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REPOSITIONING FIREFLIES' SANCTUARY AT THE NORTHERN BANK OF KERIAN RIVER, PENANG (NATURAL LANDSCAPE HERITAGE TOURISM)

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ABSTRACT

Mangrove fireflies from the genus *Pteroptyx* contribute to a nature tourism called entomotourism. This species is an ecotourism attraction in Malaysia because tourists enjoy their synchronous bioluminescent flashing in large numbers on the mangrove trees at night. However, this firefly habitat is not protected as forest reserves and is threatened by habitat destruction and fragmentation, indicating that both their numbers and habitats have been declining. Therefore, this proposed design idea is to treasure the new natural landscape heritage tourism by engaging users with the natural element in the site of Kerian River firefly sanctuary at the physical border between Penang & Perak by revealing the ecological and natural heritage values. Through targeted interviews and surveys, a comprehensive understanding of the geographic scope, magnitude, focal species, and other attributes of the Kerian River firefly's sanctuary tourism sites was established. Our surveys revealed that light pollution of artificial light, water pollution in Kerian river caused by the nearby industrial area and the riverbank erosion caused by the destructive wave produced by the "Kenka boats" for fishing activities were major disturbances or threats to the habitat. Finally, we provide recommendations for transforming tourist behavior to minimize the impact on firefly habitats. By developing design concepts, ideas and strategic plans that incorporate these recommendations, the Kerian River firefly sanctuary at Penang sites which is an environmentally sensitive area (ESA) can enhance the visitor experience, protect natural resources, benefit local communities, and help promote the conservation of fauna biodiversity.

Keywords: *Landscape heritage, Ecology, Mangrove, Fireflies, Entomo tourism, Ecotourism*
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INTRODUCTION

This project is focusing on enhancing the fireflies' habitat with the mangrove ecosystem as well as engaging users with the natural element in the site in order to reminisce the value of the natural heritage by revealing the ecological and natural heritage affecting a site for natural heritage tourism. The aim of this project is to enliven the Kerian River firefly sanctuary in order to treasure the new natural landscape heritage tourism. Several issues were detected at the site related to the project. There are a declining number of fireflies caused by the light pollution of artificial light, water pollution in the Kerian river caused by the nearby industrial area, and the riverbank erosion caused by the destructive wave produced by the "Kenka boats" that often come in for the fish.

Fireflies contribute to the stability and sustainability of mangrove ecosystems around the world (Dawood and Saikim, 2016; Nallakumar, 2003). The main species of trees in which fireflies congregate along the mangrove area is *Sonneratia caseolaris* (Jusoh et al., 2018; Jusoh et al., 2010; Prasertkul, 2018). Conversion of mangrove forests to other land use resulted in a decline of more than half in the number of these trees as well as the firefly population (Jusoh and Hashim, 2012; Asri et al., 2020; Jusoh et al., 2012). A decrease has also been reported in the occurrence and abundance of many firefly species in recent decades (Faust, 2017; Lewis, 2016; Lloyd, 2008). The populations of fireflies are increasingly being threatened in Malaysia. Therefore, fireflies and their habitat must immediately be protected before they go extinct.

SITE LOCATION

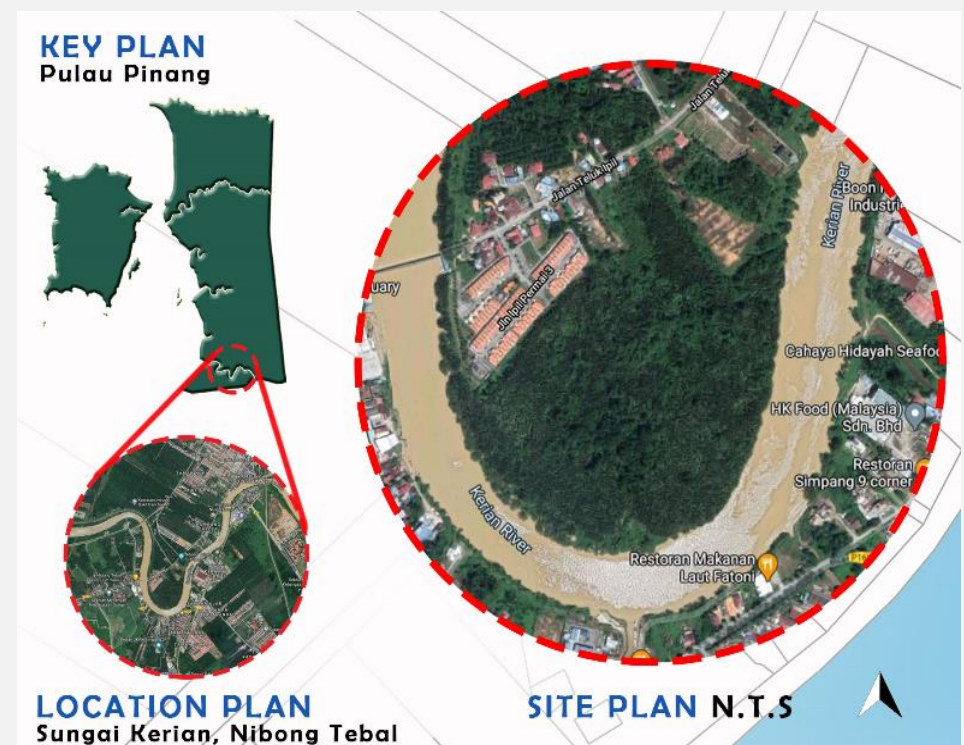


Figure 1: Key plan and location plan

LITERATURE REVIEW

Fireflies

Fireflies with attractive bioluminescent courtship displays have become ecotourism icons that attract many tourists to Malaysia (Nallakumar, 2003). There are many firefly-based ecotourism areas in Malaysia, including Kg. Kuantan Kuala Selangor, Kg. Dew Perak, Kg. Yakyah Terengganu, Kota Tinggi Firefly Park Johor and Kelip-kelip Klias Wetland Sabah (Nor Shafikah et al., 2021; Lewis et al., 2020). Fireflies are a type of beetle (Coleoptera: Lampyridae) that congregate nightly on mangrove trees along rivers, where they produce a synchronised bioluminescent pattern. In some areas, firefly ecotourism has been a popular attraction and has become an important contributor to the nation's gross domestic product (Syed et al., 2001; Mohd-Shahwahid et al., 2016).

Globally, 2000 firefly species have been recognized (Lewis et al., 2020) but in Malaysia, a total of 13 species (Genus: Pteroptyx) have been recognized (Norela et al., 2015; Shahara et al., 2017). The Pteroptyx species are semi-aquatic fireflies, as adult females lay eggs in the moist soil in the intertidal zone of the river. During the larval stage, they feed on mangrove snails and other soft-bodied prey as the firefly larvae can survive underwater for a period of time and live on muddy riverbanks (Thancharoen et al., 2007; Barrows et al., 2008; Lewis et al., 2020). They are fully developed when they transform into pupae and eventually emerge from the pupal case as adult fireflies. Firefly adult male congregates on trees at night with bioluminescent lights at the bottom of the abdomen (Buck, 1988) which attracts females to find a mate (Jaikla et al., 2020; Asri et al., 2020).

