructure are the main point why Tangerang Regency is a strategic area for industrial activities. Many business operator and developer tempted to build industrial estate. But various economic and social activities in industrial estate tend to affect and change the physical condition of the environment. Environmental carrying capacity becomes one important component to understand the ability of environment in supporting every organism’s activity. This research aims to analyze environmental carrying capacity in an crucial industrial estate in Tangerang Regency, that is conducted by seeing two main elements: land carrying capacity and water carrying capacity. The selection of research location was conducted based on the complexity of industrial activities and the scale of the industry. Quantitative method was applied and data analysis was done to analyze the current status of water carrying capacity and land suitability. Water demand in the study area is higher than the supply, it is cause a deficit condition in water carrying capacity. Meanwhile, the soil types (alluvial and mediterranean) have a low erositivity levels, so it will be safe for industrial activities. Furthermore, geography and hydrology condition is very compatible for an industrial estate.

1. Introduction
The spatial change becomes a problem that happens as caused development activities. With the spatial changes, the ecological environmental condition of an area is influenced. Basically, all production and consumption activities always produce waste in the form of gas, particulates, solid waste, liquid waste, or chemical waste, and when waste and pollution have exceeded the capacity of nature to absorb it, there will be problems in the ecological system process [1]. The development process in the past really depends on nature system capacity in absorb, transport, and process waste [1], this what makes the implication of carrying capacity and environmental capacity. Environmental carrying capacity consists of several factors, that are atmosphere, soil environment, social economy, water ability in conducting self-purification also limitation of an area to fulfill the needs according to natural resource and ecological environment [2]. The ecological carrying capacity is focused on good and stable condition in ecological system, species, community, and population, while environmental carrying capacity aims
to realize evolution that gives benefits to human [3]. Analysis of environmental carrying capacity really help in determining the sustainable development status of an area [4]. The utilization of environmental carrying capacity that is closed to 100% which will cause risks such as flood, erosion, decrease in ground water level, also the decrease of water resource. The growth of population and the increase of energy use also environmental pollution is a big pressure for limited natural resource and vulnerable environment [2]. When the demand towards ecological resource passes over what can be provided by nature sustainably, then it is called as ecological overshoot.

The development of industrial estate is closely related to land conversion, where productive land is often converted into industrial land. In fact, the change of land function in Tangerang Regency is quite significant, in 1992 the large of industrial area reached 1.236 Ha or 1.11 % from overall large of Tangerang Regency, then in 1997 the large of industrial area was increased for 0.3 % becomes 1.567 Ha or 1.41 % from overall large of Tangerang Regency, then the highest increase occurred in 2002 where the area of industrial land became 3,398 Ha or 3.07% of the total area of Tangerang Regency or an increase of 1.66% [5]. The change of land function will affect the decrease of carrying capacity and land quality [6]. Beside has implication in land, plants, and rapid development, will affect to soil water resource, such as impacts on aquifer natural infiltration, due to concrete pavement and pollution of groundwater quality because of drainage effluents and industrial wastes [7]. But, in other hand, industrial estate has important role in development of a country, the bigger the industrial capacity of a country, the bigger its potential for growth and development of economy, and if the sustainability principle is implemented in its development, the society life quality standard will increase, beside the income, type of jobs, education, and health also get better [8].

The purpose of the industrial estate development in Indonesia has been explained in Government Regulation No 142 of 2015 which include accelerating the spread and equitable distribution of industrial development, enhancing industrial development efforts that are environmentally sound, increasing investment competitiveness and industrial competitiveness and providing location certainty in accordance with spatial planning. The developed countries that focused on industrial sector is generally has regulation that arrange and manage water availability by managing water flow in big rivers, save water as reserve for various kinds of needs and protect the water quality [9]. Indonesia also has regulation related to industrial estate, that is PP No 142 of 2015 concerning Industrial Estate, Minister of Industry Regulation No 40 of 2016 concerning Technical Guidelines for the Development of Industrial Estates also the industrial wastewater quality standards arranged in the Minister of Environment Regulation No 03 of 2010.

Cikupa Mas Industrial Estate is chosen as research location based on consideration that according to RTRW of Tangerang Regency, Cikupa District is an area chosen as industrial area. There are many research method to quantify water carrying capacity, the most popular method is indicator-evaluation method that establishes a reasonable indicator system that yields intuitive and clear results [10]. According to environmental water carrying capacity, it is necessary to select various goals (e.g., of the society, economy, population, and ecological environment) and simultaneously quantify optimizing objectives and constraint conditions coordinated with the aforementioned goals [10]. Geographical information system and matrix method is one of the effective method to identify land carrying capacity, this method could identifying effective factors in environmental degradation including climate, geology, hydrology data, and some degradation factors in the region [11]. But in this research, analysis of environmental carrying capacity of industrial estate using calculation that has been predetermined in Minister of Environment Regulation Number 17 of 2009 concerning Guidelines for Determination of Environmental Carrying Capacity in Determination of Regional Space. The writer decide to use this method because of the data availability is suitable for calculate based on it. Land productivity and water availability are two main variables, those two can represent the environmental carrying capacity in research location whether could or not support every industrial activities. This assessment is needed to quantify the current condition to minimize the environmental impact in the future.
2. Materials and methods
Cikupa Mas Industrial Estate is located in Cikupa District (Figure 1) which is based on its use, this area consists of 1,91 Ha rice fields area and 202,88 Ha non-rice field area with domination of industries and settlements [12]. In general, Cikupa district is located in the 41 meter above the sea level, thus from its geographical condition Cikupa District is included in lowland zone (below 100 mdp) [13]. The primary arterial road network approximately 25 kilo meters makes Cikupa District is quite in strategic location, and Tangerang-Merak Toll road facilitate the vehicles access. The sufficient infrastructure makes Cikupa Mas IE as the best choice to conduct industrial activities. On 2018 Cikupa Mas IE total area reached 250 Ha and consists of 136 tenants with domination of manufacture industries. In its planning, cluster system of Cikupa Mas IE is divided based on industrial scale (small, medium, and large). But, in its implementation, big scaled industry determines their development location and generally far from other industries to make it easy if they are going to expanse their industry.

