Final Proposal (Phase 2)

For

Sustainability Cities Challenge 2024

PacificLight Crea8 Sustainability

On

Hillview Community Centre

By

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Overview

Hillview Community Centre, centrally located in the heart of the Hillview neighbourhood, was officially opened in 2019 by Prime Minister Lee Hsien Loong. The centre offers a wide array of amenities, encompassing multipurpose halls and recreational spaces such as a culinary studio, dance studio, and more. Featuring a diverse schedule of activities and events tailored to various age groups, the centre provides avenues for fitness classes, workshops, and social gatherings.

The building has a total area of 3867.79 square meters, comprising four stories and one basement carpark. The TOP (Temporary Occupation Permit) for the building was obtained in 2017, and cyclical maintenance is scheduled to be completed by the end of 2024.

The purpose of Hillview Community Centre is to serve as a dynamic focal point within the Hillview neighbourhood, fostering community engagement, social interaction, and personal development through a variety of programs, events, and facilities tailored to the needs and interests of residents of all ages.

List of Figures

List of Tables

Phase 1

The following are proposed solutions our group has suggested for HVCC in the areas of energy efficiency, interior design, greenery integration, mobility, water efficiency, and waste management.

1.1 Energy Efficiency

At the Hillview Community Centre, energy efficiency initiatives target specific areas to optimize usage and promote sustainability. One proposed improvement is the installation of solar panels on Level 4, which not only generate renewable energy but also provide shade for the playground, reducing direct sunlight exposure and potentially offsetting a significant portion of electricity consumption. On Level 4, the installation of shade structures and shelters contributes to energy efficiency in the building by reducing the reliance on artificial cooling systems. Additionally, retractable roofs allow for flexible control of sunlight exposure, further optimizing energy usage within the building. Moreover, integrating a solar panel roof offers an additional advantage by harnessing renewable energy to power various components of the building, further reducing reliance on traditional energy sources and promoting sustainability. Another initiative involves transitioning from singular bulbs to tube lamps on Level 3 to achieve uniform illumination, reduced glare, and enhanced energy efficiency, resulting in substantial cost savings. Additionally, the installation of Low-E windows throughout the building minimizes heat transfer, stabilizing indoor temperatures, and reducing reliance on heating and cooling systems. These measures collectively create a more comfortable, eco-friendly environment while demonstrating a commitment to renewable energy adoption.

1. Level 4

The Level 4 playground at Hillview Community Centre is exposed to intense morning and afternoon sunlight due to its eastward orientation, refer to attached. This results in high temperatures, making it unsuitable for children to play during the day. Hence, to address this issue, we've explored various potential solutions, such as installing solar panels.

Figure 1: Level 4 of Hillview Community Centre

Solar panels can be installed on the roof or walls adjacent to the playground, refer to attached. An example of the solar panel is a wall mounted solar panel. It serves a dual purpose of generating renewable energy while also providing shade for the playground. The solar panels can be strategically positioned to partially shade the playground area during the day, reducing direct sunlight exposure and lowering ambient temperatures. Consequently, Solar energy from the sun will then be harvested by the solar panels to generate power for various components of the building.

The cost of wall mounted solar panel can cost up to $50k with installation cost of $15k-$38k. It can produce approximately 546-874 kWh of electricity annually. Wall-mounted solar panels can provide additional energy on roofs with limited space for solar panels. Furthermore, wall-mounted panels are easier to clean and maintain than roof-mounted ones. Due to their steep angle, they won't accumulate as much dust and debris.

For Example, Hillview Community Centre, faces the eastern side and receives abundant sunlight. If wall-mounted solar panels are installed there, they can harness this sunlight to generate electricity for the centre. Supposedly the community centre consumes around 10,000 kWh of electricity per month. With wall-mounted solar panels, it could potentially generate

3,000 kWh of electricity per month. This means the centre would only need to pay 7,000 kWh of electricity, which hence results in significant energy savings.

By utilizing solar panels, Hillview Community Centre can reduce its electricity expenses and environmental footprint. It showcases a sustainable approach to energy usage while contributing to cost savings and promoting renewable energy adoption within the community.

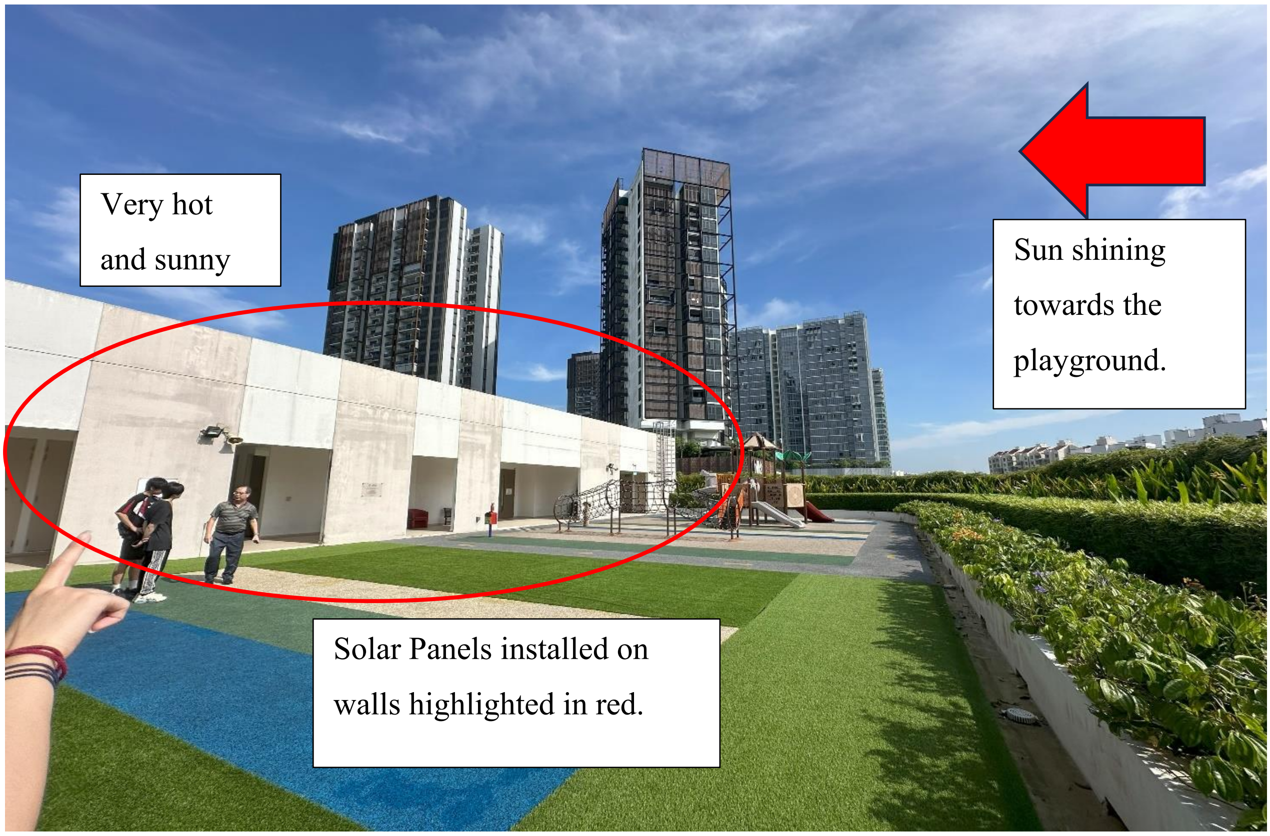

Figure 2: Level 4 of Hillview Community Centre

Figure 3: Mounted Solar Panel (Solar power world, 2019)

At Level 4 of the community centre, shelters or shade structures can be constructed over the playground area to provide protection from direct sunlight and heat exposure. The shelters can be designed with materials that provide effective UV protection while allowing sufficient airflow to maintain comfort for children and caregivers. Movable or adjustable shades can be incorporated to allow flexibility in controlling sunlight exposure throughout the day. Moreover, in unfavourable weather conditions, retractable roofs shield occupants from rain, wind, and other elements, allowing them to stay comfortable and utilize the space without interruption from inclement weather.

Three varieties of retractable awnings are available: Canvas or Fabric Awnings, Aluminium Awnings, and Acrylic Fabric Awnings. Canvas or Fabric Awnings are classic and budget-friendly, offering versatility in design and colour options. However, they may necessitate more upkeep. Aluminium Awnings are known for their resilience and ease of maintenance, aluminium awnings boast impressive longevity. They are also immune to rust and corrosion. Acrylic Fabric Awnings is a striking a balance between aesthetics and durability, acrylic fabric is a favoured option. It is resistant to mildew and fading. However, acrylic awnings is the most pricey out of the three.

The estimated price range for aluminium awnings typically falls between SGD 1,500 and SGD 4,500. Opting for motorized retraction incurs an additional cost, typically ranging from SGD 500 to SGD 1,500. The provided figures are estimations and may vary depending on the factors mentioned earlier. Furthermore, installation expenses can vary from SGD 300 to SGD 1,000, contingent upon the complexity of the project.

Hence, Aluminium awnings present an ideal choice for playground areas due to their durability and minimal maintenance needs. With excellent longevity and resistance to rust and corrosion, they are well-suited for outdoor environments.

Solar panel roofs offer an alternative solution for the community centre, which is consistently subjected to sunlight exposure. These roofs are equipped with solar panels that capture sunlight and convert it into electricity, which can be used to power various components of the building. By installing solar-panelled roofs, not only can you provide shade and protection from the sun, but you can also harness renewable energy to reduce electricity costs and promote sustainability. This also falls within the realm of energy efficiency.

In the realm of solar panels, three distinct types are available, each offering its own set of advantages and considerations.

Firstly, monocrystalline solar panels stand out for their exceptional efficiency and sleek aesthetics. These panels typically yield the highest power output per square foot, making them a preferred choice for those aiming to maximize energy generation. However, their upfront cost tends to be higher compared to alternative options.

On the other hand, polycrystalline solar panels present a compelling option for those seeking a balance between performance and affordability. While slightly less efficient than their monocrystalline counterparts, polycrystalline panels offer a lower initial investment, making them accessible to a broader range of consumers.

Lastly, thin-film solar panels offer a unique proposition with their lightweight and flexible design. This versatility allows for installation in various scenarios, such as curved surfaces or portable applications. Although they typically exhibit lower efficiency compared to crystalline silicon panels, thin-film options can be cost-effective solutions in specific contexts.

When comparing the three options, Polycrystalline Solar Panels emerge as a favourable choice due to their cost-effectiveness. They offer a more budget-friendly alternative compared to monocrystalline panels, making them an attractive option for individuals with financial constraints. Despite being slightly less efficient, polycrystalline panels still deliver reliable energy generation and are well-suited for larger installations where space availability is not an issue.

The cost of installing solar panels can vary depending on factors such as the type of roofing and the specific technology used in the panels. For instance, if you have tiled roofing, you may need to budget extra for scaffolding, which typically ranges from SGD $2,000 to $6,000. On the other hand, if your roof is made of metal, particularly standing seam metal, the installation process tends to be simpler and more cost-effective.

The cost of a solar panel system for a terrace house, with around 20 solar panels and an 8 kWp system, is estimated at SGD $18,000. For semi-detached houses and bungalows, the costs can be around SGD $24,000 and SGD $36,000, respectively.

Yet, prior to installing retractable roofs or solar-panelled roofs, it's imperative to account for factors like structural integrity, adherence to building codes and regulations, sunlight exposure, and budgetary limitations.

Figure 4: Level 4 of Hillview Community Centre

Figure 5: Retractable roof (Smart Zip, 2023)

Figure 6: Solar-panelled roof (Megawatts, n.d.)

2. Level 3

At Level 3, where individuals gather for various activities and social interactions, the significance of proper lighting cannot be overstated. However, upon closer observation during the site visit, it was apparent that the current lighting setup, predominantly composed of singular bulbs, falls short in providing adequate illumination. Instead, it casts uneven shadows, leaving certain areas shrouded in darkness while others are uncomfortably bright and glaring. This imbalance not only detracts from the ambience but also poses practical challenges for occupants and visitors to navigate through the space properly.

One of the primary shortcomings of the existing lighting arrangement is its failure to ensure uniform distribution of light across Level 3. The reliance on singular bulbs results in localized pools of illumination, leaving peripheral regions dimly lit or entirely obscured in shadows. Consequently, individuals traversing these poorly illuminated zones may encounter difficulties discerning obstacles or engaging in activities with precision.

Moreover, the stark contrast between the excessively bright areas and the darker sections creates a disorienting visual experience, disrupting the harmony of the environment.

Compounding the issue further is the obstruction of light flow caused by the placement of decorations and furnishings. While these embellishments contribute to the aesthetic appeal of Level 3, they inadvertently impede the propagation of light, casting elongated shadows and exacerbating the existing lighting disparities. Consequently, the intended purpose of these decorative elements is compromised, as they inadvertently hinder the functionality of the space.

To address these challenges and optimize the lighting conditions on Level 3, the lighting condition of the corridor could be improved with a better lighting design. A transition from singular bulbs to tube lamps would be a considerably better solution. Unlike their counterparts, tube lamps emit diffuse light that disperses more evenly across the environment, mitigating the formation of shadows and minimizing glare. By adopting tube lamps, the entire expanse of Level 3 can be covered in consistent illumination, which better fosters a welcoming and visually comfortable atmosphere for all occupants and visitors.

Moreover, the implementation of tube lamps facilitates the unrestricted flow of light, transcending the barriers posed by decorations and furnishings. With their elongated design, tube lamps can be strategically positioned to circumvent obstacles and penetrate previously obscured areas, ensuring comprehensive coverage throughout Level 3.

Consequently, the visual continuity of the space is preserved, allowing individuals to navigate seamlessly and engage in activities with enhanced clarity and ease.

To further add on, tube lamps are renowned for their energy efficiency, consuming significantly less electricity than traditional singular bulbs. This not only reduces operational costs but also aligns with sustainability objectives, minimizing the carbon footprint associated with lighting usage. The cost of tube lamps can range up to $100 depending on size, wattage and brand. Additionally, tube lamps boast extended lifespans, requiring less frequent replacement and maintenance, thereby enhancing operational efficiency and minimizing disruptions to occupants. Furthermore, the versatility of tube lamps enables customization to suit the specific requirements and preferences of Level 3. Whether adjusting brightness levels, selecting optimal color temperatures, or incorporating smart lighting controls, tube lamps offer unparalleled flexibility in tailoring the lighting environment to accommodate diverse activities and atmospheres. This adaptability ensures that Level 3 remains dynamic and responsive to the evolving needs of its occupants, fostering a conducive environment for social interaction, productivity, and relaxation.

When it comes to comparing the advantages of using tube lamps over singular bulbs, there are a few significant points that show why using tube lamps are more cost saving and energy saving compared to singular bulbs.

1. Tube lamps have a longer lifespan than singular bulbs.

On average, a traditional incandescent bulb will last between 800 to 1500 hours, while fluorescent tube lamps go way beyond that, lasting about 10,000 hours, some may go a high as 50,000 hours.

On average, they last 10 to 20 times longer than incandescent bulbs, which makes them much more efficient.

Although the initial cost of fluorescent tube lamps may be more expensive than incandescent bulbs, with a longer average lifespan means lesser replacement costs, which on average saves a lot more than using incandescent bulbs which are cheaper but replacing it more regularly which in turns generate higher expenses.

