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# Ecological Design of Fernery based on Bioregion Classification System in Ecopark Cibinong Science Center Botanic Gardens, Indonesia

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**Abstract.** Indonesia as mega biodiversity country has a wide variety of ferns. However, the natural habitats of ferns are currently degrading, particularly in lowlands due to the increasing level of urban-sprawl and industrial zones development. Therefore, Ecology Park (Ecopark) Cibinong Science Center-Botanic Gardens as an ex-situ conservation area is expected to be the best location to conserve the lowland ferns. The purpose of this study is to design a fernery through an ecological landscape design process. The main concept is The Journey of Fern, this concept aiming on providing users experiences in fernery by associating conservational, educational, and recreational aspects. Ecological landscape design as general is applied by the principal of reduce, reuse, and recycle (3R). Bioregion classification system is applied by grouping the plants based on the characteristics of light, water, soil, air, and temperature. The design concept is inspired by the morphology of fern and its growth patterns which is transformed into organic and geometric forms. The result of this study is a design of fernery which consist of welcome area, recreation area, service area, and conservation education area as the main area that providing 66 species of ferns.

## 1. Introduction

The Total amounts of ferns diversity in Indonesia is no less than 2,000 species. Papua and Borneo Island is estimated to have around 2,000 and 1,000 species of ferns. However, during the last five decades, the natural habitat of ferns has been degraded due to the massive land changing for urban, industrial, and agricultural [6]. One way to remain the sustainability of ferns diversity is through conservation. The Centre for Plant Conservation – Bogor Botanical Garden as government institution has various of ex-situ area, one of them is Ecology Park (Ecopark), Cibinong Science Center-Botanic Gardens (CSC-BG). Ecopark as ex-situ conservation areas have urgency in preserving the diversity of ferns. The urgency arises because the current natural habitat in the lowlands are more likely to be more degraded than the highlands.

Conservation of ferns in Ecopark conducted through the development of garden collection. Aside from being a conservation area, a garden collection can also be used as facilities of research, education, recreation, and environmental services, corresponding to the functions of the botanical

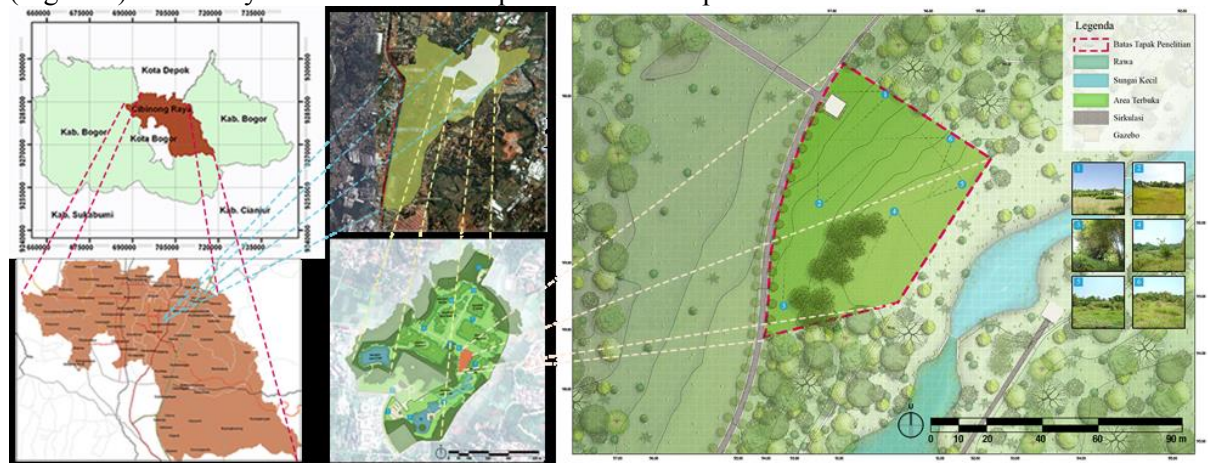


garden in the law of Indonesian Institute of Science (LIPI) No. 1 Year 2014. Therefore, the purpose of this study is to design a fernery in Ecopark through an ecological approach by assessing the site characteristic.

