



# Design of Toba Caldera Geopark Museum in Balige With A Green Architecture Approach

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**Abstract.** The Lake Toba area as a Global Geopark Network is imaged as a super destination with the world's largest and one of the deepest volcanic lakes, thus making it a world heritage with diverse diversity such as geology, biology, and culture. Lake Toba creates extraordinary natural phenomena, making this area rich in geological diversity such as expanses and rock types, and contains geological heritage values (heritage), cultural heritage, and bio-heritage that are well known International. However, attractions in the Toba Caldera Geopark area have not provided education only as a place of recreation for tourists. Therefore, it is necessary to design the Toba Caldera Geopark Museum as a place for organizing, collecting, maintaining, researching, presenting information about the benefits and potentials of the Toba Caldera Geopark area with the theme of green architecture and accommodating recreational and educational activities for visitors. This study used qualitative research methods. Several data collection, several data collection methods are used, primary data and secondary data. In designing the geopark museum utilizing the concept of energy-efficient green architecture in natural lightings such as skylights, natural ventilation, respect for the site, respect for users, and experience materials.

**Keywords:** caldera, geopark, green architecture, museum, Toba

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## 1 Introduction

Indonesia is a country that is blessed with great geological tourism potential with an extensive area and has a stunning landscape, various geological natural formations such as volcanic craters, rivers, and waterfalls, limestone mountains (kars), with caves and beaches. With a variety of uniqueness, all owned by the state of Indonesia [1]. This diversity needs to be utilized and maintained to provide benefits to local communities and the world. Geoparks are a solution to support diversity and sustainability by transforming the site into a nature reserve with geological heritage value, managed with a zoning system. They can use as a nature

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reserve for educational, research, horticultural development, entertainment, and tourism that benefit the surrounding community [2].

As a global network of geoparks, the Lake Toba region is considered a super destination with the largest volcanic lake and one of the deepest volcanic lakes in the world, making it a World Heritage Site with rich diversity such as geology, biology, and culture. It does power by artificial attractions as a source of life for local communities and the center of attention of tourists. In 2019 the Toba Caldera was designated as a UNESCO Global Geopark (UGG) at The 6th Asia Pacific Geopark Network (APGN) [3].

Geopark is a geographical unit where geological sites and landscapes of international standard are managed based on the concepts of protection, education, and sustainable development. Understanding the history of the earth's formation shaped every aspect of life and social society [4].

The Lake Toba area, is located in North Sumatra, Indonesia, was declared a National Geopark of the Republic of Indonesia with the theme Supervolcano and its uniqueness as the enormous Tectonic Quarterly Mountain in the world [5]. According to Craig A. Chesner, 2011, Lake Toba was declared a lake. The largest volcano-tectonic in the world and the widest in Southeast Asia. The area of Lake Toba is 100 x 30 km<sup>2</sup>, with an altitude of 904 meters above sea level and a lake depth of 505 meters. Lake Toba is a giant volcanic caldera that once erupted violently, changing the world's climate and ending humanity. About 74,000 years ago, Mount Toba erupted violently (supereruption), resulting in a giant hot cloud that covered nearly the entire east to the west tip of Sumatra Island. With a magma eruption reaching 2800 km<sup>3</sup> and an eruption index going on a magnitude scale of 8.8, it does categorize as the most powerful eruption in the history of planet Earth [6].

Lake Toba creates extraordinary natural phenomena, making this area rich in geological diversity such as landscapes and rock types and containing internationally recognized geological heritage values (heritage), cultural diversity, and biodiversity. So this area has the potential as a world-class tourism destination and is very worthy of being a member of a global geopark [6].

Geoparks must provide supporting facilities in scientific development activities, especially geoscience and the concept of environmental protection to the public. Such as essential infrastructure, namely information centers, museums of history and natural knowledge, and the development of geo-track routes for the benefit of field studies, are very important to support public education regarding natural potential, especially geoparks [4].

The number of natural attractions in the Toba Caldera area is an attraction for local and foreign tourists to visit and travel. However, interests in the Toba Caldera Geopark area have not provided education only as a place of recreation for tourists. Primarily, in this case, the Toba

Caldera Geopark tourist attraction stores much information about the formation process, functions, and other benefits of the Toba Caldera Geopark. Because the potential of the Toba Caldera area is not widely known to the general public which can be used as a means of education, research, and recreation. Must be preserved. However, in their activities in the Toba Caldera, tourists only travel for recreation without any knowledge of the Toba Caldera Geopark itself.

