Eco-Industrial Estate Strategy Application for Conventional Industrial Estate

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Abstract- Several previous researches state that industrial estate tends to negatively impact its surroundings, both to its natural environment and its social impact to people around the area. Previously, an eco-industrial park / estate (EIE) concept that could be a solution to the common problem of a conventional industrial estate has already exist. However, the concept is still rarely applied. Surabaya Industrial Estate Rungkut (SIER), an industrial estate that has been operating for more than 44 years, would be better to start applying EIE concept. The following research was conducted at SIER, which is arguably the largest and the best well-known industrial estate in Indonesia, especially in East Java. Despite this, SIER still has a chance to be optimized and developed by applying EIE concept. The research was conducted with the aim of knowing; whether EIE concept can be applied to SIER, the application of EIE strategy, and how to determine the most suitable alternative application of EIE concept that could be applied to SIER's development. The method used in this research is qualitative and quantitative approach, using descriptive analysis techniques, AHP techniques (analytical hierarchy process), and descriptive statistics. The results show that in the application of EIE concept to SIER, the prioritized criteria that has to be applied would be effective management with the sub-criteria of inter-company cooperation in product (productive networking). Whereas, the most appropriate EIE implementation strategy would be to apply alternative green industrial park models to SIER by applying the appropriate building-code.

Index Terms- Building-code, Eco-Industrial Estate, Green Industrial Park, Product Networking, SIER.

I. INTRODUCTION

Surabaya had always been prioritizing the application of environmentally-oriented concepts in every part of the city. The city is supposed to be a green city in 2020 [1]. However, its industrial estate hasn't been showing any evidence of support. All of the industrial estates in Surabaya are still conventional, thus, the concept of eco-industrial park/estate (EIP/EIE) were not applied. The industrial estate holds a rather important role which could produce a tremendous impact, especially a negative impact to the environment [2][3]. The application of eco-industrial park/estate (EIP/EIE) could be a solution to the common problems of the conventional industrial estate.

Eco-industrial estate (EIE) or more commonly known as eco-industrial park (EIP) is a set of industries (producers of products / services) and businesses located within an area aimed at improving environmental, economic, social and environmental management capabilities as well as the resources generated from an area [4][5]. The difference between a conventional industrial estate and an industrial estate that applies the concept of eco-industrial estate in energy usage as well as other effectively (cost) is relatively large and significant [6]. By applying the concept of eco-industrial estate, many advantages are gained so that industrial estate can become more optimal.

Surabaya Industrial Estate Rungkut (SIER) is an existing industrial estate that will be used as the study case of this research. SIER is a conventional industrial estate that had applied several eco-friendly concepts on its complex [7] but still has an opportunity to be developed more by applying the concept of eco-industrial estate (EIE). Departing from the background that had been described, the purpose of this research is: to determine the characteristics and potential opportunities that affect the development of SIER in becoming EIE, to discover the criteria and the sub-criteria priority in applying the concept of EIE to SIER, and to decide the most suitable alternative strategy of the EIE concept application to SIER.

II. METHODOLOGY

The method used in this research is a combination of qualitative and quantitative methods. In this research case studies are conducted along with field observations and literature studies of both conventional industrial estate and industrial estate that had implemented the EIE concept. This research is then followed by data collection, data analysis, and interpretation of the analysis results to obtain information that will be processed to be taken as a conclusion.

A. Analytical Technique

In the research conducted, there are three research objectives. To achieve each goal, different analysis techniques are used.

1) Qualitative Analysis and Quantitative Statistic Descriptive.

Conducted to determine the characteristics, potential opportunities and problems that affect the development of existing industrial estate (SIER). This would then help in establishing whether EIE concept can be applied to SIER. In the first phase, a case study and descriptive analysis were conducted to find out the criteria and sub-criteria for applying EIE concepts that were used as variables from the research.

2) Analytical Hierarchy Process (AHP).

Conducted to determine the order of priority criteria and sub-criteria from the most important to the least important in the application of EIE concept to SIER. The application of EIE strategy will be based on this order. The analytical hierarchy process technique is used as a tool for decision analysis with many criteria and also involves many variables of choice (Saaty, 2000) [8]. This technique has three main principles: the principle of hierarchy, the principle of priority setting, and the principle of logical consistency.

