08

MARINE REHABILITATION AND RESEARCH CENTRE AT PERHENTIAN KECIL ISLAND, TERENGGANU

Muhammad Zulhilmi Mohd Johan & *Zeenat Begam Yusof
Department of Architecture, Kulliyyah of Architecture and Environmental Design,
International Islamic University Malaysia

ABSTRACT

Tourism is one of the biggest industries in Malaysia. Malaysia Marine Park Islands are among the main contributors to the tourism industry, one of Malaysia's biggest industries. Perhentian Island, famous for its coral reef beauty, has unfortunately deteriorated over the past years due to climate change and irresponsible tourism activities. Therefore, this study aim is to design a comprehensive rehabilitation coral reef centre at Perhentian Island. The centre aims to rehabilitate the damaged corals, provide appropriate research facilities, and increase awareness and education about coral reefs for tourists visiting Perhentian Island. The study was conducted at the Perhentian Kecil Island in Terengganu. The centre is proposed to be located at the sea, 50 km from the island shore.

This study had adopted a qualitative method. With several site analyses, in-depth interviews, case studies and observations, the findings identified several appropriate spaces for rehabilitation, research and education purposes. The spaces for rehabilitation area is coral husbandry and coral propagation. Spaces for research are coral labs, and education is a coral gallery, coral book store and, coral adoption area.

Keywords: *Aquaculture, Ecotourism, Offshore, Marine ecosystem*
Corresponding author: zeensoni@iium.edu.my

INTRODUCTION

Focus of this study is the coral reef ecosystem. In the 1980s, coral patches were in abundance along the Perhentian beaches. However, in the 2000s, these patches started to disappear due to the tourism activities such as diving, snorkelling, and inappropriate operation of tourism accommodations. The 'Status of Coral Reefs of the World 2008' report stated that the world has effectively lost 19% of the original area of the coral reefs, and 15% are seriously threatened with loss within the next 10 - 20 years, with a further 20% under threat of loss in the next 20 years.

In 2012, a similar revisited report stated that more than 60% of the world's reefs are under immediate and direct threat from one or more local sources (Burke, Reytar, & Spalding, 2012). Currently, Malaysian marine parks corals are deteriorating gradually due to the high numbers of tourist arrivals, and impacts are often related to the physical damages by divers, snorkelers and boats (Gazi et al., 2013). However, it also means that where tourist numbers are low, impacts are often related to fishing pressures, particularly fish bombing, which is still common in Sabah (Reef Check Malaysia, 2020).

The Perhentian islands are located 20km from Kuala Besut Jetty in Terengganu, Malaysia. The islands have one village with approximately 2,300 villagers, which primarily work in tourism. The islands have been gazetted as Marine Park since 1994. They are popular tourist destinations, particularly among backpackers. They have over 40 resorts consisting of mainly small, family-run chalets with prominent resorts and over 20 dive shops spread around the two main islands.

Diving and snorkelling are the main tourist activities. Tourism growth has been rapid on the island, and resort development continues. There is no grid-supplied electricity nor centralized sewage treatment. In Perhentian, groundwater is limited. Thus, the freshwater supply is from the mainland (Reef Check Malaysia, 2020).

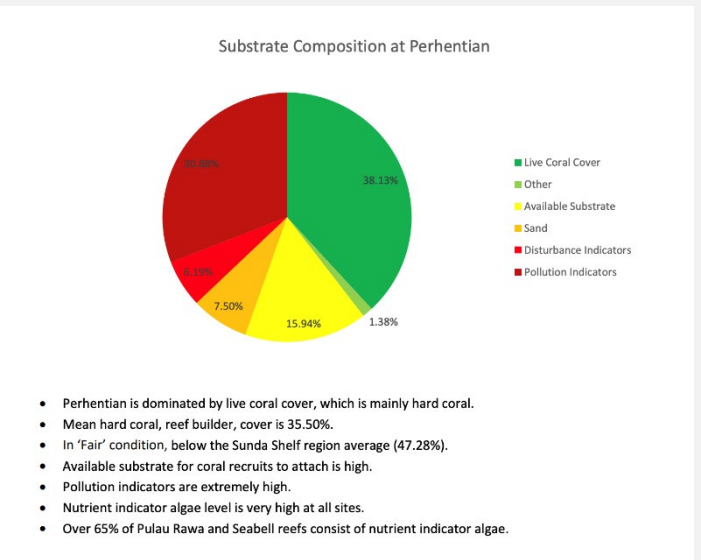


Figure 1 : Percentage of Coral Reefs Sites Condition in Perhentian Island in 2020 (Source : Reef Check Malaysia, 2020)

LITERATURE REVIEW

Perhentian Kecil Island has two famous beaches: Coral Bay and Long Beach. Many tourist arrivals at these beaches cause the depletion of marine biodiversity resources, pollution, solid waste accumulation, and coral reefs disappearance (Safuan et al., 2021).

Perhentian Kecil Island is well-known for its famous terrestrial and marine ecosystem. Sadly, there is no food grown by plantations and seafood from the island anymore, and everything is imported from the land. It shows that the sustainability of food sources had been moved away from the island, unlike the previous situation where the crops and the seafood supplies were abundant to cater to tourists and locals.

The six coral reef species commonly found at Perhentian Island beaches are *Acropora speciosa*, Acropora aspera, *Montipora digitata, Montipora foliosa, Stylophora pistillata, and Seriatopora hystrix*. There are initiatives from the State of Government to rehabilitate these species of coral reefs by providing a nursing ground at certain spots along Perhentian Island beaches (Reef Check Malaysia, 2017). Imperatively, a centre to nurse and rehabilitate the corals is proposed. In addition, coral fishes such as *Clownfish, Black Tip Reef Shark*, Teira *Batfish, Zebra Lionfish, and Giant Pufferfish* are spotted at coral reefs in Perhentian Kecil Island (Safuan et al., 2021).

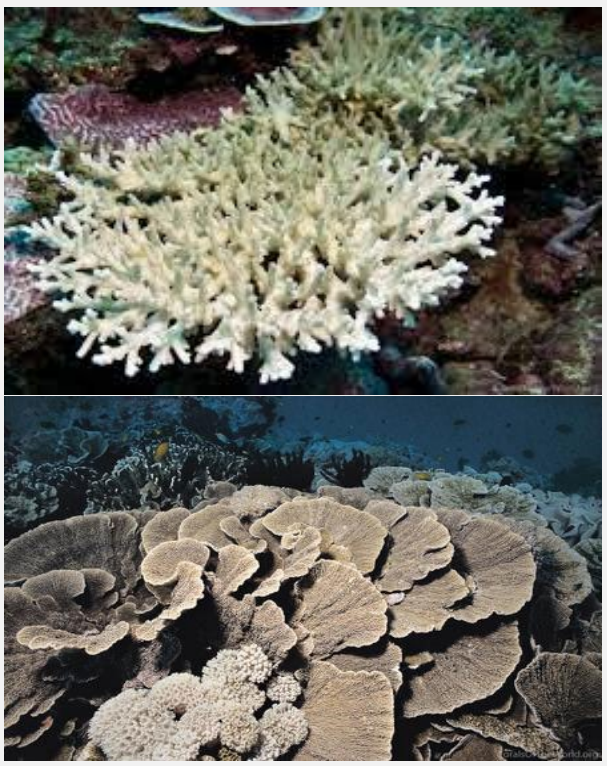


Figure 2 : *Acropora speciosa and Montipora foliosa* in Perhentian Island
(Source : Reef Check Malaysia, 2017)

A marine ecosystem includes coral reefs and coral fishes, as they are mutually beneficial. Hence, an increasing number of ecotourism sector activities, such as scuba diving and snorkeling, negatively affect the ecosystem, such as substrate cover and fish abundance.