This study aims to realize a building with an energy-efficient green architecture concept as a geopark image and to explore the design of the Toba Caldera Geopark Museum as a place to organize, collect, maintain, research, and present information on the benefits and potentials of the Caldera Toba Geopark area.

Toba Caldera Geopark Museum does locate on Gereja street, Longat, Balige, Toba Samosir Regency, North Sumatra. The Balige area is an area designated as a cultural tourism area and a geological tourism area. Around the site, there are many heritage tours and tours of the Balige-Liang Sipege and Lumban Silintong Geosites. The Geopark area must have an educational/educational facility to develop science, especially knowledge of geoscience and the concept of environmental protection to the public. Therefore, there is a need for a design for the Toba Caldera Geopark Museum to organize, collect, maintain, research, and present information about the benefits and potentials of the Toba Caldera Geopark area with the theme of green architecture and accommodating recreational and educational activities for visitors.

The Geopark Museum is a vital tourism activity that provides opportunities for tourists to gain experiences about nature and culture that can be learned and understand how important the conservation of biodiversity and local culture is. At the same time, it can generate income for conservation activities and economic benefits for the local community.

## **2 Literature Review**

### **Toba Caldera Geopark Museum**

The museum is a repository of cultural heritage that connects people from the past to the present. Cultural heritage is evidence of a human civilization that has gone through a social process [7]. However, the International Council of Museums (ICOM) defines a museum as "a non-profit, permanent institution that serves society and its development and is accessible to the general public, acquiring, preserving, investigating, and communicating." is. It then publishes substantial evidence of people and their environment for research, education, and enjoyment. Cultural experts place the museum as part of a social institution and a vehicle for providing an overview and educating the community and the public about the development of nature and human culture. In developed countries, the museum is a vehicle that has a strategic role in strengthening the community's identity, including the surrounding community [8].

Concerning creating an exciting exhibition, a museum can realize it by applying a mass communication model combined with an interpersonal communication model. Visitors can actively participate and be part of the exhibition because this is what the community expects. A museum can achieve the two-way model of interpersonal communication through educational programs, participatory, living interpretation, and interactive exhibitions through various media such as audio-visual, touch screen, and multimedia [9].

The discussion on the museum's interior design does divide into several parts: space formation, space atmosphere, display and presentation techniques, steps and circulation arrangements, lighting [9].

### **Toba Caldera Geopark**

Toba Caldera Geopark, when viewed geologically, surface area and physical geographical characteristics, as a result of the Super Volcano, this area is a giant volcanic area (volcano-tectonic caldera) which forms the largest lake in Indonesia. The Toba Caldera wall area has wavy steep hills and valley valleys forming a basic morphology with a watershed caldera rim boundary. Lake Toba has an area of 3,658 km<sup>2</sup> and a lake surface area of 1,103 km [10].

The following are the potentials of the Lake Toba area so that it becomes a world-class Geopark, including:

#### **Geological Diversity**

Sipiso Piso-Tongging Geosite, Silalahi-Sabungan Geosite, Haranggol Geosite, Sibaganding Geosite, Eden Garden Geosite, Balige-Liang Sipege-Meat Geosite, Situmurun-Uluan Block Geosite, Hutaginjang Geosite, Muara Sibandang Geosite, Sipinsur-Baktiraja Geosite, Bakara Geosite- Tipang, Geosite Tele – Pangururan, Geosite Pusuk Buhit, Geosite Hutatinggi – Sidihoni, Geosite Simanindo – Batu Hoda, Geosite Ambarita – Tuktuk [10].

#### **Biodiversity**

Species of flora and fauna in the Toba Caldera geopark, there are tree endemic flora species in Lake Toba and eight protected flora species sourced from Government Regulation No. 7 of 1999 concerning Conservation of Plant and Animal Species [10].

#### **Cultural Diversity**

Cultural heritage can be in the form of cultural heritage objects, cultural heritage buildings, cultural heritage structures, cultural heritage sites, and cultural heritage areas on land and water. Cultural heritage found in the Lake Toba area includes traditional Batak settlements, traditional woven fabrics (ulos), museums, traditional dances, and music [10].