Example:

Assume we have a 60-watt incandescent bulb and a 20-watt fluorescent tube lamp, both lamps are used for 8 hours per day, 365 day per year, and electricity cost is $0.12 per kilowatt-hour(kWh).

Power consumption for incandescent bulb: 60 watts x 8 hours/day x 365 days = 175,200 watt-hours = 175.2 kWh

Cost per year: 175.2 kWh x $0.12/kWh = $21.02

Power consumption for fluorescent tube lamp: 20 watts x 8 hours/day x 365 days = 58,400 watts-hours = 58.4 kWh

Cost per year: 58.4 kWh x $0.12/kWh = $7.01

Savings with fluorescent tube lamps: annual savings = cost of incandescent bulb – cost of fluorescent tube lamp = $21.02 - $7.01 = $14.01 per year

2. Tube lamps emit lesser heat than singular bulbs.

   These fluorescent tube lamps convert more of the electricity supplied into visible light than incandescent bulbs do as most of the energy is released as heat instead of light, hence incandescent bulbs consume more energy. Incandescent bulbs emit warmer light thus increasing the surrounding temperature which fluorescent tube lamps emit less warm light hence the increase in temperate in the surrounding is not significant.

   Moreover, incandescent bulbs consume more energy than fluorescent tube lamps for the same rating. Incandescent bulbs produce about 15 lumens per watt of input power while fluorescent tube lamps produce 50 to 100 lumens per watt of input power.

   Along with that, fluorescent light bulbs emit lesser heat and distributes light evenly without putting a strain on the eyes.

Figure 7: Hallway at Level 3 of Hillview Community Centre

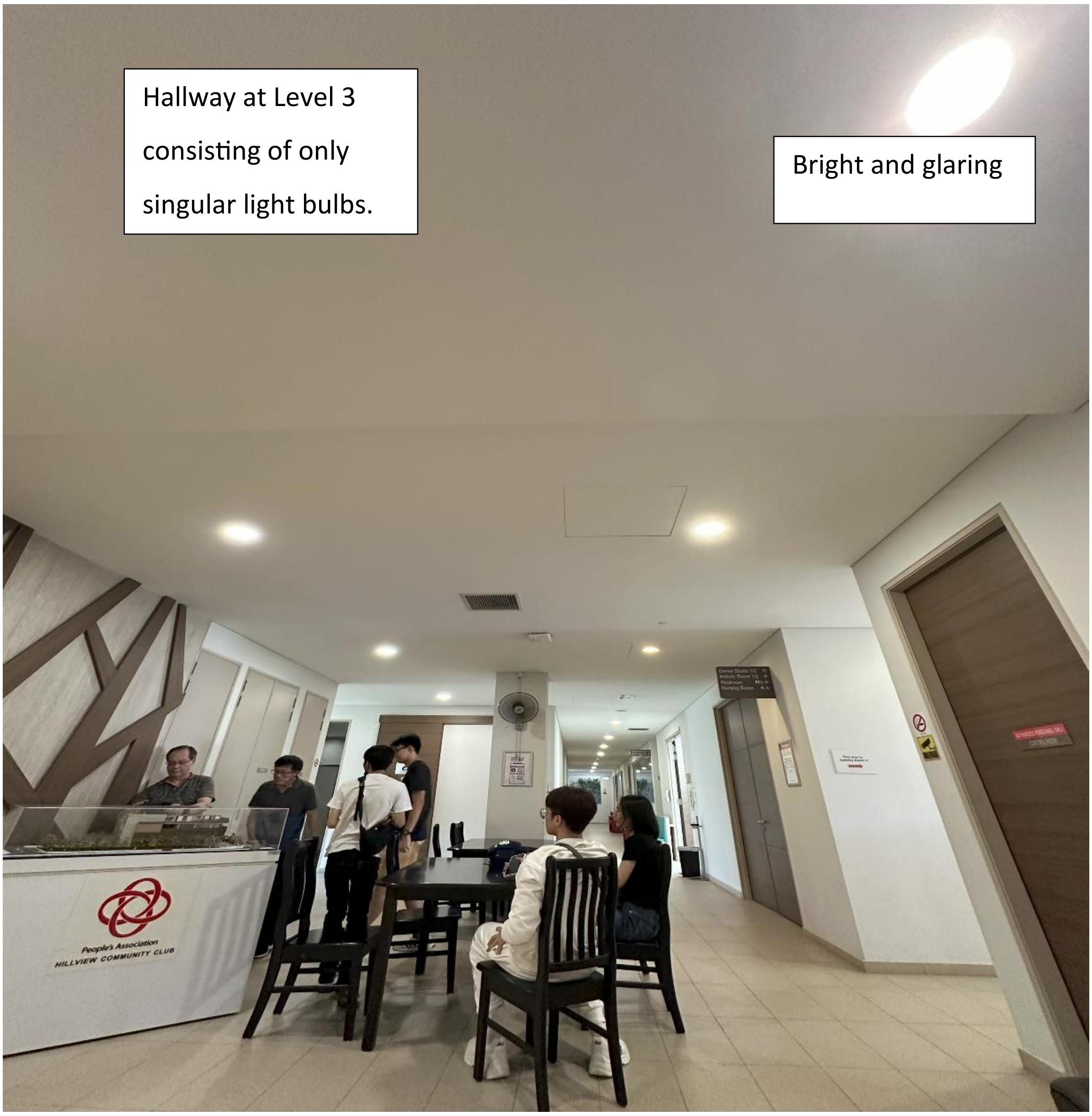

Figure 8: Hallway at Level 3 of Hillview Community Centre

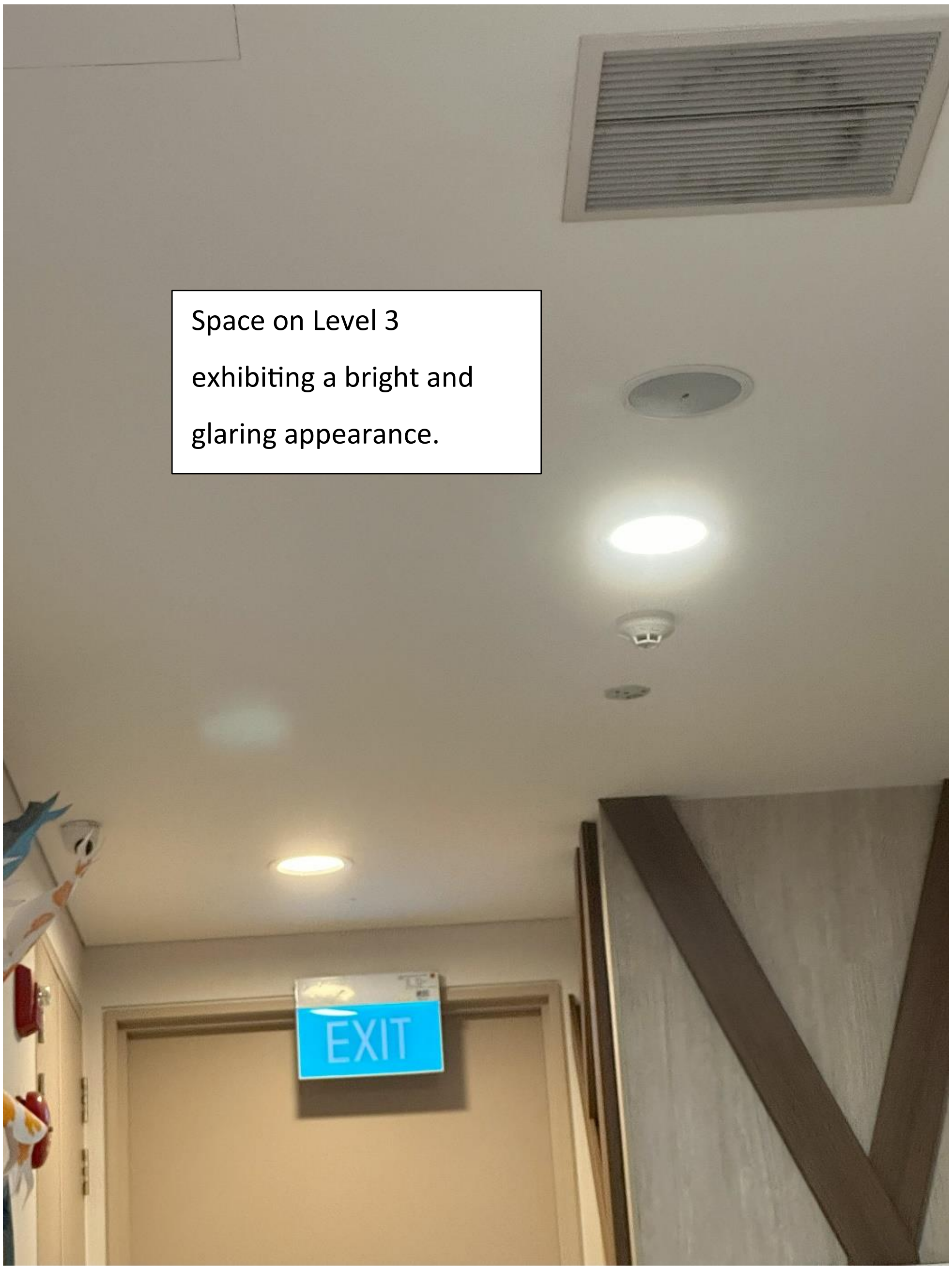

Figure 9: Light at Level 3 of Hillview Community Centre

3. Overall Building

Additionally, Low-E windows enhance building energy efficiency by minimizing heat transfer between indoor and outdoor environments. The infrared-reflective coating in Low-E windows prevents excessive heat from entering during hot weather and retains warmth indoors during colder seasons. This maintains a stable indoor temperature, reducing reliance on heating and cooling systems and ultimately lowering energy usage. Additionally, these windows promote a comfortable indoor atmosphere, ensuring occupants experience consistent and pleasant temperatures throughout the year.

One possible type of Low-E windows suitable for use is the Solar Low-E window. Solar control Low-E glass are a specific type of low-emissivity windows designed to reduce heat transfer and block ultraviolet (UV) radiation while allowing visible light to pass through. These windows typically have a special low-emissivity coating that helps reflect solar heat away from the building, thus making it an excellent choice for window glass in moderate to warm climates. They are particularly effective in improving energy efficiency and maintaining indoor comfort levels while still allowing ample natural light to enter the space.

In comparison to single-pane windows, solar low-E windows are engineered to reduce heat transfer by reflecting infrared heat from the sun while still permitting visible light to enter. These windows boast a low solar heat gain coefficient and a low U-factor, contributing to their exceptional energy efficiency. Conversely, single-pane windows provide minimal insulation and exhibit subpar thermal performance, allowing heat to penetrate easily. This characteristic leads to increased heating and cooling expenses.

The cost of solar Low-E glass windows can fluctuate based on factors like window size, manufacturer, framing material, and optional coatings. Typically, these windows are positioned at the upper end of the price scale relative to standard windows because of their energy-efficient attributes and specialized coatings. Although solar low-E windows may entail a higher initial investment compared to single-pane windows, they offer substantial long-term savings on energy bills owing to decreased heating and cooling expenses. Conversely, although single-pane windows boast lower upfront costs, they lead to elevated energy expenditures over time, rendering them less economically advantageous in the long term.

Ideally, the Solar Low-E windows should be installed on the eastern side of the community centre (circled in red), as it receives intense morning and afternoon sunlight due to its eastward orientation. This placement aims to optimize their ability to minimize heat gain and improve energy efficiency. Solar low-E windows contribute to maintaining stable indoor temperatures by mitigating heat gain in summer and heat loss in winter, ensuring a pleasant indoor environment year-round. Conversely, single-pane windows offer limited insulation against outdoor temperature fluctuations, leading to discomfort for building occupants.

Finally, Solar Low-E windows play a role in promoting environmental sustainability by decreasing energy usage and greenhouse gas emissions linked to heating and cooling activities, which hence lessen the electricity usage on air-conditioning and mechanical ventilation. In contrast, single-pane windows have a more significant environmental footprint due to their inferior energy efficiency, resulting in heightened carbon emissions and energy consumption.

All in all, this contributes to enhanced thermal comfort, minimized glare, and increased energy efficiency, resulting in potential cost savings and a more enjoyable indoor environment for building occupants.

Figure 10: Outdoor view of Hillview Community Centre

Example of Solar Low-e Window

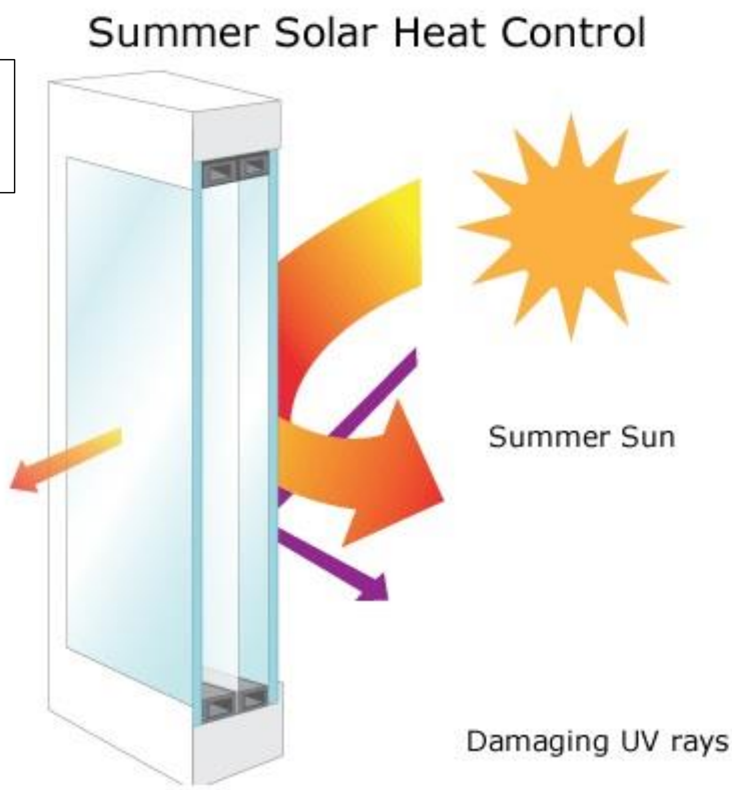

Figure 11: Solar Low-e Window (Solar Low-e coatings, 2015)

1.2 Interior Design

Interior design upgrades at Hillview Community Centre aims to enhance functionality, comfort, and sustainability across its different levels. Level 3 introduces improvements in ventilation with solar-powered fans, while inviting seating areas enhance the library's ambiance. Sustainable seating options and artwork from the childcare centre enrich Level 2, while the Basement implements mechanical ventilation systems and natural ventilation strategies to improve airflow and air quality. These upgrades collectively aim to create a more comfortable and environmentally friendly space for all visitors.

a) Level 3

Ventilation at level 3 was also found to be stuffy due to the direction of airflow from one end to another, as this cannot be changed, a solution to it would be to add more fans around the area such as ceiling fans but instead of using the normal electricity, we could make use of the solar panel idea from the roof top and use the energy converted from sunlight to use for the fans instead. We could also make use of the space to have a wall of greens as well to improve indoor air quality. By utilizing solar power for ventilation, we not only reduce electricity expenses but also contribute to environmental conservation.