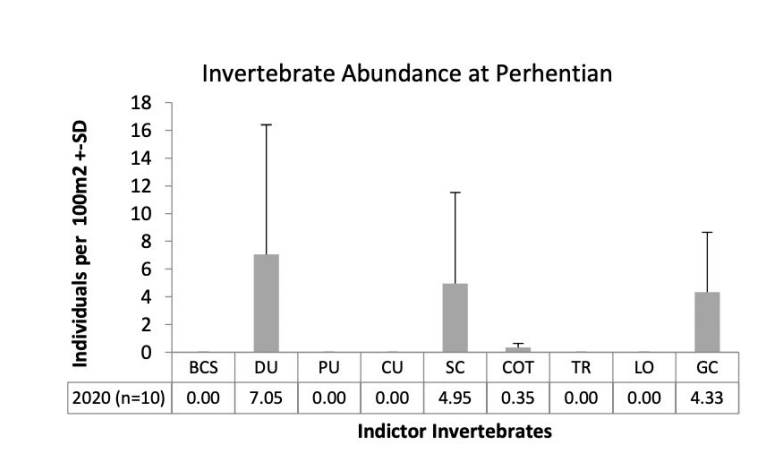


Figure 3 : Percentage of Substrate Cover in Perhentian Island in 2020
(Source : Reef Check Malaysia, 2020)

Coral reefs around the Perhentian islands are considered 'Fair' condition, with 35.5% live coral cover, below the average (47.28%) for reefs within the Sunda Shelf region. Diadema urchin is the highest. Invertebrates targeted for food are low in abundance. Indicators for curio trade are absent. COT is an issue in Perhentian. Crown of thorn fish increased due to sewage increase from the chalet's operations. A healthy coral reef can support a population of 0.2-0.3 individuals per 100m2.

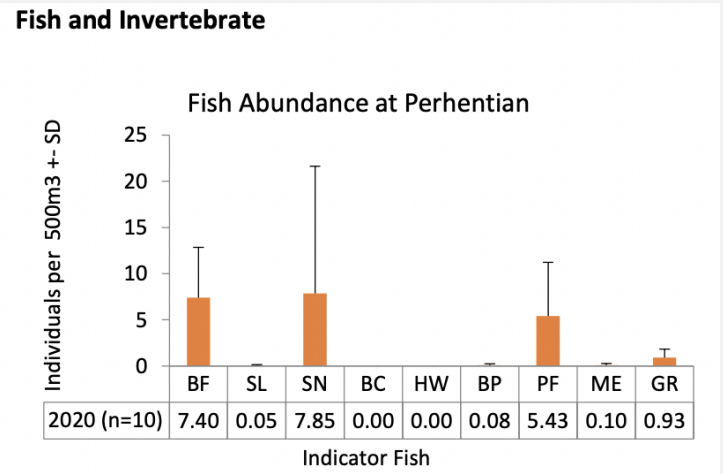


Figure 4 : Percentage of Fish Abundance in Perhentian Island in 2020
(Source : Reef Check Malaysia, 2020)

Among the six indicator fish recorded during the survey, the most abundant was Snapper (SN), followed by Butterfly Fish (BF) and then Parrotfish (PF). However, an indicator fish for trade -The Humphead wrasse, was absent. Bumphead parrotfish was also very low in abundance. The fish targeted for food are very few, except for Snapper and Parrotfish. The findings suggest that snapper and parrotfish for food were excessive. The absence of high-value fish indicates the corals' deteriorating condition because fish are the bioindicator for the coral ecosystem.

Coral reefs are very fragile and sensitive to their surroundings. Any immediate changes around them can quickly affect their health condition. When designing the coral centre, the essential factors are ample sunlight, the appropriate surrounding temperature, and suitable water parameters. The best temperature for coral reefs is between 20 - 27 degrees Celsius. The preferred depth of seawater is 5-10 m for corals to receive sunlight. There are three coral restoration techniques: structural, biological, and physical restoration (Reef Check Malaysia, 2018). This centre adopted the physical restoration method, as shown in Figure 5.

Figure 5 : Coral reef restoration using physical method using PVC pipe frame
(Source :Reef Check Malaysia, 2018)

STUDY AIM AND OBJECTIVES

This study aims to propose a marine rehabilitation and research centre at the long beach in Perhentian Kecil Island, which will rehabilitate the damaged of marine ecosystem on the island. The objectives of this study are:

•
•To rehabilitate damaged coral reefs.
•To provide research facilities for coral reef rehabilitation.
•To educate and create awareness of the condition of the marine ecosystem.

Figure 6 : Proposed site at the Long beach Perhentian Kecil Island
(Source : Author)

STUDY FRAMEWORK

ISSUES	CAUSE	EFFECT	SOLUTION
i) Deterioration of coral reefs	i. Climate changes and natural disasters ii. Irresponsible human activities	i. Coral Reef bleaching ii. The destruction of coral's natural habitat	i. Design a marine research centre focusing on coral reefs with a comprehensive facilities
ii) Improper research facilities	i. Insufficient research equipments ii. Lack of accommodation for researchers	i. The research cannot be done properly ii. No proper space for coral reef to be transferred during rehabilitation process	i. Provide enough facilities for research purposes and researchers' convenience
iii) Lack of knowledge and public awareness about the condition of coral reefs	i. Lack of education corners ii. No proper space for awareness and skill development	i. The public do not aware on how to treat coral reefs	i. Design proper spaces for environmental programs

Figure 7 : Summary of Design Thesis
(Source : Author)