Balige is the capital city of Toba Regency, North Sumatra, Indonesia. Balige District is also a tourist area on the shores of Lake Toba. The Batak Museum, the T.B. Silalahi Center, and Sisingamangaraja XII National Heroes Cemetery are in this sub-district. Tourism conditions in Balige consist of nature tourism, cultural tourism, agro-tourism, and recreational tourism. The most dominating tourism activity in this area is nature tourism, with as many as 47 tourist objects. The development of KTA Balige does focus on the theme of urban heritage-based tourism. The Balige area is an area designated as a cultural tourism area and a geological tourism area. Around the site, there are many heritage tours and tours of the Balige-Liang Sipege and Lumban Silintong Geosites.

### **Basic Concepts of Green Architecture**

Green Architecture is an architectural concept that seeks to minimize adverse effects on the natural and human environment and produce a better and healthier place to live, which does do by utilizing energy and natural resources efficiently and optimally. The concept of 'Green Building' refers to structures and using environmentally responsible and resource-efficient processes throughout the building's life cycle [11].

According to Abimanyu Takdir Alamsyah, green architecture is an environmentally friendly building, preserving nature, supports sustainability, prioritizes environmental protection, the theme of architectural design or the piece of architectural design. Architecture aims to use energy and material efficiency locally or globally. It is the embodiment of architectural works. Green architecture takes ecology as a standard and as a whole as anthropology [12].

According to Brenda and Robert Vale in their book "Green Architecture: Design for A Sustainable Future," there are six basic principles in planning Green Architecture, namely: Conserving energy, Working with climate, Minimizing new resources, Respect for site Respect for users, Holistic [13].

Energy conservation is a strategy to reduce fuel and electrical energy in the most efficient way. Energy conservation and management can result in substantial savings in the operating costs of a building. To meet the energy use efficiency aspect, the facility must meet the following requirements: building envelope, ventilation system, air conditioning system, lighting system, transportation system, and electrical system [14].

The principle of an embodiment of green buildings/architecture is to be efficient in using energy and natural resources. The criteria for 'green' in buildings in Indonesia must refer to the suitability of facilities with the climate in Indonesia, namely tropical with high humidity. Tropical architecture must overcome heavy rain, hot sun, high air temperature, high humidity, or low wind speed. Thus, the achievement of green for buildings in Indonesia is the fulfillment of tropical building design criteria.

In Indonesia, the Architecture/Green Building movement has begun with the Green Building Council Indonesia (GBCI) with its Greenship. GREENSHIP as a rating system does divide into six aspects consisting of • Appropriate Site Development (ASD) • Energy Efficiency & Refrigerant (Energy Efficiency & Refrigerant/EER) • Water Conservation (WAC) • Sources & Cycles Materials (Material Resources & Cycle/MRC) • Air Quality & Air Comfort (Indoor Air Health & Comfort/IHC) • Building Environmental Management (Building & Environmental Management) [15].

### **3 Method**

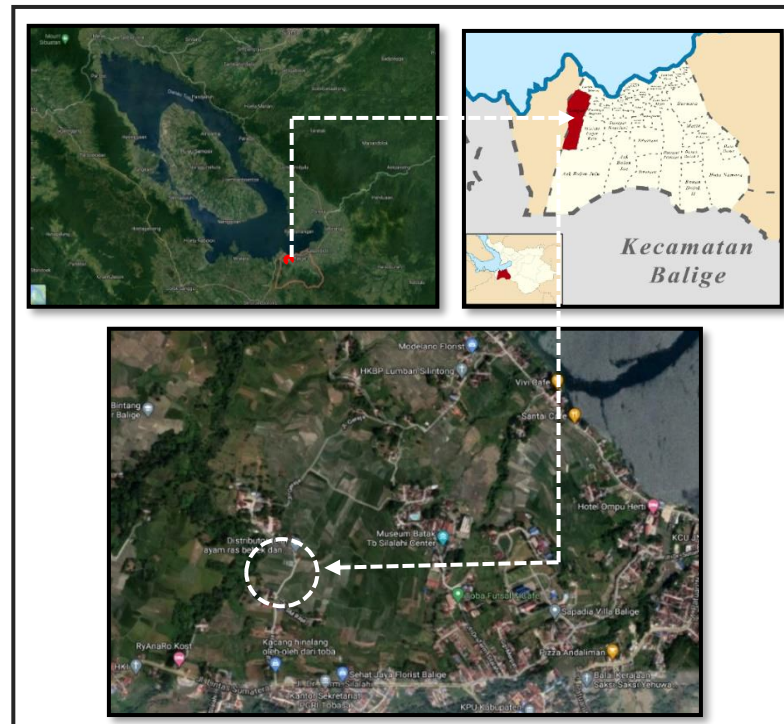
This study used qualitative research methods. Qualitative research starts in the field based on the natural environment, not on theory. The data and information that have been obtained from the field are taken for their meanings and concepts and presented in an analytical, descriptive manner, generally without using numbers, because they prioritize the processes that occur in the field [16].

