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Sumatera Utara Botanical Conservatory (With Ecology Architecture Design Approach)

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ABSTRACT

Climate change affects many things, especially plant diversity. Indonesia's number of endangered plant species continues to increase every year. Meanwhile, ex-situ conservation and research facilities are still unavailable in North Sumatra. The conservatory itself has the primary function as a conservation institution that seeks to maintain and breed various types of plants, especially endangered plants, used to protect and preserve nature, education facilities, development of science and technology, and recreation. The research was conducted using the descriptive-analytic method by drawing problems regarding the concept of conservatory design that pays attention to the environment while collecting data and theories related to the conservatory. The conservatory applies an ecological architectural approach that includes harmony between humans and nature; the balance of development between the natural environment and buildings that need to be considered will become a sustainable green building. This project is expected to create a medium for conservation and research beneficial to the community, as educational and interactive tourism facilities between humans and nature that are sustainable and have no negative impact on the environment**.**

Keywords: conservatory, sustainable building, ecology

1 Introduction

As the largest archipelagic country in the tropics, Indonesia has rich biodiversity and is one of the world's most prosperous centers of biodiversity. Indonesia is the second-highest terrestrial biodiversity country in the world [1]. Climate change resulting from global warming, an environmental issue, also significantly impacts plant diversity. Indonesia has many endangered plant species that continue to increase every year. Overall, Indonesia has 437 threatened plant species, while until 2018, the existing Botanical Gardens were only able to collect 122 threatened plant species or 28.5% of all threatened species in Indonesia [2]. Climate change-led increases in local and global temperatures pose a significant threat to plant growth and crop production [3]. Climate change causes temperatures to change erratically and makes it difficult for plants to adapt. The effect of climate change on vegetation may be from cellular to molecular level. Consequently, the existing literature on the plant's response to different environmental factors varies. Given the future impacts of

climate change, understanding the response of plants becomes critical in developing strategies to cope with the threats to plant growth and development [4]. If the destruction of natural habitats continues, the population of endangered species will also continue to grow. In addition, until now, in North Sumatra itself, there is no ex-situ conservation medium that sufficient enough to support the functions of conservation, edutourism, and research.

To conclude these problems, a conservatory needs to be established. A conservatory is a place or medium primarily used as an ex-situ conservation or protection institution, which collects, maintains, and reproduces various plants to form and develop new habitats [5]. The conservatory includes five main functions: conservation activities, tourism, research, education, and environmental services. The project needs harmony between humans and nature, balanced development between the natural environment, and green buildings requiring sustainable development. The design must consider the site environment, users, and plants to be conserved as the main object with an ecological approach. The ecological approach in architecture is bioclimatic design, namely the design of a system specifically responsive to the local climate besides the benefit of low-energy systems. This conservatory is expected to be a sustainable area, maintain the harmony and balance of environmental ecosystems and improve the ecological quality of a healthy site. Sustainable development must meet the quality of people's lives to improve or conserve natural resources and diversity.

2 Literature Review

Botanical gardens devote their resources to the study and conservation of plants and making the world's plant species diversity known to the public. These gardens also play a central role in meeting human needs and providing well-being. In this minireview, a framework for the integrated missions of botanical gardens, including scientific research, in/ex-situ conservation, plant resource utilization, and citizen science, are cataloged [6]. In this case, the conservatory accommodates research activities where students and researchers carry out plant research according to researchers' needs to obtain accurate data for plant development. Conservation as an educational tour contributes to introducing the diversity of plant collections and providing peace or pleasure for visitors.

Climate has a significant influence on the functional conditions of the greenhouse in creating optimal conditions for plant cultivation [7]. Research activities can carry out research activities in a greenhouse because environmental conditions can be controlled and adapted to the needs of plants, known as controlled environment agriculture [8]. Temperature, humidity, and light intensity are variables that need to be regulated or considered in a greenhouse [9]. Greenhouses are used as space for plant conservation. This greenhouse will protect the nursery and plants from sunlight, temperature, water content, etc. Greenhouses also protect plants from pests or plant diseases. It is necessary to carry out a functional analysis of the greenhouse building, which is closely related to the adaptability of microclimate conditions to the needs of optimal plant growth in the building. The greenhouse cannot optimally perform its functions in environmental conditions where the microclimate is unsuitable for plant growth.

