5 SOCIO-ENVIRONMENTAL DIMENSIONS IN TROPICAL SEMI-OPEN SPACES OF HIGH-RISE HOUSING IN SINGAPORE

Joo-Hwa Bay, Na Wang, Qian Liang and Ping Kong

Department of Architecture, National University of Singapore

Abstract

What are the relationships of community, tropical environment and semi-open spaces in the high-rise high-density housing? The social and environmental aspects of the veranda spaces of the traditional kampong (village) houses in the tropical regions are integrated and sustainable. Is it possible to have community living in semi-open spaces such as entrance forecourts and corridor spaces in high-rise apartments? What are the environmental conditions that permit this? What are the relationships of socio-climatic aspects with plants in sky-gardens and sizes of semi-open spaces? All these are discussed in the case of Bedok Court condominium, with comparison with a typical public housing block in Singapore.

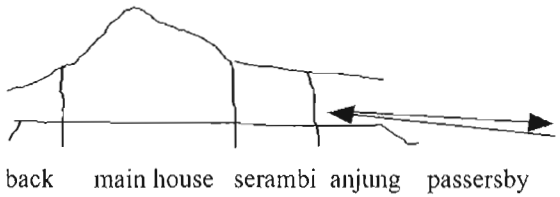
Keywords

Sustainability, environment, design guidelines, high-rise high-density, housing, community, semi-open space, socio-climatic, tropical.

5.1 INTRODUCTION

Traditionally, the *angung* and *serambi* (both veranda spaces) of the kampong (village) houses in the region (Chen, 1998; Lim, 1981) are environmentally conducive for various social activities, including children's play, dining and receiving guests (Figure 5.1). Besides providing shade for the interior, reducing the direct heat from the sun, the veranda spaces are highly visible from the kampong streets, encouraging high levels of familiarity and neighbourliness

5.1.
Indigenous traditional house in Malaysia with the anjung porch and the serambi behind it. (*Source:* J.H. Bay)



5.2.
Highly visible semi-open veranda of traditional Kampong house in the region. (*Source:* J.H. Bay)

(Figure 5.2). A similar socio-climatic phenomenon is also observed in Bedok Court condominium that has a forecourt (veranda) to each apartment in the high-rise high-density context, where almost a hundred percent of the residents expressed that they have a strong sense of community and security (Figure 5.3).

What is the implication of this socio-environmental phenomenon of the veranda in relation to the issue of sustainability of community and environment in the high-rise high-density context of Singapore?

5.1.1 Quantity and quality of high-rise living in Singapore

Singapore's public high-rise housing (Figure 5.4) developed rapidly since independence in 1965 to accommodate an astonishing 84% of the population today (HDB, 2004). The remaining 11% live in private high-rise condominiums (URA, 2004). Only 5%, mainly from the more affluent strata of Singapore society, live in so-called "landed properties" such as a detached, a semi-detached or a terrace house, and enjoy the use of a private garden.

Some of the pressing questions are: how can community life be encouraged; how can natural ventilation be improved and the

5.3.
View of typical semi-open forecourt from common corridor, Block 1, Bedok Court. (*Source:* J.H. Bay)

5.4.
Typical public housing partment blocks in Singapore. (*Source:* J.H. Bay)

reliance on air-conditioning be reduced; how can the heat island effect be reduced; how can energy consumption, CO_2 emissions be cut and other air pollution be reduced; how can vegetation be increased and how can some of the benefits of "landed living" be made available to apartment dwellers?

Few architectural critics have attempted to analyze the environmental and social characteristics of life in the island's high-rise apartments together. Most books and journal articles[1] focus exclusively on the garden houses of the wealthy. While many would prefer to stay on the ground, land scarcity, as in many cities, results in many efficient typologies of high-rise housing that maximize and manage quantity of people in highly built-up environments.

The issue now is how to provide sustainable social and environmental qualities.

5.1.2 Social and environmental aspects studied separately

Bay (2005) noted that the social aspect has often been studied independently from the environmental aspect. The tropical veranda has been studied as a device for providing shade, reducing cooling load and improving thermal comfort (for example, Yeang, 1996; Hyde, 2000), while others have discussed the feasibility of developing architectural language based on a "bioclimatic" and related environmental design approach (for example, Olgyay and Olgyay, 1963; Yeang, 1996; Hagan, 2001). Lim (1981) compared the traditional Malay house and the modern housing-estate house, observing the differences of lifestyle and the lack of casual semi-open spaces, but did not discuss how aspects of the kampong might be adapted for high-rise high-density living. Gehl (1996) discussed "life between buildings" as street life on the ground, but stopped short of considering the possibility of creating "street life" at upper levels in high-rise apartment developments. There has been little discussion, on the relationship between environmental design and the development of community in high-rise housing in the Tropics.