Several data collection methods do use to collect the necessary data: a. Primary Data: Primary information is data obtained by searching directly from the source. Primary data collection methods that can carry out in this design are a. Surveys of physical conditions in the field and interviews with related agencies. b. Secondary data collection techniques carried out in the design process are looking for data and information about the design area, literature on functions, and themes similar to building functions. The following are some secondary data obtained: a. Literature study, comparative study. And the last is the analysis and data processing is carried out based on the required data, then classified according to the search for objectives so that the study becomes effective.

### **4 Results and Discussion**

#### **Design Location**

The design location for the Toba Caldera Geopark Museum is on Gereja street, Longat, Balige, Toba Samosir Regency, North Sumatra. Astronomically, Toba Samosir Regency does locate at 2003" - 2 040" North Latitude and 98056" - 99040" East Longitude. Toba Samosir Regency has an area of 202,180 Ha. The Balige area is an area designated as a cultural tourism area and a geological tourism area. Around the site, there are many heritage tours and tours of the Balige-Liang Sipege and Lumban Silintong Geosites. The design of the Toba Caldera Geopark Museum has an area of  $\pm 1.5$  Ha (Figure 1).



**Figure 1** Site Location

Museum Geopark chose this location with several considerations, including Ease of achievement/accessibility by visitors, managers, and service vehicles, close to the main road to/from settlements. Adjacent to public open spaces (e.g., city parks), for clarity of orientation, sequence, possibilities for the development of related activities such as carnivals, and others. adjacent to art facilities, culture, and other geopark natural attractions. , adjacent to supporting facilities such as hotels, shopping centers, restaurants, and others, close to security accessibility, availability of utility networks, such as State Electricity Company PLN, Municipal Waterworks PDAM, Telecommunications Network In Indonesia Telkom, Riol City networks, and others, site location is in the geopark tourism corridor, Toba Caldera. KDB1: 60%, KDH2 :40%, KLB3 : 3, GSB4 : 15 meter ,GSD5 : 50 meter (Figure 2).

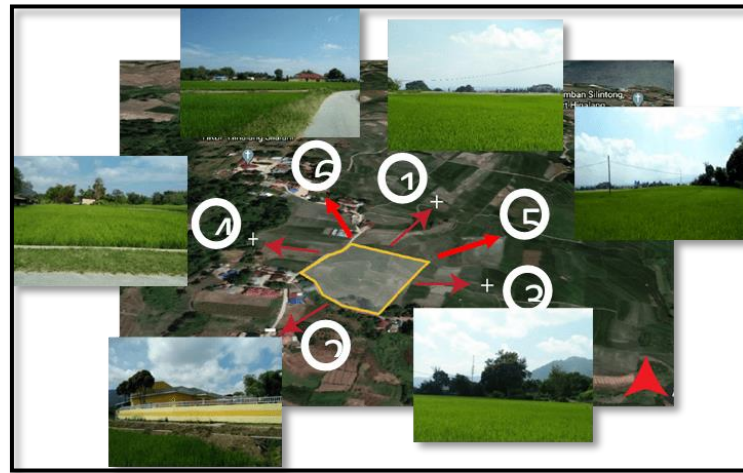
<sup>1</sup> KDB : Building Base Coefficient