The interior design of the library on level three can be improved by incorporating more engaging and inviting sofas and resting areas to enhance the attractiveness of the library.

b) Level 2

Level 2 has good ventilation due to the open space that allows airflow to be efficient and has a ventilation duct as well. Nevertheless, the area has not been fully utilized to its potential; there is a lack of seating space, and the interior design could be enhanced to make it more appealing and inviting. One potential solution is to incorporate seating areas where individuals can study or rest. Rather than using conventional tables, we could opt for more captivating and sustainable alternatives, refer to attached.

Figure 12: Kinetic Bench (Dornob, Shapeshifting slinky-inspired Kinetic Bench 2021)

The area on Level 2 can be enriched by featuring artwork created by children from the childcare center or those attending drawing classes at the community center. Additionally, decorative accents and accessories can be incorporated to further enhance the overall ambiance of the space. As an example, Jurong Regional Library maximizes its space by exhibiting artworks and incorporating interactive boards to engage children. These artworks are created by children attending art classes at the library. Depending on the festive season, the selection of artworks and decorative accents is adjusted accordingly.

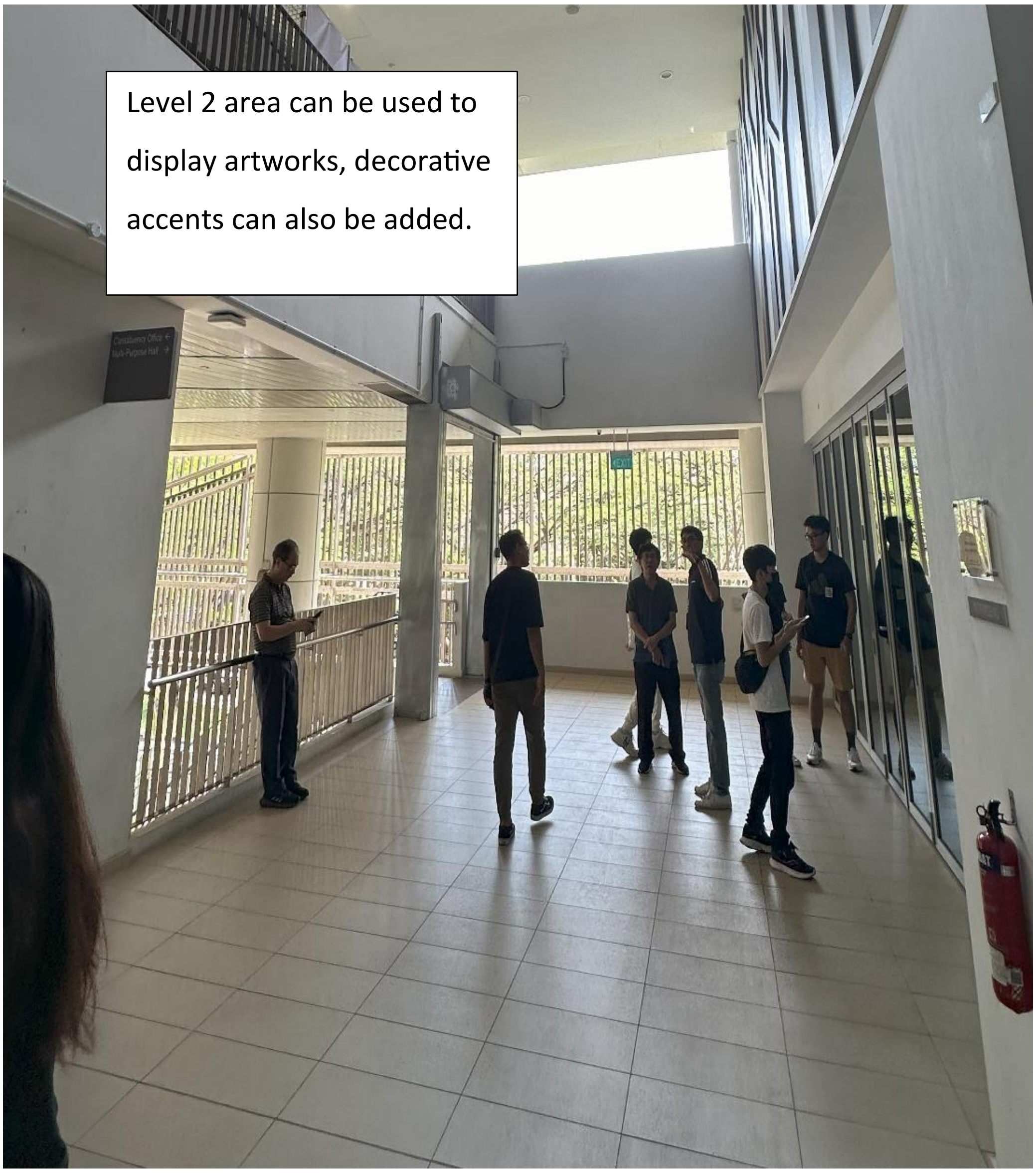

Figure 13: Hillview Community Centre Level 2

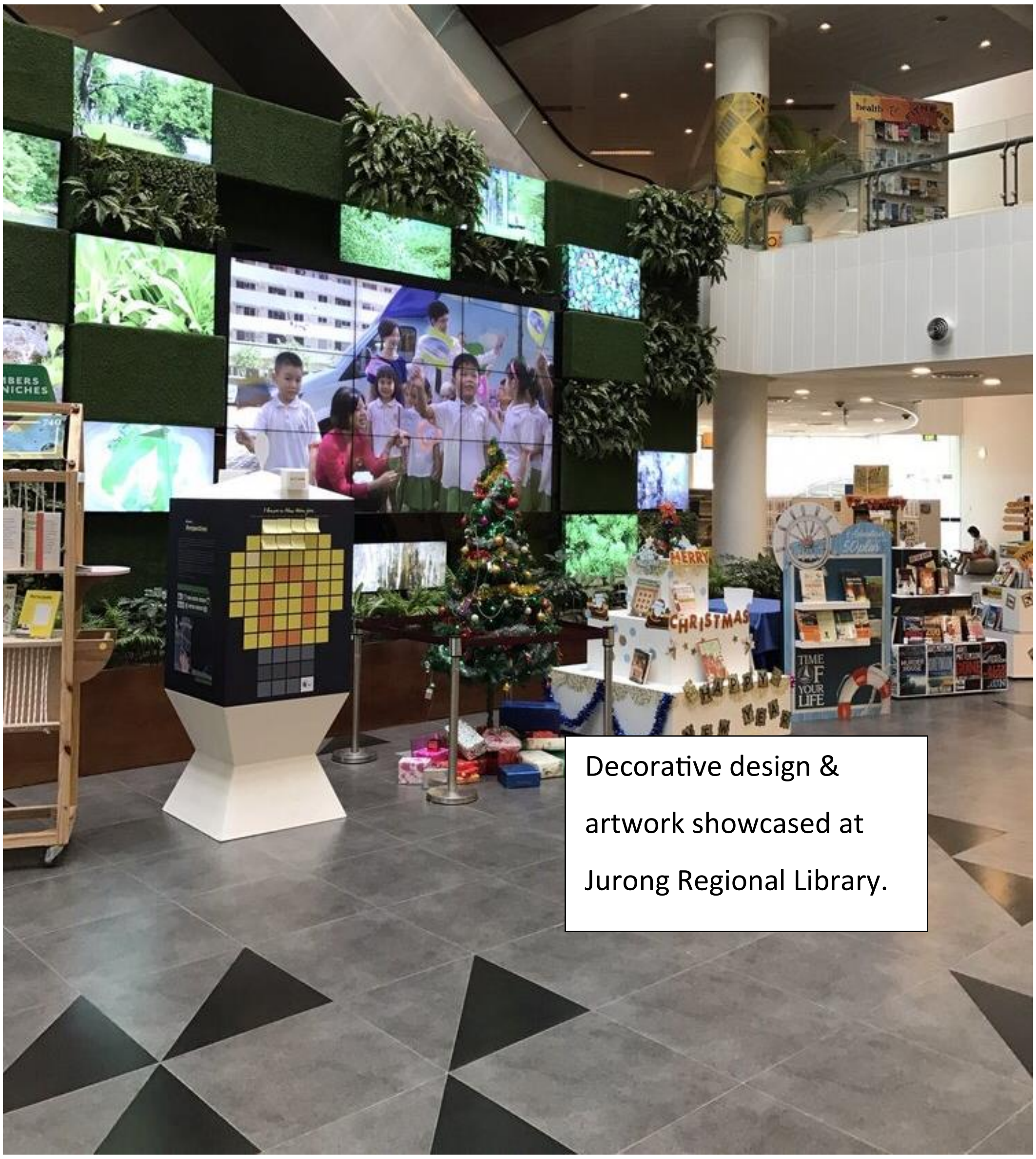

Figure 14: Decorative design & artwork showcased at Jurong Regional Library. (*Jurong Regional Library* - *Singapore, SG*)

Figure 15: Artwork done by students displayed at Jurong Regional Library. (FlyingNoodles, *Jurong Regional Library: Singapore* 2022)

c) Basement

During the site visit, one notable observation about the Basement was its limited airflow, which contributed to a somewhat stifling atmosphere. The absence of adequate airflow causes visitors to feel uncomfortable, especially in the enclosed area. Without proper airflow mechanisms in place, stagnant air becomes trapped within the confines of the basement, which increases humidity levels and fosters the accumulation of airborne pollutants.

One proposed solution to resolve this inadequate airflow and ventilation issue is to install mechanical ventilation systems, such as exhaust fans and air purifiers, which can help to mitigate indoor air pollutants and improve air circulation. These systems should be strategically positioned to ensure optimal airflow throughout the basement which enhances overall air quality.

Furthermore, proactive maintenance of regular servicing of HVAC systems is also essential to ensure optimal performance and efficiency. Additionally, the incorporation of natural ventilation strategies, such as operable windows and louvers can complement mechanical systems and provide an additional means of enhancing airflow and ventilation in the basement.

1.3 Greenery Integration

At Hillview Community Centre, we're considering ways to enhance greenery integration across various levels, aiming to boost environmental sustainability and visitor engagement. We're exploring the idea of establishing a rooftop garden on Level 4 to provide natural shading, air purification, and community space. Additionally, we're looking into extending the green wall on Level 2 to further improve aesthetics and air quality. Options such as implementing green walls or cooling paint on the building's facade are being considered to enhance visual appeal and sustainability. Furthermore, we're planning to install electric vehicle charging stations in the Basement to promote clean transportation options and reduce carbon emissions. These efforts are aimed at creating a more environmentally friendly and welcoming environment for all visitors at the Centre.

1. Level 4

A rooftop garden can be established on Level 4 of Hillview Community Centre, refer to attached, offering a multitude of benefits including heat reduction, environmental sustainability, and community engagement. It helps alleviate the heat generated by direct sunlight by naturally providing shading and insulation. The vegetation and soil act as a thermal barrier, diminishing heat absorption and maintaining a cooler atmosphere throughout the day.

The vegetation and soil within a rooftop garden serve as natural insulation, assisting in the moderation of indoor temperatures. This leads to decreased reliance on air conditioning during warm weather, thereby lowering cooling expenses. Furthermore, by shading the roof surface, rooftop gardens mitigate the absorption of heat by the building's structure, maintaining cooler indoor temperatures and reducing the necessity for cooling energy. Additionally, the foliage of the plants offers shade to the area below, effectively obstructing direct sunlight and diminishing solar heat gain on both the roof and lower levels of the building.

Furthermore, it contributes significantly to environmental sustainability by absorbing carbon dioxide, purifying air pollutants, and fostering biodiversity. Acting as a green sanctuary within the urban environment, it supports local ecosystems and enhances overall air quality. Additionally, the rooftop garden enhances the aesthetic appeal of the Community Centre, crafting a visually captivating and welcoming space for visitors to relish. Moreover, it serves as a distinctive outdoor venue for community members to congregate, interact, and partake in leisure activities, nurturing a sense of community pride and ownership.

Figure 16: Hillview Community Centre Level 4

2. Level 2

Despite the presence of a green wall, the current efforts are insufficient. The existing rooftop plant feature descends downward, but it fails to fully cover the railings as originally intended.

Figure 17: Outdoor view of Hillview Community centre

Hence, we can further enhance it by extending the green wall downward until it completely covers the railings. Integrating green walls can elevate air quality and augment the area's aesthetic appeal. We can use a mix of plants with different water needs, sun requirements, and heights to create a thriving ecosystem. We can also include flowering plants to attract butterflies, bees, and other pollinators, which benefits the overall biodiversity of the green wall. Additionally, green wall assists in regulating temperatures by offering insulation against both heat and cold, thereby diminishing reliance on mechanical heating and cooling systems and reducing energy consumption. Having a green wall also reduces ambient noise as they can adsorb up to more than 50% of the sound than a regular wall. This allows the area to be more peaceful and can potentially boost the productivity of the area. For additional sustainability, we can consider using recycled materials for the green wall structure whenever possible.

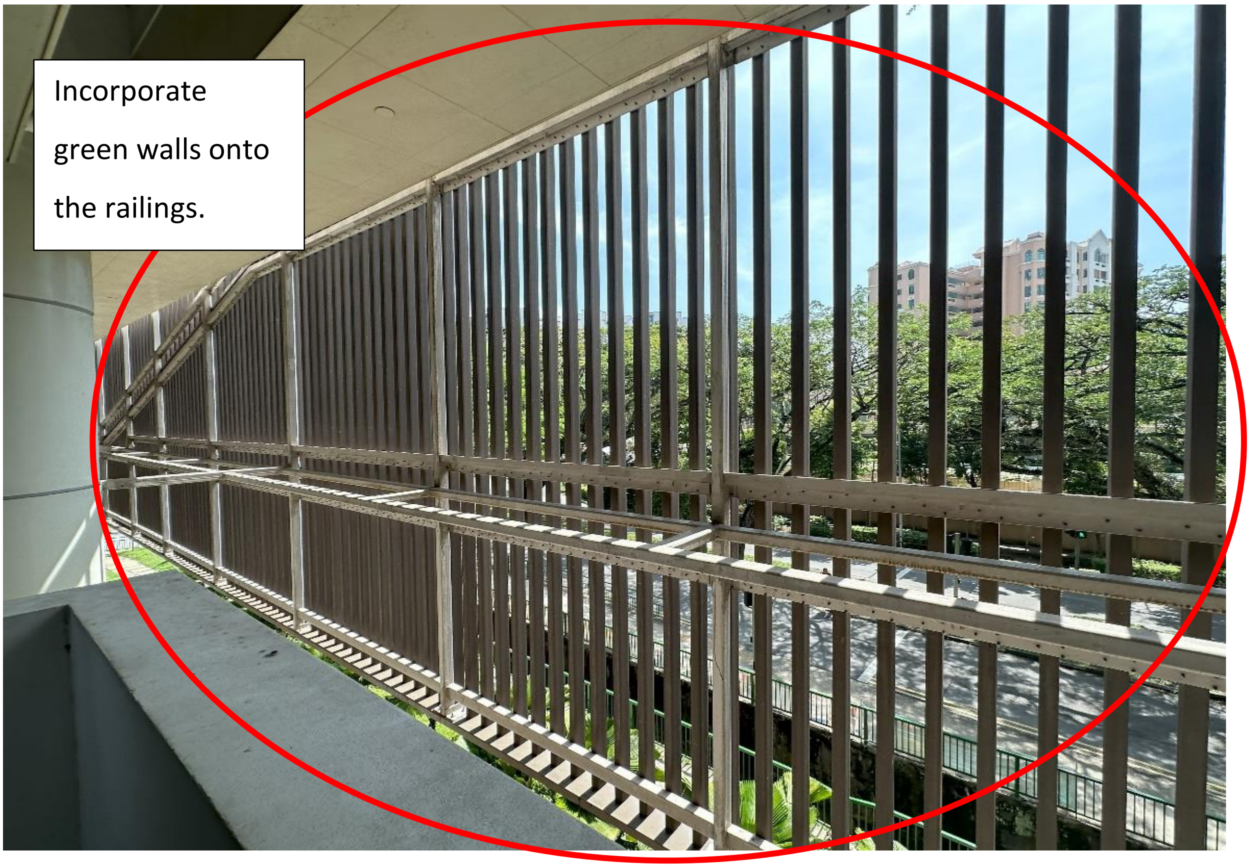

Figure 18: Level 2 Railing of Hillview Community Centre

An elevation view is provided to clearly visualise the area that the green wall will be put at. The green highlighted parts are the green wall, however a section in the middle is removed to show the interior but the Greenwall is still there. It stretches across the whole building to optimise the Greenwall effect. To make the green wall grow fully to cover the railings as intended, more efforts and maintenance should be made to ensure that care is provided for the plants to grow. This is to ensure that the investment of our green wall does not go to waste.