STUDY FLOW

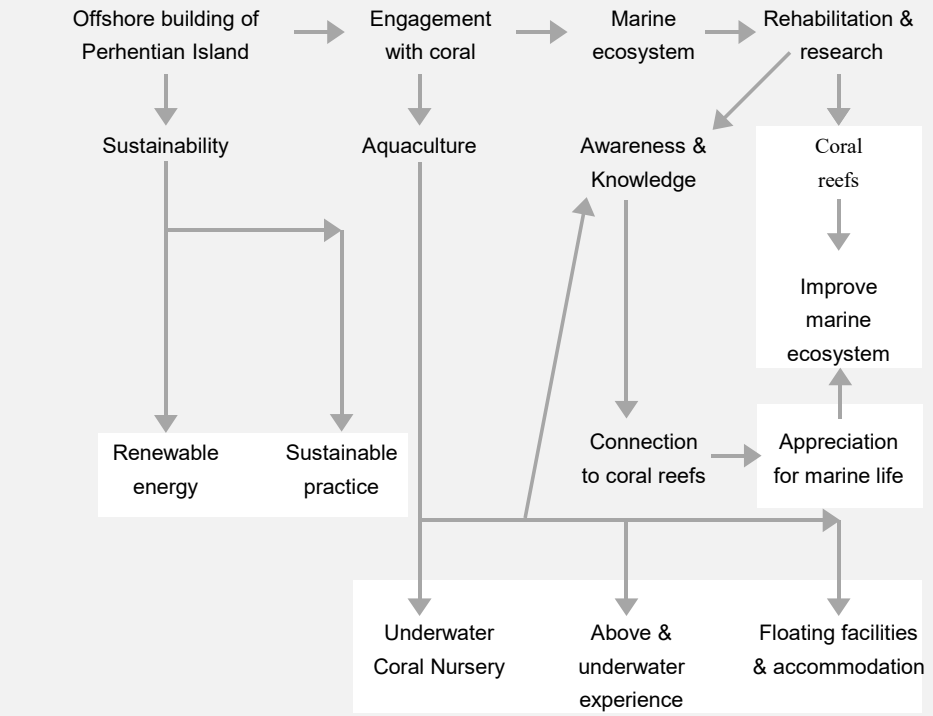


Figure 8 : Design Thesis Framework
(Source : Author)

METHODOLOGY

This research adopted several research techniques to achieve the objectives. The techniques are case studies, site studies, site observations, and in-depth interview (refer to Fig 9)

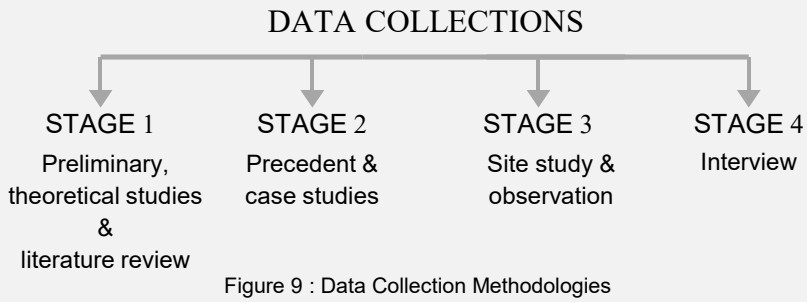


Figure 9 : Data Collection Methodologies
(Source : Author)

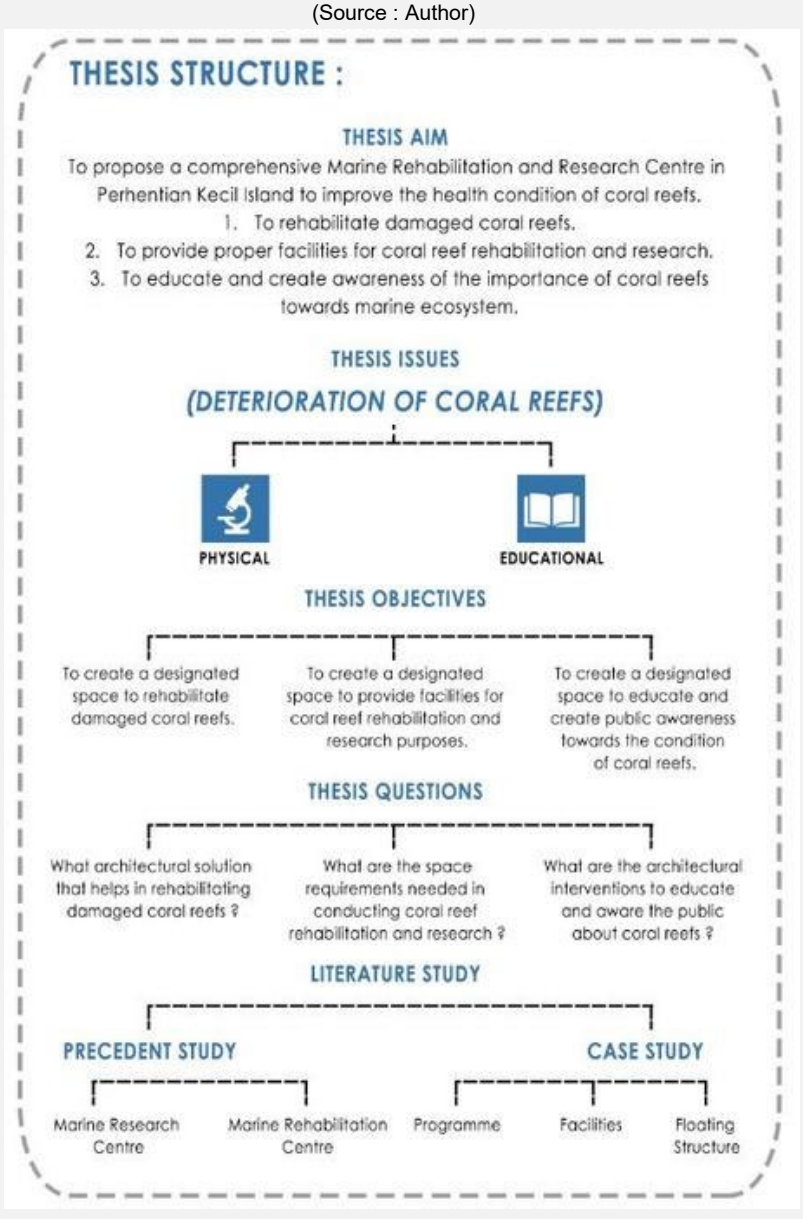


Figure 10 : Thesis Structure
(Source : Author)

SITE INTRODUCTION

Perhentian Island is part of Terengganu Marine Park located at the northern part of the East Coast of Peninsular Malaysia, in the South China sea, 25 kilometers away from the coast of Kelantan and 21 kilometers away from the mainland of Terengganu State. The whole island comprises Perhentian Kecil Island with 867 hectares and Perhentian Besar Island with 524 hectares, with 1,392.15 hectares.