## 2. Methodology

### 2.1. location and time

The study is located at Jln. Prof. Dr. A. Tisna Amidjaja, Ecology park, Cibinong Science Center-Botanic Gardens, Cibinong District, Bogor Regency, West Java Province, Indonesia. Geographically, the site of study is at coordinates 6o29'26" LS – 6o29'28" LS and 106o51'5" BT – 106o51'7" BT (Figure 1). The study was conducted in April 2015 until September 2016.



**Figure 1.** Site location

### 2.2. Methodology

#### 2.2.1. Preparation

The preparation phase consists of setting the goal and preparing the tools and materials. Tools and materials on this study consists of hardware (GPS, measure tape) and Software such as Autodesk AutoCad and Trimble SketchUp.

#### 2.2.2. Site Inventory

Site Inventory phase is to collect the data of biophysical, visual, socio-cultural, and regulation aspects which consist of primary and secondary data. The primary data is obtained through surveys, interviews, and questionnaires. Meanwhile, the secondary data is obtained through books, maps, journal, and other related references.

#### 2.2.3. Analysis and Synthesis

Analysis and synthesis performed to determine the most suitable areas for the use of the site and score the feasibility of the planned use of the site. Analysis and synthesis focused on three aspects, that are the potential and the constraints of the site; the characteristics, perceptions, and preferences of the visitor; and the carrying capacity of the site. The analysis-synthesis on potentials and constraints, of the site, and also on characteristics, perceptions, and preferences of the visitor is conducted by descriptive method. Meanwhile, the analysis-synthesis on the carrying capacity of the site is performed by descriptive and mathematical methods. The analysis of carrying capacity is focused on the sensitivity of ferns. The analysis is conducted by giving the score of 1-3 on each indicator that have been modified to the ferns (Table 1). Furthermore, the value of every indicator summed together and being classified into three levels of sensitivity, that are the low sensitivity (score 5-8), moderate (9-11), and high (score 12-15).

**Table 1.** Rate sensitivity of ferns

Indicator	Parameter	Score
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Status	IUCN*: least concern	1
	IUCN*: near threatened & vulnerable	2
	IUCN*: endangered & critically endangered	3
Type	seasonal plants	1
	annual plants	2
	perennial plants	3
Roots and Rhizome	tap roots	1
	fibrous roots	2
	aquatic, epiphytes, & lithophytes	3
Stem and rachis	Sturdy stem, prickly, and/or toxic	1
	Pseudo stem and/or easy to germinate	2
	Succulent	3
Leaf and lamina	The appearance of shape and colour is not attractive	1
	The appearance of shape and colour is quite attractive	2
	The appearance of shape and colour is very attractive	3

\*IUCN (International Union for the Conservation of Nature)

Source: Ruhiyat (2008) with modification

#### 2.2.4. Design

The design phase begins with a concept diagram. The concept diagram consists of the main idea, design concept, and the concept of development. The result developed through schematic design concept in the form of blocks and scenario planning phase. Then, the design is detailed through design development consisting of site plans and illustration.

### 3. Result and discussion

#### 3.1. General Condition

Ecopark is a public park that located in CSC-BG, LIPI. Ecopark is built as an extension of Bogor Botanical Garden that have a common purpose, namely as a means of education, research, and ecotourism. Currently, Ecopark has a garden collection grouped by bioregion, covering Sumatera Bioregion; Java and Bali; Borneo; Lesser Sunda Island; Celebes; The Mollucas, and Papua. In addition, there is a lake known as Dora Lake, information center, rest facilities, and parking facilities. However, there are also empty land which has not been used and developed by the manager so that not all areas can be used by visitors.

Site study located in Ecopark with 4,720 m<sup>2</sup> area dominated by grass. There are wild bamboo groves in the south and southwest arches and a gazebo in the northwestern part of the site. The site is bordered with Kalimantan bioregion on the north and northeast, the outlet of Dora Lake in the east, a path on the west, and Papua Bioregion in the southern part of the site. Currently the site is included in the area that has not been utilized by the manager of Ecopark.

#### 3.2. Analysis and Synthesis

##### 3.2.1. Analysis-Synthesis the Potentials and Constraints of the Site

The site is located near from the center of Bogor Regency administration, allowing visitors, especially from Bogor City, Depok City, and Jakarta City to visit the site. However, the site has less attraction for visitors because of the absence of the object recreation and education so that the necessary additional recreational and educational attractions that can attract visitors.

