POTENTIAL OF SMALL GARDEN OF DOUBLE STOREY LINKED-HOUSES: THERMAL PERFORMANCE AND HEALTHY ENVIRONMENT

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ABSTRACT

Linked-houses is a housing type that comes with its front yard and backyard. It provides the extra outdoor spaces for the occupants. Many would utilize these spaces following their house extension and renovation projects. Some may not be aware of its potential as green spaces that they may neglect the front yard and backyard by not making full use of them. This paper seeks to study the effect of front yard and backyard on the thermal performance of the outdoor and indoor spaces of linked-houses by comparing the air temperature readings of two units of double-storey linked-houses located in the urban area of Kuala Lumpur. Unit 1 represents a house with its front yard and back yard heavily planted. Unit 2 represents the typical renovation that takes place where its front yard is paved while its back yard is minimally extended and with simple kitchen garden. The study indicates that heavily planted front yard and backyard gives positive effects on the outdoor and indoor thermal performance of the unit, as well as healthy environment, both physically and socially.

Keywords: linked-houses, small garden, thermal performance, micro-climate

INTRODUCTION

Lazenby (1988) stated several factors that reflect housing quality including the level of satisfaction with the house, physical and social environment, and the specific housing attributes. Thus, a comfortable environment for a resident can be determined prominently by the house quality itself.

Linked-houses are among the residential types available and commonly found in the urban area. Linked-houses ‘emerged' among others to suit the needs of the society economically as the price of land especially in the urban area keeps on escalating and is being considered as the densest form of landed property development. The typical size of a unit varies for instance 20 feet by 65 feet, and 22 feet by 70 feet. Nowadays, a new double-storey linked-houses with the dimension of 24 feet by 80 feet which can be suggested having an optimum size, can hardly be found especially within Kuala Lumpur nowadays. Among the impact that can be observed is the ‘shrinking' of the dimension of the unit itself. Owners would do renovations to their houses to extend the interior spaces resulting in smaller exterior spaces. They may not realize the potential of the outdoor space as a functional garden that could positively affect their physical and social living environment, as well as the economics aspect. More built-up areas following house extension works would lead to imbalance environment particularly in the urban context as the urban area is already having limited green spaces.

Plants are considered as efficient solar collectors as they trap the energy from the sunlight for the photosynthesis process where basic salts from the soil and carbon dioxide are consumed, and oxygen is produced as the by-product. High vegetation coverage with more mature trees, turf and less hard surfaces covering the ground helps to produce cooler ambient air temperature.

According to Dimoudi and Nikolopoulou (2003), trees have the effect on the microclimate in such a way that they help to reduce solar heat gains on windows, walls, and roofs through shading; reducing the conductive and convective heat gain by lowering dry-bulb temperatures through evapotranspiration; and increasing the latent cooling by adding moisture to the air through evapotranspiration. Evapotranspiration is the combination of two processes of plants which are 'evaporation' and 'transpiration'. It is said that the process of evapotranspiration gives the cooling effect as water evaporates. Many years back, the urban heat island (UHI) effect in Kuala Lumpur was reported to be reduced, and the possible cause among others could be due to the tree planting programme by the City Hall of Kuala Lumpur (Sham, 1990/1991). The work of Dimoudi and Nikolopoulou (2003) also suggested that the ambient air temperature decreases as the size of green area increases.

DESIGN AND ORIENTATION OF LINKED-HOUSES

Looking at the current scenario with the global warming issues that is significantly affecting those in the hot regions, the design of linked-double-storey houses seems very critical to be thoroughly considered as people spend more time indoors rather than outdoor. Due to constraints such as the land size and shape, and the availability of the existing infrastructure, sometimes the design of the house cannot accommodate good orientation to be a design priority. Among the worst scenario that could happen is the house is oriented with its exterior walls and openings directly facing the sunrise and sunset to the maximum throughout the day, where its walls would be absorbing the heat and re-radiating it back to the interior of the house.

It is also to be noted that the urban area of Kuala Lumpur is experiencing the UHI where the urban temperature is often warmer than the surrounding environment. The cause of UHI varies from the sun's heat stored in the urban built form which is then released back into the ambient air, to the green-house effect where gasses such as carbon dioxide and nitrogen oxides are released and build up layers of air above the city. The location of Malaysia in general and Kuala Lumpur, being located very much near to the equatorial line results in almost 12 hours of daylight throughout the year with the sun position very high in the sky. The heat received is very intense especially between 11 am up until 3 pm.