3) Descriptive Statistics.

Conducted to determine the suitability of the criteria and sub-criteria with some alternative models of EIE implementation and determine the most suitable alternative model to be applied in SIER. Using descriptive statistics techniques, the description of the answers of the respondents will be explained based on the frequency or the number of respondents who answered the surveys from a score of 1 to 3.

B. Population and Sample

Using the technique of non-probability sampling, which will then be using purposive sampling, the population in this study is the respondents in the form of practitioners involved with the industrial estate in its management.

The sample of this research is the decision maker that works in SIER. To determine the respondents in this research, respondents were analyzed and grouped based on their roles and interests into two matrices like shown in Figure 1 (Bryson, 2004) [9].

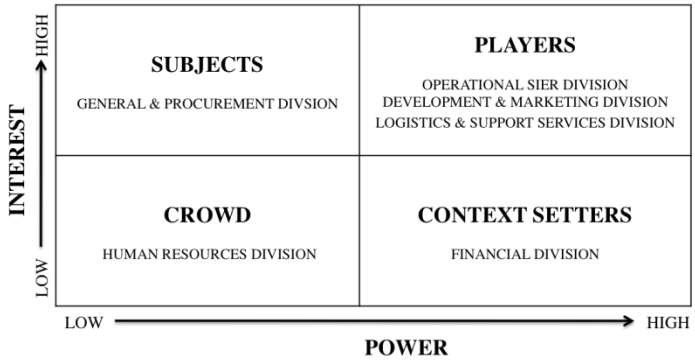

Figure 1: Matrix *Power versus Interest Grids* (Grouping of Respondents)

Respondents are the decision makers from groups of players with high roles and interests to achieve research objectives of the development of SIER to EIE.

III. DISCUSSION AND RESULT

A. EIE Criteria and Sub-criteria (Research Variables)

The variables in this research are EIE criteria and sub-criteria like shown in the Table 1. Criteria and sub-criteria are syntheses of fundamental principles and criterias in developing an EIE with the main theory of EIE that implements principles according to Lowe (2001) [5]. Subsequent surveys were carried out in the field to prove and to match the theory sites in the case study area mentioned and to conduct a descriptive analysis.

Table I: Research Variables

No	Criteria	Sub-Criteria
1	Integration with nature	Low adverse impact on the environment
		Application of green design concepts
2	Energy and water system	Suppress energy consumption
		Efficiency in energy utilization in the region (recycling and reuse)
		Use of water treatment system
3	Material and waste management	Optimal use of all materials (sorting, reuse, recycle)
		Pollution prevention
		Minimize the use of toxic materials
		Material / regional waste

No	Criteria	Sub-Criteria
		exchange
		Implementation of concept cleaner production
4	Sustainable design and construction	Optimize the use of more efficient resources
		Environmentally sensitive construction
		Low maintenance
		Use renewable and recyclable resources
5	Effective management	Cooperation between companies in the region
		Application of advanced technology at the facility
		Use of shared services and services
6	Integration with surrounding communities	Benefit the economic development of the surrounding community
		Provide training to the surrounding community

B. Ranking the Criteria and Sub-criteria.

In computing the vectors of criteria and sub-criteria weights in the development of SIER towards EIE, the first step taken is to develop a hierarchy of conventional industrial estate development (Figure 2).