Issues related to the fireflies:

1. Directly affected by land use worldwide.
2. Pesticide or weed killer.
3. Very sensitive towards environmental change.

This species also can be seen in the Indian continent and southeast Philippines / New Guinea. The distribution of *Pteroptyx tener* Oliver in Malaysia is like below”

Landscape Heritage

Landscape heritage is a combination of natural heritage and cultural heritage. It embraces both dimensions.

Natural heritage refers to natural features, geological and physiographical formation and delineated areas that constituted the habitat of threatened species of animals, plants and natural sites of value from the point of view of science, and conservation of natural beauty.

2000 species of fireflies are identified in the world and 29 are found in Malaysia. The most significant species in Malaysia is the *Pteroptyx tener* Oliver because of its synchronized flashing.



Mangrove Forest / Berembang (*Sonneratia caseolaris*)

Mangrove forests are a unique ecosystem generally found along sheltered coasts where they grow abundantly in saline soil and brackish water. It is the tidal swamp that can be found in tropical deltas estuaries, lagoon and island. The habitat is soft, silty and shallow, coupled with the endless ebb and flow of water providing very little support for most mangrove plants which have aerial or prop roots (known as pneumatophores, or respiratory roots) and buttressed trunks. Tree character that populating the ecosystem:

- Survive high amount of salinity
- Shallow root which partly exposed to the air allows them to breath in an environment frequently.

Canopy

- Good storage of carbon dioxide
- (five times more than equal area of rainforest).
- Valuable in the face of increasing frequent and violent of tropical storm and hurricane.
- Obstacle to wind and wave, decrease the intensity of the storm.

SITE INVENTORY AND ANALYSIS

Land use and site context

Nibong Tebal consist of 24,422 population. The number are divided into two which are male about 12,387 and females 12,035. The majority of the people is from Chinese (46.4%), Indian (26.3%), and lastly Malay (27.2%).

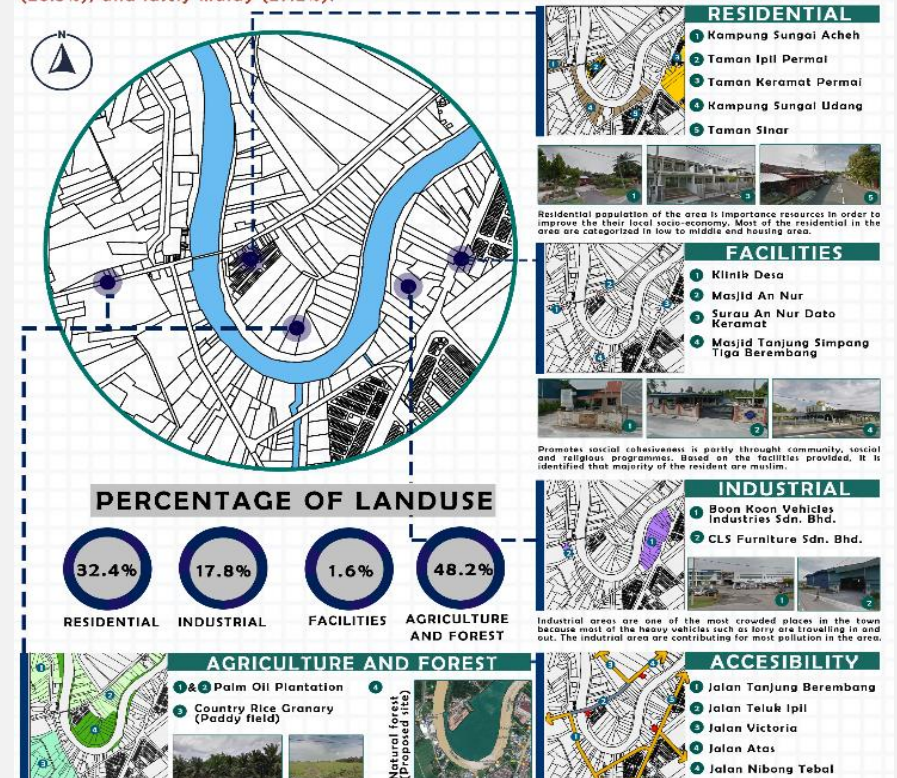


Figure 2: Land use and site context

The information in figure 1 shows the percentage of space on the site including the site context. The highest percentage of land use is dominated by agriculture and forest which cover almost half of the selected area. The lowest land use is the facilities because this area is a rural area that has less development. All the site context is important in considering the circulation and accessibility to the site. Thus, it's clear that the site is suitable for the firefly sanctuary project due to its strategic location.

Circulation and accessibility

Assessment of the existing road and linkages toward the Kerian river and specifically to the firefly jetty. The estimation of time take from one entrance to another also being observe with the measured distance.

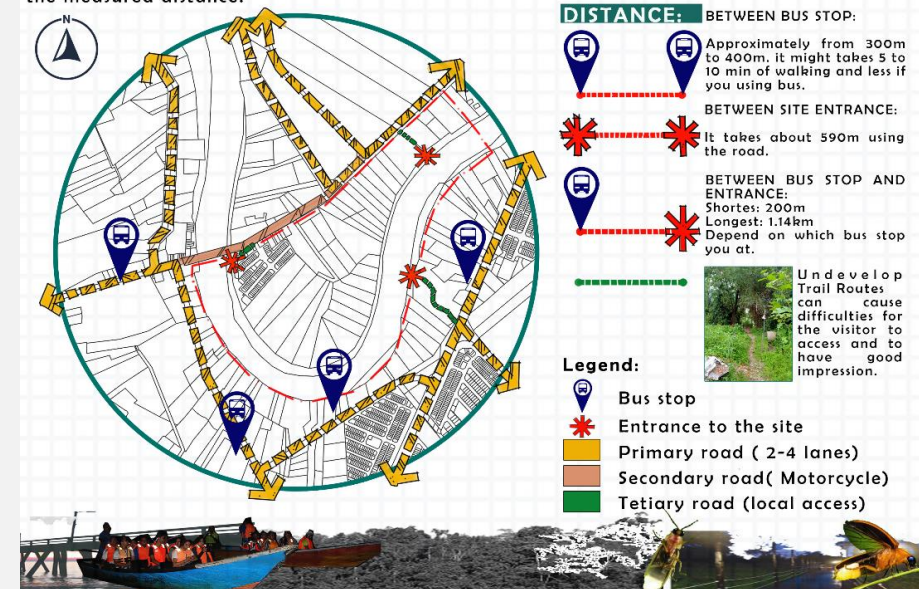


Figure 3: Circulation and accessibility

The area consists of three types of roads which are the primary, secondary and tertiary roads which are created by the locals. Cars are not allowed to enter the tertiary road because of the space and to avoid any natural destruction. But the tertiary road condition is in very poor condition for the visitors. This is because the locals use the roads for the daily routine of fishing. Therefore, there are no proper roads and connectivity through the mangrove area.

HYDROLOGY



The water body that exists in the area consists of the river and flood-prone areas. There are two rivers in the area:

1. Kerian River is a meandering channel river that acts as the main water body that channel to the sea. The river flowing gently sloping ground begin to curve back and forth across the landscape.
2. Udang River is the secondary river that channels to the Kerian river, the river mouth has been the docks for the fishermen's boats.