<sup>2</sup> KDH :Koefisien Dasar Hijau, Or Green Base Coefficient

<sup>3</sup> KLB :Koefisien Lantai Bangunan, Or Building Floor Coefficient

<sup>4</sup> GSB: Building Border

<sup>5</sup> GSD: Lake Border



**Figure 2** Site Location

### Basic Concept of Theme Application

Green Architecture is a fundamental concept with the application of environmental elements in its design. The application of ecological aspects at the Toba Caldera Geopark Museum aims to maximize the function of objects and produce buildings that synergize with the environment without destroying it. These concepts do translate into the following design:

**The pattern of determining mass**, processing forms, and arranging indoor and outdoor spaces does base on the existing site's analysis.

**With the design object**, the green architectural theme was developed from the inside out, finally contributing to the formations of the building mass with reasonable dimensions and reflecting the object's function. In designing the exhibition space, proportional and visual dimensions of space do attractive and not massive products, according to the functions and activities in it as a place of recreation and education (Figure 3).



**Figure 3** Geopark Museum

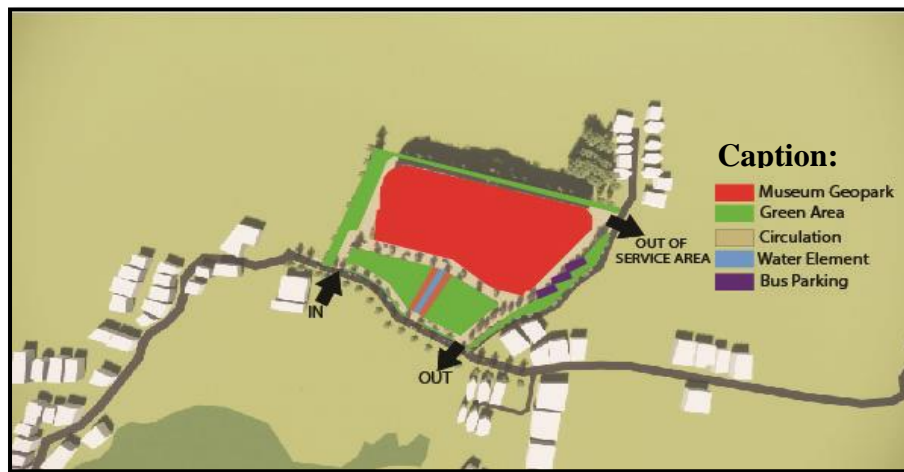
**Natural lighting and ventilation systems** utilize the environment's potential by applying openings that connect the outdoor and indoor spaces.



**To create the natural look of the building and harmonize with its surroundings,** it applies in adjusting the use of materials to finish the building envelope. Create a natural look use natural materials, namely natural stone in the roofing combined with modern materials according to the nature of the interior and exterior coverings, wood for finishing the floors, and glass for the walls.

### Basic Concept of Theme Application

The design location is the paddy field area. The design point is not far from the intersection of the main road to the field. There is only one entrance and exit for pedestrians and vehicles. The design site's zoning and mass placement division is adjusted to the soil's natural and topographical conditions to maximize the view (Figure 4).



**Figure 4** Site Location

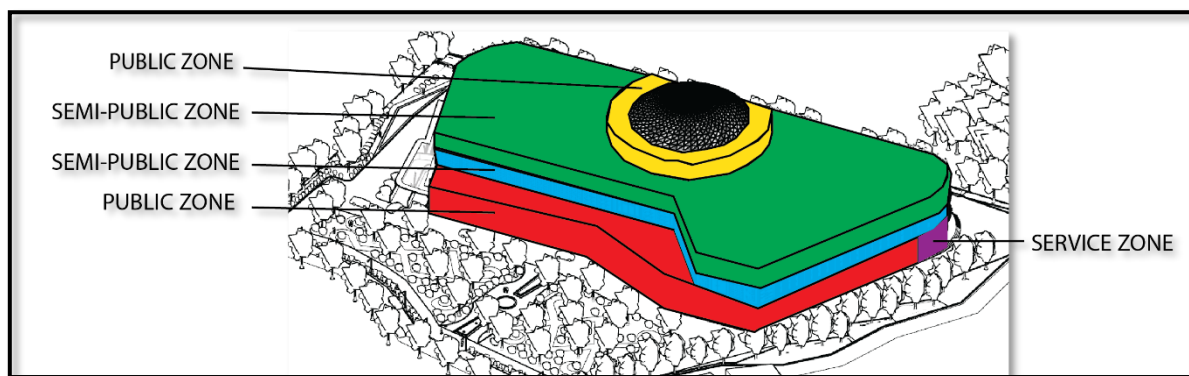
The outdoor space concept is structured to create a visualization of the geopark museum building that attracts visitors on foot or into the outdoor space of the building. Hence, occupants feel comfortable and free from boring distractions by offering open spaces to create the atmosphere of outdoor spaces designed with plants and trees. The water part fulfills the concept of outdoor activities/activities in this museum (Figure 5).