Judging from the slope of the land, the site has a slope ranging from 0-15%. The of 1-10% is category of ideal slope to serve a variety of functions without the need for grading room. Meanwhile, the slope of 10-15% is considered too steep for variety land use and easily eroded [1]. Therefore, engineering footprint through excavation, embankment, and retaining wall into solutions to minimize and avoid the problem of erosion.

Soil at the site is latosol that manifold with high clay content is not good for the growth of ferns for texture is hard and the lack of aeration. The problems addressed by the addition of organic mulch on planting area. On the other hand, clayey soil has good soil strength. That conditions allow the construction of small to medium scale landscape can be built without special treatment of the soil.

The quality of water included in the category quite well through the identification of physical, chemical, and biological functions of water. However, there is garbage in some parts of the water body so that it can have negative effects on water quality. Therefore, the application of the bulkhead in spam filter is required to facilitate garbage collection. Review of aspects of drainage, the absence of drainage channels with clay soil become obstacles footprint. Stormwater management becomes the means used to overcome these obstacles [7]. Temperature and humidity monthly average in Bogor in 2014 was 25.93 oC and 82.83 %. The ideal temperature for tropical ferns range 21-27 oC with humidity between 60-80 % [3]. The comfortable temperature for human in tropical regions are ranged at 22.80-25.80 oC with humidity between 40-75 % [5]. Based on that, the temperature is ideal for fern habitat and human comfort. Instead, the humidity is less than ideal for fern habitat and also human comfort. The humidity is reduced through modifications to the wind, by arranging landscape elements and pursed tightly thereby creating Windstream [8]. Judging from the sun's radiation, the site conditions are still comfortable to visit because of the solar radiation absorbed by vegetation tended lawns with 0.25 albedo values and broadleaf vegetation albedo values between 0.15 to 0.18 [10].

The site is dominated by vegetation and reed (*Imperata cylindrica*) makes visibility horizontally and vertically extensive, but also creates the impression of monotony. The monotony can be reduced through adding landscape elements. While from an ecological standpoint, vegetation plays in climatic amelioration, improving water quality, and affect wildlife.

The element of landscape dominated vegetation present a natural character and provide a positive visual impression. Objects outside the footprint of Dora Lake, Mount Halimun-Salak and Mount Gede-Pangrango be borrowing landscape to the site. This potential needs to be improved through the addition of landscape elements that support. However, there are also bad view due to litter and vandalism. These obstacles are overcome through the addition of garbage bin.

### 3.2.2. Analysis-Synthesis the Characteristics, Perceptions, and Preferences of Visitors

Based on data form the questionnaire, respondents consisted of men (32.26 %) and women (67.74 %). Almost half of them live in Bogor City (48.38 %). Distribution of the age of the respondents was dominated by the age of 16-20 years (54.84 %). Most of the respondents were students (64.52 %) and amounted to 45.16 % of respondent receive allowance < Rp 1,000,000 per month. Judging from visitor perception, most respondents know Ecopark as an education-tourism area (31.43 %). However, the activity of dominant recreational activities just like enjoying the scenery (27.27 %) and photographed (25.00 %). Most Respondents found hot climate (54.55 %) and dirty park (24.24 %) as a major problem at the site.

Based on the preferences of the fernery function, the majority of respondent want the facilities that support leisure activities such as bench (36.17 %), gazebo (21.28 %), and water feature (14.89 %). Meanwhile, the preference for educational facilities such as interpretation boards that giving information of the fernery (47.22 %). Judging from the preference for fernery design, most respondents wanted organic pattern (51.61 %) or a blend of organic and geometric patterns (41.94 %). Elements of landscape vegetation (93.55 %) was selected as the main elements compared to building and pavements. Meanwhile, the use of natural landscape material (64.52 %) such as stone and wood is preferred as the main material than the manmade materials such as glass and metal.