Climatic Factor

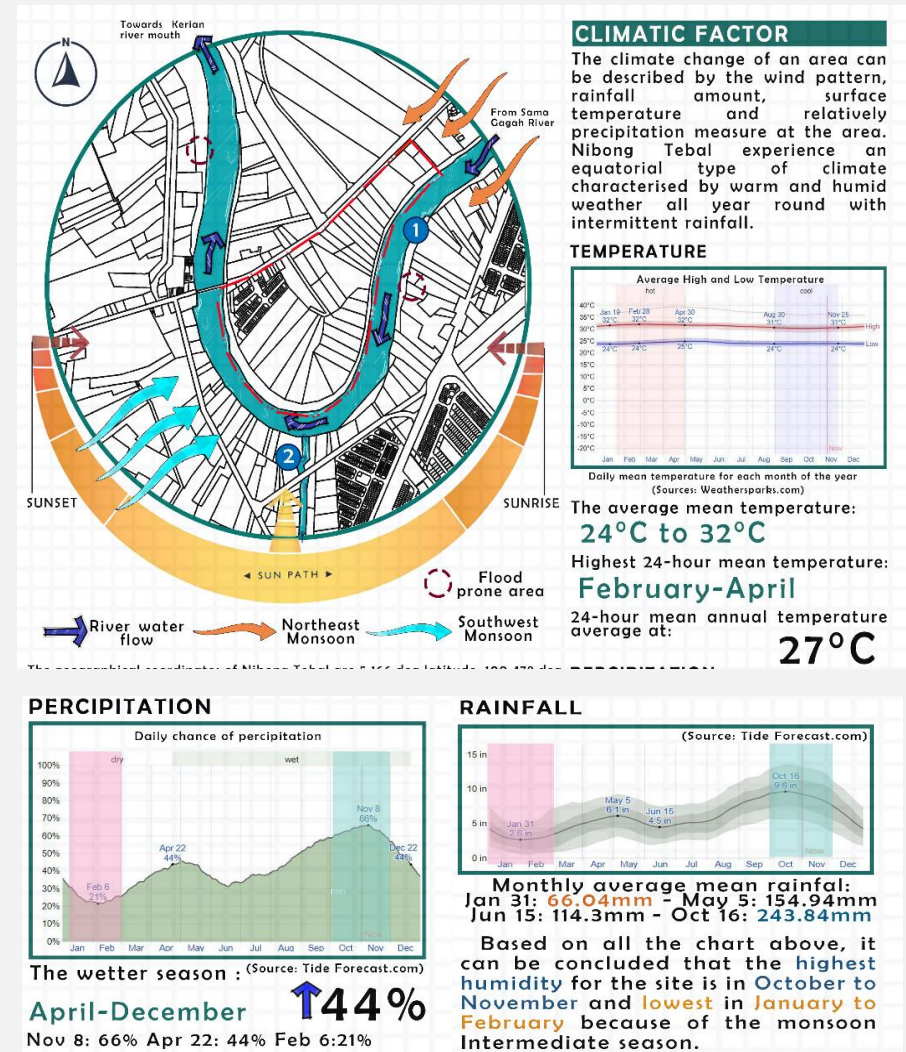


Figure 4: Influence of climate towards hydrology

WATER QUALITY

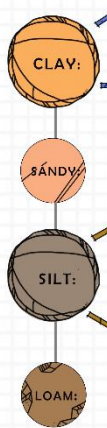
1. "Sungai Kerian famous for its fireflies' colonies, it is being threatened with industrial waste pollution from factories operating in Kebung Kuyung".
2. "The villagers and fishing community claimed that the pollution had been ongoing for the past 10 years".
3. "There also report from the Friends of Earth Malaysia (SAM) which state that the drain water turning black and smelly and affected nearby Sungai Kerian.

(Source from: News Straight Times, 2016)

SOIL CHARACTER

ALLUVIAL SOILS

Alluvial soil is the combination of 4 different type of soil which is:



Advantages:

- Hold onto nutrients so that the plant has food its needs.
- Great for growing plants that need a lot of water.

Disadvantages:

- Hold onto water, slow to drain.
- Slow to warm the spring Compact easily.
- Tend to be alkaline.

Advantages:

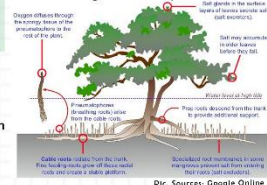
- Good for growing crops.
- Promotes water retention and air circulation.
- More fertile than sandy soil.
- Easier to work than clay soil.

Disadvantages:

- Water filtration can be poor.
- Has greater tendency to form crust.
- Can become compact and hard.

Topsoil	Porous and facilitate water percolation and aeration during low tide.
Sub-soil	Typically waterlogged having the little aeration facility which reduce with depth and contain alot of organic matter.
Salinity	Slightly acidic (7.3-8.2pH)
Composition	Organic matter and organic carbon- forest structure values varies depends on location.

Mangrove Adaptations



Pic. Sources: Google Online

Figure 5: Soil character in the selected area.

SOCIAL STUDIES

ACTIVITIES ON THE SITE

Most of the activities here are affected by the fishing culture. This is because there so many fishermen who came to the area to sell their haul to the local here.

Fishing docks:
Fishing activities that contribute to the local economy.



Playground:
The local spending their leisure time by exercising



Fish Market:
Morning activities take place here where the local buying their fresh fish from the seller.
Can produce bad smell.



Morning market/ food court:
local and tourist can find their daily essentials here.



River:
Spot for local people who like to catch shrimp. Visitor who are willing to catch the shrimp also welcome here



POTENTIALS:
1. Soil very suitable for the growth of mangrove forest.
2. Activity in the area are healthy and contribute to their social growth.

CONSTRAIN:
1. Increase human activities near riverback can degrade the soil condition.
2. Small place that crowded by people can produce bad view and senses.

Market:
Wholeseller come and by the fish from the fisherman who just arrived after finishing their catch.



Figure 6: Social studies of the site

Figures 5 and 6 show two important characteristics that need to be observed for the project's effectiveness. Soil character will determine the suitable strategies to be taken for the firefly's sanctuary. This is because the mangrove ecosystem will be disturbed if the soil character were not suitable, and this will affect the firefly's habitat. While social studies are important to observe the local activities that will be attractive to the visitors and how to improve their economy based on their daily routine.

VEGETATION AND WILDLIFE

Both are very important and they show the diversity of existing vegetation and wildlife this help to provide a great atmosphere of natural element without the disturbance of building materials. It provides a great view and sense of the surrounding which helps any human being feel relaxed and comfortable.

This area is also suitable for habitat conservation and preservation as for the high density of vegetation in the area.

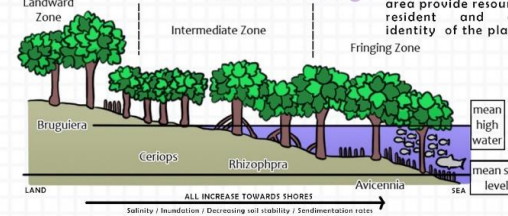
VEGETATION

The vegetation in the proposed site can be divided into two categories which is the Mangrove area and the residential area.



- Residential area
- Spot on Berembang tree
- Ongoing river development

- Mangrove plants provide several benefits to the riverbank ecosystem such as nursery to many types of animals especially fireflies.
- Riverbank development disturbed the harmony of mangrove ecosystem with fireflies and give long term effect to the riverbank ecosystem.
- Vegetation in residential area provide resources for resident and creates identity of the place.



EXISTING TREES

MANGROVE AREA

LANDWARD ZONE:



INTERMEDIATE ZONE:



FRINGING ZONE:



RESIDENTIAL AREA



BIOTIC (FAUNA)

WILDLIFE (Existing animals):

Survey for terrestrial vertebrate fauna was carried out by observing and researching the mangrove habitat within the proposed project.