Thus, the house which is not strategically oriented would absorb heat the most through its walls, and the sun radiation could also penetrate to the inner side through its openings. This will significantly increase the internal temperature not only during the day time but also at the night time as the heat accumulated in the walls would be radiated continuously until the temperature of the walls and inner air temperature achieve balance.

To counter this problem, some occupants would opt for mechanical solutions by installing air-conditioning units in their houses. This also means increased expenditure for both short terms and long terms for having to buy the air-conditioning unit plus the operation and maintenance costs. This mechanical solution may be successful in modifying the internal environment. However, it should be noted that among the reasons for the increased indoor air temperature is due to the hot outdoor environment itself. The air-conditioner installed would release heat to the outdoor environment. This would also add up to the already accumulated heat from all other external sources. Hence, leading to a chain and perhaps cycle reaction. The hotter outdoor environment, the hotter the indoor environment will be. Therefore more energy would be required to run these air-conditioners. To understand this, the following figure 1 attempts to provide an insight of this chain or cycle reaction by understanding the basic physics behind it.

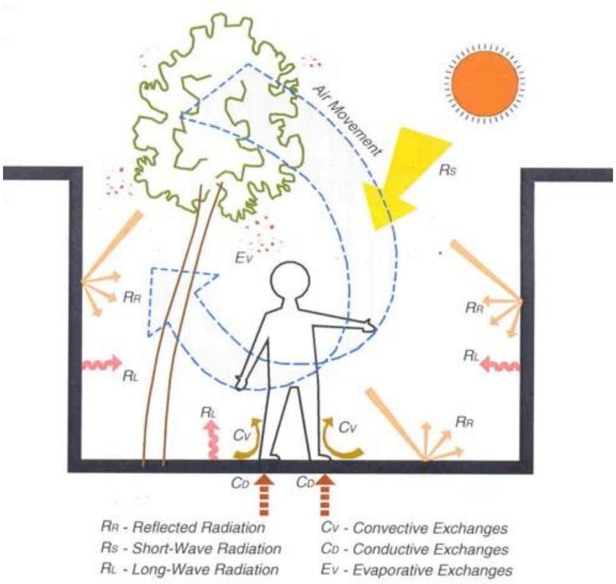


Fig.1: Energy exchanges between a person and his environment (reproduced by Muhaisen, 2005)

This diagram was constructed by Cadima (see Muhaisen, 2005) in explaining the interaction of energy exchanges of a person and his immediate environment. Solar radiations (short waves) are partially absorbed by the wall and floor surfaces, partially reflected back (RR) and partially absorbed by the evaporation process (EV). The absorbed radiation shall heat the surfaces and create a temperature difference between the surfaces (high temperature) and the air layer (low temperature) adjacent to it. Thus, the heat accumulated on the surfaces shall be released to the surrounding through the processes of convection (CV), which is emissivity of long wave radiation (RL), and conduction (CD). The long wave radiations are then absorbed again by elements within the space until an equilibrium state is achieved. Thus, when another source of heat is added up which in this case is the air-conditioning unit, the air temperature will increase.

Due to its small size, some people may perceive that their lawn within double-storey linked-houses cannot be transformed into a functional garden. Some people would find a quick solution in maintaining their house compound by converting the small lawn into a paved and roofed porch. Although it creates the shaded environment that might perhaps help to cool the interior of the house, it also reduces the potential of daylighting.

Thus, this article is intended to emphasize on the manipulation of the exterior space to cater for the thermal comfort of the internal space via passive solution which is through the creation of the functional garden of double-storey linked-houses in Kuala Lumpur.

THE CASE STUDY UNITS AND INVESTIGATION METHODS

For the purpose of this study, "functional garden" here is defined as a garden that serves its purpose for outdoor leisure while creating a conducive environment thermally. This is because "*one of the main reasons for considering microclimate in landscape design is to create thermally comfortable habitats for people*" (Brown and Gillespie, 1995:63). In order to compare and contrast the effect of dense vegetation on the outdoor and indoor temperature of a double-storey linked houses, two methodologies are applied in this investigation which are observation on the aspect of the physical site, and measurement of the air temperature of the outdoor and indoor spaces of the two case study units using data logger to provide empirical evidence.

Two units of a typical double-storey linked-houses located in Kuala Lumpur are compared – Unit 1 is heavily planted at its front and backyard; while Unit 2 has paved its front yard and with a kitchen-garden at its backyard. Focus is given to the air temperature readings of both the interior and exterior spaces of these case study units. These units are built on 22 feet by 75 feet land dimension each with shared gated-back-lane, and with North-East and South-West orientation. The following figure 2 shows part of the housing area described, with the two studied units (indicated in red).

