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REVAMPING A FORMER LANDFILL INTO AN ENERGY PARK IN ALAM IMPIAN, SHAH ALAM

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ABSTRACT

This project takes place in a former landfill in Alam Impian, Shah Alam, where it aims to repurpose a former landfill into a community-friendly energy park by addressing social, environmental and economic aspects. The energy park aims to educate the users on energy and waste management, the process of waste from site for environmental care, and the creation of opportunities for nearby sites to be developed into more commercialised land use and systems that help the site to be self-sustained. Document analysis, site inventory and SWOT analysis were carried out along with risk assessments to identify the site's potential and constraints. The analysis was concluded with an Analysis of Interconnected Decision Areas (AIDA) for synthesis. In order to achieve the aim of this project, Waste-to-Energy was developed as the design concept to tackle the available resources into electric energy and user-friendly energy park.

Keyword: L*andfill park, Post-closure maintenance, Renewable energy park*
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INTRODUCTION

Alam Impian Landfill, located in Section 35, Shah Alam (Figure 1) has been closed and is currently under post-closure maintenance. It falls under the jurisdiction of Shah Alam City Council (MBSA).

Figure 1 shows key plan of Shah Alam city (on the left) and location plan (on the right)

This project aims to repurpose a former landfill into a community-friendly energy park. The aim is followed by three objectives addressing the aspects of environment, social and economy.

The respective objectives are to propose an energy park with the goal to educate the users on energy and waste management; to properly process of waste from site for environmental care and to create opportunities for nearby sites to be developed into more commercialised land use and systems that help the site to be self-sustained.

Issues

The concerns raised on site have been categorised into three categories namely (1) environmental concerns:

- leachate may disrupt the quality of groundwater, surface water, soil and human health (Science For Environment Policy, 2017);

(2) social concerns:

- public preference in park development for former landfill development (Simis, M. & Awang, A., 2015)
- rapid urban development requires demand for open space (National Landscape Policy)

(3) economic concerns:

- perception of old landfill as “dead zones” for development (The Start Online, 2017)
- opportunity to maximise land value in complementary with its vicinity’s rapid urban development.

LITERATURE REVIEW

CATEGORISATION OF LANDFILL

Category B of Brownfield classification:
Former landfill area that has reached its maximum capacity/permanently terminated as a landfill.

Level C3 in safe closure level:
The measure of a leachate collection system and a leachate re-circulation is taken, with the aim of preventing an environmental impact by leachate.

WHY AN ENERGY PARK?

National Physical Planning Council justifies redevelopment of former landfills in Malaysia as park for “community security and well-being.”

According to KPKT (2004), National Physical Planning Council (2004) and PLANMalaysia (2010), redevelopment of a former landfill is methodically limited to:

- Agricultural areas/Fertigation-oriented agriculture
- Parking areas and roads
- Public parks
- Golf course
- Energy production hub
- Housing areas
- Commercial/industrial areas

Renewable Energy Act 2011 lead to incentives for local producer of renewable energy. Public programmes suitable for the studied site are

Solar energy harvesting

- Self-consumption (SELCO)
- Net Energy Metering (NEM)
- Large Scale Solar (LSS)

Biofuels and small hydro

- Feed-in-Tariff (FiT)

SUMMARY: PRECEDENT STUDIES

Item	Air Hitam Landfill Park	Georgswerder Energy Hill	Landschaftspark Duisburg-Nord

Technical	Contains 3 Phases:
	• Solid Waste Management
	  • Landfill capping
	• Post-Closure Maintenance
	  • Gas management and energy production
	  • Leachate management
	  • Slope maintenance
	• Recreational Landscape Space Installation and Management
	  • Planting maintenance
	  • Secured area
		• Capping the landfill
		• Multi energy production
		  • Installation of wind-turbine on capped landfill hill
		  • Installation of solar panels on the slope of the hill
		  • Biomass from mowing of the Hill's meadows
		  • Methane gas from landfill is used as heat energy for Aurubis AG, a copper producer
		  • Heat from groundwater is used to air condition the Hill's information centre
			Minimum intervention of external tools for site remediation
			• Phytoremediation
			• Former sewage canal is reused as method of cleaning the site
			• Highly toxic soil is sequestered in the existing bunkers

Design	• Coarse tree planting • Minimum installation of recreational utilities • Landfill post-closure treatment area is separated from recreational area	• Minimum structure considering long term needs for Hill's treatment • Elevated walkway providing scenic and unique view of the city • Elevated walkway is light up at night creating a new landmark	Vernacular design • The design is meant to be a memory park • Following the philosophy of "The past does not recur as such…[it is] not preserved but is constructed on the basis of the present." • The existing structures are revived fitting the use as recreational area • The identity of the place is retained but is translated into a more contemporary image

Table 1 (above): Examples in closed landfills and Table 2: Issue Overview (below)

CASE EXAMPLES	ISSUES OVERVIEW
Effects of Heavy Rain	• The landfilled waste was washed out by heavy rain.
Damage to the Utility Pipelines Caused by Subsidence	• The low-rise apartments constructed at the closed site were provided with precast concrete foundations. • There was almost no subsidence to the building but the surrounding grounds of the building experienced heavy subsidence of more than 200mm and thus damaged the connecting pipes.
Damage to Paddy Field by Insufficient Leachate Treatment	• The rice of a paddy field withered owing to the salt of the leachate from a nearby closed landfill site.
Crop Damaged by Landfill Gas	• The crops died at the nearby field due to over exposure to the landfill gas
Fire Caused by Landfill Gas	• At the residential area developed on the closed site, the residents burned their garden waste in their yard. • The fire was extinguished eventually, but in the evenings, bluish flames have been discovered at the garden area. This was due to the landfill gas being burning. • The flame of the burning landfill gas is difficult to see in the daylight but is highly visible at night
Generating of Ammonia Gas by Spreading of Lime	• The spreading of lime on the soil at the closed site was carried out in order to strengthen the bearing capacity of the ground for development purposes. • Gaseous ammonia was generated as a result of the unintended chemical reaction between the lime and the chemicals present in the waste. • The workers at the development complained about irritation to their eyes and to their respiratory organs.