MAMALS:



INSECTS:



BIRDS:



AQUATICS:



REPTILES:



RELATIONSHIP (BEREMBANG AND FIREFLIES)

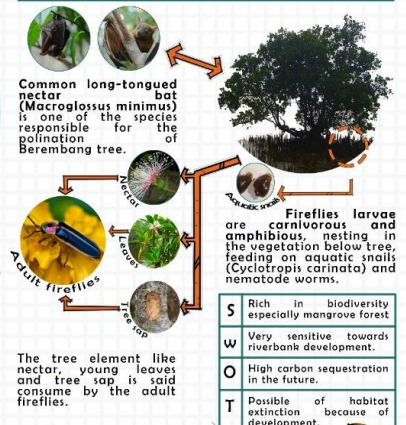


Figure 7: Vegetation and wildlife

SITE SYNTHESIS



1. CONSERVATION/ENHANCEMENT.

Aimed at conserving the existing mangrove character of natural heritage but incorporating proper management and enhancement of certain features that can contribute to the character of riverbank mangroves. Emphasis is given on restoring a positive and coherent character like the Berembang tree for improvement of habitat in the area especially Fireflies because the soil condition is good for mangrove trees.

2. NATURE-BASEDACTIVITIES.

Sungai Kerian has the potential to be developed as a nature tourism spot. This river can create ecological interaction between humans and animals through the water landscape element, With people can experience the natural landscape character.

3. CLIMATICMANIPULATION.

Ensure the provision of adequate landscape buffer of the river with built-up areas. Airborne or windblown dust particles due to transportation and the business area may degrade the air quality in the proposed area.

4. LESS ARTIFICIAL LIGHT INTERVENES.

Lessen the usage of artificial light in the proposed area. A barrier that can prevent the artificial light of the industrial area from entering the river vicinity.

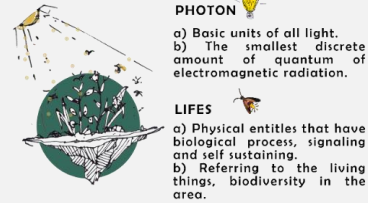
5. LINKAGES

Comfort and accessible trail for the visitor to enter the proposed site. Improvement of safety aspect for the walkable distance of bus stop to the site entrance.

DESIGN PROCESS

DESIGN CONCEPT

"PHOTON OF LIVES"



PHOTON
a) Basic units of all light.
b) The smallest discrete amount of quantum of electromagnetic radiation.

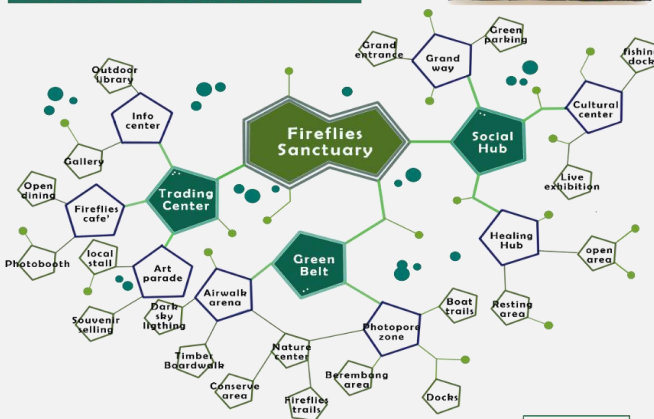
LIFES
a) Physical entities that have biological process, signaling and self sustaining.
b) Referring to the living things, biodiversity in the area.

WHY "PHOTON OF LIVES"?

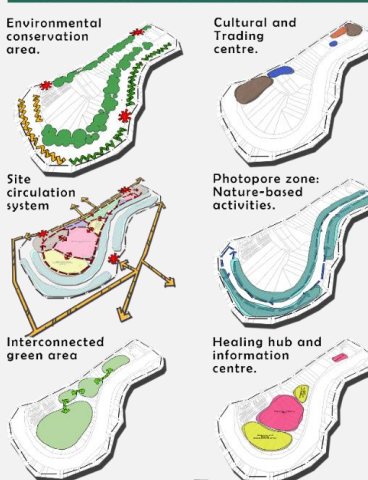
A concept that appreciate the small fireflies uniqueness of a natural heritage that can give magnificent effect along side the mangrove biodiversity that store many other form of life.

PHOTON OF LIFE

SPACE PROGRAMMING



FUNCTIONAL DIAGRAM



DESIGN STRATEGIES

ATTRACTION

ENVIRONMENT
1. Mangrove habitat restoration along the river to improve the natural barrier and lessen the soil erosion.
2. Emphasis is given on restoring a positive and coherent character like Berembang tree for the improvement of firefly's habitat in the area.



COMMUNITY

3. Interconnected network green space to create sustainable environment living for human and wildlife such as healing hub.



ECONOMY
4. Produce benefits that support local community. (Heritage Trading center)
5. Nature-based activities: Boats docks, fireflies watching trails.

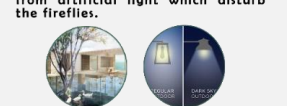


COMMUNICATION

COMMUNITY
3. Universal design trail / walkway.
4. Space for the community engagement for social and cultural values.



ECONOMY and fireflies interpretation center.
6. Usage of dark sky lighting can minimize the high rate of lighting from artificial light which disturb the fireflies.



SPACE PROGRAMMING MAP

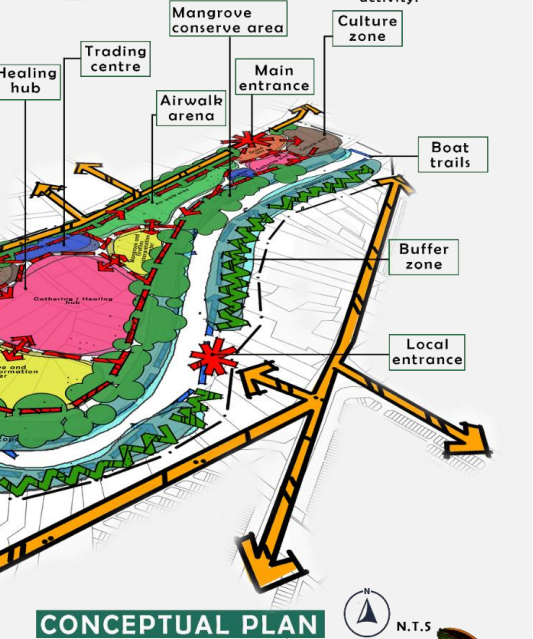
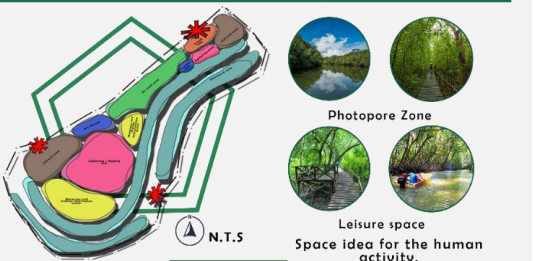


Figure 8: Design process

PLANTING CONCEPT : NATIVE AND COZY

1. GRAND AND WELCOMING AREA

Trees with a welcoming sense such as palm, *Cycas* or plants with aesthetic and fragrance value.