One example involves utilizing rainwater gathered through our rainwater harvesting system to irrigate our plants during dry periods, preventing dehydration and stunted growth. This practice not only reduces reliance on tap water and decreases water bills but also synergizes with rainwater harvesting, maximizing its effectiveness, refer to 6a for more elaboration.

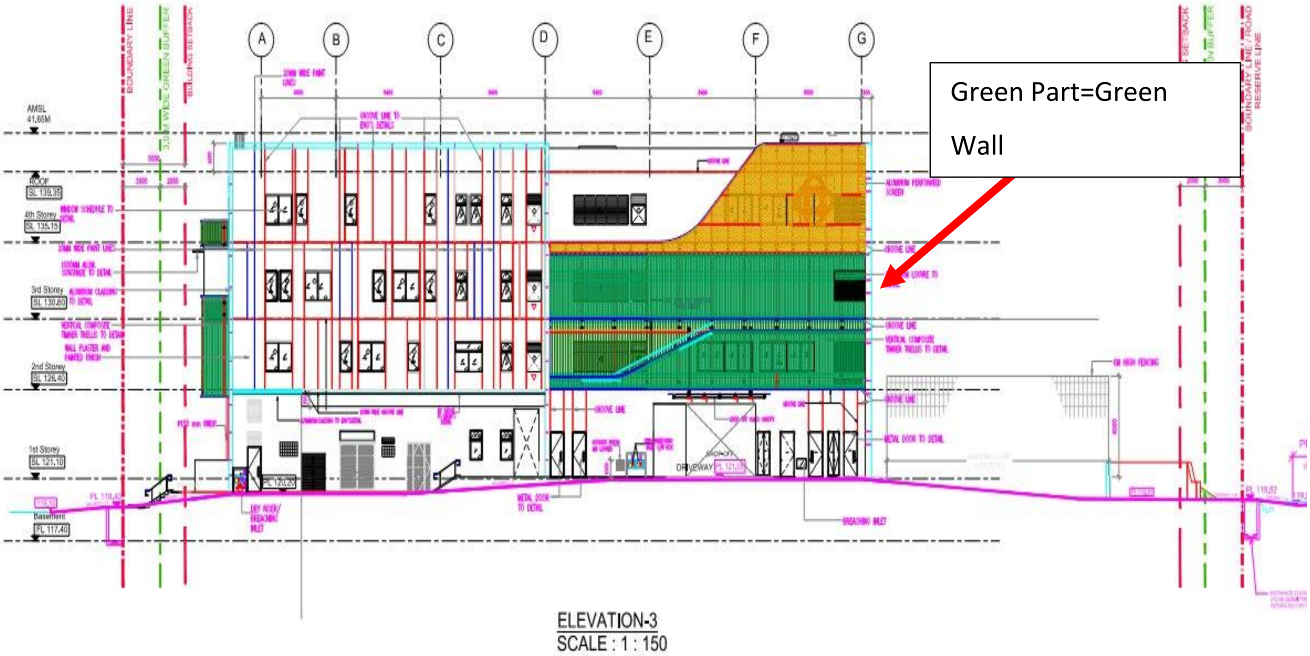

Figure 19: Floor plan of Hillview Community Centre

The cost of rebuilding and maintaining the Greenwall we have, it can range up to $76,150.00 in rebuilding alone where it includes the cost of moisture barrier, installing Greenwall system, plant material, irrigation system which we are planning to have by working together with our rainwater harvesting, and professional installation. However, some cost can be removed depending on our Greenwall condition. For cost of maintenance, we will need quarterly licensed irrigation Inspector which cost about $200 estimate each time the inspector checks, regular plant maintenance service which cost about $8,700.00 annually and Plant replacement of $2250.00 annually. However, if Greenwall is maintained properly, maintenance cost can be cut down respectively in the future. Regular plant maintenance service will normally include weed control to prevent overgrowing the Greenwall, checking plants for any diseases, ensuring plants do not intrude into the buildings through the windows or any openings, and to check the support structure for any loose fittings and damages that need repairs. All these maintenances will ensure that the Greenwall will be more sustainable and livelier.

Thus, although the installation cost is pricey, in the long run, the Greenwall can help in reducing our energy cost and is a good investment as it comes with a lot of benefits as well.

3. Overall Building

Another issue highlighted is the lack of visual stimulation in the building facade, which might be contributing to the low foot traffic and limited activities.

One proposed solution to invigorate the lackluster façade and draw visitors in is the implementation of a green wall. Such a green wall would not only enhance the aesthetic appeal of the place but also contribute to environmental sustainability by providing habitat for wildlife, improving air quality, and mitigating urban heat island effects.

Figure 20: Outdoor view of Hillview Community Centre

Alternatively, a simpler yet equally effective solution is the application of paint to cool the building's exterior. By opting for lighter hues and reflective coatings, the façade can be cooled amidst the urban heat, at the same time inviting visitors to seek shelter from the sweltering sun. Pale shades of blue, green, or cream would not only visually cool down the building but also create a sense of tranquility and serenity, beckoning passersby to linger and explore.

The introduction of a green wall or cooling paint would elevate the visual appeal of the facade, transforming it from a forgettable backdrop into a memorable landmark that captures the imagination. This enhanced aesthetic allure would undoubtedly attract greater foot traffic, drawing curious onlookers and potential patrons eager to experience the revitalized ambiance firsthand. An example is provided below.

Figure 21: Green wall at ParkRoyal (Mun-Delsalle, *Parkroyal on Pickering in Singapore* 2017)

Moreover, the implementation of green infrastructure or cooling measures aligns with contemporary trends towards sustainable urban development, reinforcing the place's commitment to environmental stewardship. A green wall, for example, not only provides an aesthetic boost but also delivers tangible ecological benefits, such as carbon sequestration, stormwater management, and biodiversity conservation. Similarly, the use of cooling paint contributes to energy efficiency and climate resilience, reducing the building's heat absorption and alleviating the urban heat island effect.

d) Basement

The use of electric vehicles (EVs) is under the concept of "greenery integration" as it refers to incorporating EVs into sustainability initiatives that aim to enhance environmental quality, reduce carbon emissions, and promote green spaces within our urban environments.

One key observation that was made was the absence of any designated electric car charging areas in the basement, which further compounds the sustainability shortcomings of the building.

Without accessible charging stations, electric vehicle owners are left without recourse, and are forced to seek alternative options outside the confines of the building, thereby causing low human traffic and also hindering the adoption of clean transportation solutions. Revamping the basement to allow allocated space for electric vehicle owners would enhance the appeal of the building, which attracts more visitors to come and visit this place.

When considering the installation of EV chargers, there's a range of options available, each with its own price tag. Outdoor charging stations resembling those seen in BlueSG installations typically come in at around $15,000 apiece. On the other hand, opting for indoor wall-mounted charging points presents a more budget-friendly choice, priced at approximately $5,000 each. These installation costs encompass electrician labour and cabling expenses.

Providing charging infrastructure can attract more tenants or customers who own electric vehicles, thereby increasing foot traffic and revenue. Moreover, supporting sustainable transportation options like EVs can enhance the building's green credentials and appeal to environmentally conscious tenants or customers. Additionally, this will potentially attract investors which aids with initial investment costs and provide financial benefits. Lastly, promoting the use of electric vehicles can contribute to reducing carbon emissions and improving air quality, resulting in broader societal and environmental advantages.

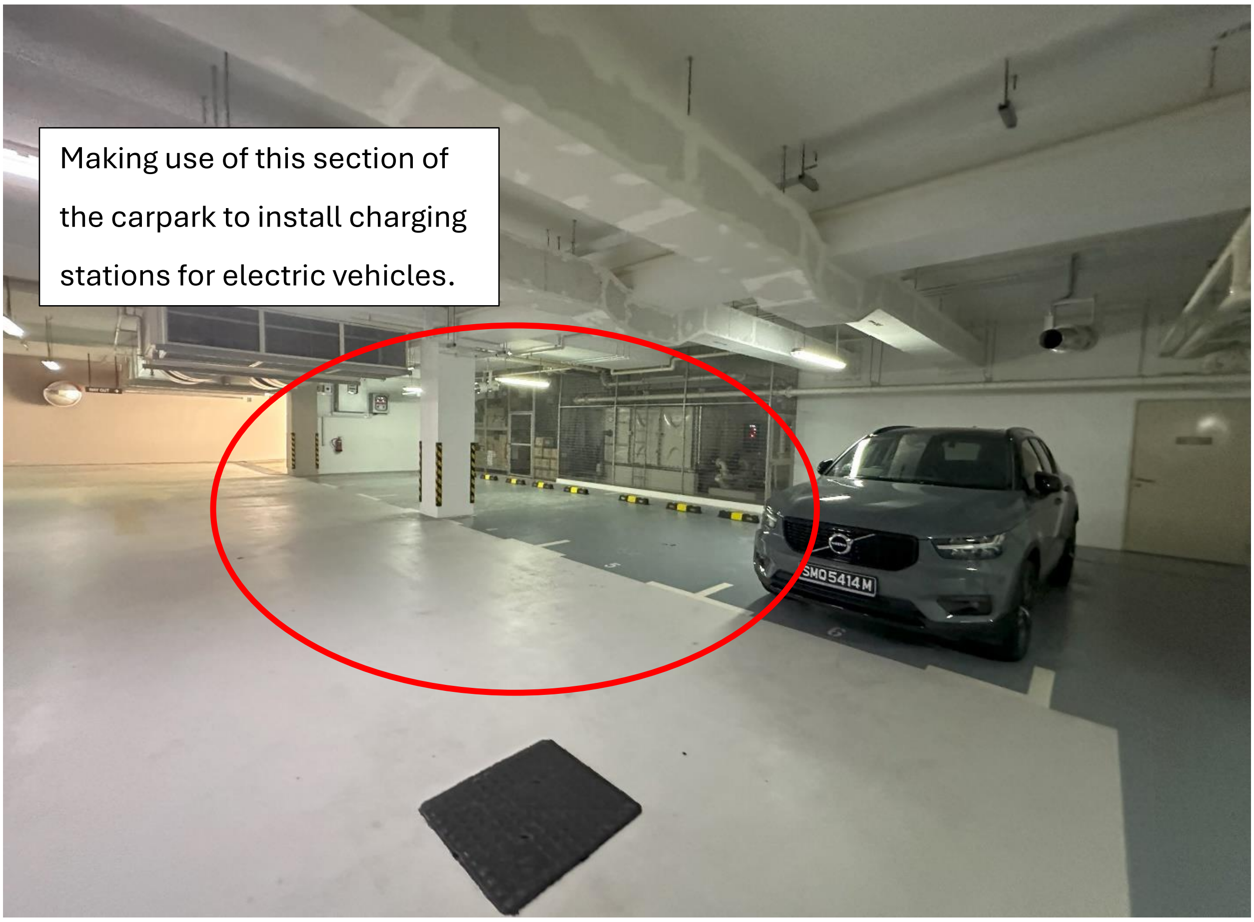

Figure 22: Basement of Hillview Community Centre

Figure 23: BlueSG (Salim et al., *electric vehicle developments in s'pore over the years*, 2021)

1.4 Mobility

Improving mobility at Hillview Community Centre involves enhancing accessibility and connectivity across levels. On Level 1, a proposed solution includes accommodating alternative transportation modes, like bicycles, is crucial. Increasing bicycle lots and connecting to nearby Park Connector Networks (PCNs) or the Railway Corridor encourages eco-friendly commuting. Initiatives like introducing Anywheel bikes and promoting cycling, similar to those seen at Funan Mall. This further engage the community and promote sustainable transportation options.

a) Level 1

During the site visit, it was evident that Level 1 maintains a tranquil atmosphere, offering a serene retreat away from the bustling crowds. However, its secluded nature may have resulted in it being overlooked by the daily flow of visitors and passersby. The quietness of Level 1 can be attributed to its limited accessibility and connectivity to nearby areas, which may have inadvertently hindered opportunities for social interaction. However, there is potential for improvement to enhance the vibrancy of the entire area.

Attention must also be directed towards accommodating alternative modes of transportation, such as bicycles. Increasing the number of bicycles lots and establishing connections to nearby Park Connector Networks (PCNs) or the Railway Corridor would not only encourage eco-friendly commuting but also facilitate easier access for cyclists, further enhancing the accessibility and appeal of the overall place.

We can also include Anywheel bike and other brands of public bike to further encourage eco-friendly commuting. An example of this can be seen at Funan Mall. Funan Mall encourages the use of bicycles through various initiatives, including providing ample bicycle parking facilities, promoting cycling as a sustainable transportation option, and organizing cycling-related events and activities to engage the community.