METHOD/PROCEDURE:
SITE INVENTORY AND ANALYSIS

PHYSICAL ATTRIBUTES

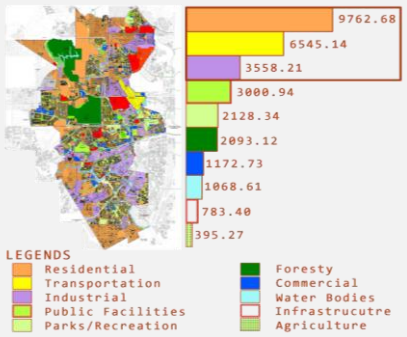


Figure 2: Landuse map for Shah Alam

1. Landuse Inventory (Figure 2) and Connectivity
   Since the site is in a highly urbanised area, the studied site context has been limited to 10 kilometres due to time limitations. types of land of site context are residential transportation and industrial. With an urbanisation rate at 91.4%, Shah Alam occupies 33% of its land to accommodate its 6.3 million population.

The site itself is sandwiched between three residential areas – Section 17 Neighbourhood, Section 24 Neighbourhood and Alam Impian Gated Residence.

Figure 3: Site's location sandwiched between three neighbourhoods

Transportation is the second highest landuse in Shah Alam. Within 10 kilometre radius from site, the areas are highly connected via highways and boulevards (Figure 3). But, looking through public transportation lens, the connectivity is inefficient as the railway systems connecting important districts (e.g. business districts) especially for workers are not well-scattered limiting users to buses and taxis for daily motion. Incomprehensive public transportation system reduces accessibility to the touristic areas, which is abundance in Shah Alam.

2. Topography and Hydrology (Figures 4 and 5 and Table 3)
   Klang river is adjacent to site making it the main water body on site. Run-off water flows from the neighbouring Alam Impian Gated Residence through the site upon being discharged into the river following the topography of the area.

Table 3: Water quality index of Klang river adjacent to site

Item	Reading
Water Quality Index	Class III/moderate
Ammoniacal nitrogen	2.52 mg/l (Class IV/moderately bad)
Biochemical oxygen demand (BOD)	6 m/l Class III/moderate

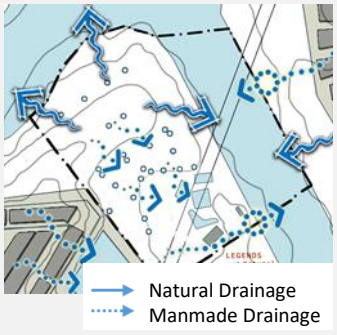


Figure 4: Natural and built drainage system on site

Figure 5: Lack of proper drainage for waterflow from flood retention point to discharged point

NATURAL ATTRIBUTES

1. Solar Movement and Resources (Figures 6 and 7).
   Understanding sun movement including its azimuth and elevation to identify the Peak Sun Hours, in this case, 11 am until 3 pm. During these hours, the site received an average of 1 kWh/m², efficient for solar energy harvesting.

Figure 6 shows site has no tall buildings blocking the sun from reaching the site

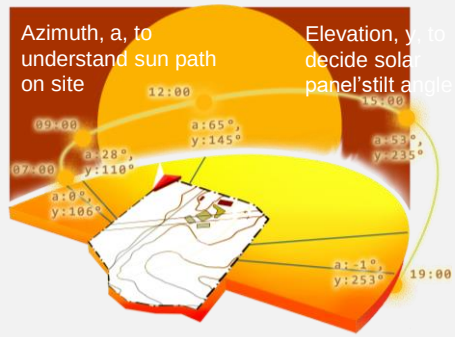


Figure 7: Daily sun path on site at five respective times

2. Landfill Gas
   Methane (CH_4) and carbon dioxide (CO_2) are produced on site, but the gases have been collected via gas wells to be harvested (Figure 8).

Figure 8: Gas wells on site

Figure 9: AQI for Shah Alam from November 3rd until November 9th, 2020

3. Air Quality
   Average annual reading for air quality index (AQI) is unhealthy. During pandemic COVID-19 with fewer people going outside, the air quality is yet to improve. Common polluters are PM2.5, PM10, ozone (O_3) and nitrogen dioxide (NO_2).(Figures 9 and 10)..

4. Wind Direction and Olfactory
   Light wind blows from east of the site at 6 km/h. Wind is not problematic for the site and nearby areas except the wind travels with the pungent smell produced on site – hydrogen sulphide, H^2S and ammonia, NH_3

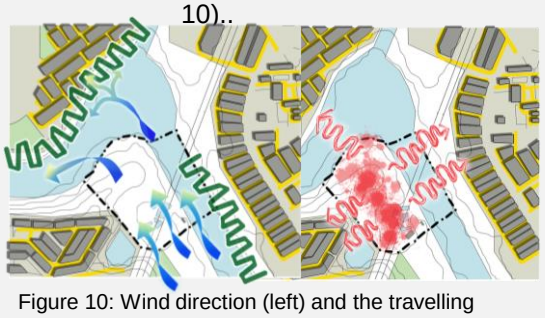


Figure 10: Wind direction (left) and the travelling pungent smells

5. Soil Structure (Figure 11)
   Original soil was gley soil with alluvial soil on recent marina and riverine alluvium and subrecent alluvium.
   Percolation of leachate contaminates the soil with heavy pollutants – sulphate, nitrates, nitrite and phosphate. Commonly found heavy metals contaminants are lead, ferum, zinc, arsenic, nickel and copper. The soil also experiences low bearing capacity.

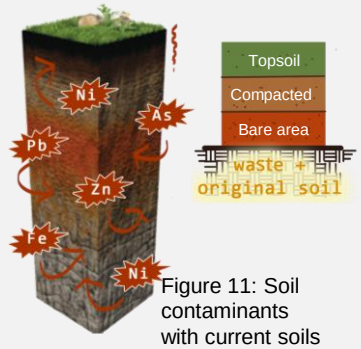


Figure 11: Soil contaminants with current soils

SOCIAL ATTRIBUTES

1. Crime Prevention Through Environmental Design (CPTED)
   The presence of crime preventive measures has been analysed at the residential areas adjacent to the site.

Figure 12 shows (a,b) lack of natural surveillance; (c) territorial enforcement and; (d,e) non-well lit and blind spots made present from self farming activities

2. Physical Safety and Health Security Risk Assessment
   Risk assessment is looking at source of risk, pathway (how the pollutants travel to receptors), target sensitivity (level of receptors vulnerability) and risk categorisation (Table 4 and 5).