2. NATURAL BUFFER / SCREENING ZONE

Tall trees with dense foliage can provide shade and safety with privacy for the visitor. It can also tolerate sunlight and prevent unpleasant views.

3. VILLAGE AREA

Dominant trees in the area like *Cocos nucifera* and fruits can help restore the cultural identity.

4. CONSERVATION AREA

Replanting the mangrove species that will act as filtration of pollution from built-up areas. Also, for the visitor to learn about mangrove

5. RIPARIAN AREA

Native riparian species to improve the water quality. (Aquatic species like sedges, rushes and others)

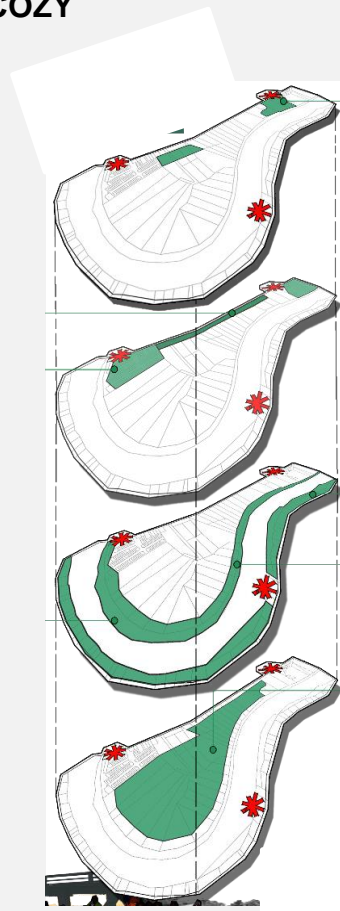
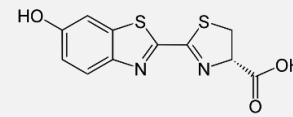


Figure 9: Planting concept

SCHEMATIC PLAN

DESIGN FORM



The form in schematic plan are adapted from the chemical form of the luciferin itself. Luciferin is the organic substance, present in luminescent organisms such as fireflies, that produces light when oxidized by the action of the enzyme luciferase.

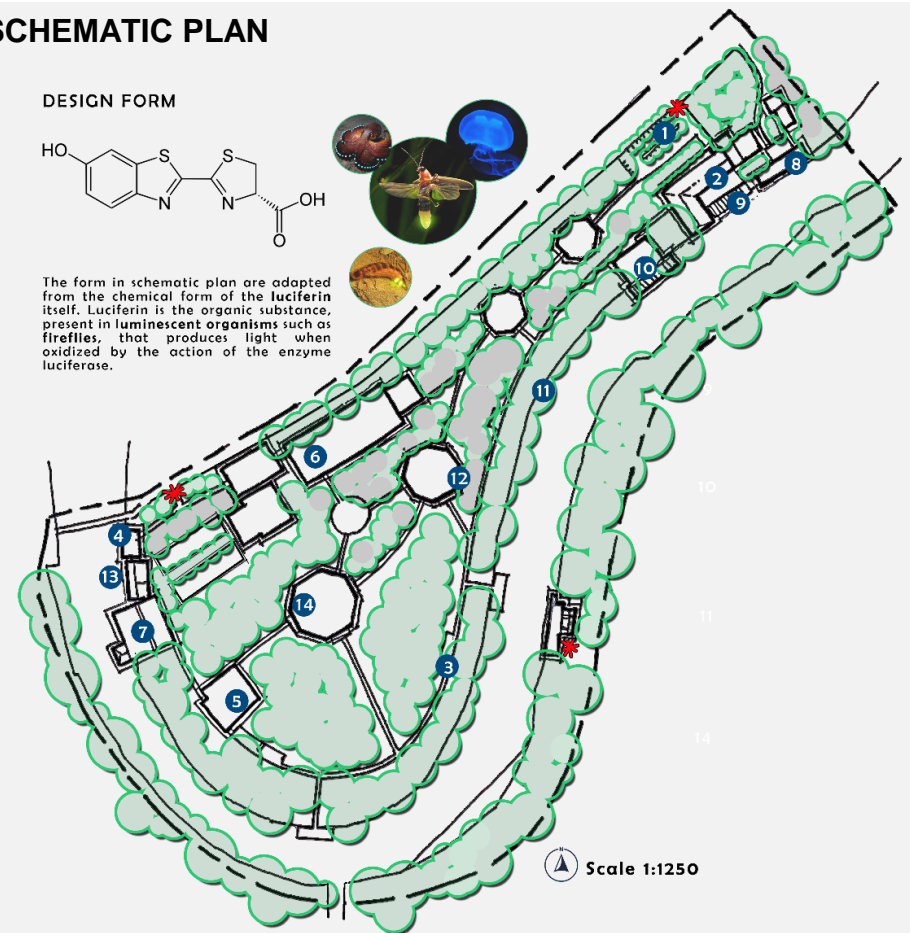
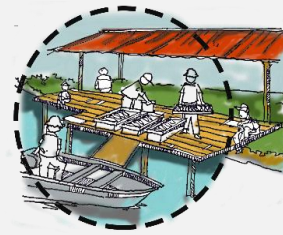


Figure 10: Schematic plan



The art parade is where the locals can promote their culture, which is handcrafting and souvenirs for the tourists. This will improve the local economy.



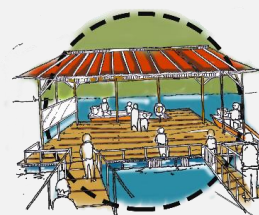
A cultural center is a place for the visitor to observe how the fishermen get their catch to the land before selling it to the buyers. This show the fishing culture in the area.



Resting area that uses dark sky LED lighting that can help in preventing the fireflies from avoiding the place



Airwalk or Timber walk is the pathway for the visitor to explore the firefly's sanctuary park



Fireflies' docks are the entrance to the firefly's watching area, this area is designed to accommodate only several people at a time.



The photophore zone is the area of conservation and preservation of the Berembang tree, especially for the firefly's habitat.

Figure 11: Design strategies

NEW LEAD OF FIREFLIES SANCTUARY

The area will be focusing on providing a good human–animal relationship by emphasizing the mangrove habitat especially Berembang (Sonneratia caseolaris) which is the main attraction for fireflies. This is a well as for humans to experience nature.