Figure 11 : Key and Location Plan
(Source : Author)

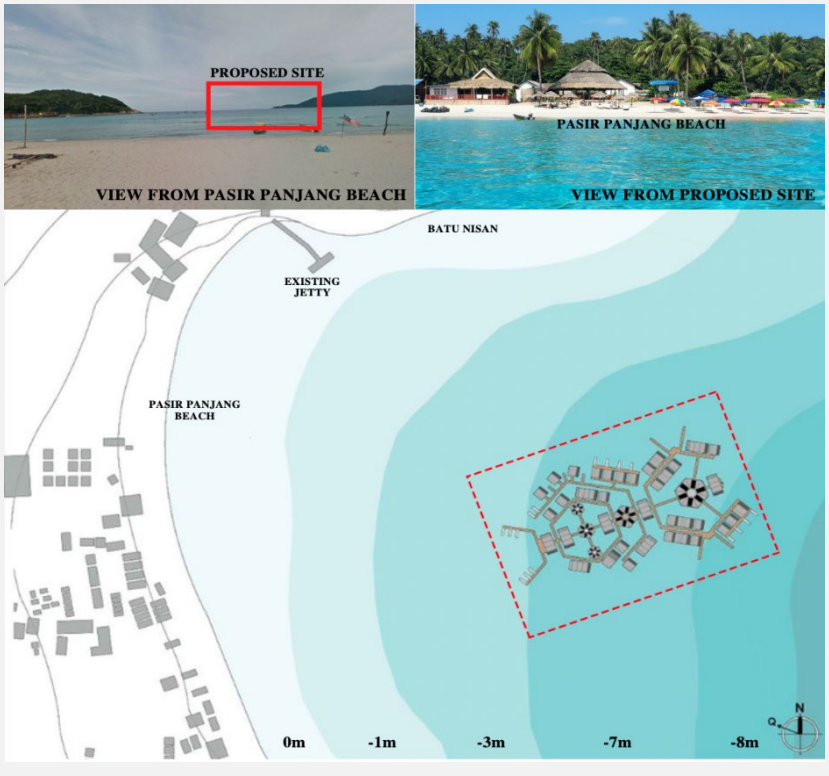


Figure 12 : Site Plan
(Source : Author)

SITE SYNTHESIS

Based on the site analysis, the synthesis is to design a centre that blend with the coral reefs environment without destroying its natural habitat. Fig 3 indicate the space arrangement of the centre to allow day light penetration on the seabed. The first-floor level should be two meters higher than the highest tide to prevent the strong wave from splashing seawater on the decking or into the building.

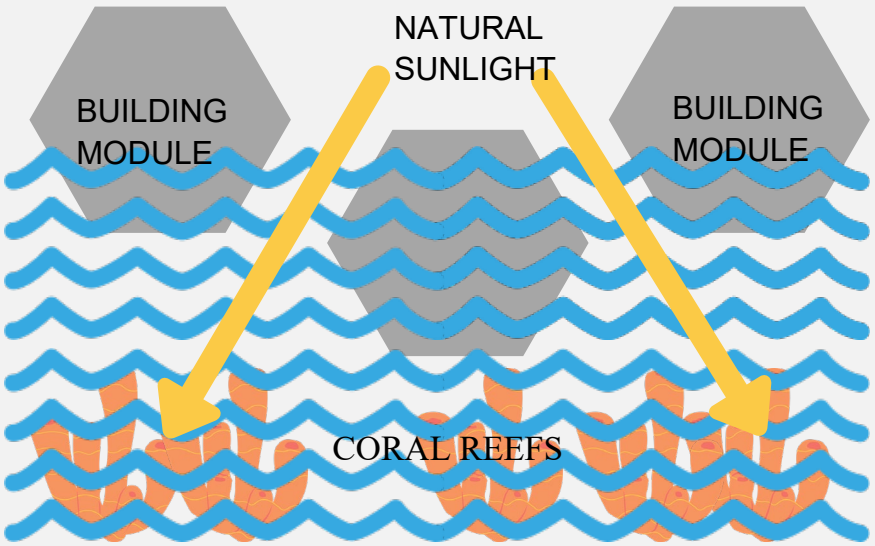


Figure 13 : Building Arrangement to allow natural lighting to penetrate the sea water to reach coral reefs for food
(Source : Author)

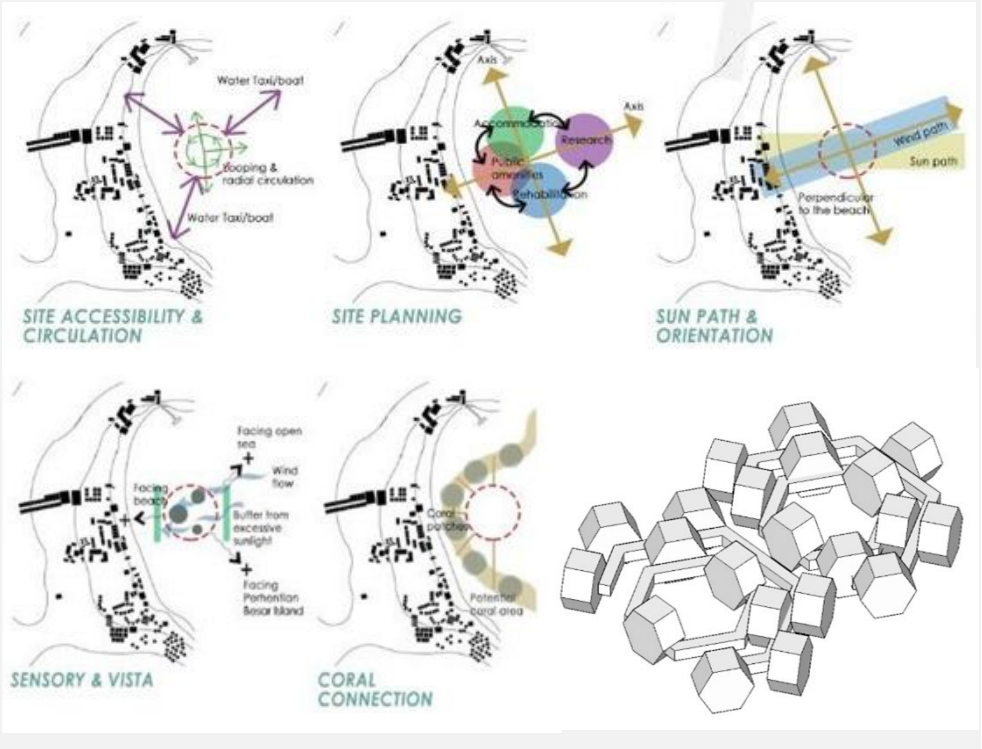


Figure 14 : Site Synthesis leads to form development
(Source : Author)

DESIGN CONCEPT

HEXAGON | HELIOPORA

The Design Concept (refer Fig 15)

- Imitate the nature of the coral in terms of its biological structure and characteristics (permeability and structural strength).
- Acts as an umbrella for damaged coral reefs
- Architectural features which benefit the coral to propagate.
- The hexagonal shape give flexibility in designing the space.