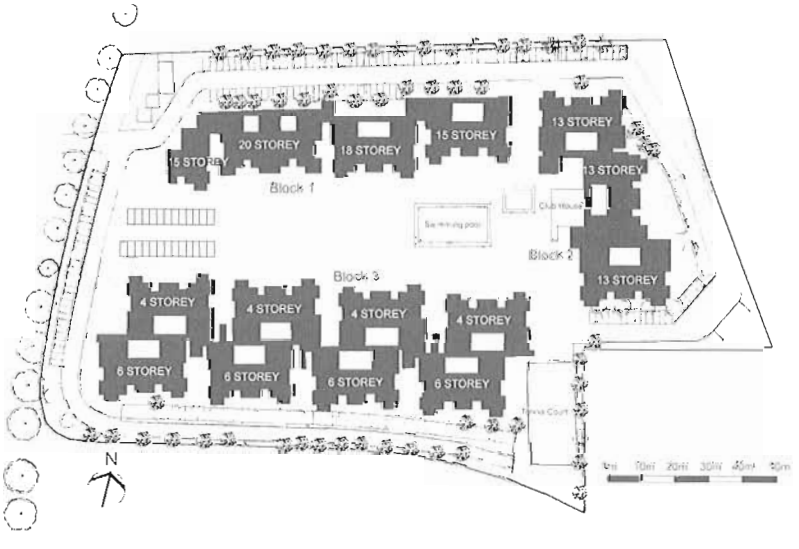
This chapter first summarizes the overall socio-climatic relationships and success found in the forecourts of Bedok Court condominium, discussed in a previous paper (Bay, 2005). Then it advances the discussion with newer detailed findings (including part of a comparative study of this case with a public housing block), concerning:

(a) the impact of shading and ventilation in achieving thermal comfort in the semi-open forecourt (the effect on the interior of the apartment is not discussed here);
(b) the relationship of gardening, social and environmental benefits;
(c) the optimal size of a typical forecourt for a successful facilitation of the social and environmental benefits.

5.2 COMMUNITY AND A PIECE OF GREEN IN THE SKY

Bedok Court was designed by Cheng Jian Fenn of Design Link Architects, Singapore, in 1982 and completed in 1985. It comprises 280 apartments, distributed in three blocks, which vary from 4- to 20-storey heights (Figures 5.5 and 5.6). The area of the site

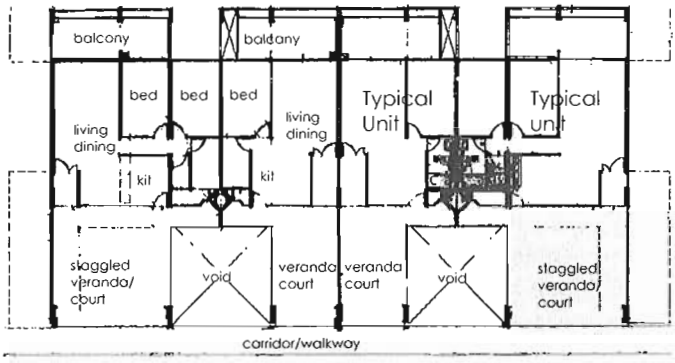
5.5.
Bedok Court Condominium with large balconies looking and not visible from common corridors. (*Source:* J.H. Bay)



5.6.
Site Plan, Bedok Court. (*Source:* J.H. Bay)

is about 3.4 ha and the total area of the development, including corridors, forecourts and balconies, is about 65 500 m^2 gross. The resultant density is 300 persons per hectare (or 82 dwellings per hectare) and the floor area ratio is 1.9. The development includes surface car parking lots, landscaped-gardens, tennis courts and a large swimming pool.