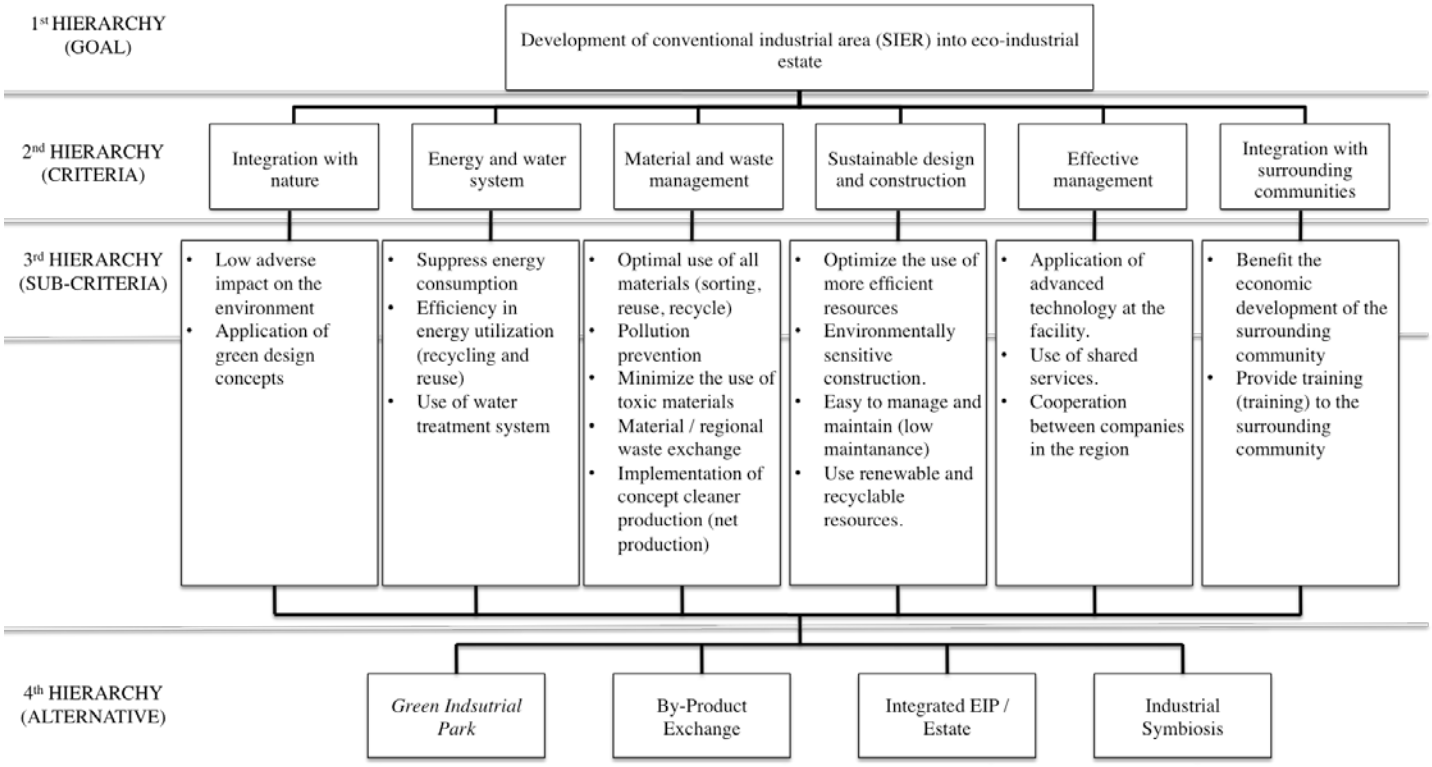

Figure 2: Hierarchy of Conventional Estate Development

This is then will be followed by doing interviews and distributing questionnaires to 7 respondents that had been chosen for weighting calculations with several steps, which are: normalization, summing the results of normalization, divide the number of each criteria and sub-criteria (comparison), and consistency test. The result of ranking is as shown by Table 2.

Table II: Overall Priority Weight Value on Criteria and Sub-criteria

No	Criteria and Sub-Criteria	Weight Value
1	Effective management	0.397
a	Cooperation between companies in the region	0.179
b	Application of advanced technology at the facility	0.13
c	Use of shared services and services	0.088
2	Integration with surrounding communities	0.165
a	Benefit the economic development of the surrounding community	0.09
b	Provide training to the surrounding community	0.075
3	Sustainable design and construction	0.161
a	Environmentally sensitive construction	0.063
b	Optimize the use of more efficient resources	0.034
c	Low maintenance	0.033
d	Use renewable and recyclable resources	0.031
4	Material and waste management	0.137
a	Implementation of concept cleaner production	0.045
b	Pollution prevention	0.038
c	Optimal use of all materials (sorting, reuse, recycle)	0.024
d	Minimize the use of toxic materials	0.022
e	Material / regional waste exchange	0.008
5	Integration with nature	0.091
a	Application of green design concepts	0.056
b	Application of green design concepts	0.035
6	Energy and water system	0.05
a	Efficiency in energy utilization in the region (recycling and reuse)	0.022
b	Use of water treatment system	0.02
c	Suppress energy consumption	0.008