**Figure 5** Geopark Museum

## Basic Concept of Theme Application

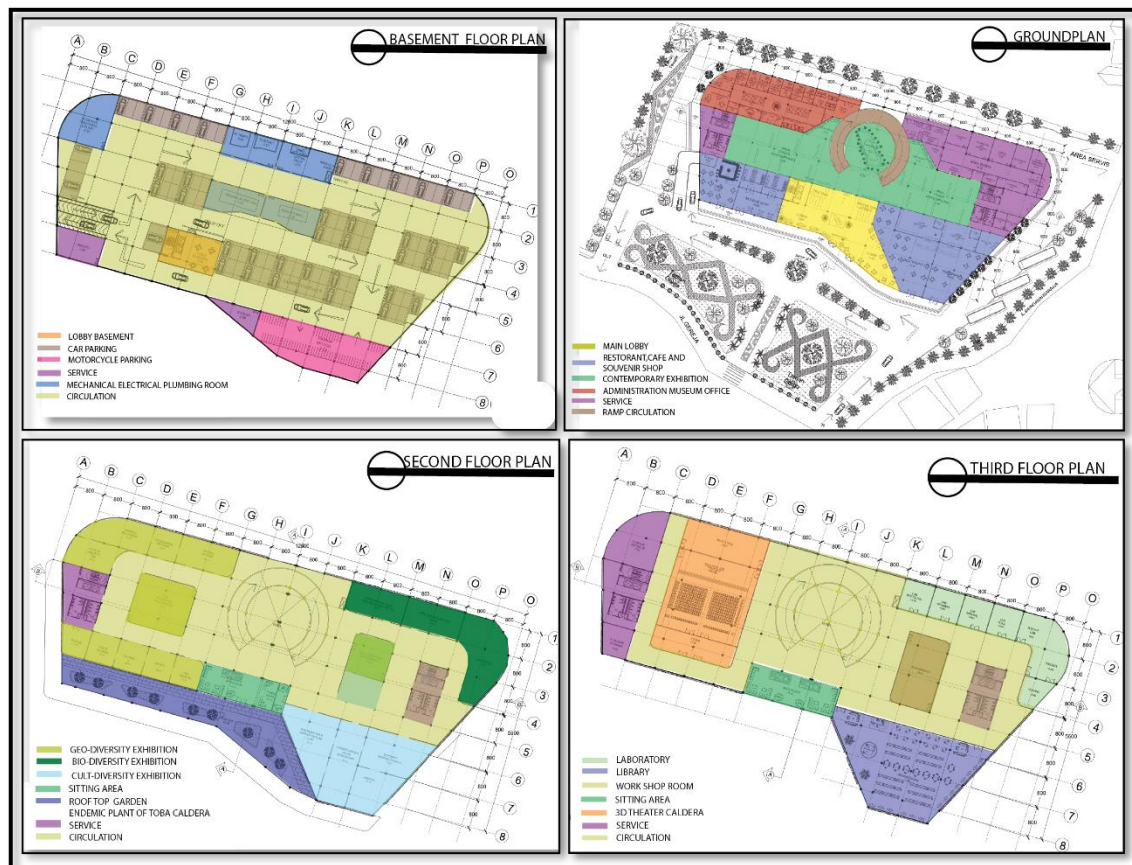
The design of the Toba Caldera Geopark Museum begins by dividing the building into several zones, namely public, semi-public, private, and green zones (Figure 6). In the recreation area, visitors do bring to feel the interior atmosphere which is bright and free with natural lighting entering from the outside into the building using the inner court. This encouraging atmosphere does expect to unite visitors' feelings with natural conditions. This Recreation Area consists of the Inner court Museum, Hall, and digital view. In the Exhibition Room, visitors do bring to feel how the interior atmosphere of the geopark element consists of Bio-diversity, Geo-diversity, and culture-diversity.