Fig. 2: Partial layout of linked-houses, and the two studied units (GoogleEarth)

Referring to figure 2, it seems that the sun does not hit the walls of the two studied units perpendicularly. Theoretically, the heat absorbed through the walls may not be as high as those units which are oriented perpendicular to the sun path.

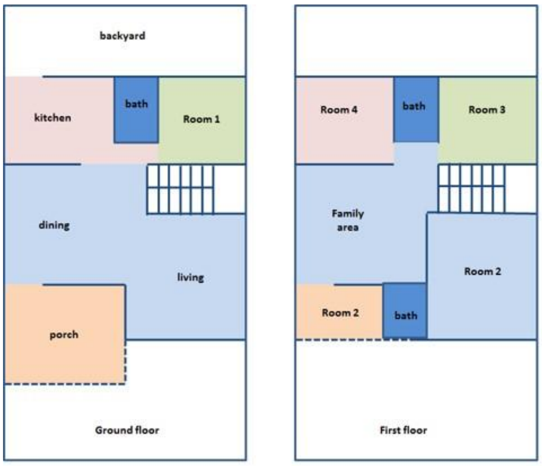


Fig. 3: The original layout of the house

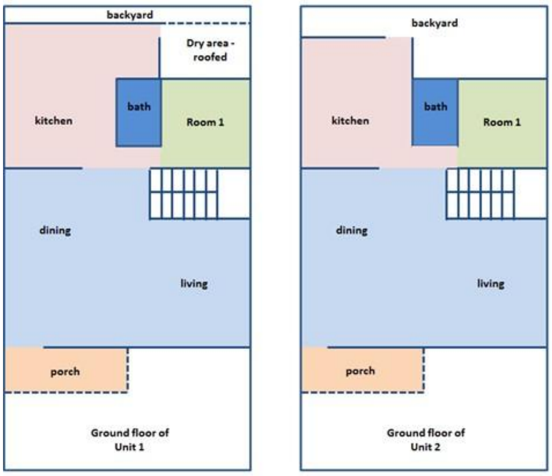
The original layout and façade of these units are shown in figure 3 and figure 4 respectively. However, these two units have been extended. To investigate and compare the thermal performance, for each studied unit, three data loggers that measure air temperature (°C) are used and placed on the porch, living, and family area. Readings are taken continuously with the interval of 15 minutes for seven days (Monday to Sunday) in the month of April, where it is the inter-monsoon period leading towards the dry season that starts by late May or early June. During this period, high air temperature is observed. The interior spaces where the data loggers are placed do not have any air-conditioner. These readings are important to quantify the difference of the air temperature between these two units as to see the effect of the garden on the thermal performance of the house.

The measurement at the porch represents the air temperature of the outdoor area, while those in the living and the family area represent the air temperature of the shared areas or public areas of the unit. Moreover, these two spaces can be regarded as the spaces where the family members may spend their time the most.

Fig. 4: Typical original front façade of the unit, its front lawn, and backyard

DESCRIPTION OF THE TWO EXTENDED UNITS STUDIED

Both studied units have extended their kitchen area by taking up some of the backyard space. Unit 1 has extended the kitchen area and has retained about 1-meter space from the fence for greeneries; while Unit 2 has minimally extended its kitchen area as shown in figure 5. The first floors of these two studied units remain unchanged.



It is quite common for a house to be renovated and extended due to various reasons. Sometimes, the extension is being done in such a way that the backyard is fully built, while the frontage is paved and roofed. Thus, the potential garden space is either being shrunk or ‘eliminated'.

Fig. 5: The ground floor layout of the extended Unit 1 and Unit 2.

UNIT 1

On the size of the lawn, some may perceive that it is inadequate to create a functional garden. The following images show Unit 1 (fig. 10) – an extended unit that has been planted heavily – both front and back. Here, the ‘green' exploitation of spaces is demonstrated while extending the built-up area of the unit.

The planted garden covers and softens the façade of the unit. A pergola is built at Unit 1 to support creepers that give the ‘sheltered' or ‘roofed' effect while providing the structure to hang potted plants (figure 7).

Fig. 6: Landscape of Unit 1 – front elevation

Fig. 7: Varieties of plants available within the front yard

The space created seems to be more spacious to support outdoor family activities such as gardening, relaxing and gathering. By conducting these activities outdoor, it also enables the occupants to socialize with the neighbour. The 'bushy' environment created by the planting provides the cool garden environment. The pergola with the creepers created shady areas. Referring to figure 8, it can be roughly estimated that only about 20% of the sunlight could penetrate to the ground.