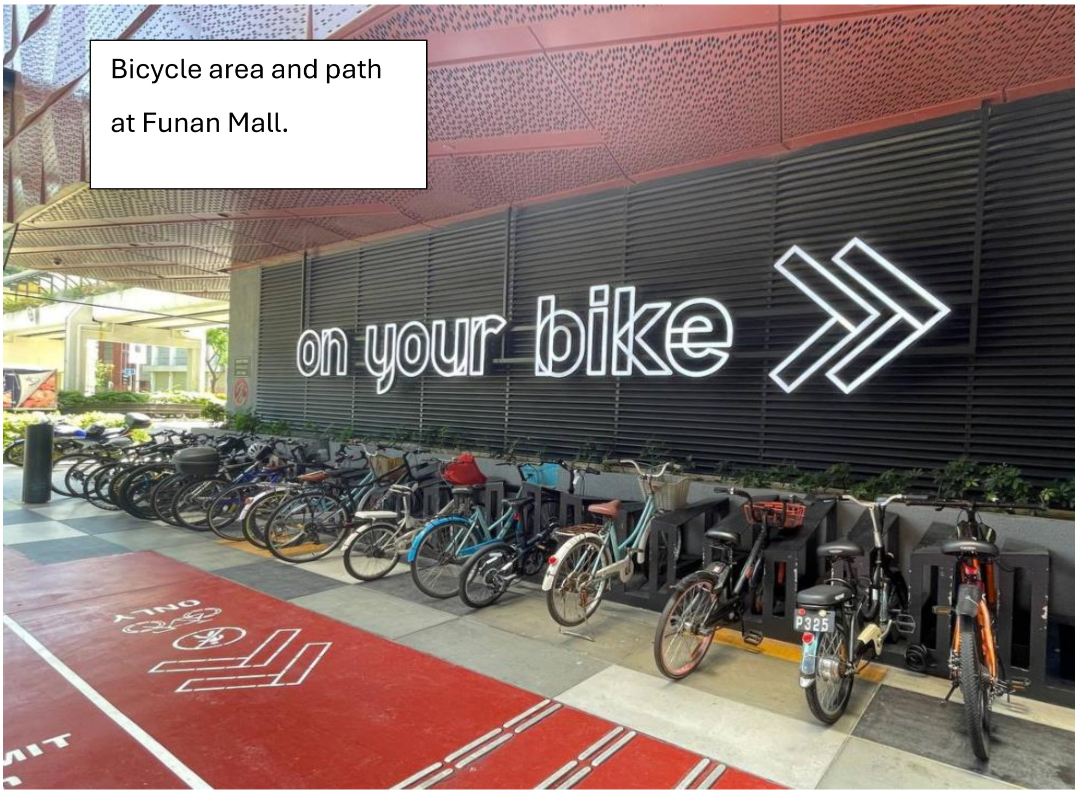

Figure 24: Bicycle area and path at Funan Mall (Funan Cycling Path Usage, Singapore)

Figure 25: Anywheel bicycle (Anywheel parking, Singapore)

1.5 Waste Management

The community centre's waste management, encompassing levels from 4 to the Basement, currently lacks adequate recycling bins and initiatives. Regular trash bins are prevalent on every floor, indicating a missed opportunity to promote responsible waste disposal. While some recycling efforts exist near the vehicle roundabout, they are limited and potentially hazardous. To improve, dedicated recycling bins should be installed on each floor, clearly labelled, and colour-coded for different materials. Prominent placement and signage can encourage active recycling participation among visitors, enhancing the centre's waste management practices and fostering a culture of sustainability.

a) Overall Building

Throughout the whole building, from Level 4 to the Basement, there was inadequate provision of recycling bins and initiatives for recycling efforts. The lack of recycling bins throughout the building reflects a missed opportunity to minimize waste and promote responsible resource consumption. Below are images depicting regular trash bins found on every floor of the community centre (CC).

Figure 26: Bin at Level 3 of Hillview Community Centre

Figure 27: Bin at Level 2 of Community Centre

Figure 28: Bin at Basement of Hillview Community Centre

Despite their recycling efforts, it is currently limited to a small area near the vehicle roundabout, posing potential hazards. Additionally, the bins are difficult to locate as they are concealed in a small corner, refer to attached.

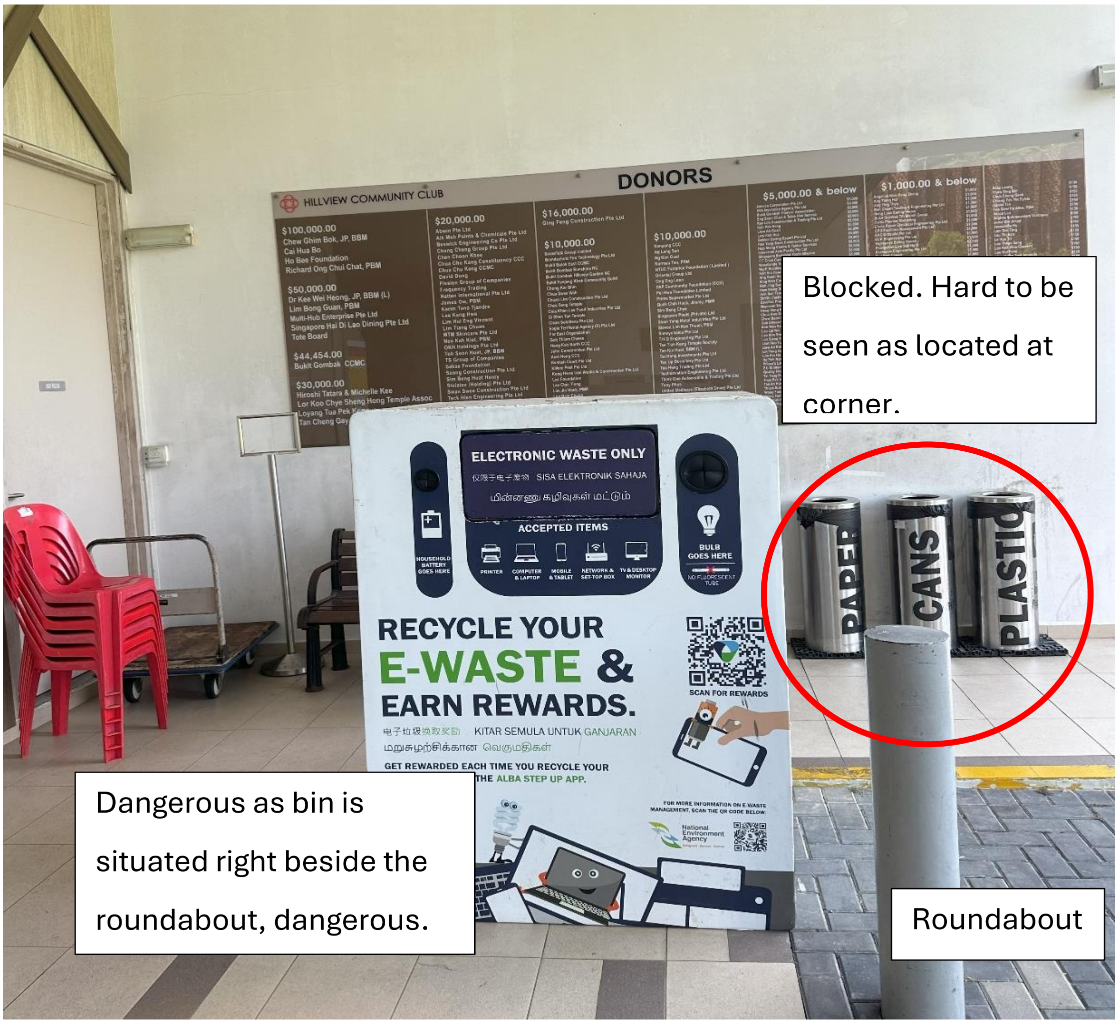

Figure 29: Recycle bin at roundabout of Hillview Community Centre

To improve this issue, installation of dedicated recycling bins on each floor would be crucial to facilitate convenient waste segregation. These bins should be clearly labelled and color-coded to distinguish between different types of recyclable materials, such as paper, plastic, glass, and metal, thereby streamlining the sorting process for users. Furthermore, these recycling bins should be positioned visibly and prominently to encourage active recycling participation among the public or visitors. Signage could also potentially be used to direct visitors on where to recycle their belongings.

An example of the Level 1 floor plan is given. Light green is where the current recycling bin is located. As from the picture above, it is partially blocked by the Electronic Waste Bin. People coming from the behind side where the entrance is and people coming down from lift will unconsciously throw their trash into the bin the see first which is the bin beside the lift labelled as yellow. Thus, to improve this situation, another placement to put the recycling bin would be beside the lift lobby, labelled as blue. This is because people coming from the lift, toilet or entrance would be able to see it more easily, and it will put the recycling bin to more use. This method can be put throughout all levels, where the bins are placed at a more visible place to encourage people to throw their trash and recycle it.

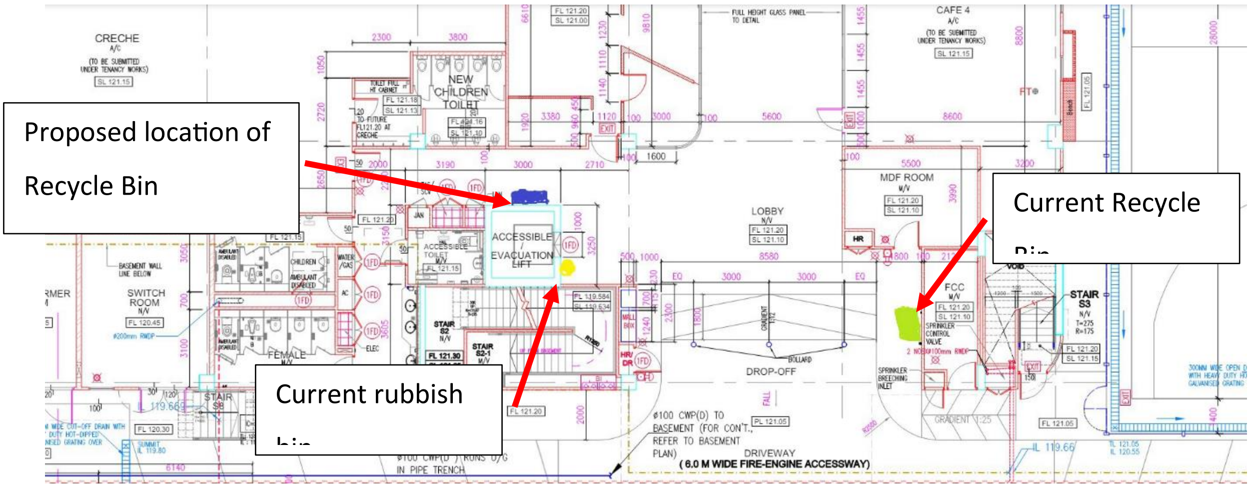

Figure 30: Floor plan of Hillview Community Centre showing locations of bins

1.6 Water efficiency

At Hillview Community Centre, water efficiency measures are proposed, notably on Level 4, where rainwater harvesting systems like stormwater harvesting and roof collection can be implemented. Despite initial costs ranging from $3,000 to $11,500, these systems offer significant long-term benefits, including up to 50% water bill savings and environmental preservation. Additionally, innovative concepts involve using rainwater for cooling building exteriors through drip irrigation or sprinkler systems, promoting sustainable water management. While costs for these systems vary, ranging from $20 to $100 per square foot for vegetative screens and $500 to $5,000 for drip irrigation, the environmental benefits outweigh the expenses, making them valuable investments for the community centre.

a) Level 4

Rainwater harvesting can also be done to use the rooftop to its full potential. Among all the methods of rainwater harvesting, Stormwater harvesting, and Roof collection is some method that we find suitable. Rainwater harvesting can be seen in other buildings as well such as JEM at Jurong East. The rooftop area of Hillview CC is spacious, presenting an opportunity for rainwater collection. However, the flat nature of the roof makes it less conducive for this purpose. To optimize the use of this ample space, a slight slope can be constructed on the roof. This modification would facilitate easier and more efficient collection of rainwater, ensuring that the rooftop area can be effectively utilized for harvesting rainwater resources. For stormwater harvesting, rainwater is collected from storm drains and directed towards storage tanks or reservoirs. This collected water can serve various purposes such as toilet flushing, landscape maintenance, cleaner to clean the toilets and irrigation. By using rainwater for toilets, we can significantly reduce our reliance on treated municipal water. The process involves installing a system that captures rainwater, diverts it through gutters and downspouts, filters out contaminants, and stores it in tanks or reservoirs. Components of such systems include gutters, downspouts, filters, storage tanks, pumps, and treatment systems. Stormwater harvesting alleviates pressure on municipal water supplies by offering an alternative water source for non-potable uses. Additionally, it helps reduce stormwater runoff and mitigates the risk of urban flooding.

Figure 31: Rainwater Harvesting System (Jem, Rainwater harvesting system)

Rainwater harvesting system can help save on water bills to up to 50%, making it very efficient and cost saving.

An example of rainwater harvesting implementation can be observed in approximately 90 HDB blocks located in Yishun and Jurong. These blocks are set to have rainwater harvesting systems installed. It is estimated that these systems could yield water savings of up to 17,500 cubic meters per year. To put it into perspective, this amount of saved water is equivalent to the average yearly consumption of potable water for over 85 units of four-room HDB flats. Therefore, assisting in future cost management and potential savings. Furthermore, it was said that directing stormwater into the UWHS' harvesting and detention tank can help reduce the risk of flooding in the neighbourhood during heavy rainfalls. This is achieved by slowing down the discharge of stormwater into the downstream drainage system.

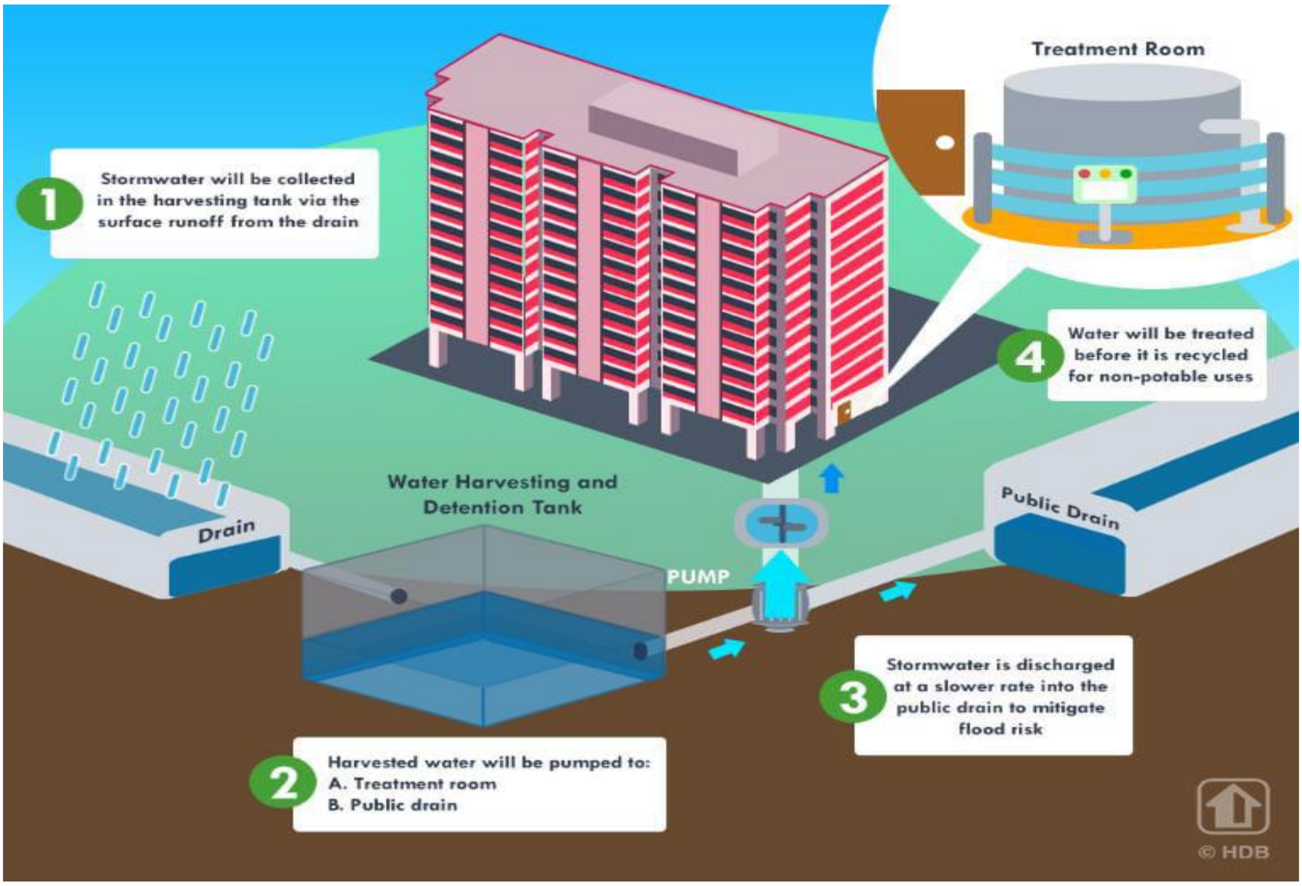

Figure 32: UrbanWater Harvesting System (Cheng, *UrbanWater Harvesting System* 2022)

For the cost of building it, the average amount for Rooftop collection is about $3000, it is a simple and affordable method. However, for stormwater harvesting, it is more complicated as digging of ground and putting the tank with the labour cost, total can add up to about $11,500. Each rainwater collection system relies on essential components to operate effectively, encompassing collection, filtration, conveyance, and storage. The overall cost will encompass the expenses associated with each of these elements, and it can add up to $12,000.