## 3.3. Design

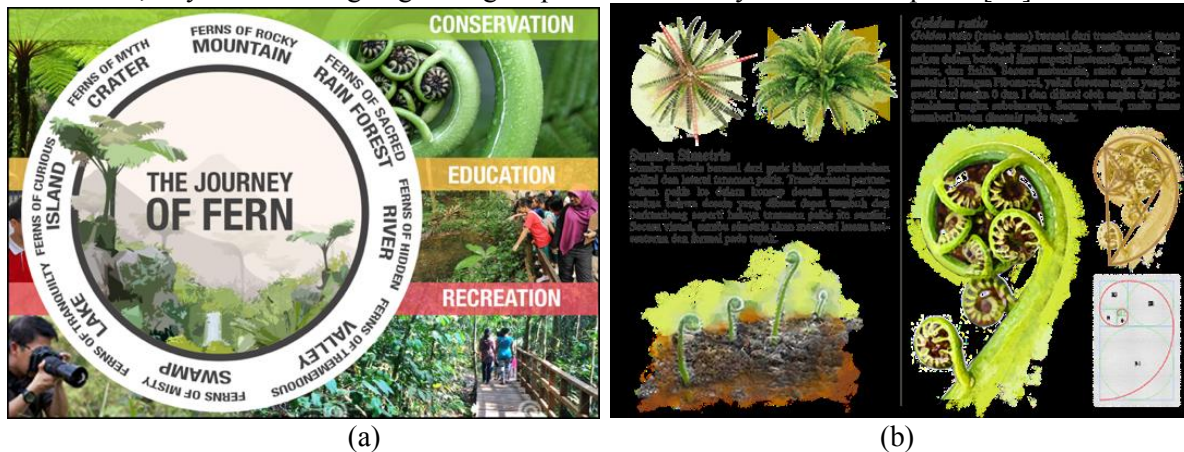
### 3.3.1. Basic Concept

In general, the planning and design of the site in this study raised the concept of The Journey of Fern, which is a concept of the park harmonize aspects of conservation, education, and recreation, through grouping ferns based classification proximity habitat/bioregion/ecoregion (Figure 2a). This concept

was formulated on the basis of the unity of the theme in Ecopark and also consistent with respondents high interest to the implementation of the fernery based on bioregion classification.

### 3.3.2. Design Concept

The design concept of the site is inspired by the morphology of the ferns. Ferns morphological transformation into an organic form is the basis for the design (Figure 2b). This form gives an dynamic, cheerful, soft, and grows on the landscape. In addition, the symmetrical shape will also applied to the design. Symmetrical horizontal lines provide a relaxed and calm atmosphere. Meanwhile, a symmetrical zig-zag lines give passionate and dynamics atmosphere [10].



**Figure 2.** (a) basic concept (b) design concept

### 3.3.3. Concept Development

The concept of space, activities, and facilities of the site consists of four main area namely welcome area, recreation area, conservation and education area, as well as service area (Table 2). The concept of circulation and accessibility of the site refers to the concept of universal design [2]. Universal design is an approach to design that provided circulation for visitors, including persons with disabilities. However, not all circulation at the site is designed using a standard disability circulation. Therefore, the concept of circulation and accessibility at the site is divide into three types, two of them, the primary circulation and secondary circulation is used for all visitors, meanwhile, the tertiary circulation is used to be specific visitors.

The concept of vegetation refers to the basic concept of the site. Fern planting plan carried out systematically through bioregion proximity grouping to simplify the process of data collection and documentation of vegetation (Table 3). However, other plants outside of fern is also a consideration in the design. The concept of hydrology and drainage refers to the goal of garden design. This aspect has a role in influencing the microclimate in each collection area. In addition, the development of this concept is also done through an ecological approach that is by creating a sustainable water management system. However, the site also as a public park need to consider this aspect of the aesthetic and recreational function in addition to the ecological function. Therefore, the concept of hydrology and drainage footprint consist of three types, namely as stormwater management, water feature, and litter trap. The visual concept refers to the basic concepts, so that the natural character of the landscape elements preserved and presented at the site. The visual concept consists of themes related to landscape macro in nature. Application of theme park is used to distinguish the collection of ferns and provide a different experience for visitors. Technically, the themes raised include landscape mountains, craters, forests, rivers, valleys, swamps, lakes, islands, meadows, and cliffs. As spatial, those concept is merged to block plan and being detailed on site plan (Figure 3).