![Figure 1. Location of Cikupa Mas Industrial Estate](image)

This research comprehensively considers the variable and sub variable which influences in environmental carrying capacity of Cikupa Mas IE. The main variable in this research is the water availability and land productivity. The data used in environmental carrying capacity analysis is secondary data obtained from developer of Cikupa Mas IE, Cikupa District Office, and Budiarto Curug Meteorological Station. Some data obtained are data of water needs, water availability, rainfall, land needs, and land availability in research location. The research uses quantitative method and Minister of the Environment Regulation No 17 of 2009 concerning Guidelines for Determination of Environmental Carrying Capacity in the Determination of Regional Spaces to calculate and analyze water carrying capacity in research location. Meanwhile the land carrying capacity was analyzed by referring to Minister of Agriculture decree No. 837/KPTS/UM/11/1980 and No. 683/KPTS/UM/8/1981.

3. Results
3.1 Water carrying capacity
The water carrying capacity is analyse by comparing between water availability (SA) and water needs (DA), using calculation in Minister of the Environment Regulation No 17 of 2009 concerning Guidelines for Determination of Environmental Carrying Capacity in the Determination of Regional Spaces. The water need is calculated based on total population and water need standard for decent life.
While the water availability is calculated by seeing some components which are runoff coefficient, average of rainfall and annual rainfall. The result of calculation (table 3) shows that water carrying capacity is in deficit condition, this is caused by groundwater extraction practices for industrial, commercial, or domestic activities that is not in accordance with the permit.

### Table 1. Water carrying capacity of Cikupa Mas IE

| Water Availability (Sa) | Water Needs (Da) | Status of Water Carrying Capacity |
|-------------------------|------------------|-----------------------------------|
| 347.680                 | 781.768          | Sa<Da (Deficit)                   |

### 3.2 Land carrying capacity

Geographically, Cikupa Mas IE is located in strategic location with easy access. The availability of various land transportation (bus, city transportation, online motorbike) certainly facilitate the mobilization of population around Cikupa Mas IE and the workers. That condition is really helpful for Cikupa Mas IE significance development. Land carrying capacity is analyzed by assessing the topography condition, types of soil, and hydrology in research location. Topography of Cikupa Mas IE is flat area in 25 mdpl which has land suitability that can be developed for various kinds of urban activities. [13]. If the data is compared with land scope class criteria based on Ministry of Agriculture Decree No. 837/KPTS/UM/11/1980 (table 2), then it shows that topography condition of Cikupa Mas IE is very good. The land flat condition is very suitable and safe for industrial activities, because the potential to the occurrence of slide or flood is quite small. That becomes additional value that can give safe feelings to the investors to run their industrial activities in that location.

### Table 2. Land class criteria

| Slope Class | Slope Corner | Description | Description |
|-------------|--------------|-------------|-------------|
| 1           | 0-8%         | Flat        | Excellent   |
| 2           | 8-15%        | Sloping     | Good        |
| 3           | 15-25%       | Rather Steep| Medium      |
| 4           | 25-40%       | Steep       | Bad         |
| 5           | >40%         | Very Steep  | Very Bad    |

Cikupa District has various types of soil, but it is dominated with podsolic, andosol, brown alluvial dan mediterranean. Based on scoring criteria of soil types by Khardiyanto [14] it is known that the level of erosivity in Cikupa District is vary (table 3).

### Table 3. Erosion level of Cikupa District

| No | Type of Soil | The Sensitivity Level Towards Erosion | Score |
|----|--------------|---------------------------------------|-------|
| 1  | Aluvial      | Non Sensitive                         | 15    |
| 2  | Mediterranean| Less Sensitive                        | 45    |
| 3  | Pedosolic, Andosol | Sensitive                  | 60    |

Based on the table, alluvial and mediterranean soils which have low erosivity levels are very suitable for industrial estate, so it will be safe to build buildings. While, for areas with pedosolic and andosol soil types, permanent building should not be built, because they will be prone to erosion. Furthermore, rainfall data are needed to conduct hydrological analysis in the research location. Basically, the lower the intensity of rain in the industrial estate, the better it will be because the possibility of flood is smaller. Based on data obtained from the Budiarto Curug Meteorological Station, it is known that the average rainfall intensity in Cikupa District is only around 173.84 mm/year. The rainfall intensity that below 1500 mm/year is included in category of very low rainfall

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intensity, indicating that the hydrological conditions in the Cikupa District are very suitable for industrial estate. So that there will be no inundation or flood which is dangerous for the sustainability of industrial activities. But on the other hand, with the low intensity of rain the industry cannot collect rainwater in infiltration wells and only depends on water supply from PDAM which its quantity, quality and continuity are strongly influenced by the season.

4. Conclusion
Basically, land carrying capacity of Cikupa Mas IE is in accordance with its functions as industrial estate, but the high water demand makes water carrying capacity becomes deficit. There is a need of technology utilization for the recycle of non-contaminated used water from industrial activities and maximization of infiltration wells in every industry, beside can reduce cost of water purchase from PDAM, of course it can reduce water pumping from the ground that can cause the decrease in ground water level. Regulation that is compatible with environmental sustainability principle, supervisory and good implementation, has become external component that can help to maintain environmental carrying capacity in that industrial estate.

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