While the initial installation costs may pose a challenge, implementing rainwater harvesting for non-potable tasks such as irrigation, toilet flushing, and laundry offers significant potential savings on water bills for the community centre. Additionally, these systems help alleviate pressure on stormwater drainage infrastructure, reducing the risk of urban flooding during heavy rainfall. As water consumption decreases over time, lower water bills become achievable, contributing to overall cost savings. Moreover, rainwater harvesting promotes the conservation of freshwater resources and alleviates strain on existing water infrastructure, ultimately leading to long-term savings for both individuals and communities. Embracing rainwater harvesting practices supports sustainable water management, playing a vital role in environmental preservation and resilience.

Another concept involves the installation of rainwater harvesting techniques to cool the sides of the building, presenting a sustainable solution for reducing heat absorption and enhancing environmental friendliness. This approach includes the establishment of a rainwater collection system, comprising gutters, downspouts, and pipes, to efficiently capture rainwater from the roof. The collected rainwater is then stored in strategically placed tanks or cisterns near the building. To utilize this harvested water for cooling purposes, a drip irrigation or sprinkler system can be implemented along the building's exterior. This system evenly disperses the rainwater onto vegetative screens or green walls, which offer natural shading and cooling effects as the water evaporates from the vegetation. Implementing intelligent irrigation controls ensures efficient water usage by adjusting watering schedules based on weather conditions and plant requirements. Regular maintenance and monitoring of the system are essential to prevent issues and ensure effective cooling. Overall, rainwater harvesting presents an environmentally friendly approach to cooling building exteriors while promoting sustainable water management practices.

Vegetative screens can range from around $20 to $100 per square foot, including materials and installation costs. Higher-quality materials, specialized plants, and custom designs may incur additional expenses.

Drip irrigation is a method of watering plants by delivering water directly to the roots through a network of tubes, pipes, and emitters. This system conserves water by minimizing evaporation and runoff, making it highly efficient for irrigation purposes.

For instance, it cost $500 for essential components like a tap timer controller, backflow preventer, driplines, and accessories. Alternatively, for a larger landscape, the cost could range up to $5,000 or more. The total expense depends on factors such as the size of the landscape, your budget, and the expertise of your irrigation specialist. The design of an irrigation system is adaptable, allowing you to tailor the components based on your financial constraints. A seasoned irrigation specialist responsible for designing, installing, and maintaining the system should have no trouble ensuring its longevity, potentially lasting 20 years or more. If the installation is executed correctly initially, ongoing maintenance shouldn't incur significant expenses.

Due to significant technological advancements, modern irrigation systems and components such as controllers and valves are highly dependable. However, certain materials like driplines, sprinklers, and pumps will naturally degrade over time. Therefore, it's recommended to have annual maintenance to check on the systems.

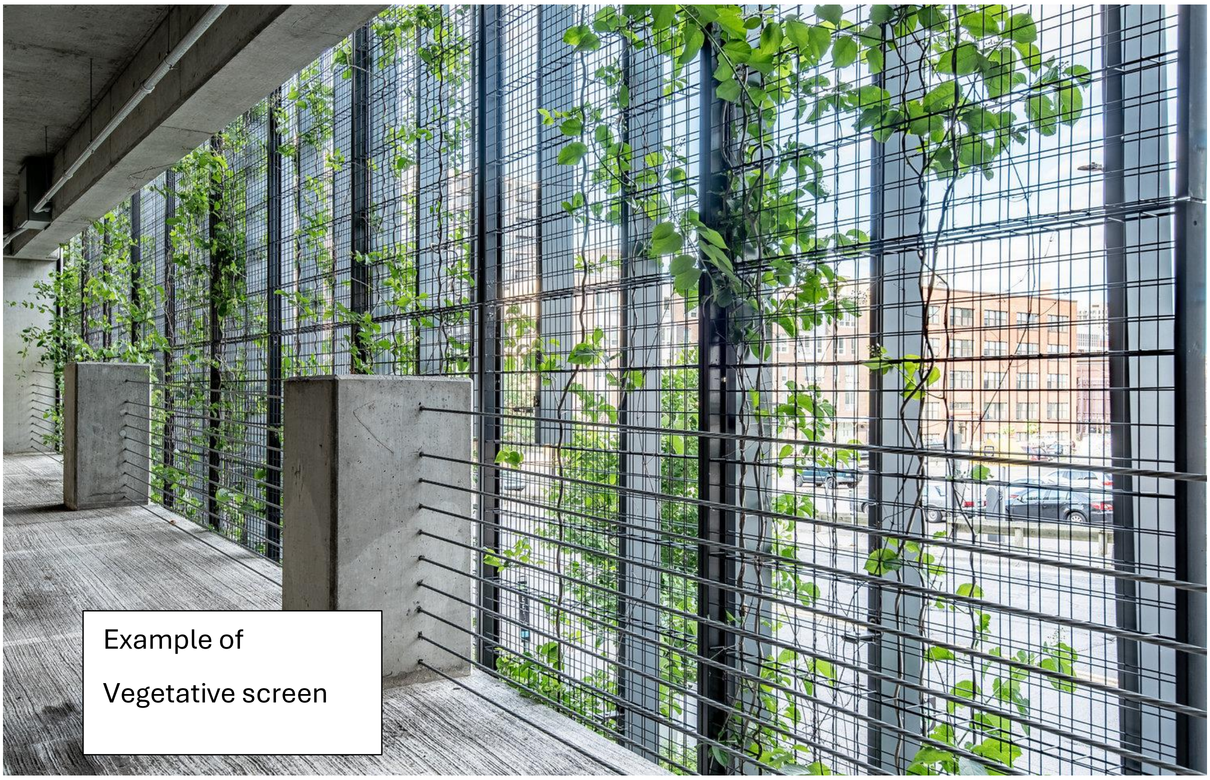

Figure 33: Vegetative screens (*Vegetative screens, n.d.*)

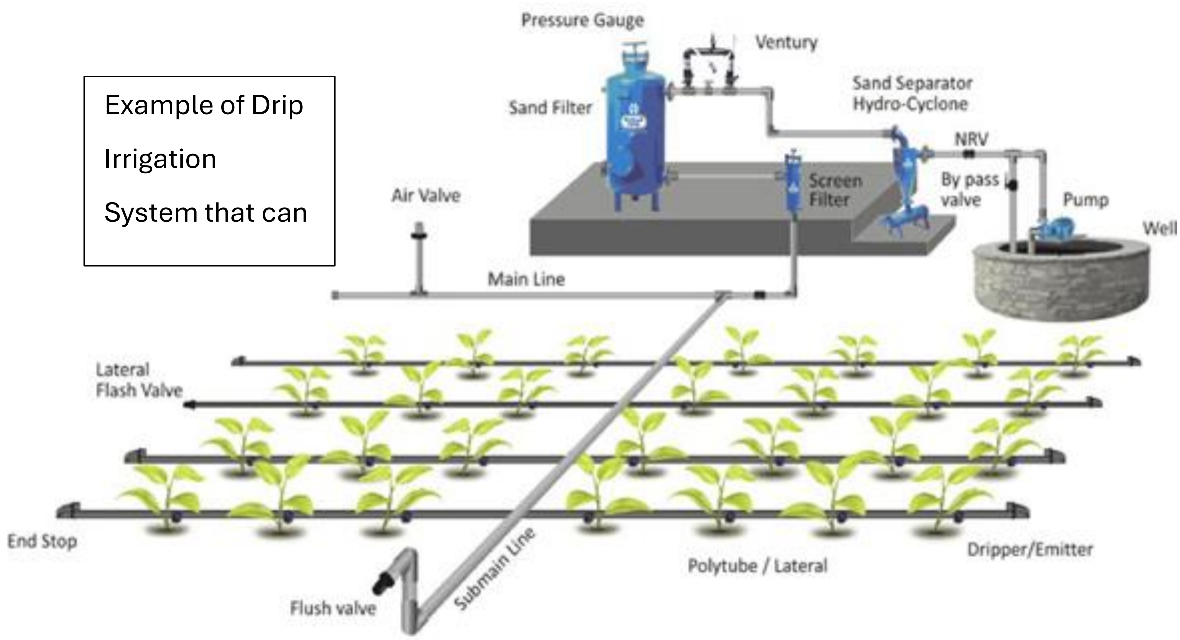

Figure 34: Drip Irrigation system (*Plantations International Drip Irrigation Systems,* 2018)

Phase 2

Based on six months of consumption data, the following are the consumption patterns in the building, carbon reduction measures, and proposed solutions to achieve the desired efficiency improvement and carbon reduction targets.

3.1 Six months of consumption data of Hillview Community Centre

Based on the information obtained from the National Environment Agency (NEA), PUB, Singapore's National Water Agency, Energy Market Authority (EMA), SGBC Embodied Carbon Calculator, S&P Global, and Data.gov.sg, we were able to determine the factors for electricity, water, waste, and recyclables.

The electricity grid emission factor is 0.4168 kg CO2 per kWh. For water consumption, the factor is 0.42 kg CO2 per cubic meter. General waste consumption has an emission factor of 0.76 kg CO2 per kg, and recyclables have an emission factor of 0.04 kg CO2 per kg. Hence, with the provided six months electricity, water, and waste consumption data, we have calculated the consumption data for each category.

Energy Consumption, Factor: 0.4168kg CO2/kWh

Rounded off to one dp.

Total CO2 consumptions:

Nov 23 = 2863 × 0.4168
= 1193.3 kg/CO2

Dec 23 = 2935 × 0.4168
= 1223.3 kg/CO2

Jan 24 = 3448 × 0.4168
= 1437.1 kg/CO2

Feb 24 = 2876 × 0.4168
= 1198.7 kg/CO2

Mar 24 = 3321 × 0.4168
= 1384.2 kg/CO2

Apr 24 = 3046 × 0.4168
= 1269.6 kg/CO2

Total Energy Consumption = 7706.2 kg/CO2

Water Consumption, Factor: 0.42kg CO2/cubic meters

Rounded off to one dp.

Total CO2 consumptions:

Nov 23 = 566.14 × 0.42
= 237.8 kg/CO2

Dec 23 = 591.79 × 0.42
= 248.6 kg/CO2

Jan 24 = 757.32 × 042
= 318.1 kg/CO2

Feb 24 = 549.03 × 0.42
= 230.6 kg/CO2

Mar 24 = 692.61 × 0.42
= 290.9 kg/CO2

Apr 24 = 709.98 × 0.42
= 298.2 kg/CO2

Total Water consumption = 1624.2 kg/CO2

Figure 35: Energy and Water Consumption Calculations

Waste Consumption (Refuse), Factor: 0.76kg CO2/kg

Rounded off to one dp.

Total CO2 consumptions:

Nov 23 = 5700 × 0.76
= 4332.0 kg/CO2

Dec 23 = 5950 × 0.76
= 4522.0 kg/CO2

Jan 24 = 6020 × 0.76
= 4575.2 kg/CO2

Feb 24 = 4950 × 0.76
= 3762.0 kg/CO2

Mar 24 = 4860 × 0.76
= 3693.6 kg/CO2

Apr 24 = 5490 × 0.76
= 4172.4 kg/CO2

Total waste (refuse) consumption = 25057.2 kg/CO2

Waste Consumption (Recyclables), Factor: 0.04kg CO2/kg

Rounded off to one dp.

Total CO2 consumptions:

Nov 23 = 210 × 0.04
= 8.4 kg/CO2

Dec 23 = 120 × 0.04
= 4.8 kg/CO2

Jan 24 = 160 × 0.04
= 6.4 kg/CO2

Feb 24 = 110 × 0.04
= 4.4 kg/CO2

Mar 24 = 160 × 0.04
= 6.4 kg/CO2

Apr 24 = 150 × 0.04
= 6.0 kg/CO2

Total waste (Recyclables) consumption = 36.4 kg/CO2

Figure 36: Waste Consumption Calculations

The total CO2 emissions for all categories amount to 34,424 kg CO2. The highest emissions come from waste refuse.

3.2 Analysis of largest consumption and waste generation

After calculating the consumption data for each category, the highest contributor to CO2 emissions is general waste, followed by electricity, water, and then recyclables. We can conclude that the largest consumption/waste generation comes from general waste refuse, with 25057.2 kg/CO2 of consumption from November 2023 to April 2024. This suggests that the community centre could focus its waste reduction efforts on general waste to have the greatest impact on reducing its overall CO2 footprint. Therefore, focusing on waste reduction strategies will have the greatest impact on reducing the total carbon footprint. Food scraps, paper products, plastic packaging, yard waste, and other discarded materials may fall into the general waste category.

We came across that the current lack of recycling bins throughout the community centre (CC) contributes to the high waste consumption. Hence, we have proposed to install dedicated recycling bins. Firstly, to place clearly labelled and colour-coded recycling bins for different materials (paper, plastic, etc.) on each floor (Level 4 to Basement). Also, a prominent placement near regular trash bins will make them easily accessible and encourage people to recycle. We also propose to include clear signage on the bins explaining what materials can be recycled in each bin and consider adding posters or informational displays throughout the CC to educate visitors about the importance of recycling and proper sorting practices. Other additional initiatives include the exploring options for composting food scraps and yard waste (if possible) to further reduce landfill waste and organising of workshops or events focused on waste reduction and sustainability practices.

Regarding the recycling bins which are currently limited to a small, concealed area near the vehicle roundabout, making them difficult to find and use, we have proposed to install dedicated recycling bins on each floor of the community centre. As shown in the floor plan above (Fig 29), the current recycling bin is partially hidden and placed beside a frequently used trash bin and people often throw recyclables in the more visible trash bin. Hence, we propose to place recycling bins in prominent and easily visible locations, like beside elevator lobbies or entrances. This will make them the first bin people see and encourage proper sorting. We should also consider relocating existing bins on other floors if they are poorly placed.

This will help to increase the Community Centre's recycling rate as readily available and well-marked bins will encourage people to recycle instead of throwing everything in the trash. We can also reduce landfill waste by diverting recyclables from landfills reduces environmental impact and promote sustainability by focusing on recycling which fosters a culture of environmental responsibility among visitors and staff.

Overall, it is difficult to determine a clear trend with only six months of data. However, there seems to be some fluctuation in the amount of waste generated each month, with January showing the highest (6020 kg) and February showing the lowest (4950 kg).