What distinguishes Bedok Court is the generous provision of semi-open forecourts and balconies. Typical apartments range in gross area from about 110–220 m^2, including balconies and forecourts and excluding common circulation spaces. The larger three bedroom apartments have an internal area of about 110 m^2 each, while the two- and one-bedroom apartments have about 85 and 55 m^2 each, respectively, typical of housing development at that



5.7.
Typical Plan, Block 1, Bedok Court. (*Source:* J.H. Bay)

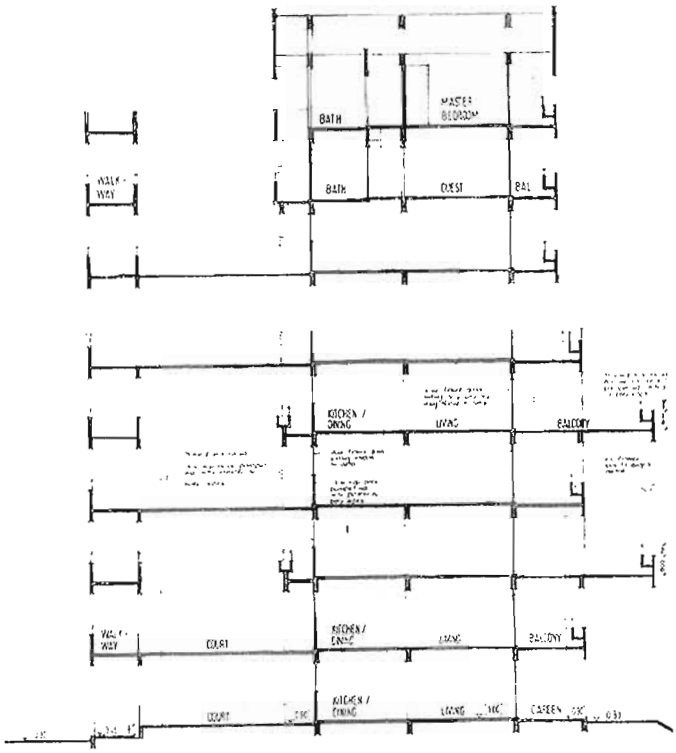
time. About 30–40% of each apartment is dedicated semi-open space (Figure 5.7).

Interestingly, Cheng chose to develop three different sky-street situations in his scheme. Block 1 (a 15- to 20-storey block) has a single loaded sky-street along its north elevation (Figures 5.7–5.9); Block 2 (a 13-storey block) has a central wing with two side wings placed at right angles to it; and Block 3 (a 4- to 6-storey block) has a double loaded street with a staggered configuration of apartments. In terms of ventilation, Block 1 is the most successful and Block 3 is the least successful. In terms of solar gain limitation, Block 3 is the most successful. In terms of social interaction all blocks are equally successful.

5.2.1 Design Intentions

In an interview by Bay, Cheng stated that his inspiration came from his first-hand experience of the kampongs in Singapore.[2] He wanted to re-create the relaxed friendly atmosphere and strong sense of community and security found in this setting. He suggested that the high degree of visual connectivity of residents in their entrance porch spaces contributed to high levels of social interaction and familiarity, resulting in a strong sense of identity and security. Any visitor would be identified immediately as a stranger.

The architect also wanted to design high-rise apartments, where each resident could own a "piece of green" and a "house" in the sky. In Singapore terraced, semi-detached and single houses are called "landed properties", and apartments are called "non-landed properties". For Bedok Court Cheng wanted to give each dwelling unit an entrance garden similar to that of a "landed dwelling". He mentioned that in the land-scarce Singapore, it would be important to create the possibility for people to own a new kind of "landed



TYPICAL SECTION B-B - BLOCK 1

5.8.
Typical Section, Block 1, Bedok Court. (*Source:* J.H. Bay)

5.9.
Multi-level visibility and comfort in forecourts, Block 1, Bedok Court. (*Source:* J.H. Bay)

5.10.
Semi-open space of Bedok Court, a piece of green in the sky. (*Source:* Authors)

property in the sky", where buying an apartment would be likened to buying a "landed dwelling" (Figure 5.10).

Cheng also mentioned that he had been very much influenced by the writings of Jacobs (1962) and her assertion that the modern city needs a vital street life. However, he went on to admit that, as in the original kampongs, some degree of privacy would have to be sacrificed in order to gain the necessary familiarity and trust.