The ecological architecture includes harmony between humans and nature [10]. Ecological architecture has an environmental perspective, paying attention to the balance of development between the natural environment and the site where the artificial environment is placed as an architectural work, including buildings, landscapes, regional arrangements, monuments, or architectural works in other forms. In other words, the concept of ecological architecture is architecture that supports human relations with the natural environment harmoniously and sustainably [11]. Quoting from Jerobisonif [12], the idea of environmental design is broken down into several principles, namely: the use of natural design systems, designing energy-efficient systems, waste minimization explore the ecological conditions of the site form a harmonious relationship with nature, and explore the environmental conditions of the site.

Based on the Regulation of the Minister of Forestry of the Republic of Indonesia No. 31 of 2012 about conservation institutions [13], criteria for Botanical Gardens consists of: has a collection of various types of wild plants; have management support facilities, at least consisting of a greenhouse; laboratory; and seed garden. Also, have a permanent workforce according to their field of expertise, including botanists, interpreters, plant nurses, security personnel, and administration staff. Besides, it also needs management office facilities.

3 Methodology

The site selection for the review was carried out based on a literature review, Indonesian Institute of Sciences (LIPI) Regulation No. 4 of 2019 [14], and the regional structure to ensure that planner could develop the selected area. The criteria for site selection are the land conditions have sufficient space, easily reached with a good road network that does not cause congestion, and other requirements such as local regulations.

Data collection techniques used in the North Sumatra Botanical Conservatory design include literature studies and field studies. The data from the literature study in this study were obtained from books and journals by taking into account aspects of adaptive concepts, ecological approaches, functions, conservatory users, and comparative studies of conservatory function areas. This aspect becomes the focus of analysis in planning environmental problems and the need for principles of ecological architecture for the function of the botanical garden. Planning research is carried out by identifying the data that has been collected, parsing ecological concepts, and conducting a comparative method to compare the literature study on the principles of an ecological approach with site conditions and functions. The results of subsequent analysis resulted in a strategy for the concept of ecological architecture on the function of the conservatory and the local climate of Sibolangit.

4 Result and Discussion

The conservatory function is filled with three domes or greenhouses with three different temperature and humidity environments based on the division of altitude; there are lowlands, highlands, and mountains. Other functions are filled with laboratories, multi-function rooms for workshops, discovery gardens where the

visitors, especially children, will carry out educational activities about flora by seeing and experiencing firsthand the experience of botanical educational activities such as nurseries also greenhouse restaurants where visitors can eat while enjoying the landscape view.

4.1 Location Selection

The writer chose the site on Bandar Baru st., Suka Makmur Village, Sibolangit District, Deli Serdang Regency, North Sumatra. This location was selected because it met the site selection criteria; namely, the physical condition of the design site has a carrying capacity for plant collections. Because its located in Sibolangit, the temperature is mild, which is a sub-district included in the Development Plan for Natural Tourism Designated Areas and can be reached by modes of transportation. Other building functions around the site are dominant with residents' homes and residents' shops. The site is also close to the Sibolangit Hillpark recreation area, The Hill Resort, Al-Kamal Mosque, and Loka Buddhist Temple (Figure 1).

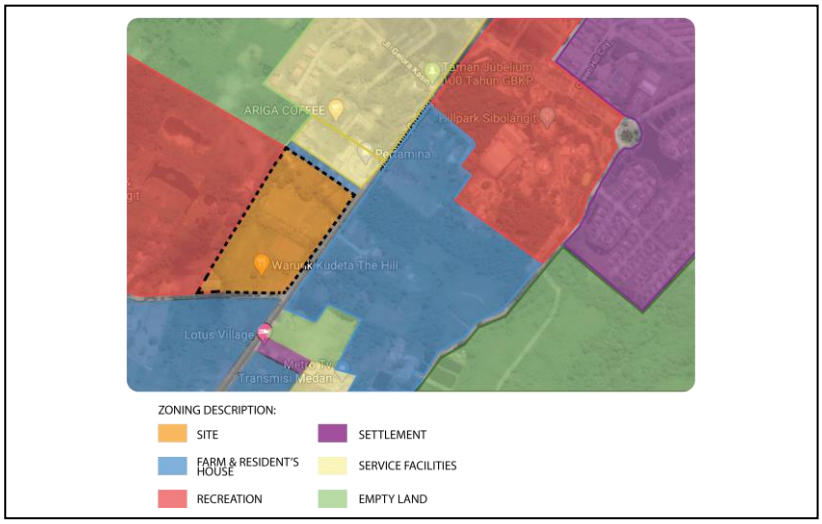

Figure 1 Land Management Around Site Project

4.2 Basic Concepts

The conservatory function is filled with three domes or greenhouses with three different temperature and humidity environments based on the division of altitude; there are lowlands, highlands, and mountains. Other functions are filled with laboratories, multi-function rooms for workshops, discovery gardens where the visitors, especially children, will carry out educational activities about flora by seeing and experiencing firsthand the experience of botanical educational activities such as nurseries also greenhouse restaurants where visitors can eat while enjoying the landscape view.