CONCEPTUAL IDEAS

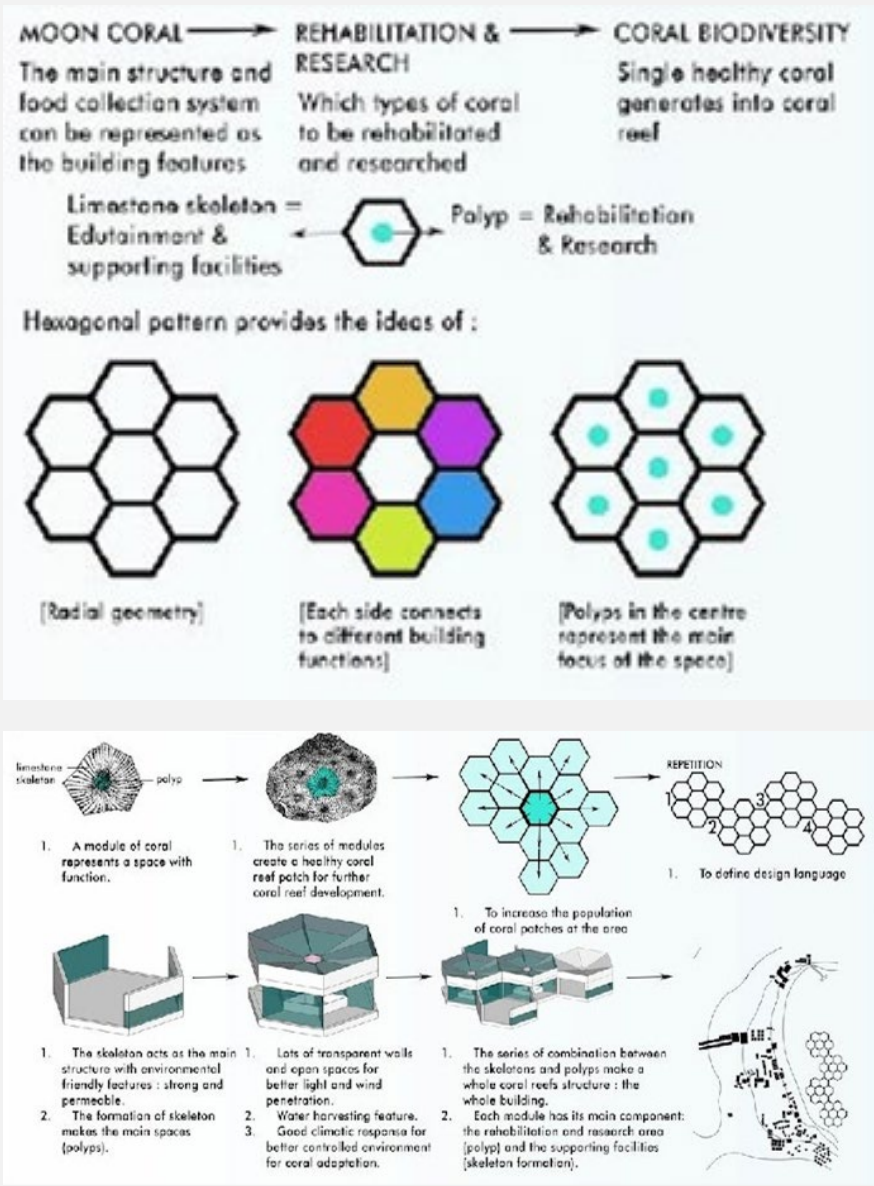


Figure 15 : Conceptual Ideas
(Source : Author)

SITE ZONING

The centre consists of three zones which are tourism, rehabilitation and research, and services (refer to Fig 16). The tourism area is a public zone— encompassing a coral museum, coral aquariums, toilets and café. Rehabilitation, research and accommodation are private zones. The accommodation zone is meant for the researchers and administrators to stay when conducting the research. The rehabilitation and research area is the most private zone, consisting of laboratories and coral nursing areas.

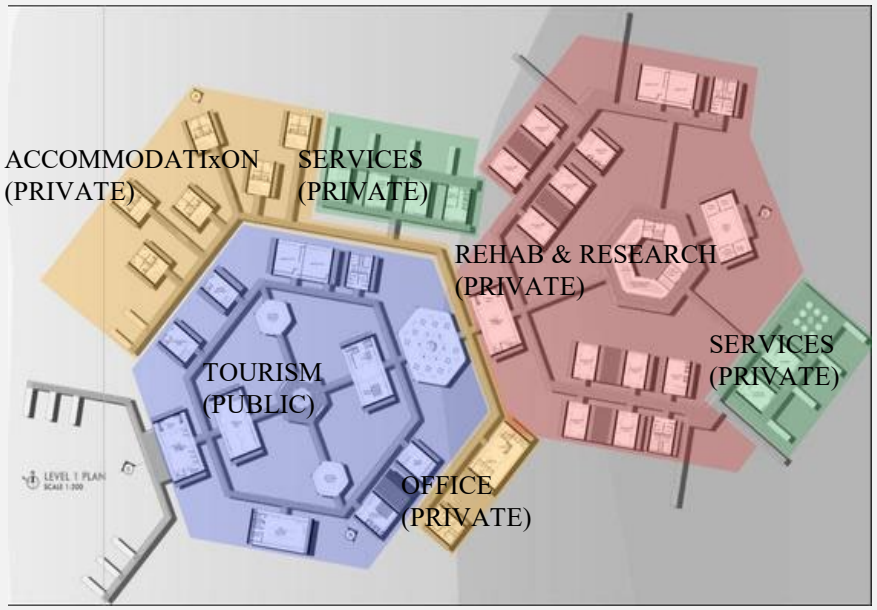


Figure 16 : Site Zoning
(Source : Author)

SITE PLANNING

The tourism zone has the most facilities such as jetty, gallery, restaurant, marine shops, and auditorium. The building is zoned according to public, semi-public, and private areas. The structure is segmented and separated from each other to allow good natural lighting for coral reefs located at the seabed. Building services are at the core building's second and third-floor levels. The accommodations zone are designed further from the research and public for privacy.

DESIGN MORPHOLOGY

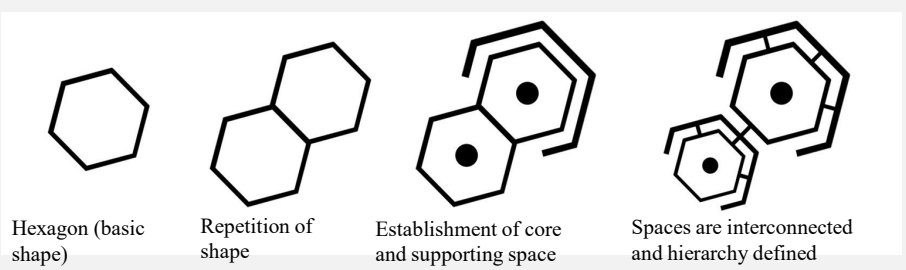


Figure 17 : Design Morphology
(Source : Author)

SITE PLAN

The main idea of the planning is to provide a 360° view of the sea for each space. There are two cores of the building, as shown in Fig 18. All spaces are interconnected through the elevated decking. The planning allows the boats to access the building at several entrances, such as the main entrance and services boat dock area.