Table 4: Risk assessment for physical safety and healthy security

Source	Pathway (Physical/Human/Biological mecahnism)	Target Sensitivity (Social/Ecological receptor)	Risk Category (Physical Safety/ Health Security)
Surface water run-off	Physical - waterborne	Ecological – Klang river	Physical – polluted water bodies
Leachate pond	Physical Biological – accidental ingestion	Ecological – Klang river, groundwater Social – nearby residents	Physical – polluted water bodies, groundwater Health – pest infestation
Differential subsidence	-	Ecological & social – landfill collapse	Physical – may affect soil structure of the nearby residence
Landfill gas	Physical Biological – inhalation	Ecological – air quality Social - nearby residents, workers at the former landfill	Physical – sudden fire/explosion risk Health – inhalation of poor air
Hydrogen sulphide & ammonia – pungent odour	Physical – airborne Biological – inhalation/accidental ingestion/dermal contact	Social – nearby residents	Health – pest infestation, psychological impact
High environmental temperature	Physical - airborne	Social – nearby residents	Health – more susceptible fore heat stroke

SWOT ANALYSIS

Table 5: SWOT analysis for the studied site

STRENGTH	WEAKNESS
• Barren land – reduced obstructions for design process • Energy producer • Locality – located in highly developed area • Direct sunlight – maximise opportunity to accumulate solar energy • Surrounded by residential areas	• Barren land – uninteresting view, drop property value • Leachate and lethal gas producer • High maintenance – soil went through extreme character change due to its history • Low soil bearing capacity • Accessibility – poor access to site • Direct sunlight and high humidity proposed high thermal perception on site • Smell – leachate ponds, gas from decomposing materials
OPPORTUNITIES	**THREATS**
• Energy production – gas and solar • New type of park in Malaysia • Cater land problem in Malaysia – 2 hectares of park per 1000 population (JLN) • Assimilation of clean energy and human activity	• Susceptible to fire and explosion • Mismanagement of leachate may pollute the river • High chance for exposure pathway • Nearby residents are exposed to health risks

SITE SYNTHESIS

The synthesis uses Analysis of Interconnected Decision Areas (AIDA) as the framework. Its approach that considers all available methods and seeking for mutual connectedness between attributes and decision areas helps in final decision consideration that covers as much issues as possible.

From the analysis, it can be understood the proposed site is a bit different than usual proposal. Its physical character is EMPTY and BARREN. Therefore, the site context and site's benefits to it are important for retrieving the lost value of the site (Figures 13 and 14).

1. Resource Utilisation
   The site is rich in potentials for renewable energy harvesting. Resources from the site can be utilised to generate economy by joining government's renewable energy programmes.

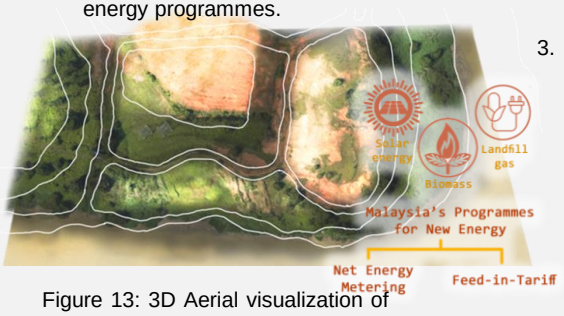
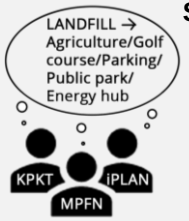


Figure 13: 3D Aerial visualization of the site

2. Soil Quality Control
   - Phytoremediation to treat polluted soil
   - Avoid lime treatment to avoid undesirable chemical reactions with the soil
   - Ecological engineering for slope stabilisation
   - Open spaces instead of structures



3. Vegetation Restoration
   Lack of vegetation and site's bareness amplify the heat from Malaysia's climate

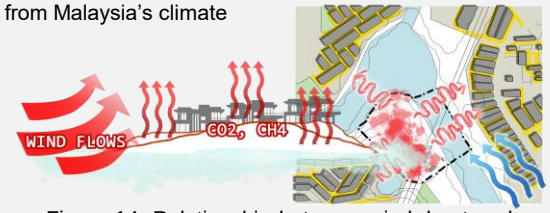


Figure 14: Relationship between wind, heat and smell on site

Synthesis Summary

Site condition conclude decision link towards ecological approach
- Ecological succession
- Ecological engineering
- Phytotechnology

Site also depends on site context to retrieve its own identity.

MASTER PLAN DESIGN CONCEPT:

WASTE-TO-ENERGY

Figure 15 :The design concept

Inspired by the concept of Sustainability, the concept aims to create a user-friendly energy park turning the available resources into electric energy (Figures 15 and 16).

Objectives for this concept are:

- [ECONOMIC] To reduce expenditure on external source of energy and gain income by generating its own energy which can be used for site's maintenance among other things
- [ENVIRONMENTAL CARE] To use eco-friendly method of generating energy from the landfill gases while reducing environmental pollution as the gases are not releases into the atmosphere
- [SOCIAL] To provide an informal platform for the surrounding users to learn about renewable energy while encouraging outdoor activities for healthy lifestyle

CONCEPT DEVELOPLMENT

Space Programming

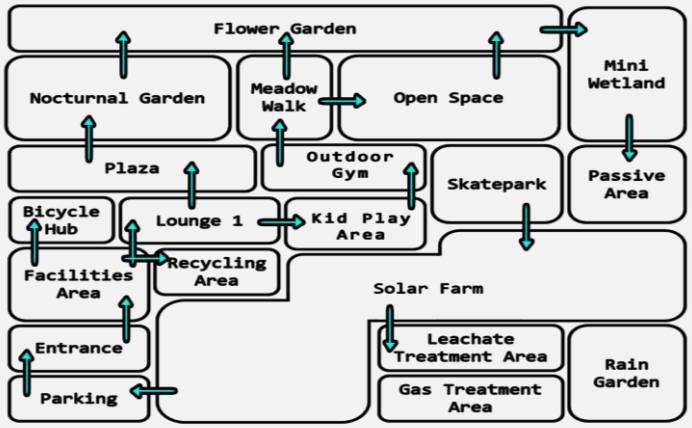


Figure 16: Space programming for Waste-To-Energy Park

DESIGN STRATEGIES

ENVIRONMENTAL CARE

- Provide children activities that develop their knowledge on waste management
- Incorporate technology like mobile applications to create reward for visitors
- Provide space for all types of people – family, friends, individuals both passive and active
- Create an environment with unique juxtaposition enough to invoke curiosity yet maintain the space legibility and wayfinding