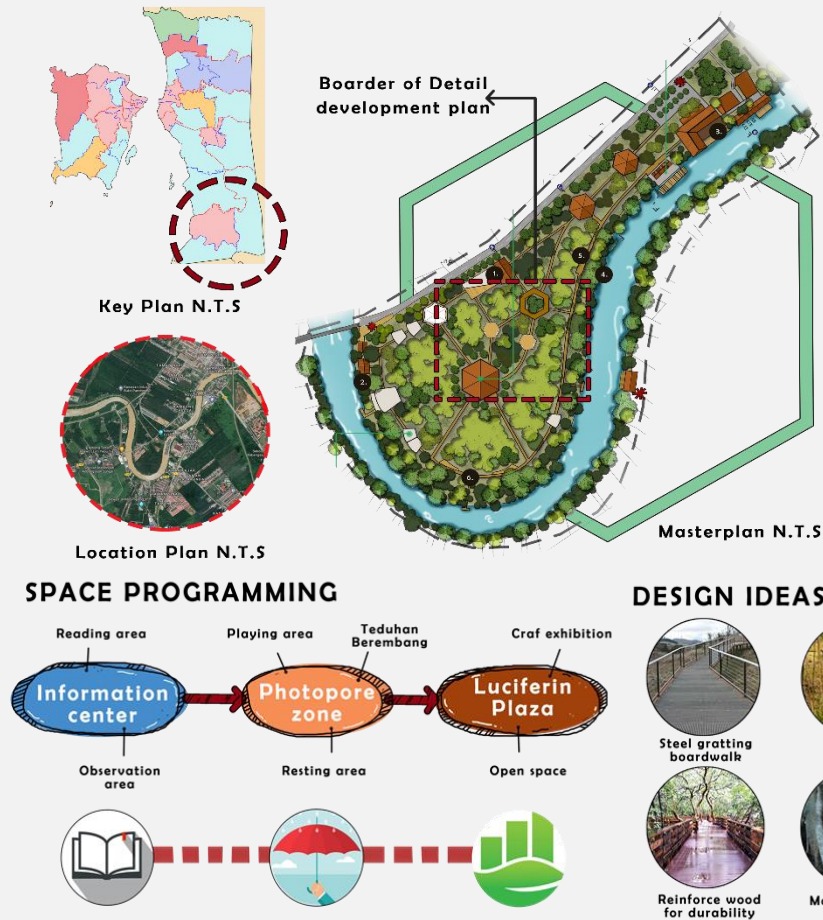


Figure 12: Site planning and Space Planning

AIM & OBJECTIVE

To create a platform for the relationship of humans and fireflies by highlighting the aesthetical environment of mangrove habitat conservation and preservation in Sungai Kerian.

1. To Identify the significant natural landscape heritage values for the improvement of the local economy.
2. To protect and recreate the habitat for the fireflies and mangroves with proper management.

PHOTON OF LIFE

The concept is inspired by the light particles produced by the fireflies called luciferin. The particles have a hexagon shape that is connected to each other. The layout form of the design are referring to the luciferin itself. Hence, with the combination of mangrove forests in the area, it is a suitable concept for the project.

DETAIL DEVELOPMENT PLAN



Figure 13: Detail site Planning

SECTIONAL AND ELEVATION

There are 2 sections and 2 elevations that show below. All these sections highlight the main space and area of the site. All these areas are accessible for humans; therefore, they can interact more with nature, especially the mangrove tree and fireflies themselves.

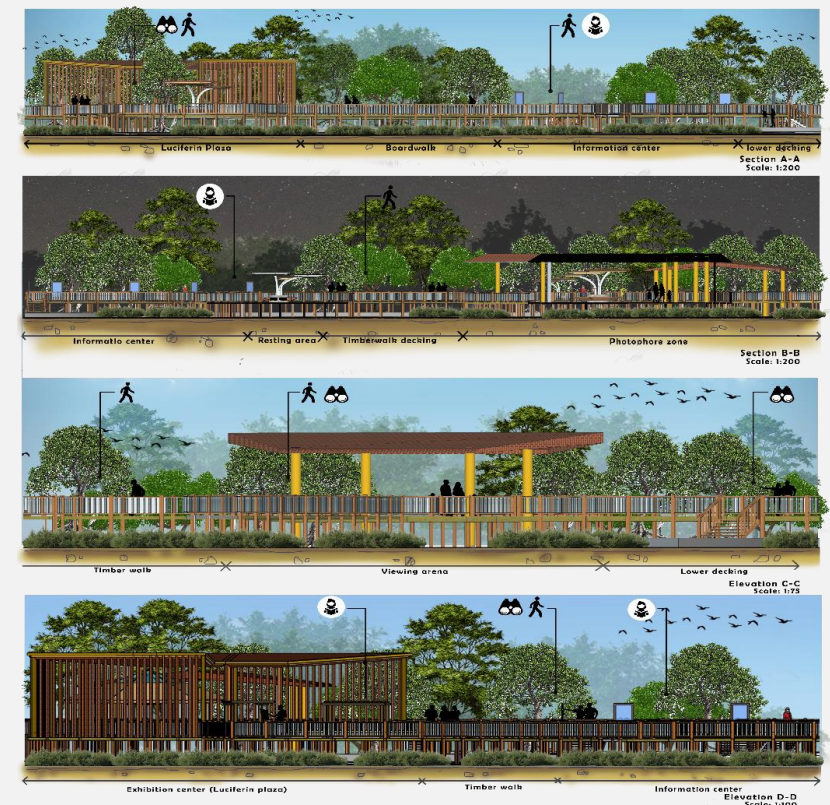


Figure 14: Elevations

HARDSCAPE PLAN

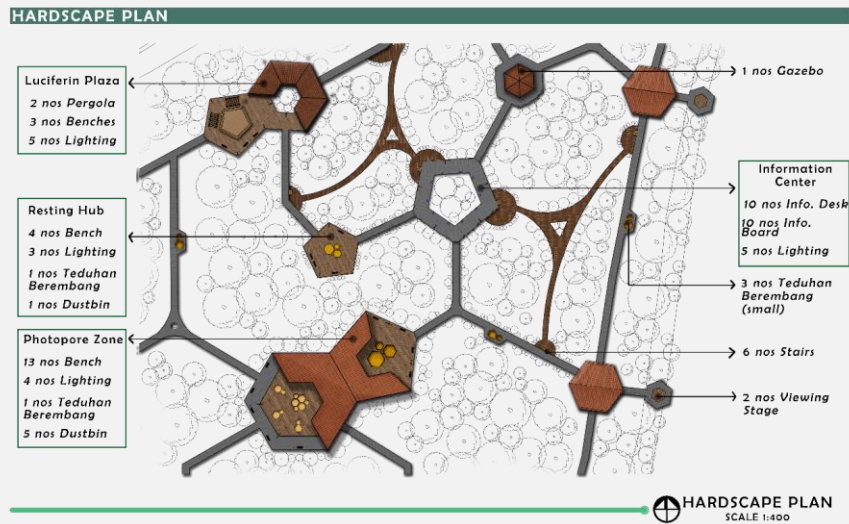


Figure 15: Hardscape Plan

HARDSCAPE SCHEDULE

The list showed all the Hardscape elements proposed on the site. The hardscape element is purposely to help the visitors to have a safe and comfortable experience. There are no excessive elements that can degrade the natural element in the site.

Table1: Hardscape Schedule

NO.	SYMBOL	NAME	QUANTITY	REMARKS
1.		Steel Grating	3000m ²	> low maintenance > Mix material in the area
2.		Light finish Timberwalk	400m ²	> More natural for the larger area
3.		Dark finish Timberwalk	600m ²	> Differentiate the lower decking with boardwalk
4.		Bench	20	> 2m to 3m lenght for resting purpose
5.		Lighting	17	> Mostly located at larger area for safety purpose
6.		Pergola	2	> Aesthetic value and can act as shelter
7.		Railing	200	> Height of 1m > Safety purpose
8.		Dustbin	10	> Located at bigger area with many visitor
9.		Teduhan Berembang	5	> Multifunctional shelter > Bench and planter box
10.		Information Board	8	> Transparent board > While reading visitor can see the mangrove
11.		Information Desk	10	> Provide information
12.		Stairs	6	> Height of 1500mm > Lift by 150 x Rest 300

HARDSCAPE PALETTE

The palette shows some of the landscape furniture measurements on the site which can cater to various types of visitors.



Figure 16: Hardscape Design and measurement

PERSPECTIVES

1. INFORMATION CENTER

The area provides facilities such as information boards and desks for the visitor to access and gain knowledge about the mangrove and firefly's habitat.