The basic concept also refers to some ecological approaches: using energy-efficient building systems, minimizing the negative impact on nature, and using technology that considers ecological values [15].

The result of the ecological approach in the design is applying a natural design system by using domes or greenhouses to protect plants from extreme climates so the plant can adapt to their origin climate. The greenhouse also has a glass cover with adjustable ventilation, passive design, water efficiency with rainwater harvesting, detraction of waste with biomass by burning the organic waste that generates electricity, and

efforts in establishing a harmonious relationship. The design must consider proper land management and adequate proportions for water absorption.

4.3 Zoning Concept

The landscape zoning is divided into the conservatory, outdoor garden, parking, and commercial zones. The Conservatory Zone is the building mass zone with conservatory, research, and education. Outdoor Garden Zone is a tourist or recreation zone for visitors in outdoor spaces consisting of a seating area, discovery garden, an educational garden where visitors can learn about plants by planting, fertilizing, harvesting vegetation and other activities and outdoor garden, a conservation garden filled with plants that are suitable for Sibolangit climate. The Parking Zone consists of parking zones for cars, motorbikes, and buses. Moreover, The Commercial Zone is filled with a restaurant with a greenhouse atmosphere. The landscape zoning of Botanical Conservatory is described in figure 2.

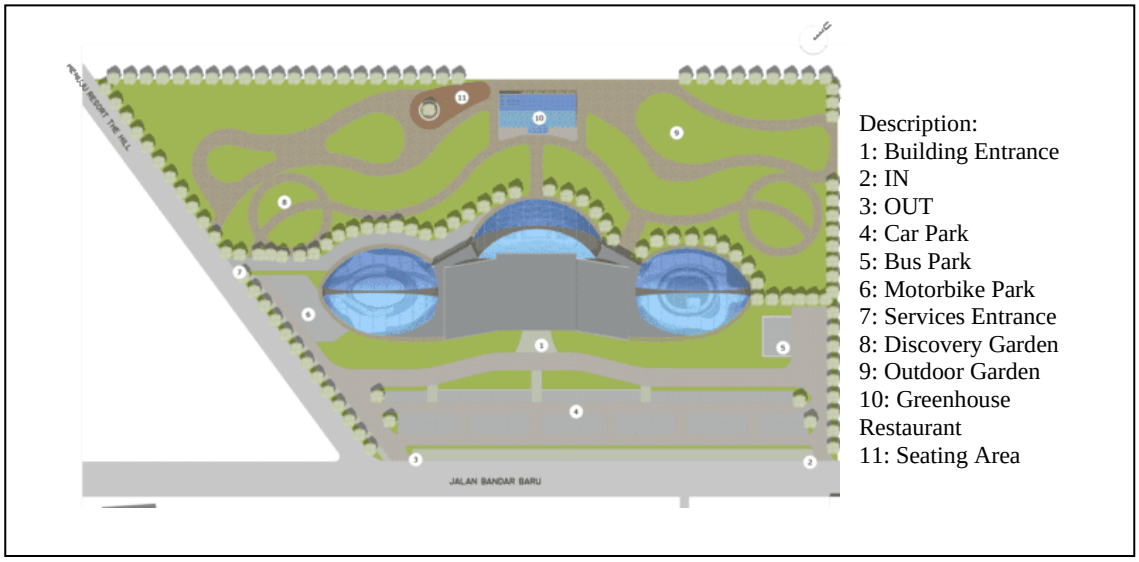

Figure 2 Site Plan

4.4 Mass and Appearance

The dome facade exposes steel and glass materials with its wide span structure and dome shape. This facade later became the conservatory's point of interest. For the connecting mass, the facade uses a glass and shading device made by a cladding material that blocks excess sunlight but can still let sunlight into the building (Figure 3).

Figure 3 Mass and Appearance

4.5 Interior Layout Concept

The interior layout concept in the conservatory maximizes the placement of related functions. The idea of each floor, namely on the 1st floor, is dominantly filled with public functions such as greenhouses, information, ticketing, or multi-function room. On the 2nd floor, the function leads to a semi-public filled with commercial functions such as restaurants and educational functions. The 3rd floor focuses entirely on the research function, consisting of laboratories and rooms for botanists and laboratory assistants. In addition, there is also a restaurant function that has a view leading to the outdoor garden. The division of greenhouse ecosystems is based on highland ecosystems with different characteristics, temperatures, and humidity.