**Figure 6** Massing Concept

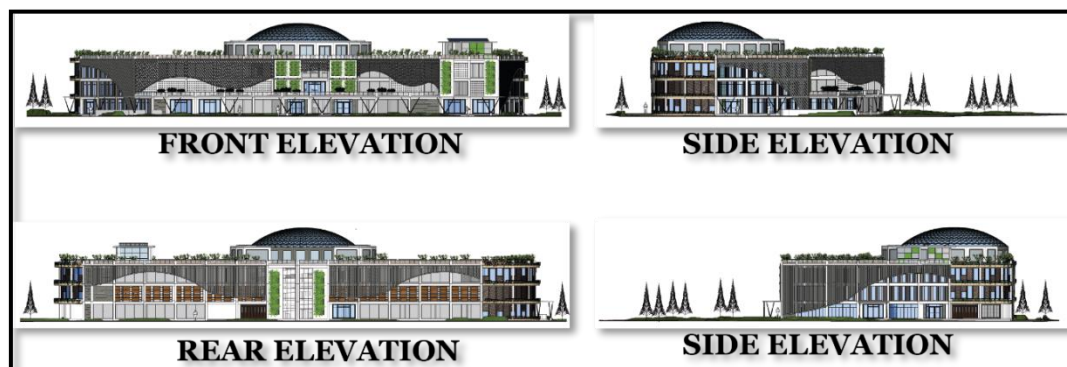
The main exhibition area does also divided into three permanent exhibition rooms containing educational and recreational information, namely Bio-diversity, Geo-diversity, and culture-diversity in the Toba Caldera Geopark. The following zone within the Toba Caldera Geopark Museum is a research zone. In this zone, there is a 3D-Theater area, workshop room, and library. This research zone does equip with the function of a laboratory room and other rooms.

Subsequent support activity zones do place to compliment and unify the previous three main zones. This supporting activity zone will accommodate the function of the lobby, receptionist, museum administration office, toilet, cafe, restaurant, museum shop, service room, MEP, and the basement as a vehicle parking area (Figure 7).



**Figure 7 Plan**

The theme applied to the building shows that this museum has a building face that implements a geopark with hills and mountains typical of the Toba caldera with a lattice finish that does curve in the visible part. With wood material as sun shading and a vertical garden that adds a natural impression to the building. And the park that surrounds the museum building adds a realistic appearance to the face of the building (Figure 8).





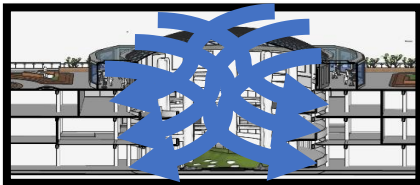


**Figure 8 Elevation**

### Basic Concepts of Green Architecture



According to Brenda and Robert Vale in their book "Green Architecture: Design for A Sustainable Future," there are six basic principles in Green Architecture planning, namely: - Conserving energy, building operations must minimize the use of fuel or electrical power by

maximizing natural energy around the building site. - Working with climate, designing the building must be based on the prevailing climate in the location where the building site does locate. - Minimizing new resources, designing by minimizing the list of natural resource needs so that these resources do not run out and can douse in the future. Respect the site, and the building should not damage the original site condition, with minimal site changes [13] (Tabel 1).

**Table 1** Concepts of Green Architecture




| Concepts of Green Architecture | Explanation  | Picture  |
|--------------------------------|--|--|
| Natural Lighting               | This museum utilizes sunlight for natural lighting to the maximum in dome-shaped skylights that can illuminate public spaces such as temporary exhibitions and sitting areas. During the day, solar panels do use as a natural energy source in the museum building, located on the roof. Shades are materials that do install on the outside of a window to reduce or block thermal insulation. |  <p>Skylight Concept</p>   |
|                                | The use of a sufficiently sizeable passive window in the middle of the building from the east does intend to let in sunlight so that this museum does not need to do light during the day.   |  <p>Big Passive Glass Concept</p>                                   |
| Natural ventilation            | It utilizes natural ventilation using cross ventilation and openings. Air can enter from the rooftop area and flow into the space below in the inner court area. Plus, some plants can cool the room.  |  <p>Natural Ventilation Concept</p>                                |
|                                |  |  <p>The concept of the lattice of the direction the wind flows</p> |
| Respect for site               | The museum building has a shape that responds to the form of the site condition, where this museum is a geopark museum that implements the formation of the Toba caldera mountain.   |  <p>Mountain Caldera Concept</p>                                   |