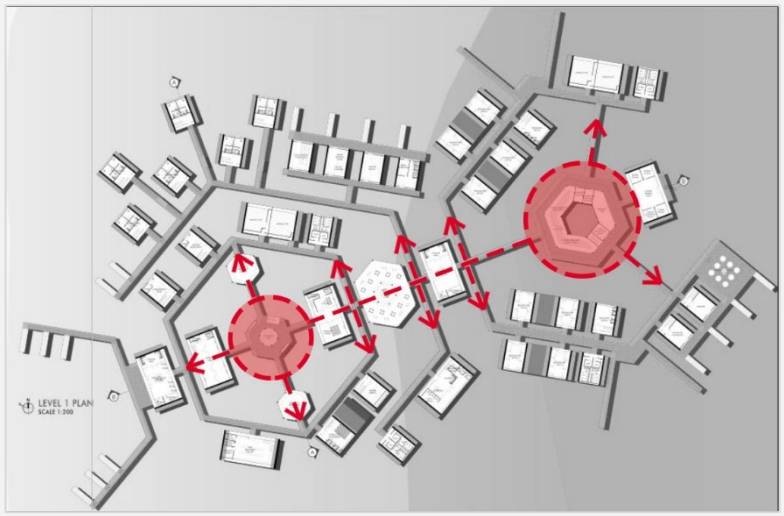


Figure 18 : Two core of the building
(Source : Author)

The arrangement of the spaces is according to their function. For example, spaces that require natural ventilation and lighting are placed above seawater level. In contrast, the spaces that can benefit from the underwater scenery are positioned underwater with artificial lighting and ventilation.

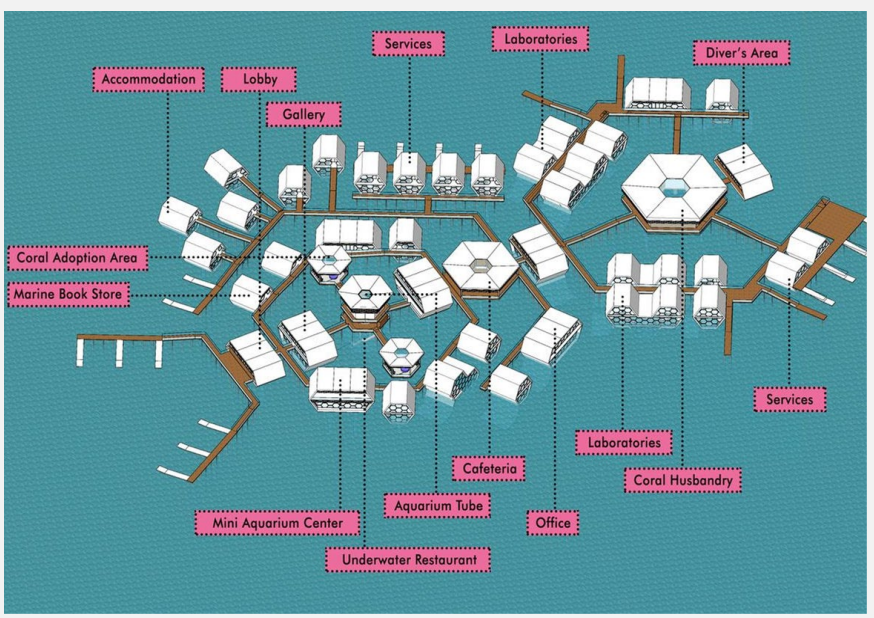


Figure 19 : Building Programme
(Source : Author)

LEVEL 1

Level 1 is where most of the activities occur (Fig 20). A covered walkway connects all spaces. The spaces are lobby, gallery, restaurants, shops, interactive areas, auditorium, cafeteria, laboratories and coral husbandry. Corals propagation and research conducted at laboratories and coral husbandry.

Figure 20 : Level 1 Plan
(Source : Author)

Figure 21 : Main Lobby Area
(Source : Author)

Figure 22 : Coral Husbandry Laboratory
(Source : Author)

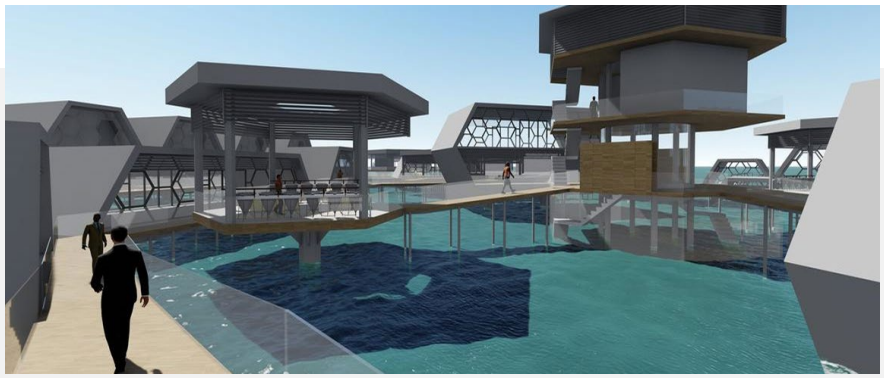


Figure 23 : Walkway connecting spaces at Level 1
(Source : Author)

SUB LEVEL 1

A hexagon module mainly consists of two floors of multiple function spaces. Some modules consist of different functions, while others act as supporting areas to the main area above. This level also has an underwater platform for coral propagation (Figure 25). The main spaces are coral reef clinic, marine biology lab, hatching lab, marine chemical lab, and marine physical lab.