3.3 Efficiency improvement percentage for each consumption type and the carbon reduction target to be achieved.

For energy consumption, our proposed efficiency improvement percentage is a decrease of 3%.

- 7706.2kg/CO^2 × 3% = 231.186kg/CO^2
  1. Our level 4 idea included installing solar panels to help harvest energy for consumption throughout different parts of the building. By installing solar panels, 546-874kWh of electricity can be generated annually which helps to reduce the overall energy consumption for the building.
- With the given 6-month consumption reading, the total energy consumption was 18,489kWh, with an average of 3081.5kWh per month.
- If we assume that the solar panels generate 546kWh annually, it would have generated 45.5kWh per month.
- 3081.5kWh – 45.5kWh = 3036kWh (New average monthly energy consumption)
- Total CO^2 emission: 0.4168kgCO^2/kWh × 3036kWh = 1265.4kg/CO^2 (1dp)
- Average CO^2 emission reduction after installation of solar panels:
  - 1265.4kg/CO^2 × 6 = 7592.4kg/CO^2
- Half year CO^2 consumption savings:
  7706.2kg/CO^2 - 113.8 kg/CO^2 = 7592.4kg/CO^2
    - 1.47673% decrease in energy consumption.

2. Our proposal stated the change of the current singular bulbs to fluorescent tube lamps as it helps to decrease energy consumption.

- Incandescent singular bulbs will result in about 175.2kWh worth of power consumption yearly, while fluorescent tube lamps will result in about 58.4kWh worth of power consumption.
- 6-month energy consumption will be as follows:
    - 175.2kWh ÷ 2 = 87.6kWh – incandescent singular bulbs
    - 58.4kWh ÷ 2 = 29.2kWh – fluorescent tube lamps
- 100 incandescent singular bulbs:
    - 87.6kWh × 100 = 8760kWh
- With the use of fluorescent tube lamps, 65 will be enough for the whole building, hence:
    - 29.2kWh × 65 = 1898kWh
- Difference between incandescent singular bulbs and fluorescent tube lamps:
    - 8760kWh – 1898kWh = 6862kWh

- By using fluorescent tube lamps, energy consumption is reduced by:
    - 6862kWh × 0.4168kg CO^2/kWh = 2860.08kg CO^2

For water consumption, our proposed efficiency improvement percentage is a decrease of 2%.

- 1624.2kg/CO^2 × 2% = 32.484kg/CO^2
- Our team proposed for a rainwater harvesting system that links to the toilet for toilet flushing purposes.
- After our second site visit we found out that their current rainwater harvesting only links to the watering of the greens.
- By doing so, it reduces the amount of clean water needed to be used for the flushing of toilets which helps to reduce the amount of water consumption.
- Using the consumption figures provided, we assume that 60% of the total water consumption is used for flushing.
- Total water consumption in 6 months: 566.14 + 591.79 + 757.32 + 549.03 + 692.61 + 709.98 = 3866.87 kg/CO^2
- 60% of 3866.7 = 2320.122 kg/CO^2
- Assuming that 3% can be saved when implementing flushing of toilets to the rainwater harvesting system:
- 2320.122 kg/CO^2 × 3% = 69.60 kg/CO^2 (2dp)

- New water consumption for 6-month period: 3866.87 kg/CO^2 – 69.60 kg/CO^2 = 3797.27 kg/CO^2
    - Decreased in 1.79991%

For waste consumption, our proposed efficiency improvement percentage is a decrease of 3%.

- 25057.2kg/CO^2 × 3% = 751.71kg/CO^2
    1. Our proposal stated that there is a need to implement more rubbish bins around the building as it currently has inadequate amounts.
- Currently with the lack of recycling bins, visitors tend to throw recyclable items into the rubbish bin which causes the recyclable items to no longer be able to be recycled.
- By placing more rubbish bins and recycling bins around the building, it encourages visitors to dispose of their trash properly into the right category.
- This in turn reduces the amount of waste generated in rubbish bins.
- A standard green wheeled refuse in Singapore has a capacity of 120l ≈ 120kg
- Based on our observation, the rubbish bins around the building were not filled to the top, hence we will assume around 80% of the rubbish bin is filled.
- We will also assume that 50% of the 80% of rubbish is recyclable waste.
- 80% of 120kg is 96kg, and 50% of 96kg is 48kg.
- CO^2 consumption generated:
    - 48kg × 0.76kgCO^2/kg = 36.48kg CO^2
- The building has around 5 rubbish bins, hence the total CO^2 emission is:
    - 36.48kg CO^2 × 5 = 182.4kg CO^2
- Based on the consumption data provided to us, the total waste (refuse) consumption generated is 25057.2kg/CO^2.
- Therefore, the improved reduced total waste (refuse) consumption becomes:
    - 25057.2kg/CO^2 - 182.4kg/CO^2 = 24874.8kg/CO^2

    2. Our proposal stated the change of the current singular bulbs to fluorescent tube lamps as it has a longer lifespan
- During our site visit we observed that the majority of the lighting used throughout the building was these singular bulbs.
- If we take the example used in our proposal, we stated that tube lamps would have 10 to 20 times longer lifespan than incandescent singular bulbs.

- With a longer lifespan, fluorescent tube lamps need to be changed less than incandescent singular bulbs.
- On average, an incandescent light bulb can last 1000 hours, which is about 41.7 days, it would need to be replaced around 4 to 5 times every 6 months. However, a fluorescent tube lamp can last around 15000 to 20000 hours. If we take the lowest of 15000 hours, which is about 625 days, it will only need to be replaced close to once a year.
- With the need for lesser replacement, there will be less waste generated from the discarded light bulb.
- The average weight of an incandescent bulb is around 57g, while the average weight of a standard fluorescent tube lamp is around 230g.
- Since incandescent light bulbs are required to be changed about 4 to 5 times every 6 months: 57g × 5 = 285g (amount of waste generated).
- Take for example there are a total of 200 light bulbs around the entire building, the total amount of waste generated from changing the light bulbs for a 6-month period is:
- 285g × 200 = 57000g ≈ 57kg
- Based on the consumption data provided to us, the total waste (refuse) consumption generated is 25057.2kg/CO^2.
- With the reduction of recyclable waste generated from switching incandescent light bulbs to fluorescent tube lamps, the new 6-month recyclable waste consumption is:
- 57kg × 0.04kgCO^2/kg = 2.28kg/CO^2
- New half year CO^2 consumption = 25057.2kg/CO^2 - 2.28kg/CO^2 = 25054.92kg/CO^2

- Therefore: total waste consumption waste is reduced to:
  - 25057.2kg/CO^2 - 182.4kg/CO^2 - 2.28kg/CO^2 = 24872.52kg/CO^2

For recyclables, our proposed efficiency improvement percentage is an increase of 3%.

- 36.4kg/CO^2 × 1% = 0.364kg/CO^2
- The implementation of more recycling bins around the building will allow visitors to throw in items that can be recycled.
- Currently, there is only one recycling bin at the pick-up and drop-off point, which causes items that can be recycled to be thrown into the incorrect bin.
- We observed that the recycling bin was not being used at all, hence it was a waste.
- Based on statistics, 60% of recyclable items in the recycling bin are recycled. But with no usage of the recycling bin now, it is at 0%.

- On average, a recycling bin can hold up to 120kg. However, based on past observations, recycling bins are not filled to the top, hence for this calculation, we will use 50% of the total capacity, which is 60kg.
- 60kg × 0.04CO^2/kg = 2.4kg CO^2
- Assuming we implement 1 recycling bin on each level, which amounts to a total of 4 recycling bins:
- 2.4kg CO^2 × 4 = 9.6kg CO^2

• Hence, the improved CO^2 emission is:
  - 36.4kg/CO^2 - 9.6kg/CO^2 = 26.8kg/CO^2
    - The lower the CO^2 emission, the better improved it is.

Table 1: Summary of CO^2 emission consumption

Consumption Type	**Percentage to be saved**	CO^2 emission **Before**	CO^2 emission **After**	**Percentage saved**
Energy consumption	3%	7706.2kg/CO^2	• Solar Panels: 113.8kg/CO^2 • Fluorescent tube lamps: 2860.08kg CO^2 • New emission: 4732.32 kg/CO^2	38.59%
Water Consumption	2%	3866.87kg/CO^2	• New emission: 3797.27 kg/CO^2	1.79991%
Waste Consumption	3%	25057.2kg/CO^2	• Switch lighting: 182.4kg/CO^2 • Recycling Bins: 2.28kg/CO^2 • New emission: 24872.52kg/CO^2	0.737%
Recyclables	3%	36.4kg/CO^2	• New emission: 26.8kg/CO^2	26.37%
Total	11%	36,666.67kg/CO^2	• Total new emission: 33,428.91kg/CO^2	8.83%

3.4 Solutions to achieve the decided efficiency improvement percentage and carbon reduction target, with estimated calculation evidence and local case studies to achieve the objectives.

a) Using of LED Tube lamps

Integrating LED Tube lamps can reduce the use of energy consumption as they generate less heat and more light hence being energy efficient.

A case study would be Junction 8, where they implemented a change of lighting in common areas to efficient lighting such as T5 fluorescent lights. This change has proven effective in reducing energy consumption. Junction 8 now has an estimated saving of 2,538,862 kWh per year, which translates to 211,571.833 kWh per month.

Figure 37: Junction 8

Another case study is InterContinental Singapore, which has achieved an estimated energy saving of approximately 2,416,187 kWh per year, translating to about 201,348.9 kWh per month. InterContinental Singapore has achieved the Green Mark GoldPLUS Certification for its environmental practices. The hotel utilizes T5 and LED lamps, contributing to this significant energy saving.

Figure 38: InterContinental Singapore

b) Hybrid cooling for aircon and fan

Integrating a hybrid cooling system can help decrease energy consumption and enhance comfort levels. Using ceiling fans is environmentally friendly due to their minimal energy consumption. Additionally, we can harness energy from solar panels to power these fans. With fans, they can also enhance the ventilation and promote natural cooling gentle breeze. Hybrid cooling systems allow us to decrease our dependence on air-conditioning, which consumes significant energy. For instance, during cooler weather, we can switch to using just ceiling fans instead of running air-conditioners.

One notable case study employing hybrid cooling is the Singapore-Berkeley Building Efficiency and Sustainability in the Tropics project. They implemented a hybrid cooling system by setting the air conditioning at a slightly higher temperature and integrating energy-efficient ceiling fans. This approach successfully reduced energy consumption by approximately 30% while maintaining comfortable conditions for occupants. Moreover, it prevented overcooling, ensuring optimal room temperatures.

One example would be Singapore Discovery Centre (SDC). The building also uses hybrid cooling fans in their cafeteria, this helped to reduce reliance on AHUs, leading to improvements.

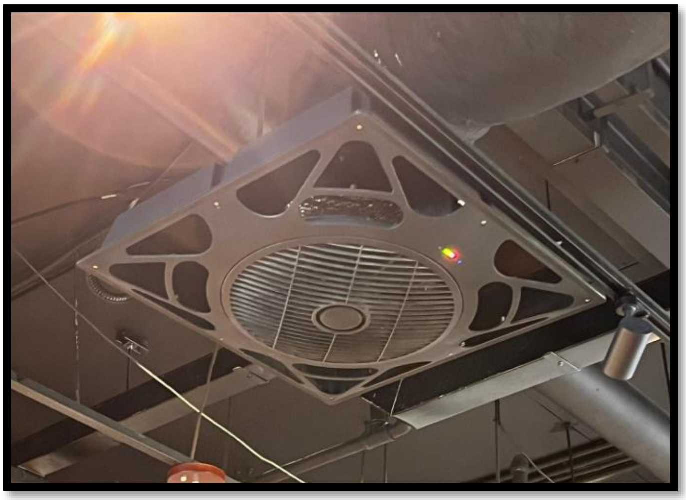

Figure 39: Hybrid Cooling Aircon and Fan at SDC

Another example is the Thomson East Coast Line MRT project, which incorporated hybrid cooling fans along the Tanjong Rhu to Bayshore stretch. This initiative aimed to maintain comfortable temperatures for passengers while also reducing overall energy consumption.

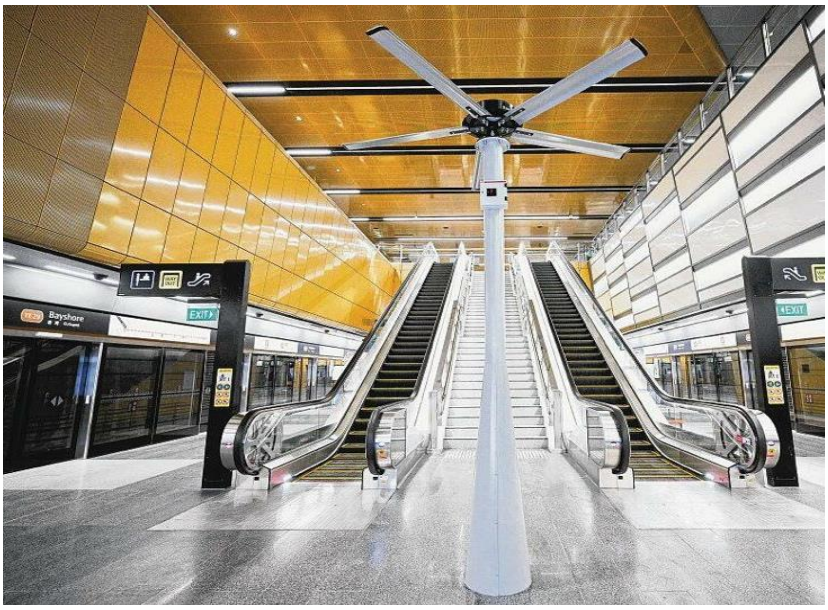

Figure 40: Cooling Fans at Tanjong Rhu to Bayshore stretch

c) Smart Recycling Boxes

800 Super has developed an innovation aimed at encouraging proper waste recycling by directing people to sort their waste into specific category bins to avoid contaminating recyclables.

Tested in the Bishan East-Sin Ming area, this approach has successfully reduced contamination rates by approximately 10%. Additionally, the initiative includes food waste recycling lockers equipped with airtight containers for convenient disposal.

To participate in the recycling program, individuals need to register an account via the Recycling@800Super app. Upon registration, users receive a QR code that they scan before sorting their recyclables into the appropriate categories. As an incentive, users earn points for each recycling action, which can be redeemed at participating supermarkets. This initiative aims to promote sustainable practices and community engagement in waste management.

Figure 41: Smart Recycling Box

d) Solar Panelled Shelter

Due to the extreme heat at the basketball court during afternoons and the exhaust from the restaurants facing directly towards it, it can make the basketball court extremely hot and unusable. We can make use of the hot sun and install a shelter with solar panels installed. These panels will convert the sun's energy into power, which can be used to power for appliances such as the air-conditioning and fan which can significantly reduce HVCC's electricity consumption in the long run. Additionally, this will make the basketball court more enjoyable, attracting more people to use it and making the area more lively.

One case study example would be Singapore Discovery Centre (SDC), it has a total of 2,874 solar panels all around SDC such as the Rooftops and Sheltered walkway. SDC solar panels have accounted for over 60% of their electrical consumption and have harvest about 72,000 kilowatt-hours (kWh) of electricity every month.

Figure 42: Singapore Discovery Centre Sheltered Walkway Solar Panel

Another project that includes the use of solar panels would be the Homes@Hong San. They use photovoltaic system and LED system as well as energy efficient air conditioning system. They have a estimated energy savings of 232,187kWh/yr, which means 19,348.9kWh/month.