| Concepts of Green Architecture   | Explanation  | Picture  |
|----------------------------------|--|--|
| Respect for Users                | This building has good facilities in paying attention to universality. The use of a ramp as the central circulation to each floor provides access for people with disabilities.  |  |
| Respect for Users Concept        |  |  |
| Use of natural materials         | Produce the natural appearance of the building and harmony with the environment. It does apply in the regulation of the use of materials in the finishing of the building envelope. One concept is to use natural materials, namely natural stone for the wall covering combined with modern materials according to the nature of the indoor and outdoor sidewalks, wooden materials for finishing floors and umbrellas, wall glass. |  |
| Use of natural materials Concept |  |  |

The interior of the Toba Caldera Geopark Museum applies the principle of Green Architecture where maximum energy utilization does carry out by providing openings in areas that need it, such as a hall in the form of an inner court. Meanwhile, the exhibition space utilizes electrical energy obtained from solar panels (Table 2).

**Table 2** Interior

| Room name                         | Explanation   | Picture  |
|-----------------------------------|---|--|
| Geo-diversity Exhibition Hall     | The exhibition room contains information on the formation of the Toba caldera, starting from the pre-caldera, caldera I, caldera II, post-caldera, caldera evolution, resurgent Samosir, and the types of rocks in the Toba caldera.. |  |
| Geo-diversity Exhibition          |   |  |
| Bio-diversity Exhibition Hall     | The exhibition room contains information about endemic plants and endemic fauna found in the Toba caldera.  |  |
| Bio-diversity Exhibition Hall     |   |  |
| Culture-diversity Exhibition Hall | The exhibition room contains information about the culture around the Toba caldera and the relationship between culture and nature.   |  |
| Culture-diversity Exhibition      |   |  |

| Room name    | Explanation  | Picture  |
|--------------|--|--|
| Digital View | Digital View is an exhibition area at the museum located on the rooftop containing information on the distribution of geosites in the Toba Caldera through digital means. There is also a microscope in it to enjoy the true natural beauty of the Toba Caldera, especially the view of Lake Toba, which is an icon of the Toba Caldera. |  <p>Digital View</p> |

## 5 Conclusion

Toba Caldera Geopark Museum does locate on Gereja street, Longat, Balige, Toba Samosir Regency, North Sumatra, Indonesia. Balige sub-district is a sub-district that has many cultural and geological tourist attractions. Distribution of cultural and geological tourist attractions in Balige District. The Geopark area must have an educational/educational facility to develop science, especially knowledge of geoscience and the concept of environmental protection to the public. Therefore, there is a need for a design for the Toba Caldera Geopark Museum to organize, collect, maintain, research, and present information about the benefits and potentials of the Toba Caldera Geopark area with the theme of green architecture and accommodating recreational and educational activities for visitors.

The design of the Toba Caldera Geopark Museum must implement the Toba Caldera formation, which does surround by caldera mountains, lakes, and valleys. Therefore, it is necessary to design buildings that apply these elements in the shape of building masses and the concept of outdoor space where visitors can directly experience the Toba Caldera Geopark. The application of green architecture in the geopark museum has the criterion of supporting the surrounding nature, so this concept uses a lot to reduce or prevent natural damage and preserve the natural heritage to implement the idea of the geopark. In the geopark museum's design, the concept of green architecture saves energy in natural lightings, such as the use of skylights, natural ventilation, respect for the campus, respect for the user, and the use of raw materials.

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This research is about designing a Toba Caldera Geopark Museum with the concept of education and preservation of geopark, and it does aim at tourism managers in Balige. The authors thank the Department of Architecture, the University of North Sumatra, for the guidance given to the author in the process of writing this research.

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