SOCIAL

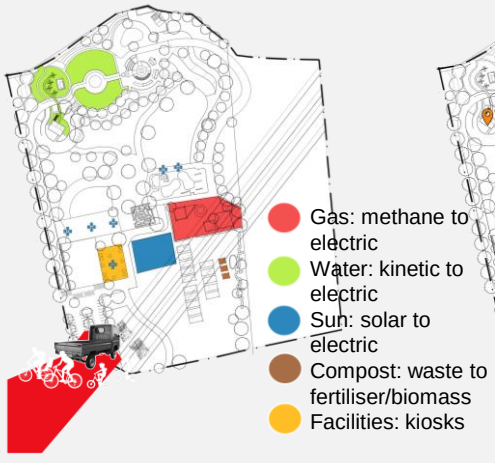
- Filter and treat the leachate water prior to being released to the water body
- Reduce the waste produced from site to end up in landfill
- Decrease the amount of waste that goes to landfill through recycle and upcycle activities

ECONOMIC

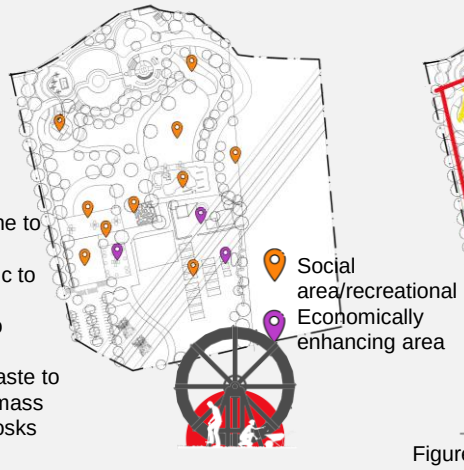
- Utilise site's peak sun hours (PSH) to harvest sun energy
- Provide outlet for recycle
- Upcycle waste into landscape furniture
- Prepare space for vendors and make the access easy
- Maximise energy generation from the sources available on the site

Functional Diagrams

Economic/Energy Resources



Activities & Landmarks



Circulation

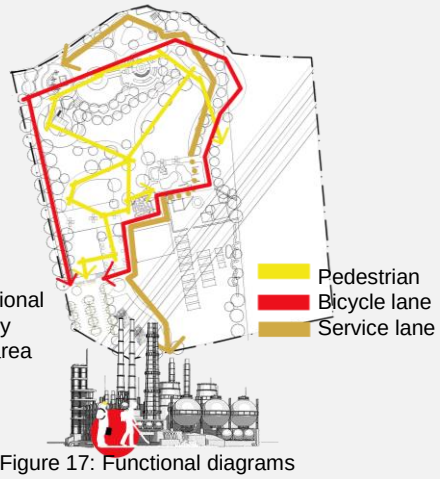
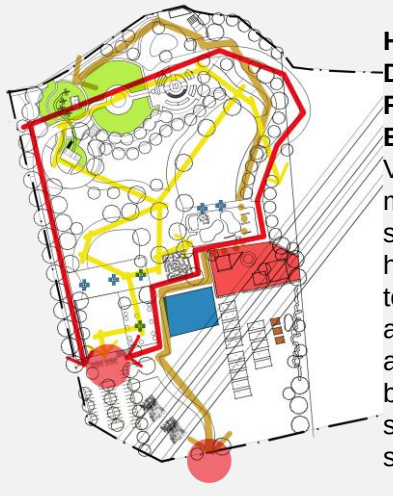