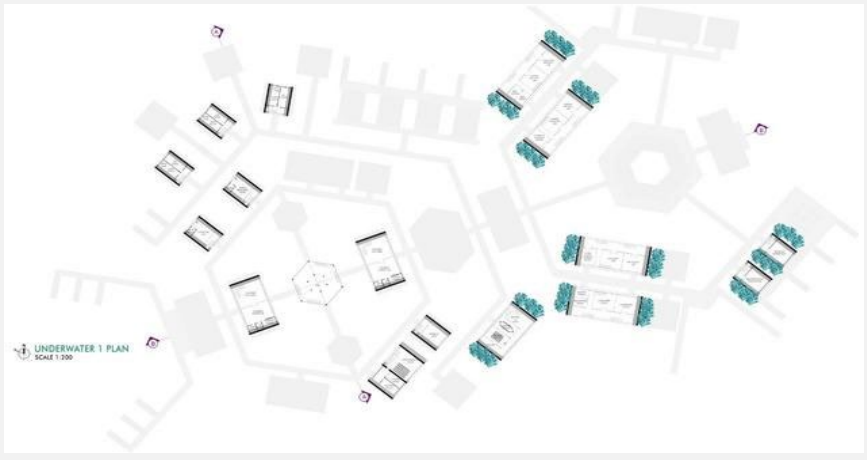


Figure 24: Sub level 1 plan
(Source : Author)

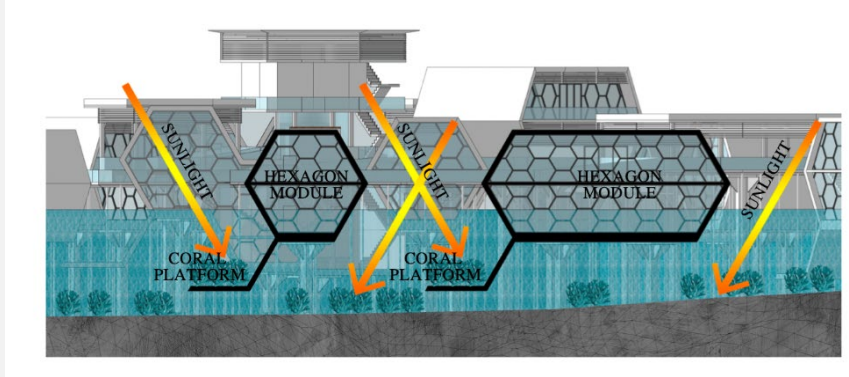


Figure 25: Coral Platform
(Source : Author)

SUB LEVEL 2 PLAN

At this level (sub level 2), the spaces are underwater. This level comprises of an underwater restaurant and filter rooms. The underwater restaurant is the main attraction in the public zone, as it provides an exceptional underwater experience for the public while enjoying their meals. In addition, seabed corals visible from the restaurant glass tube, considered as main attraction for public to enjoy.

Figure 26: Level -2 Plan
(Source : Author)

Figure 27: Underwater Restaurant
(Source : Author)

LEVEL 2 & 3 PLAN

At this level (level 2 & 3), the spaces consists of services facilities such as a control room for tube aquarium, food preparation room, diving equipment room, rainwater harvesting tank, main generator, solar panel battery room, and desalination tank room.

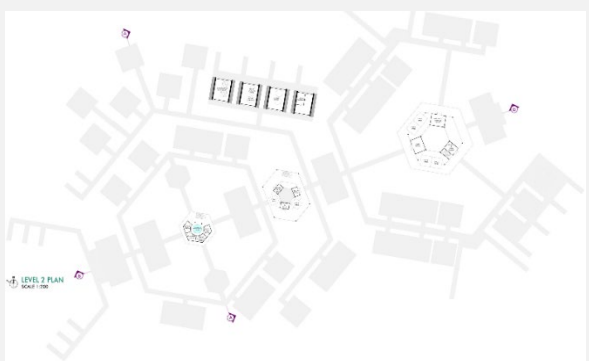


Figure 28: Level 2 plan showing generator and desalination room
(Source : Author)

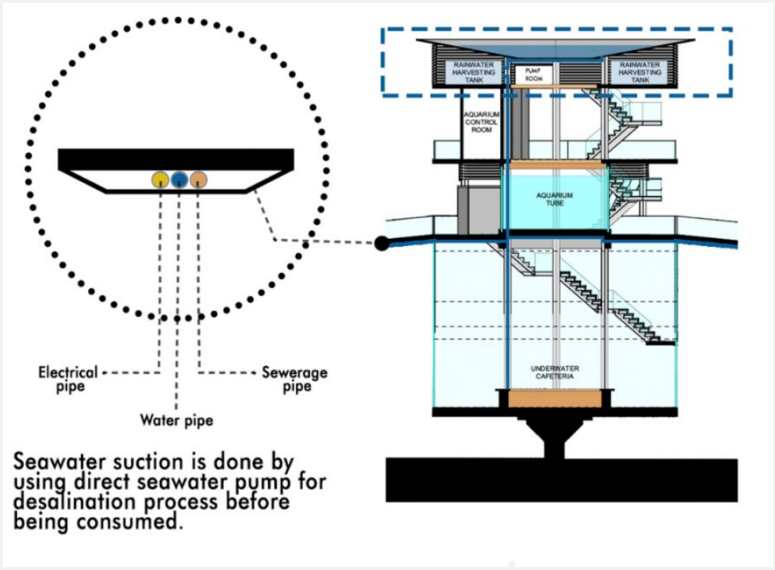


Figure 29: Diagram showing services room located on the 2 and 3 level
(Source : Author)

SPECIAL STUDIES- STRUCTURAL ELEMENTS

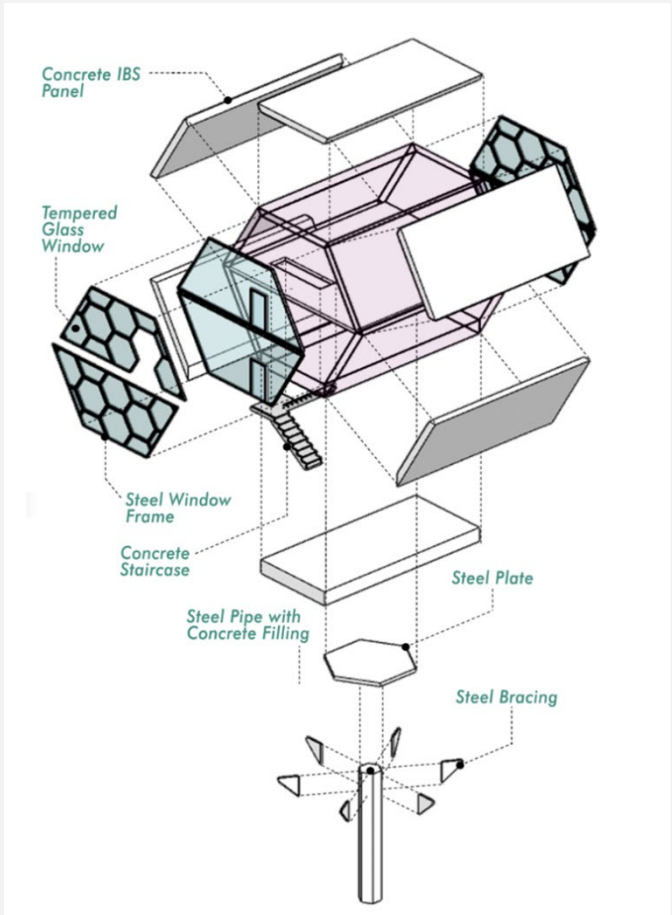


Figure 30: Structural elements of the modular unit
(Source : Author)