Fig. 8: Creepers covering the top of pergola – minimizes sunlight penetrations to the ground.

The following images in figure 9 show dense planting that borders the road from the tertiary road network, the parking area, and the neighboring unit. Since tarmac particularly and the concrete pavement have the ability to absorb a lot of heat from the sunlight, and it reradiates the heat back tremendously, it is hoped that by having this heavy planting, the reradiated heat can be screened from affecting the unit thermally. The enclosures created 'green and cool environment' and privacy too following the screening effect.

Fig. 9: Screening-effect provides not only privacy but also screens the reradiated heat from the tarmac of the road and concrete pavement

As can be seen from figure 10, the garden helps to shade almost half of the pavement of the parking area during noon time. This shortens the concrete pavement exposure to the sunlight, hence reduces the chances of heat absorption and heat from being reradiated to the surrounding.

Fig. 10: The garden shades the concrete pavement of the parking area

Matured creepers 'climb' and partially covered the façade and roof of the porch, help to minimize heat absorption on the wall and roof tiles (figure 11).

Fig. 11: Roof tiles are partially covered by the creepers

Fig. 12: Detached pergola from the house

The following images in figure 13 show the greeneries planted at the rear of Unit 1. The broad leaves help to shun the afternoon sun partially from the kitchen wall. The roofed-dried area next to the kitchen is well lit-up as some of the roof tiles are replaced with transparent roof material. As such, the ground floor bedroom benefits from the natural lighting during the daytime. Concrete pavement and white pebbles covered its floor.

Fig. 13: The rear garden

The front yard and backyard of Unit 1 have provided a large opportunity for the occupants to have alternative spaces for the family. The dense vegetation gives the feeling of coolness and privacy while providing healthy outdoor activities for the family. Hence, they often spend time outdoors for gardening, and the children would be playing outside too.

UNIT 2

Fig. 14: The front yard of Unit 2 (left) and the kitchen garden (right)

As for Unit 2 (figure 14), the front yard is paved with concrete towards the edge of the neighboring unit. A planter box with some plants is located here. The kitchen is minimally extended, and the backyard has a kitchen garden comprises of shrub-type plants, and it can be observed that the afternoon sun hits the extended kitchen wall.

Thus, these two units that are being compared have a similar orientation, a similar layout and dimension, but differ regarding their outdoor ground surface materials and density of vegetation, different backyard layout and dimension, and different types of backyard landscape.

THE IMPACT OF GARDEN AND DENSE PLANTING ON THE AIR TEMPERATURE OF THE LINKED-HOUSES

The air temperature for the seven days is averaged and compared to Unit 1 and Unit 2 as shown in figure 15. As for the front yards, between 9 am and 9 pm, Unit 1 is cooler than Unit 2 with a maximum difference in temperature of 2°C at about 2 pm. The reading from 9 pm onwards until early morning seems to be almost similar to the two units.