Figure 17: Functional diagrams

Conceptual Plan

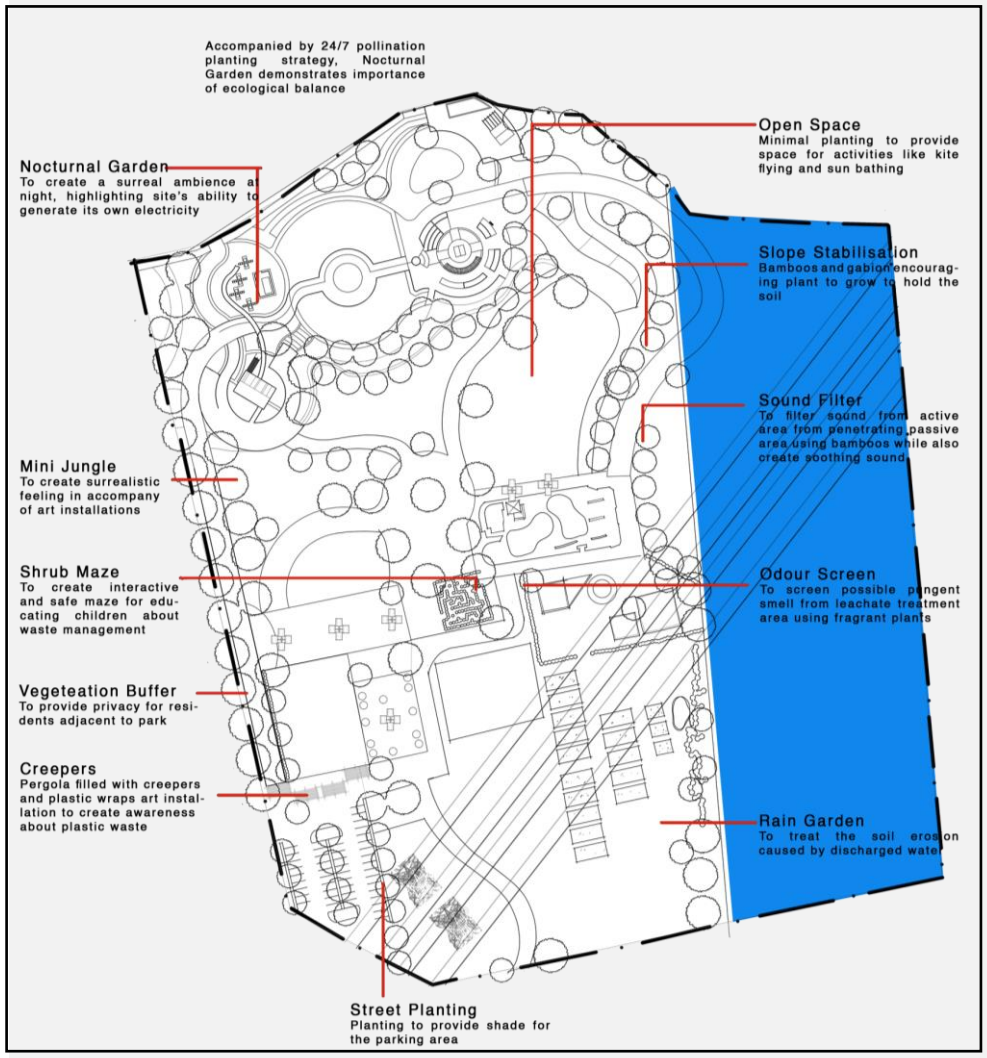


HOW FUNCTIONAL DIAGRAMS RESPONSE TO EACH OTHER?

Vegetation helps to make sense of the space e.g.: acting as hedges to limit access to certain areas such as from treatment areas; vegetation buffer aids to create a serene and quiet space,

MASTER PLAN PLANTING CONCEPT: REENERGISATION

Site's demands for nutrients call for treatment-oriented plant selection to reclaim the heathy soil and its surrounding. In other words, to reenergise the site's conditons (Figures 18,19 and 20).



SCHEMATIC PLAN

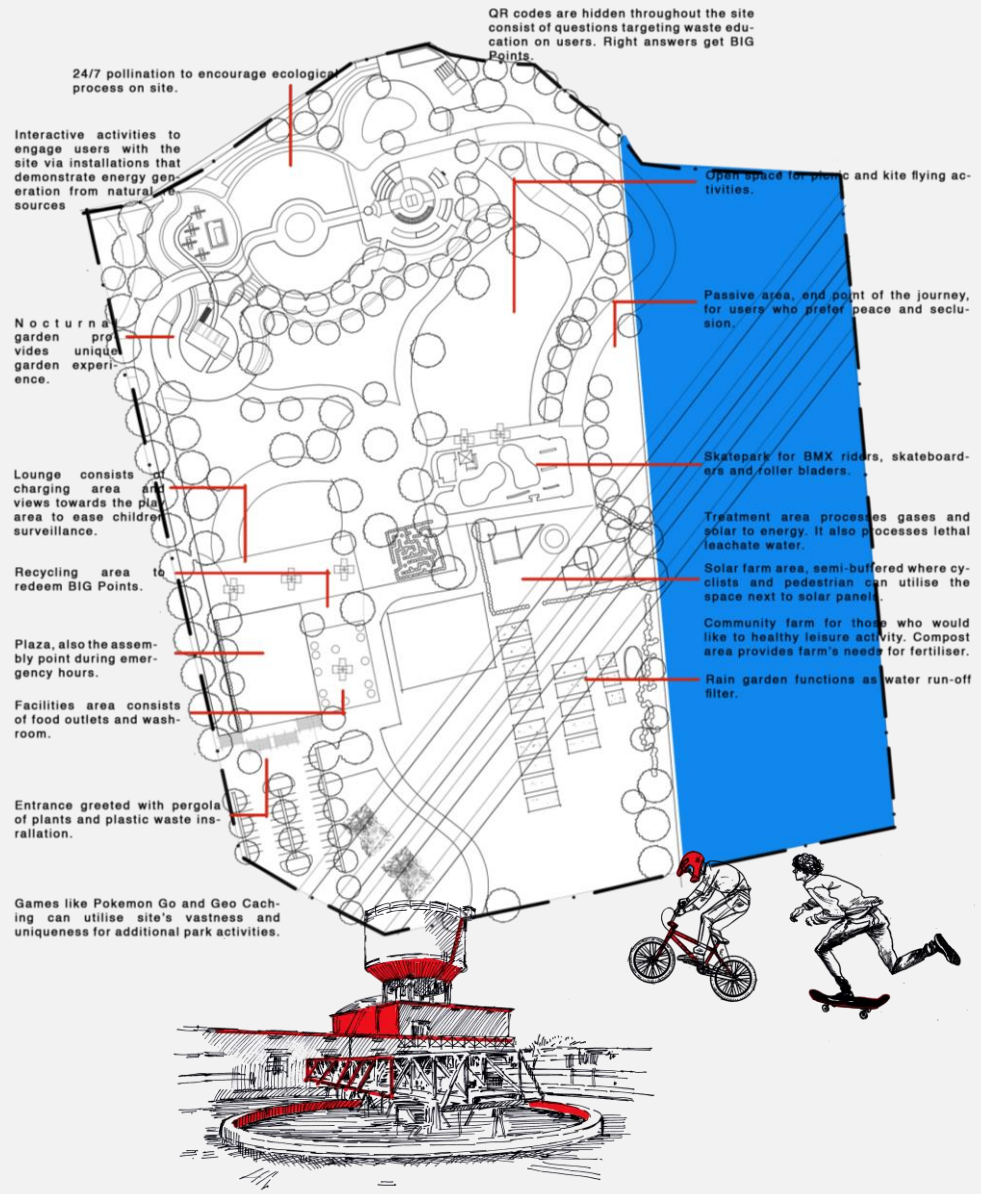


Figure 18: Plans for planting concept and schematic in scale 1:1500 on A0-size paper