Figure 43: Solar Panels at Homes@Hongsan

e) Greenwall

As mentioned above, Greenwall provide both aesthetic and energy efficiency improvements. It works by reducing the buildings heat absorption and alleviating the urban heat island effect. One case study would be the Park Royal Collection Marina Bay as shown above as well.
It includes a 13 metre high Greenwall at the entrance and aim for it to act as natural air purifiers.

Figure 44: ParkRoyal Hotel Green Wall

f) Low E Window

ParkRoyal Hotel also uses Double Glazed Glass Skylight which can help to reduce the ambient temperature by about 2 degree which is about 2% reduction to the energy consumption.
Upon research, Low e window is more towards reducing the heat flow through the glass which can effectively reduce the heat coming in from the outside to the inside. Thus, with ParkRoyal Hotel double glazed window being able to do a good job and reduce 2%, using a better option more suited to us will be able to help us reduce more energy consumption.

Figure 45: ParkRoyal Hotel Double Glazed Skylight

g) Rainwater harvesting

Rainwater harvesting is efficient in reducing water waste as recycled water can be used in many other forms such as toilet cleaning and irrigation as mentioned above.

One case study would be Pasir Ris Sports and Recreation Centre. They have included rainwater harvesting, vertical green wall, photovoltaic panels and use of efficient T5 and LED Lightings. Focusing on rainwater harvesting, they have a estimated water savings of about 27,948m3/year. Which is about 2329m3/month. They used the collection of rainwater for landscape irrigation and water efficient automatic drip irrigation systems.

Another notable example is JEM mall, which achieved the BCA Green Mark Platinum Award in 2012. JEM harnesses rainwater for both irrigation and flushing systems, effectively reducing water consumption and promoting responsible resource management. Additionally, the mall employs highly efficient water fittings and irrigation systems to further minimize wastewater output. These initiatives resulted in water savings estimated at 265,160 m3/year, underscoring

JEM's commitment to environmental stewardship and demonstrate how sustainable practices can be seamlessly integrated into large-scale commercial operations.

Figure 46: Rainwater Harvesting System at JEM Shopping Mall

Another notable example is Jewel Changi Airport, renowned for its sustainability initiatives. The iconic complex incorporates a rainwater harvesting system that serves dual purposes: irrigation and toilet flushing. By collecting up to 50% of stormwater runoff, Jewel Changi Airport achieves significant water savings, estimated at 58,300 cubic meters per year.

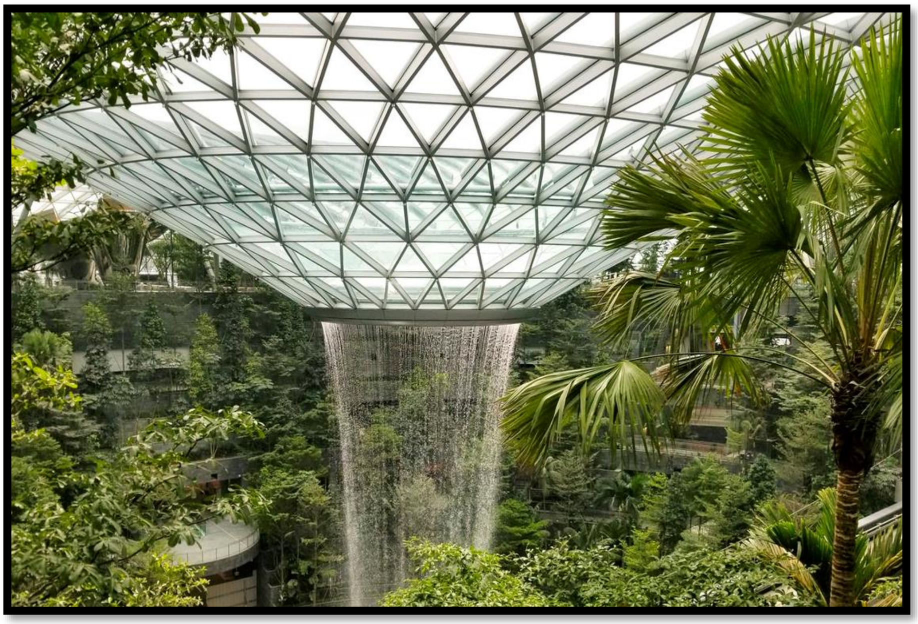

Figure 47: Jewel Changi Airport

3.5 Community engagement strategies to encourage behavioural changes to keep electricity and water consumption low and waste management to a minimum

One strategy would be to have a reuse of unwanted items centre for people that either want to donate unused items or need to borrow items. This example is seen from Resource Centre@Residents Committee. They set this resource centre up as a way to encourage donations, freecycling and swapping of used items to reduce wastage of items that are still in workable conditions. They also have a repair centre dedicated to refurbishing old items and donating them to the needy. This initiative helps ensure that items that appear unusable can actually be repaired and made functional again. One location of RC can be seen at Jurong Central Zone C, Figure 48 shows a list of items that can be borrowed. Figure 49 shows a picture of a posted by Jurong Central Zone C to encourage residents to borrow items.

Figure 48: List of items that can be borrowed

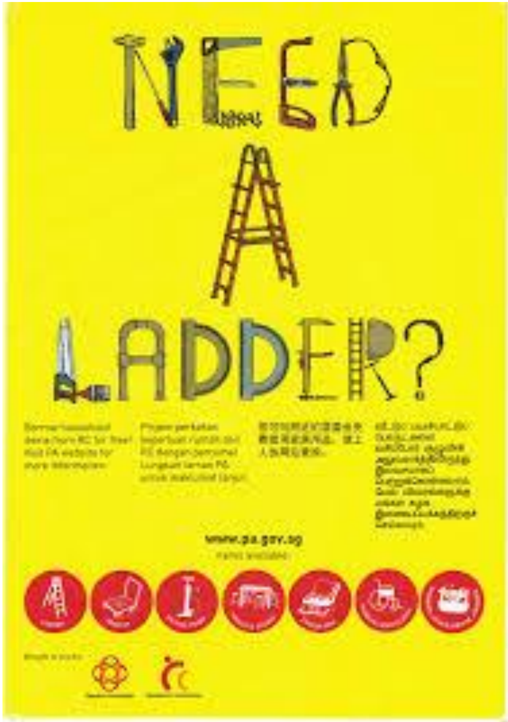

Figure 49: Photo posted on Jurong Central Zone C RN Facebook Page

Another strategy is doing a Love Your Food@School Project, this strategy can be seen by National Environment Agency. They encourage youth to learn from young that food is very precious, and they should cherish it and reduce food waste. As well as for them to understand the value of food and how much effort it takes to grow it.

There are activities held to teach students and teachers about how leftover food can be turned into something useful like compost. This initiative not only educates but also fosters community bonding.

Figure 50: Love Your Food@School Project held in schools

Another strategy is Community in Bloom, done by National parks. They support grassroot organization in setting up community gardens by engaging gardening enthusiasts to come together and work together to create their own community garden. This can foster community spirit and at the same time brings residents together through their common interest.

One example is Agape Little Uni. @ Clementi, which has been developing an outdoor garden since 2018. The centre has collaborated closely with residents to care for the garden and exchange plants, creating more varieties for the children to learn about. Thanks to the efforts of the teachers, children, and an Agape alumni resident, the outdoor garden received the Gold award for the Community In Bloom 2022 from the National Parks Board.

Figure 51: Community Garden, Agape Little Uni. @ Clementi

The term 'Sustainable week' will also be implemented where these strategies will be held. It provides environmental benefits such as awareness about the environmental issues and how everyone can do a part to make it more sustainable. It can also build resilience in the community towards changes to environmental and economic challenges.

The Sustainable Week will be held on a schedule basis around one time every few months, preferably before and after big events like Chinese New Year and Christmas. Doing it on a schedule basis gives residents a heads up and know about it beforehand. Posters will be placed around the community club and the Hillview area to remind residents of the event in case they need a reminder. A target will also be set for Sustainable Week, such as the amount of recyclable waste to be collected or the number of plants to be planted. This provides a clear vision of the goals to be achieved during the week.

In summary, if Hillview Community Club implements these strategies, it would encourage sustainable behaviours, lower electricity and water consumption, and minimize waste.

Optional/ Appendix

1.4 Mobility

Improving mobility at Hillview Community Centre involves enhancing accessibility and connectivity across levels. On Level 1, a proposed solution of constructing a link bridge between Hillview 2 and Hillview Community centre would be further engage the community and promote sustainable transportation options.

a) Level 1

During the site visit, it was evident that Level 1 maintains a tranquil atmosphere, offering a serene retreat away from the bustling crowds. However, its secluded nature may have resulted in it being overlooked by the daily flow of visitors and passersby. The quietness of Level 1 can be attributed to its limited accessibility and connectivity to nearby areas, which may have inadvertently hindered opportunities for social interaction. However, there is potential for improvement to enhance the vibrancy of the entire area.

One proposed solution is to construct a link bridge, seamlessly connecting it to HV2, which grants visitors easier access from HV2, instead of walking under the sun at the roadside which is not easily accessible. This would foster a seamless flow of foot traffic between these 2 places. With this link bridge implemented, it would be more appealing for visitors from HV2 to head over with proper shelter and footpath. An example would be the link bridge connecting Frontier Community Centre and Jurong Point Shopping Mall, which was opened in 2022.

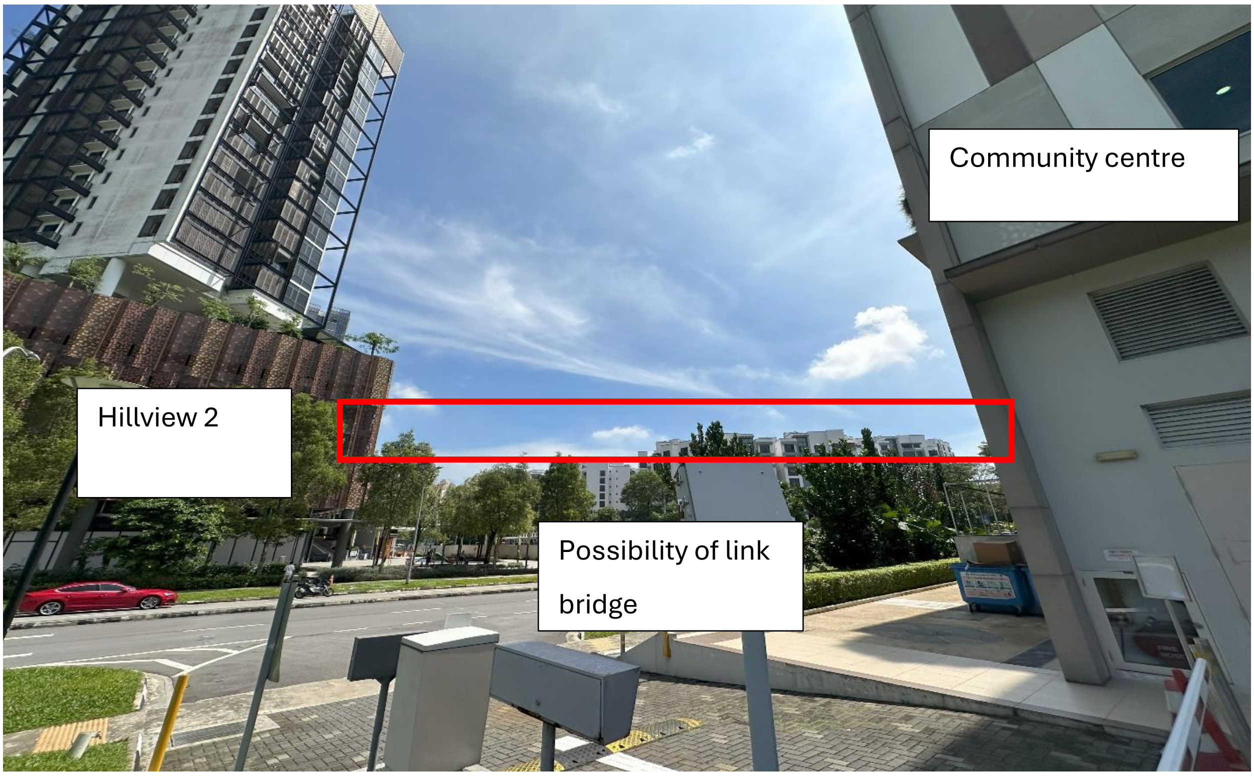

Figure: Outdoor view of Hillview Community Centre and Hillview2

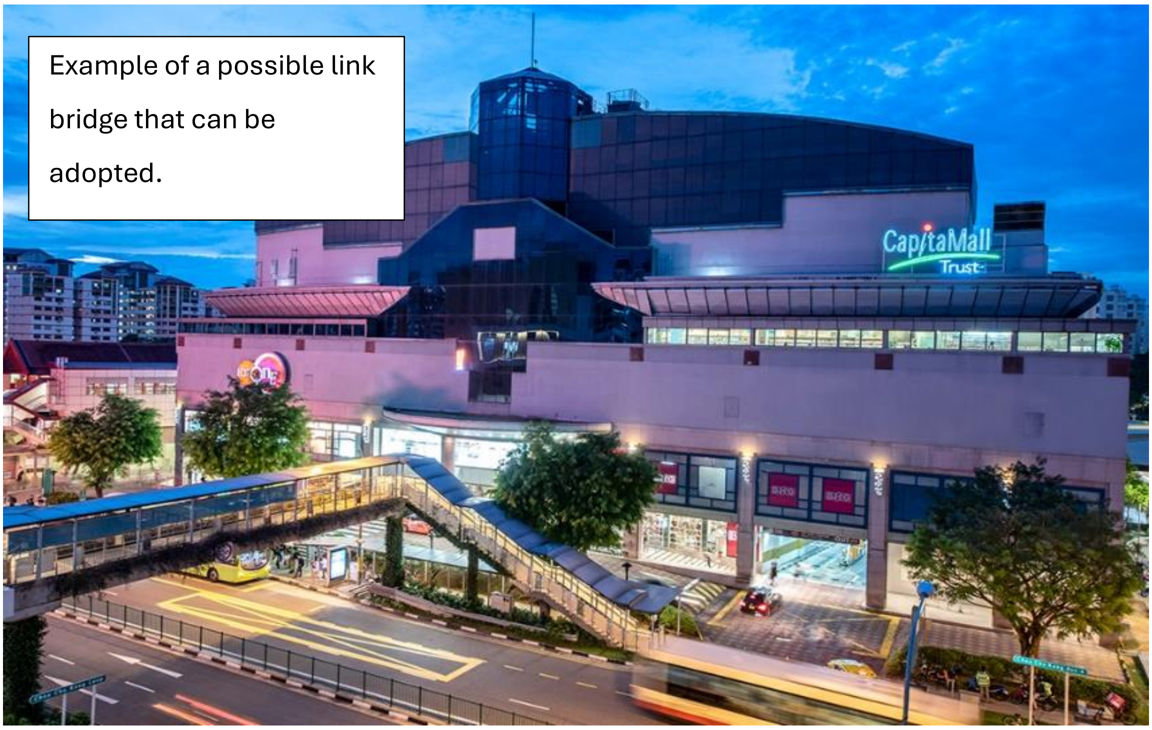

Figure: Link bridge at Lot One Mall (Lot One Shoppers Mall, Singapore)

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