**Table 2.** The concept of space, activities, and facilities of the site

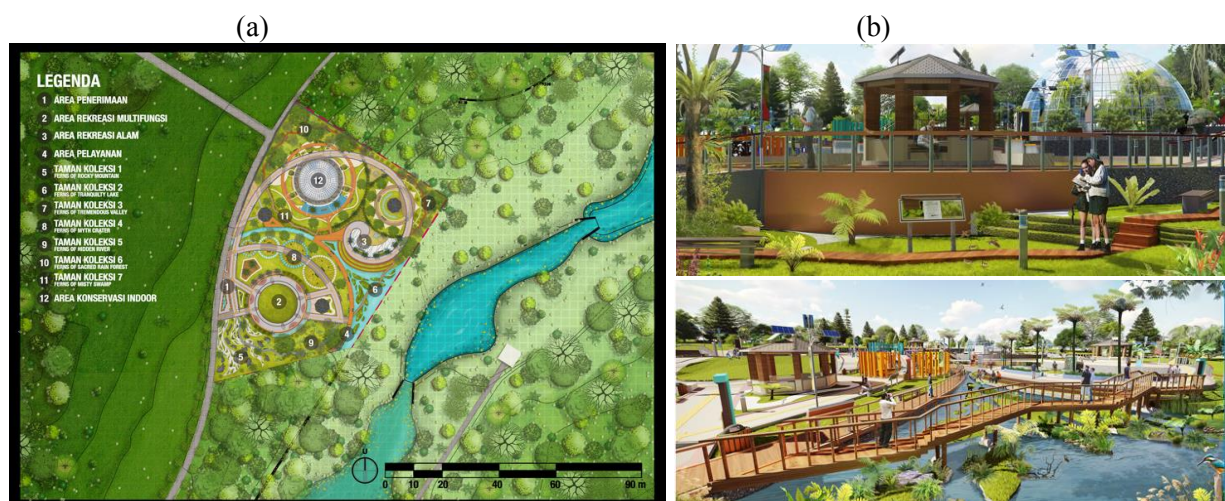
Space	Sub space	Activities	Facilities	Area (m <sup>2</sup> )	Percentage (%)
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Welcome area		Marking spot	Gate, signage, information gate	90	1,9
		Meeting point	Bench, plaza		
Recreational area	Nature recreation area	Gathering, photo	Bench, gazebo	1400	29,7
		Viewing landscape	Promade, water feature		
	Multifunctional recreation area	Gathering, photo, picnic	Bench, gazebo, lawn, outdoor auditorium, plaza		
Conservational & Educational Area	Collection gardens	Marking spot	Interpretation board, signage	3200	67,8
	Indoor conservation	Observe	Fern collection		
		Research, breeding	Green house		
Service Area	Waste management area	Waste management	Garbage bin, litter trap	30	0,6
	Water management area	Water purification	Vegetated swales, bioretention swales, bioretention basins/ rain gardens		
Total				4720	100

**Table 3.** Ferns classification through bioregion closeness and vegetation sensitiveness

No	Zone	Amount of species
1	<i>Open/ direct sun plant - Terrestrial – Normal land</i>	10
2	<i>Open/ direct sun plant - Terrestrial – Moist land</i>	8
3	<i>Open/ direct sun plant - Epiphyte – Normal land</i>	2
4	<i>Open/ direct sun plant - Epiphyte – Moist land</i>	2
5	<i>Shaded plant - Terrestrial – Normal land</i>	15
6	<i>Shaded plant - Terrestrial – Moist land</i>	12
7	<i>Shaded plant - Epiphyte – Normal land</i>	10
8	<i>Shaded plant - Epiphyte – Moist land</i>	7

No	Vegetation sensitiveness	Amount of species
1	Low	19
2	Moderate	40
3	High	7

**Figure 3.** (a) site plan (b) perspective

#### 4. Conclusion

Based on research, the site has a characteristic lowlands with high rainfall throughout the year. Site conditions in accordance with ferns lowland habitat. The number of species of ferns have been identified with 66 species are classified into seven types of garden collections based on proximity bioregion and three categories of sensitivity by the sensitivity analysis of vegetation. The site as exsitu conservation has the function to preserve a diverse collection of plants. The site as a public park to accommodate visitors in a variety of outdoor activities. The fernery design uses the concept of The Journey of Ferns that links the aspects of conservation, recreation, and education nature through ecological approach and grouping ferns based bioregion. The pattern of fern garden design collection comes from the transformation of morphology and growth patterns of fern into organic and geometric shapes. Ecological design of the garden fern collections applied through stormwater management, litter trap, environmentally friendly energy, and composting organic waste. There are four main area on this design, that are welcome area, recreation area, service area, and conservation-education area as the main area. The conservation-education area consist of ferneries with the various kind of visual themes, those are fernery with mountainous, lake, valley, crater, river, rain forest, swamp theme, and an indoor conservation as the core of the ferneries with island theme.

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