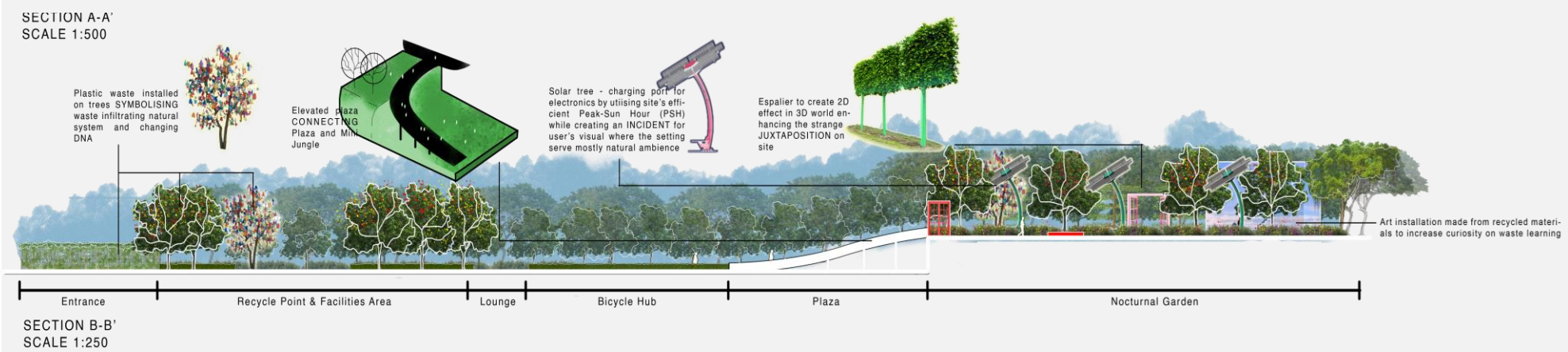
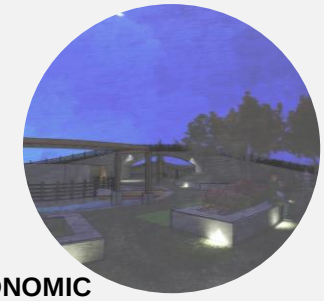


Figure 19: Different roles of planting

DETAIL DEVELOPMENT AREA

CONCEPT: NOCTURNAL GARDEN

Covering an area of 7,350 m² (0.16 ac) or 1:1.02 for the ratio of football field, Nocturnal Garden is one of the main spaces showcasing a unique ambience for the human experience and friendly for the animals. (Table 6).



AIM OBJECTIVES

To provide sustainable methods for area treatment while intriguing the users towards energy harnessing and waste management

ENVIRONMENT

To treat the site to become better by utilising the available resources around the site

SOCIAL

To provide platform for the users/community to be part of the energy harnessing activities

ECONOMIC

To maximise the self-regulating system to cater the maintenance cost

DESIGN STRATEGIES

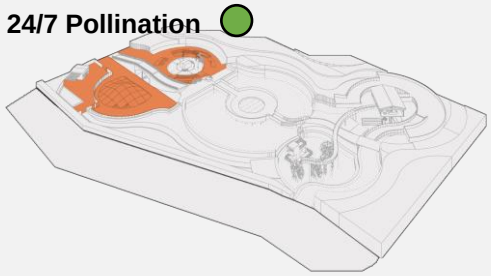
Environmental Care Economic Social

1. Self-regulating Water System

Sub-Spaces:
- Water Raising Area
- Water Collecting Pond
- Water Filtration Basin (Figure 23)

Type of Energy:
- Electrical from water's kinetic energy

2. 24/7 Pollination



Sub-Spaces:
- Diurnal Pollination Pitch
- Nocturnal Pollination Pitch

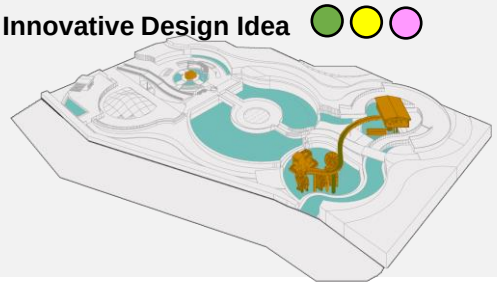
Type of Energy:
- Ecological balance

3. Responsible Consumption

Sub-Spaces:
- Compost Area

Type of Energy:
- Biomass from grass clippings of the garden and green waste from pollination pitches

3. Innovative Design Idea



Sub-Spaces:
- Water Raising Device

Type of Energy:
- Electrical from water's kinetic energy

PROJECT RATIONALES

1. Moral Responsibilities

- Islam deems balanced relationship between the Creator, nature and other human beings. The Quran is constantly reminding human's role as the vicegerent (khalifa) on Earth where life should be led sustainably, and corruption must be avoided.
- The environment is one of God's blessings to human beings and He entrusted them with a role to preserve the environment so that the balance of this universe can be maintained .

Responsibilities towards God

Responsibilities towards the environment

Responsibilities towards the people

2. Global Sustainable Development Goals

- reduce the adverse per capita environmental impact of cities (Strategy 11.6)
- universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities (Strategy 11.7)

- achieve the sustainable management and efficient use of natural resources (Strategy 12.2)
- achieve the environmentally sound management of chemicals and all wastes throughout their life cycle (Strategy 12.4)
- substantially reduce waste generation through prevention, reduction, recycling and reuse (Strategy 12.5)
- Promote public procurement practices that are sustainable, adhering to national policies and priorities (Strategy 12.7)
- ensure that people everywhere have the relevant information and awareness for sustainable development and lifestyles (Strategy 12.8)

3. National Policies and Agendas

- Report of National Physical Planning No. 2/2004
- KPKT (2004), National Physical Planning Council (2004) & PLANMalaysia (2010)
- National Landscape Department (2010a); PLANMalaysia (2010)