SPECIAL STUDIES- MODULAR SYSTEM

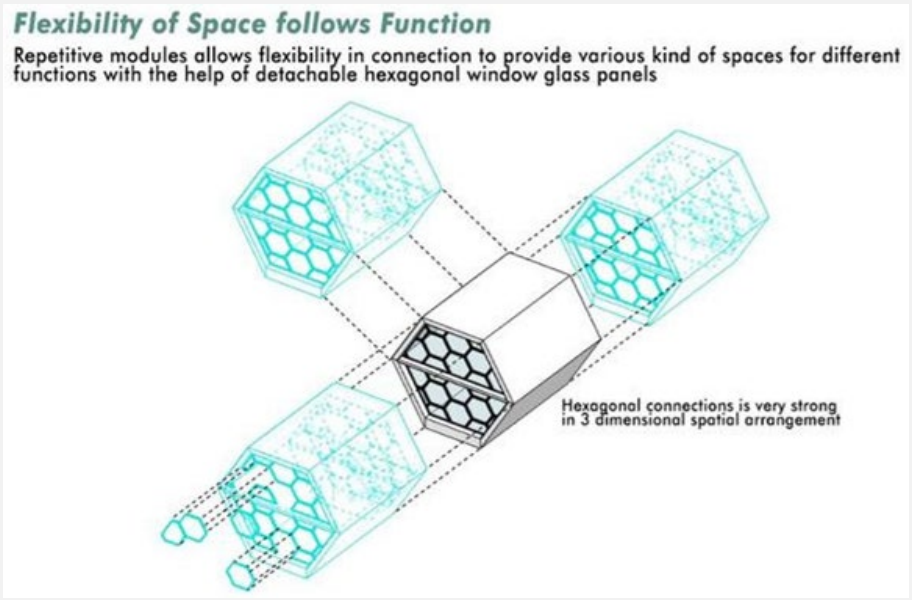


Figure 31: Modular units flexibilities
(Source : Author)

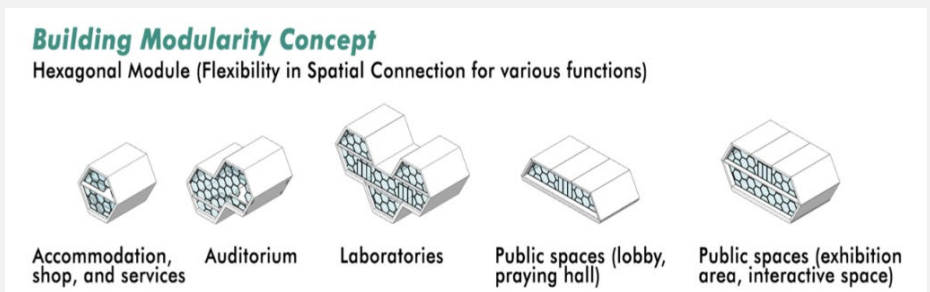
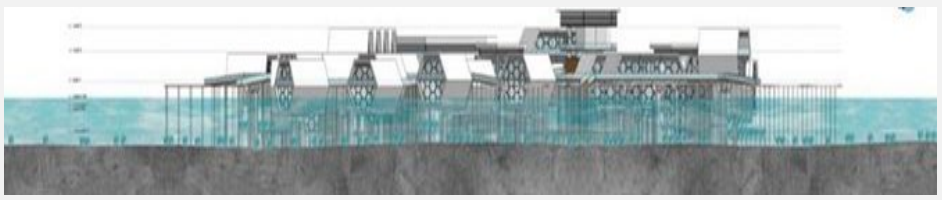
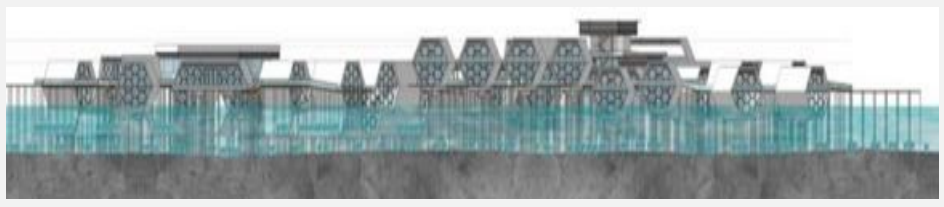


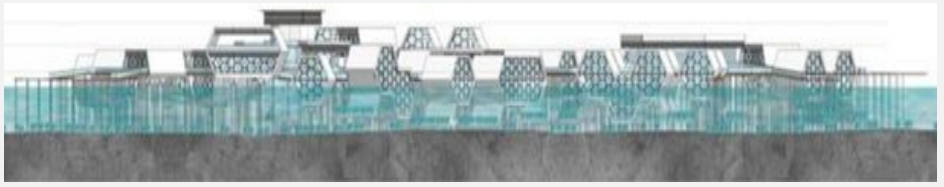
Figure 32: Modularity forms
(Source : Author)



WEST ELEVATION N.T.S



NORTH ELEVATION N.T.S



SOUTH ELEVATION N.T.S

SECTION A-A N.T.S

SECTION B-B N.T.S

Figure 32: Elevations and Sections
(Source : Author)

CONCLUSION

This research had produced a holistic and sustainable design of an offshore coral research centre that can rehabilitate marine environment of Perhentian Island. The use of concrete IBS system for hexagonal forms reduces the destruction of the surrounding environment. Moreover, concrete is the best building material for coral growth.

ACKNOWLEDGEMENT

This research was conducted for Master of Architecture program by Muhammad Zulhilmi Bin Mohd Johan under the supervision of Asst. Prof. Dr Ts. Zeenat Begam Binti Yusof.

REFERENCES

Burke, L., Reytar, K., & Spalding, M. (2012). *Reefs at risk revisited in the Coral Triangle*.

Chen, S.Y., Chelliah, A. J., Lau, C. M., Nadhirah, R., & Hyde, J. 2018. Reef Rehabilitation Experiments Edition 2: A Review of Various Approaches. Reef Check Malaysia. 28p.

Gazi, M., Kusairi, M. N., Yew, T., & Aswani, F. (2013). Assessing environmental damage to marine protected area: a case of Perhentian Marine Park in Malaysia. *Journal of Agricultural Science (Toronto)*, *5*(8), 132-141.

Reef Check Malaysia. (2020). Status of Coral Reefs in Malaysia, 2020.

Reef Check Malaysia. (2018). Status of Coral Reefs in Malaysia, 2017.

Safuan, C. D. M., Ashraf, A. R. M., Tan, C. H., Jaafar, S. N., Yusop, P. A. M., Lai, R. K., & Bachok, Z. (2021). Coral health status assessment in Malaysia islands; looking towards Marine Spatial Planning. *Ocean & Coastal Management*, *213*, 105856