Figure 17: information centre



Figure 18: Exhibition Area

2. LUCIFERIN PLAZA (EXHIBITION AREA)

Luciferin plaza provides an area for the local to exhibit their handmade craft and any type of art that can improve their economy.



Figure 20: Plaza area

3. PHOTOPHORE ZONE

This is the main area where most human activities occur, and it is the largest area on the site. The area is suitable for the visitor to rest and feel the calmness of the natural environment.



Figure 19: Photophore zone

5. LOWER DECKING (Info. Center)

Along the boardwalk is using the downlight system that attaches to the railing which will avoid the disturbance to the fireflies.

SOFTSCAPE PLAN

The concept for the planting plan is Native and Cozy. Therefore, most of the proposed trees are from the native area which is the mangrove forest. The mangrove trees will provide a sense of welcome and place. This is suitable for the habitat of flora and fauna in the area because most of the native mangrove trees will become the home to many fauna species, especially fish and fireflies. Thus, this concept is very suitable for enhancing the firefly habitat.

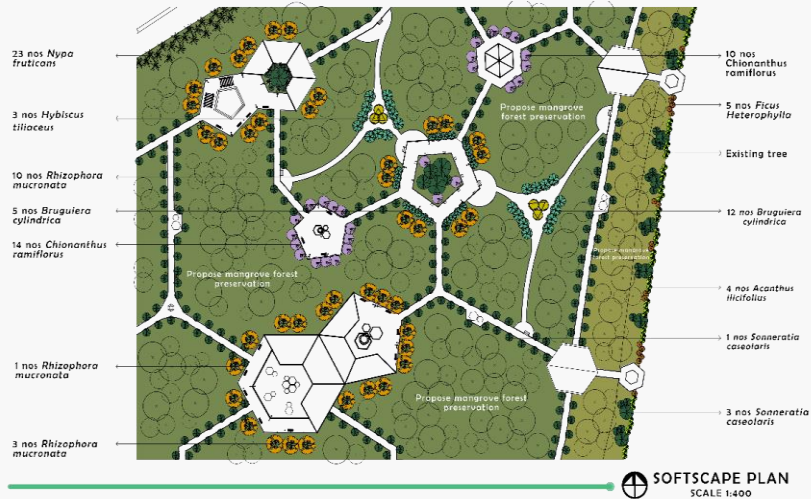


Figure 21: Softscape Plan

PLANTING CONCEPT



Conservation and Preservation of the native species to experience the sense of places of mangrove forest. There is also an expansion of the area of certain species of mangroves for the fireflies' habitats. This will prevent the natural character of mangroves from being disturbed so that the area will be more comfortable and livable for human-animal interaction.

Native species that have an important role in the area

Sonneratia caseolaris

1. A place for fireflies finds their mate.
2. Source of food for fireflies.
3. Attract more firefly habitats.



Rhizophora mucronate

1. Prevent soil erosion at the riverbank
2. Home for many types of animals.



Figure 22: Fireflies- Berembang tree species

Table 2: Planting Schedule

PLANTING SCHEDULE

NO.	SYMBOL	SCIENTIFIC NAME	COMMON NAME	HEIGHT(m)	CANOPY (m)	QTY (NOS)
1.		<i>Sonneratia caseolaris</i>	Berembang	10	3-8	180
2.		<i>Rhizophora mucronata</i>	Bakau Kurap	15	15	43
3.		<i>Bruguiera cylindrica</i>	Bakau Putih	10	3-10	43
4.		<i>Hibiscus tiliaceus</i>	Sea Hibiscus	8	6	6
5.		<i>Acanthus ilicifolius</i>	Jeruju Putih	3	10	62
6.		<i>Nypa fruticans</i>	Nipah	6	4	23
7.		<i>Jasminum polyanthum</i>	Melor	0.6	2	23
8.		<i>Chionanthus ramiflorus</i>	Native Olive	6	3-6	24
9.		<i>Ficus heterophylla</i>	Water Fig	3	5	18

PLANTING PALETTE

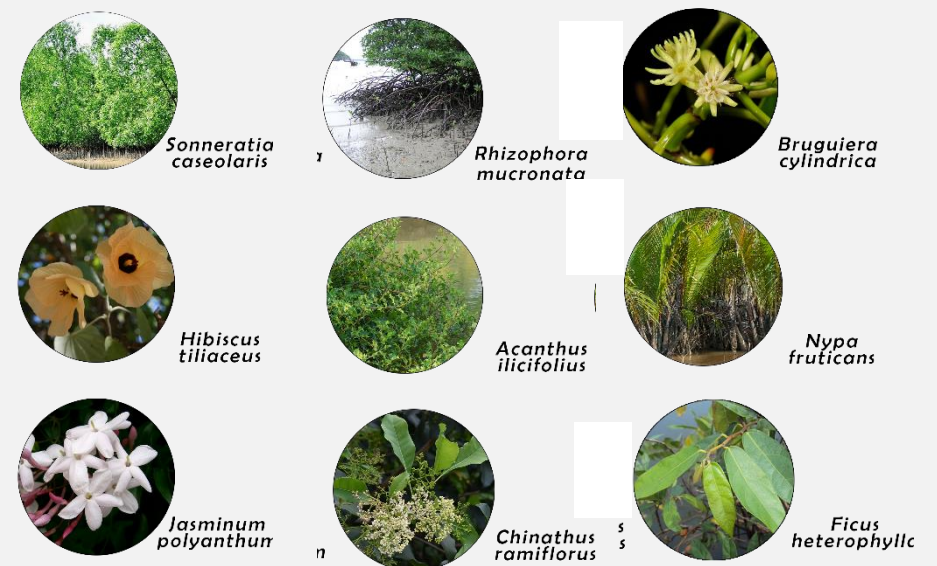


Figure 23: Planting Palette

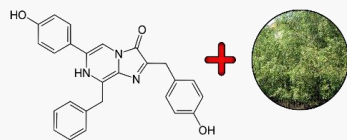
INNOVATIVE DESIGN ELEMENT



INTRODUCTION

“Teduhan Berembang” is an innovative design element that is like a shelter. It's located in various places in the Fireflies Sanctuary, This shelter has a height of 2.5 to 3 meters so it is suitable for all ages to use it. The light that is installed is LED which uses a downlight system so the light produced will not disturb the view of the fireflies. It has three roofs that take on the hexagon shape inspired by the shape of luciferin in the fireflies.

DESIGN IDEA



The idea of this design are referring to the relationship of fireflies with the Berembang tree. The relationship happens when the fireflies come to the Berembang tree for food and shelter. As for the shape of the design, It came from the light particles in fireflies themselves called luciferin.

FUNCTION



1. Act as shelter to the visitors that protect them from extreme weather such as heavy rain and high temperature.

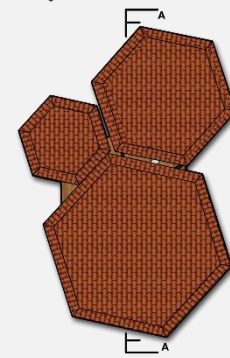


- 2, Resting area for the visitors who are tired after exploring the site.