DETAIL DEVELOPMENT PLAN

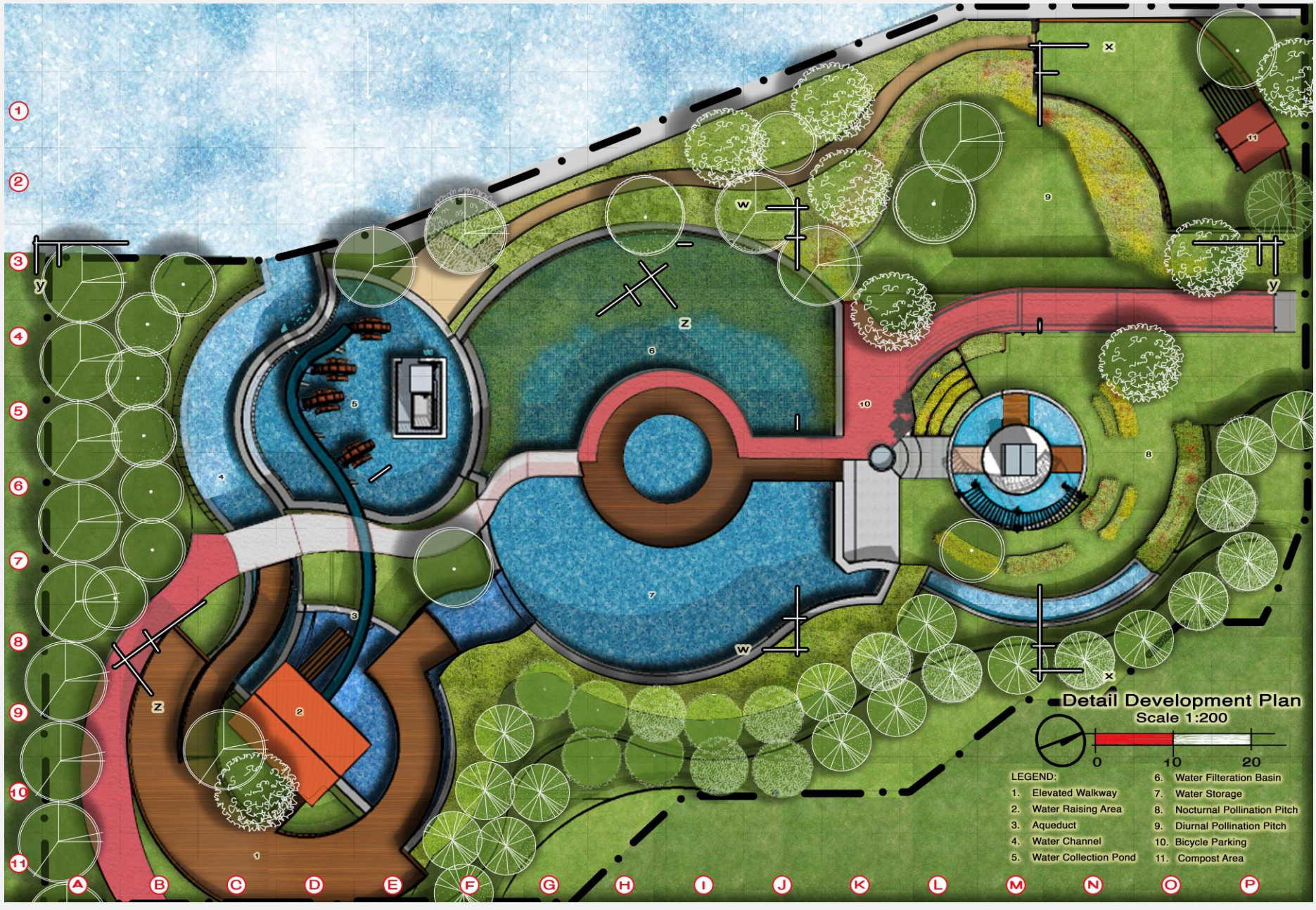


Figure 20: Detail Development Plan

Sections and Elevations for Detail Development Plan

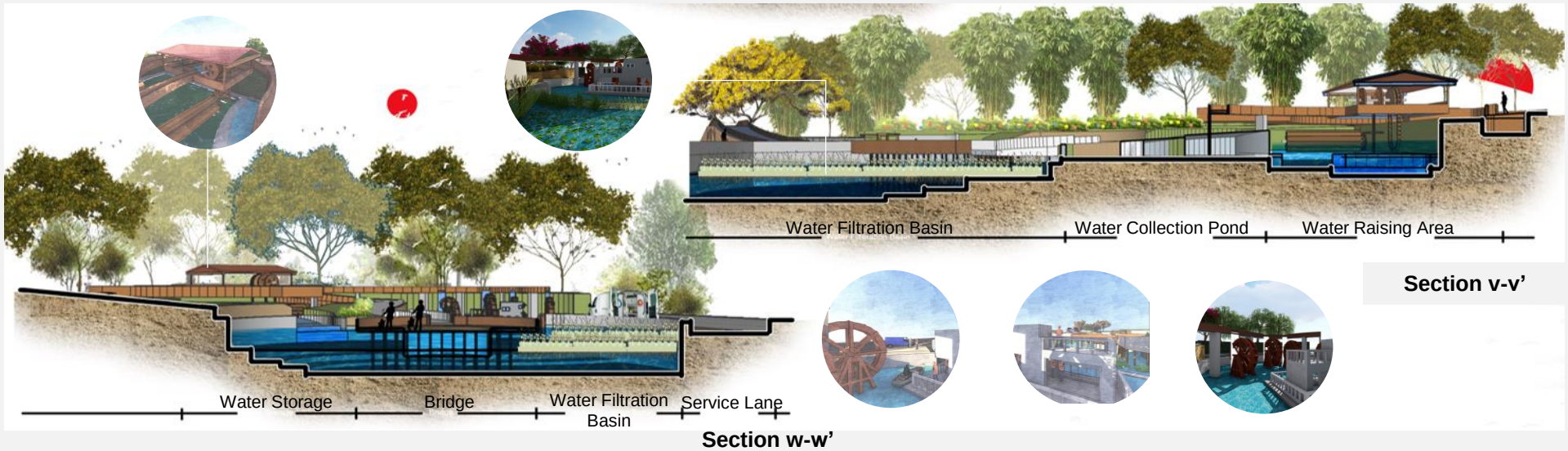


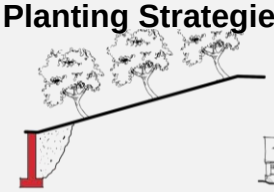
Figure 21: Sectional Elevation

Softscape Schedule

Table 6: Planting Schedule for Nocturnal Garden

No.	Type	Botanical Name	Common Name	Max. Height (mm)	Max. Spread (mm)	Qty
1.	Tree	*Lagerstroemia speciosa*	Bungor	30,000	10,000	17
2.	Tree	*Peltophorum pterocarpum*	Jemerlang	45,000	10,000	7
3.	Tree	*Delonix regia*	Semarak Api	18,000	7,000	10
4.	Tree	*Salix babyonica*	Weeping Willow	25,000	10,000	13
5.	Tree	*Cinnanomum iners*	Kayu Manis	15,000	10,000	6
6.	Tree	*Terminalia catappa*	Ketapang	25,000	10,000	8
7.	Shrub	*Callistemon lanceolatus*	Bottle Brush	8,000	1,000	4
8.	Shrub	*Cassia spectabilis*	Scented Cassia	6,000	1,000	15
9.	Shrub	*Caesalpinia pulcherrima*	Jambol Merak	3,000	1,000	15
10.	Shrub	*Lochnera rosea*	Kemunting Cina	500	1,000	15
11.	Shrub	*Plumbago capensis*	Plumbago Blue	250	1,000	15
12.	Groundcover	*Arachi Pintoi*	Pinto Peanut	200	N/A	550 m²
13.	Groundcover	*Mimosa Pudica*	Touch-Me-Not	200	N/A	550 m²