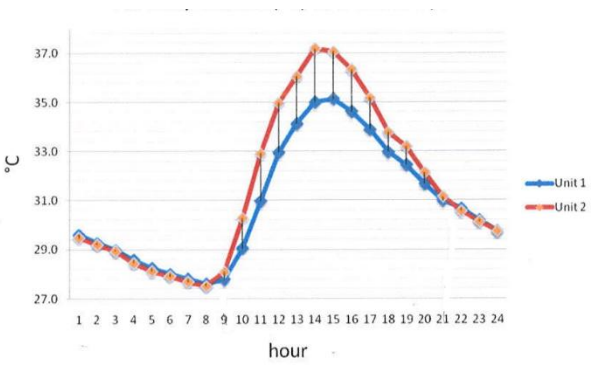


Fig. 15: Air temperature of the front yard

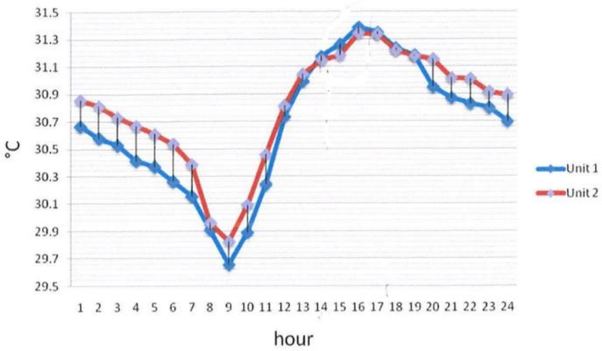


Fig. 16: Air temperature of the living area

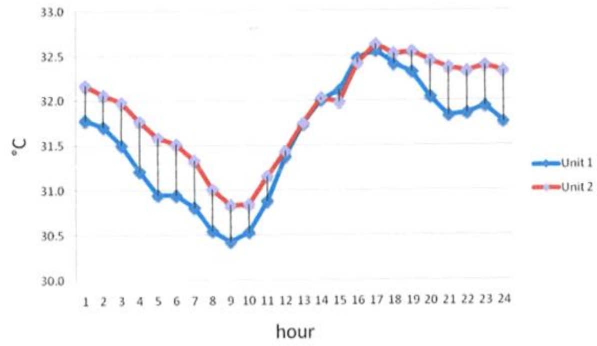


Fig. 17: Air temperature of the family area

For the living areas, figure 16 shows Unit 1 is also cooler than Unit 2 except from 2 pm until 5 pm where Unit 1 is demonstrating a slightly higher reading than Unit 2 with the maximum difference of 0.1°C at 3 pm.

For the family areas (figure 17), again Unit 1 is cooler than Unit 2 except from 1 pm until 4.30 pm with the maximum difference of 0.1°C at 3 pm. The reason could be because the windows of Unit 1 are left open during the day while Unit 2 are not, which allows the heat from outside to get in. It is also worth to be noted that for the living and family areas, Unit 1 shows quite a significant drop in the air temperature reading compared to Unit 2 at 7 pm.

The maximum-minimum air temperature readings of these spatial areas are compared. The results show that the outdoor spaces have a broad range of air temperature readings with Unit 1 of 7.6°C while Unit 2 of 9.6°C, compared to the indoor spaces – refer Table 1. This is due to the dynamic outdoor environment as it is exposed to the sun and other environmental factors such as radiating heat from the surrounding elements. It is also observed that Unit 1 has about 2°C lower in range than Unit 2. During the night time, for the indoor spaces, Unit 1 also demonstrates cooler air temperature than Unit 2.

Table 1: The maximum-minimum air temperature of the three spatial areas

		Unit 1		Unit 2	
		time	°C	time	°C
Front yard	Max	3pm	35.2	3pm	37.2
	Min	8am	27.6	8am	27.6
Living area	Max	4pm	31.38	4pm	31.34
	Min	9am	29.66	9am	29.82
Family area	Max	5pm	32.55	5pm	32.6
	Min	9am	30.4	9am	30.8

The simple observation carried out within one week time gives some initial idea of the effect of the small garden on the air temperature as well as the thermal performance of the house. For the indoor spaces, it can be observed that the air temperature of Unit 1 is lower than Unit 2 most of the time. The living area and family area of Unit 1 recorded lower air temperature reading by 87.5% (21 out of 24 hours) and 85.3% (20.5 out of 24 hours) respectively. As both units are similarly oriented, it can be suggested that the outdoor ambient temperature may be affecting the ambient temperature of the indoor spaces. In the hot-humid regions, people would feel thermally uncomfortable as the ambient air temperature increases.

It can also be concluded that having dense vegetation within the limited space of a linked-house may help to reduce the ambient temperature of both its indoor and outdoor spaces and eventually create a more thermally comfortable environment. This could lead to reduced energy consumption as less energy may be needed for the air-conditioner or fan. Based on the response from the occupants of Unit 1, they do not rely on the air-conditioner day and night. Furthermore, they only have one unit of the air-conditioner, while there are several units of the air-conditioner at Unit 2 and they use them quite frequently. It was also highlighted by the occupant of Unit 1 that the electricity bill has never gone beyond RM100 per month.

CONCLUSION

Based on the results of this observation, vegetation seems to play very crucial roles in creating a healthy environment - physically, socially, and also economically. Some may not realize the potential of the small outdoor spaces of a linked-houses or may perceive that small garden does not bring any significant change towards our lives that this space is ignored or abandoned. However, this observation has proved differently. The importance of transforming small spaces into a functional garden without waiting for action to be taken by others at the macro level must be instilled among the people in the society. When small spaces are transformed into a functional garden, the combined effect would be even significant for a larger area.

As such, it can be seen that having more trees or dense vegetation could help to reduce the ambient air temperature of the environment as they obstruct, absorb, and reflect a high percentage of solar radiation, and also prevent hard surfaces from being heated up and emitting long wave radiation. Hence, dense planting at the outdoor spaces within the compound of linked-houses could bring positive impact to the occupants and the environment as a whole.

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