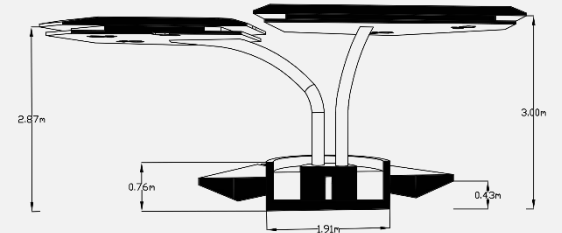


3. The designated planter box in the middle can be used to plant shrubs that are aesthetically good and have a nice fragrance.

DETAIL DRAWING

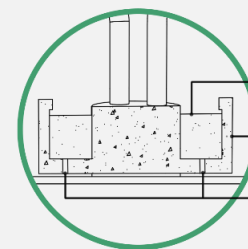


PLAN VIEW SCALE 1:100

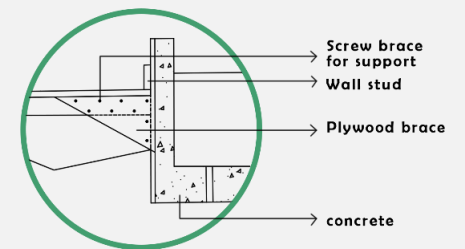


SECTION A-A SCALE 1:100

CONSTRUCTION DETAIL



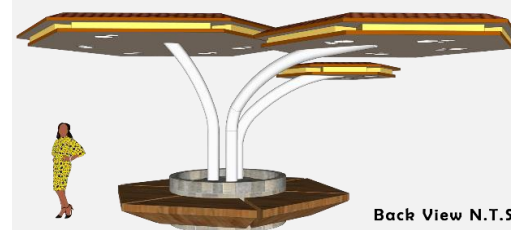
Planter box N.T.S



Bench support N.T.S

Figure 24: Construction detail

PERSPECTIVES



Back View N.T.S



Figure 25: Gazebo perspectives

CONCLUSION

The initiative of designing with the integration of natural elements with humans is giving many positive impacts on the environment, society and economy aspect. The main approaches that have been proposed are the firefly sanctuary and mangrove forest which act as the main attraction as well as improving the nature ecosystem nicely. This also helps to educate the users on the importance of keeping the balance between nature and man-made in our life.

REFERENCES

- <http://www.mdkerian.gov.my/ms/pelawat/info-kerian / 25/10/2020>.
- Asri, L. N., Abdullah, N. A., Sulaiman, A., Asri, M. H. M., Sulaiman, N., Satiman, E. M. F. E. N., Husin, S. M., Shukor, A. M., & Darbis, N. D. A. (2020). Abundance and species composition of synchronous flashing firefly at Sungai Rembau, Negeri Sembilan, Malaysia. *Int. J. Trop. Insect Sci.*, 41, 1095–1106.
- Barrows, E. M., Arsenault, S. B., & Grenier, N. P. (2008). Firefly (Coleoptera: Lampyridae) flight periods, sex ratios, and habitat frequencies in a United States Mid-Atlantic freshwater tidal marsh, low forest, and their ecotone. *Banisteria*, 31, 47–52.
- Buck, J. (1988). Synchronous rhythmic flashing of fireflies. II. *Q. Rev. Biol.*, 63, 265–289.
- Dawood, M. M., & Saikim, F. H. (2016). Studies on congregating fireflies (Coleoptera; Lampyridae; *Pteroptyx* sp.) in Sabah, Malaysia: a review. *J. Trop. Biol. Conserv.*, 13, 13–25.
- Faust, L. (2017). *Fireflies, Glow-worms, and Lightning Bugs: Identification and Natural History of the Fireflies of the Eastern and Central United States and Canada*. University of Georgia Press.
- Jaikla, S., Lewis, S. M., Thancharoen, A., & Pinkaew, N. (2020). Distribution, abundance, and habitat characteristics of the congregating firefly, *Pteroptyx Olivier* (Coleoptera: Lampyridae) in Thailand. *J. Asia Pac. Biodivers.*, 13, 358–366.
- Jusoh, W. F. A. W., & Hashim, N. R. (2012). The effect of habitat modification on firefly populations at the Rembau-Linggi estuary, Peninsular Malaysia. *Lampyrid*, 2, 149–155.
- Jusoh, W. F. A. W., Hashim, N. R., & Ibrahim, Z. Z. (2010). Firefly distribution and abundance on mangrove vegetation assemblages in Sepetang estuary, Peninsular Malaysia. *Wetl. Ecol. Manag.*, 18, 367–373.
- Jusoh, W. F., Ballantyne, L., Lambkin, C. L., Hashim, N. R., & Wahlberg, N. (2018). The firefly genus *Pteroptyx Olivier* revisited (Coleoptera: Lampyridae: Luciolinae). *Zootaxa*, 4456, 1–71.
- Lewis, S. M. (2016). *Silent Sparks: The Wondrous World of Fireflies*. Princeton University Press.
- Lewis, S. M., Wong, C. H., Owens, A. C. S., Fallon, C., Jepsen, S., Thancharoen, A., & Reed, J. M. (2020). A global perspective on firefly extinction threats. *Bioscience*, 70, 157–167.
- Lloyd, J. E. (2008). Fireflies *Encyclopedia of Entomology* Springer in Capinera JL, ed., 1429–1452.
- Mohd-Shahwahid, H. O., Mohd-Iqbal, M. N., Amirammas-Ayu, A. M., Rahinah, I., & Mohd-Ihsan, M. S. (2016). Social network analysis of Kampung Kuantan fireflies Park, Selangor and the implications upon its governance. *J. Trop. For. Sci.*, 28, 490–497.
- Moktar, J., Asmah, A., & Zaini, Z. (2010). The survival of an eco-tourism industry, Evidence from the Kg Kuantan's firefly's sanctuary tourism attraction. *Malaysia Journal of Society and Space*, 3, 89-97.
- Nallakumar, K. (2003). The synchronously flashing aggregative fireflies of Peninsular Malaysia. *Biodiversity*, 4, 11–16.
- Nor Shafikah, I., Muzzneena, A. M., Norela, S., Shamsul, K., Shahril, M. H., & Nurul Darsani, A. D. (2021). The dynamics of landscape changes surrounding a firefly ecotourism area. *Global Ecology and Conservation*, 29, 1-21.
- Norela, S., Shahril, M. H., Noh, A. M., Maimon, A., & Khairunnisa, S. (2015). Abundance of Lampyridae in relation to vegetation and abiotic conditions along the Johor River in Malaysia. *Malay. Nat. J.*, 67, 395–402.
- Prasertkul, T. (2018). Characteristics of *Pteroptyx* firefly congregations in a human dominated habitat. *J. Insect Behav.*, 31, 436–457.
- Shahara, A., Nura, A. M. R., Maimon, A., & Norela, S. (2017). Assessment of firefly abundance at a new ecotourism site of Sungai Bernam, Selangor, Malaysia. *Malays. Nat. J.*, 69, 67–74.
- Syed, A. R., Sivapragasam, A., & Rasainthiran, M. (2001). Entotourism in Malaysia: status and prospects, in: *Proceeding of the 4th Asia Pacific Conference of Entomology*, Kuala Lumpur. Malaysian Plant Protection Society (MAPPS) and Entomological Society of Malaysia (ENTOMA).
- Thancharoen, A., Ballantyne, L. A., Branham, M. A., & Jeng, M. L. (2007). Description of *Luciola aquatilis* sp. nov., a new aquatic firefly (Coleoptera: Lampyridae: Luciolinae) from Thailand. *Zootaxa*, 1611, 55–62.