14.	Groundcover	*Axonopus Compressus*	Cow Grass	200	N/A	750 m²
15.	Groundcover	*Zoysia Matrella*	Taiwan Grass	200	N/A	4550 m²
16.	Creeper	*Angligonon Leptopus Alba*	White Coral Vine	N/A	N/A	N/A
17.	Creeper	*Stephanotis Floribunda*	Madagascar Jasmine	N/A	N/A	N/A
18.	Fern	*Davallia Denticulata*	Tasmanian Tree Fern	500	1,000	6
19.	Fern	*Asplenium Nidus*	Bird Nest Fern	500	1,000	6
20.	Fern	*Dicranopteris Linearis*	Resam	500	1,000	6

Planting Strategies



Slope Stabilisation

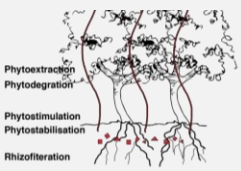
- Reduces the risk of subsidence
- Improves sense of security

Privacy Buffer

- Heighten soil quality
- Secure the adjacent residence's privacy from the park

Diurnal and Nocturnal Pollination

- Regulate the ecosystem and conserve the biological diversity
- Vibrant colour during the day and scent during the night



Phytoremediation

- Water treatment
- Public awareness

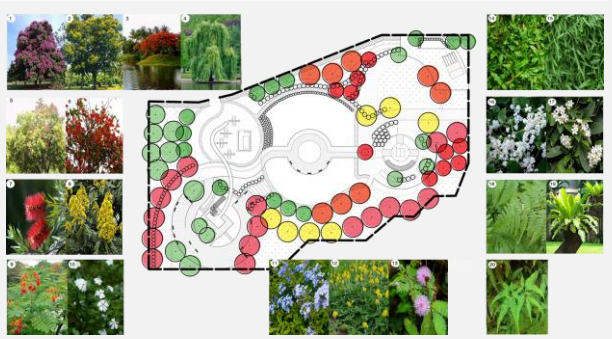


Figure 22: Planting Strategies

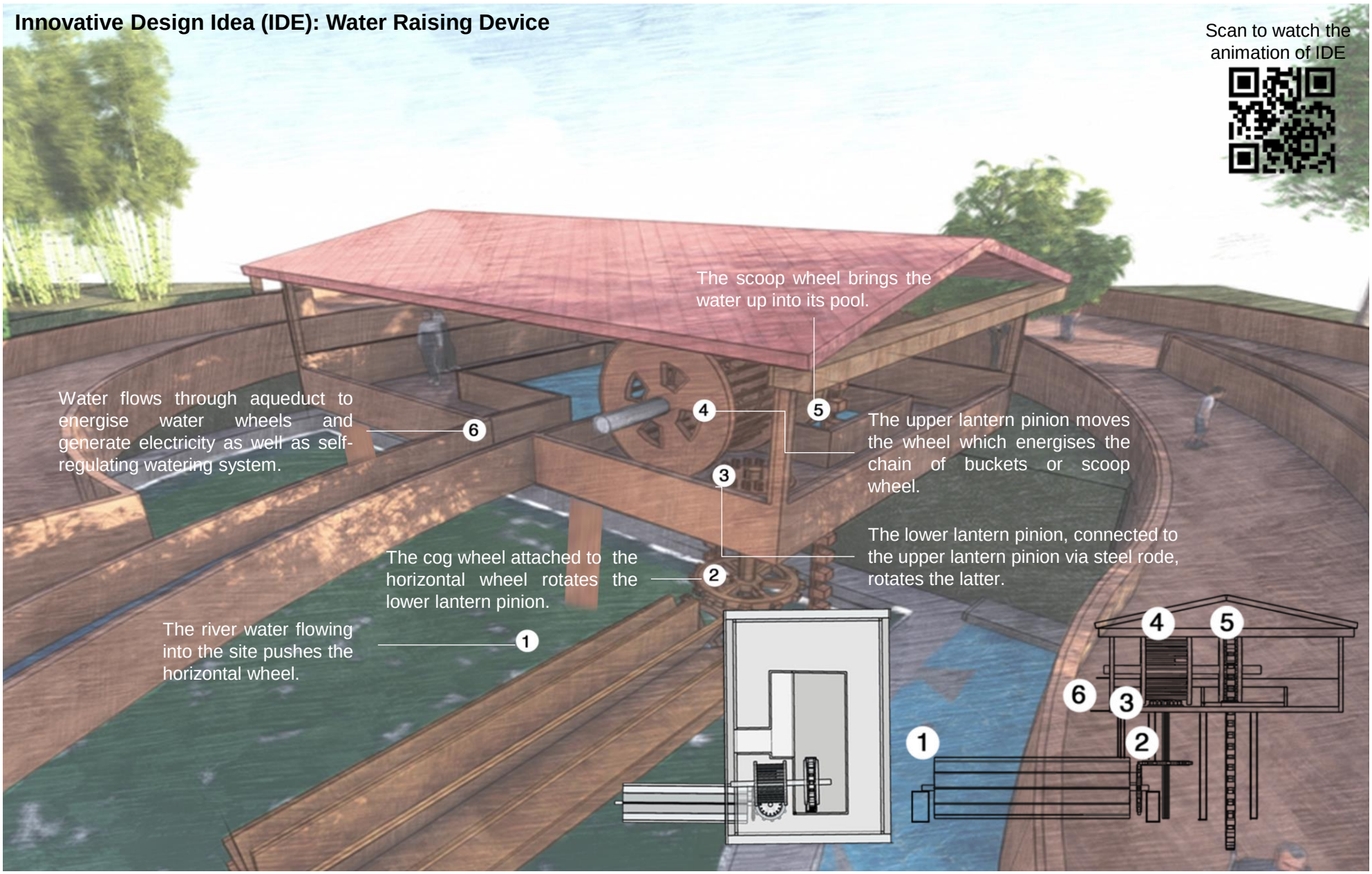


Figure 23: Plan view and sectional elevation of Water Raising Device

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