Lowland Dome

Lowlands tend to be hotter, drier, and have higher rainfall. The ecosystem samples taken are Mangrove Beach & Barus Beach. The flora on the coast is divided into two groups, namely mangrove and non-mangrove vegetation. Based on this division, the ecosystem is divided into two, namely the mangrove ecosystem where the mangrove vegetation is provided with an artificial ecosystem in the form of water that surrounds the utility and service rooms, and the non-mangrove ecosystem in the form of soil, which is supplied with sprinkler supports for vegetation irrigation. In the lowland dome, there is a circular circulation at the bottom and a ramp surrounding the utility and service rooms so visitors can see the vegetation display and experience a different space (Figure 4).

Figure 4 Lowland Dome

Highland Dome

The highlands have a mild climate, less rainfall, and the air tends to be dry. The ecosystem samples used for the highland dome are Tangkahan & Bukit Lawang. From the ecosystem samples, the elements that adapted to the dome are the river and bridge. The circulation is arranged around the plant display at the bottom, and visitors can take a walk to the top to enjoy plant displays from different elevations (Figure 5).

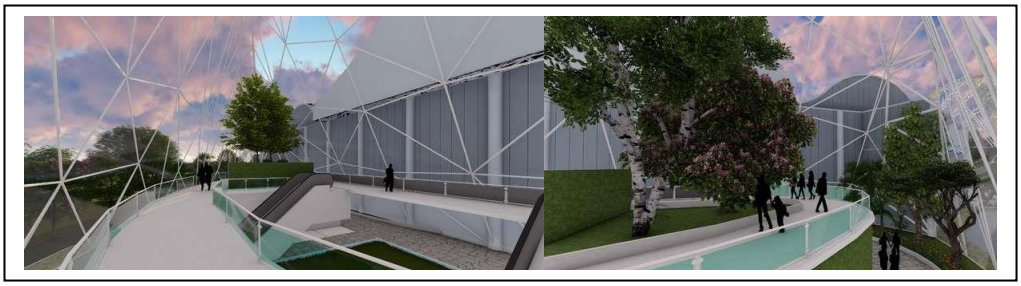

Figure 5 Highland Dome

Mountain Dome

The waterfall element attached to the mountain forest is applied in this dome—the interior consists of three floors. The first floor functions as utilities and services; the second floor is a hidden garden that is closed so that it cannot be seen from the bottom of the display, while the third floor is an open display where visitors can walk around enjoying the vegetation display on the lower floor (Figure 6).

Figure 6 Mountain Dome

4.6 Air Conditioning System Concept

In the greenhouse, the air conditioner uses a Liquid Desiccant system. This desiccant liquid system is an air conditioning system that processes hot air into the cold air, which is then channeled into the room. The heat generated from the biomass combustion process can be used as a liquid desiccant. The ventilation system in the greenhouse will cool the air only at lower levels to reduce energy use. This is achieved through thermal stratification - cooling the soil with pipes of cold water thrown into the floor slabs allowing cold air to settle in the lower zones while warm air rises and is expelled at high levels. Desiccant cooling systems have been considered an efficient method of controlling moisture content in the supply air. They do not use any ozone-depleting coolants and consume less energy than the vapor compression systems [16].

For the main building of the conservatory, the air conditioning system used is a chiller system. The conditioning system in the dome or greenhouse is divided into natural systems and artificial systems. The natural system uses manageable panels connected to a temperature and humidity sensor system. The manageable panels can be opened and closed so that the hot air can rise and escape. This manageable panel may also be set up automatically. Meanwhile, the artificial system uses a liquid desiccant and humidifier unit in a mountain dome. This unit emits a non-wetting mist that can maintain temperature and humidity like a mountain ecosystem.

4.7 Structure and Construction System

The building consists of 3 floors with a wide-span structure. The main building uses a truss frame structure, while the structural system in the greenhouse use wide-span arches structure with a flat truss frame. The arch binds to a flat truss structure or frame arranged vertically, becoming a wind-resistant unit. Steel panels with the mero system were added as a frame to cover the dome with glass from the structural design. The construction of both truss and arch uses steel, a strong and easily formed material.

5 Conclusion

The design of Sumatera Utara Botanical Conservatory, located on Bandar Baru, Suka Makmur Village, Sibolangit District, is designed to fill the needs of ex-situ conservatory in Sumatera Utara since Indonesia has many endangered plant species that continue to increase every year. The principle of ecological architecture is applied in the design of the conservatory as expected to be a place for conservation and research medium that is beneficial to the community, educative and interactive site, which are sustainable and do not harm the environment also helpful both in the botanical and economic sectors for the community around.

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