C. Alternative Model

There are four predefined model alternatives that are a tangible form of applying the EIE concept to some pre-existing industrial estate [10]. The four models are: green industrial park, by-product exchange, integrated EIP, and industrial symbiosis. To determine/come up with the most suitable alternative model to be applied to SIER, descriptive statistical technique is used. At this stage, the description of the answers to the sub-criteria compliance to the alternative model will be explained based on the frequency or the number of respondents who answered the surveys from the score of 1 to 3, the calculation of the average of each variable, and the category of categorized average values. The rules used in categorizing are:

$$\text{Class interval} = \frac{\text{Highest value - lowest value}}{\text{Number of classes}}$$

Information:

The highest value is 3, the lowest value is 1, the number of classes is 3.

From the formula above, obtained the value of class interval as shown by Table 3.

Table III: Assessment category

Interval	Category
0.0 – 0.7	Not appropriate
0.8 – 1.5	Appropriate/corresponding
1.5 – 3.0	Very appropriate

Description of the respondents' answers to the alternative models of eco-industrial estate application which is the result of the respondent's answer on each variable (sub-criteria) to the alternative model indicates that alternative 1 is the most suitable green industrial park to be applied to SIER. According to the respondents, almost all sub-criterias determined are appropriate for this alternative.

The definition of a green industrial park is a group of companies / industries that have a shared commitment and goal to realize an industrial area that produces clean products (eco-friendly) and contributes significantly to the development of sustainable industries. In industrial zones, every company / industry applies production cleaning technology, processes a lot of the waste that they produce and / or undertakes efforts to reduce greenhouse gas emissions within the area where they operate. In the production process each industry prioritizes sustainable efficiency and effectiveness of resource use, uses environmentally friendly materials, minimizes waste, uses low energy and utilizes energy as efficiently as possible by reducing, recycling, and reusing.

D. Strategy of Application Eco-Industrial Estate to SIER

In applying EIE to SIER, the most important priority criterion or criteria to be applied is effective management, whereas the criteria considered as the least important is the criteria of the water energy system. The most important priority sub-criteria is inter-company cooperation, while the least important sub-criteria is to reduce energy consumption.

Strategy of applying alternative 1 (green industrial park) at SIER at this time can be done by applying building code stipulation for all existing building, such as:

1) Application of green design concept in building
2) Environmentally sensitive construction
3) Easy to manage and maintain (low maintenance)

with the following objectives:

1) Minimize negative impacts on the environment
2) Emphasis on energy consumption
3) Efficiency in energy utilization in the region
4) Optimize the use of more efficient resources

In addition to the establishment of building code to realize an ideal green industrial park, every production process and operation of the the factory in the complex should also be encouraged and expected to:

1) Optimize the use of all materials (sorting, reuse, recycle)
2) Minimize the use of toxic materials for the purpose of pollution prevention
3) Apply the concept of cleaner production (net production)
4) Use renewable and recyclable resources
5) Benefit the economic development of the surrounding community
6) Provide training (training) to the surrounding community

IV. CONCLUSION

The conducted research shows that EIE concept can be applied to SIER. Based on the result of weighting the responses of the decision makers of SIER management, it had been stated that in the application of EIE concept strategy to the conventional industrial estate (SIER) the prioritized criteria that has to be applied would be effective management. Whereas, the criteria considered as the least important is the criteria of the water energy system. The most important priority sub-criteria is inter-company cooperation, while the least important sub-criteria is to reduce energy consumption.

Based on the result of data processing of conformity criteria and sub-criteria with alternative models of applying eco-industrial estate using descriptive statistic, a conclusion could be drawn that the most suitable alternative to be applied to SIER is the application of the green industrial park model.

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