5.2.2 Forecourt, environment and community

The surveys and measurements by Bay[3] to assess the quality of community life and the environment of the forecourt in Bedok Court produced several surprising results:

1. *Preference of the forecourt over other spaces* A high percentage of interviewed residents (86%) nominated the forecourt/veranda as the most desirable space compared to the interior of the apartment, the balcony, the lift, the lobby, the playground, the swimming pool, and the car parking areas;
2. *High frequency of social activities in forecourts* Most residents (86%) used this space for social activities, receiving guests, gardening, hobbies, children's play, study group activities and parties, more than once per week;
3. *Thermal comfort condition* Most residents (80%) felt slightly warm, comfortable, or slightly cool for the three periods of the day, morning, just after noon and evening before dark, for the warmest month of the year;
4. *Daylighting levels* The majority of the respondents (80%) found the daylighting slightly too bright, comfortable, to slightly dim, and therefore reasonably acceptable;

5. *Acoustic levels* Most of the respondents reported that they felt comfortable with the overall acoustic levels at the forecourts (most recorded levels were below 65 dBA). Noise was not a problem in the case of Bedok Court. This could be due, in part, to a high level of neighbourliness and tolerance for a certain level of ambient background noise;
6. *Privacy issue* Majority of residents reported not feeling a lack of privacy (90%). Although there will always be some people who demand total privacy, there seemed to be a large number of people who are willing to trade off reduced "privacy" for increased social contact. In any case, they could still enjoy the usual privacy of the interior of their apartment units, just as in any other apartments;
7. *Sense of belonging, ownership and security* Almost all the residents interviewed felt a strong sense of belonging, ownership and security.

In interviews Bedok Court residents used the term "kampong" to describe both the spatial system and the community in which they live, and they used the terms "court" and "garden" to refer to the forecourt. The developer adopted even the name, "Bedok Court", because it expressed the unique "court" feature of the design.

Similar to the traditional Malay kampong, each entrance veranda of Bedok Court provided a comfortable environment for social activities, visible to the neighbours. There is a spatial continuity between the semi-privacy of each forecourt and the openness of the common sky-street[4] at various levels, thus functioning as 3-dimensional multi-layered streets within a high-density context, where 66% of the residents knew neighbours on higher or lower levels. The high level of visibility of the daily activities and casual encounters in the corridors and in the forecourts is the key to the intensification of familiarity, which promotes the sense of community.[5] This familiarity was not at the superficial level, but involved home visits on a regular basis.

The shade provided by each veranda together with the vegetation, the wind, and the ventilation in each forecourt provided substantial cooling of the environment to afford the thermal comfort condition. There was no lighting or acoustic problem. The qualities of the environment encourage more social activities, leading to better sense of community, and in turn leading to higher preference for the forecourt environment, strongly inter-connected in a sustainable cycle (Bay, 2004a, 2005).

Introduced in 1986,[6] a year after the completion of Bedok Court, changes in planning and building regulations, effectively discouraged developers from providing semi-open balconies and forecourts.

As a result, most apartments built since 1986 have been conceived as sealed air-conditioned envelopes with almost no outside veranda and balcony space. Singaporeans have retreated further into artificially cooled environments, moving in air-conditioned cars between their air-conditioned homes and air-conditioned offices, shopping in air-conditioned malls and pausing to exercise in air-conditioned gyms.[7] But this life pattern is not only energy expensive – it is also socially isolating. The Bedok Court example suggests that the provision of semi open (non-air-conditioned) spaces can positively encourage a more natural and sustainable way of life and environment, encouraging neighbourliness in high-rise apartments.

5.2.3 Framework for research on semi-open forecourts

Does the above study suggest further lines of investigation in relation to social and environmental dimensions?

Baruch Givoni has observed departures from ASHRAE comfort range in Colima, Mexico (Givoni, 1998, 24–25). For tropical high-rise dwellings, Nyuk-Hien Wong (Wong et al., 2002) has studied the thermal comfort range for the naturally ventilated unit interiors, but there is not yet a similar study for the tropical semi-open spaces. What are the key factors that differ? Boon-Lay Ong (2002) has developed a "green plot-ratio" concept for regulating the amount of planting needed for an urban context to enjoy the environmental, aesthetic, and recreational benefits. This application relates better to top-down decisions of planting, and requires much centralized maintenance. Individual owners manage their own plants in the Bedok Court type of forecourts, and therefore it is worth exploring how these may be increased as a more self-sustaining approach. What can be learnt about the relationship between plants, people, climate and semi-open space that can give clues to increase the desirability of forecourts and gardening?

What are the optimal sizes of semi-open forecourts to achieve a reasonable quality of environment as well as facilitate visible social activities and casual encounters, and thus provide the chance for better community building?

5.3 WIND AND SOLAR RADIATION

Even though the structure of a Bedok Court forecourt (semi-open or semi-enclosed space) comprise a ceiling and a floor plate like the interiors (enclosed spaces) of each apartment, the openings on the sides are substantially much larger then those for the

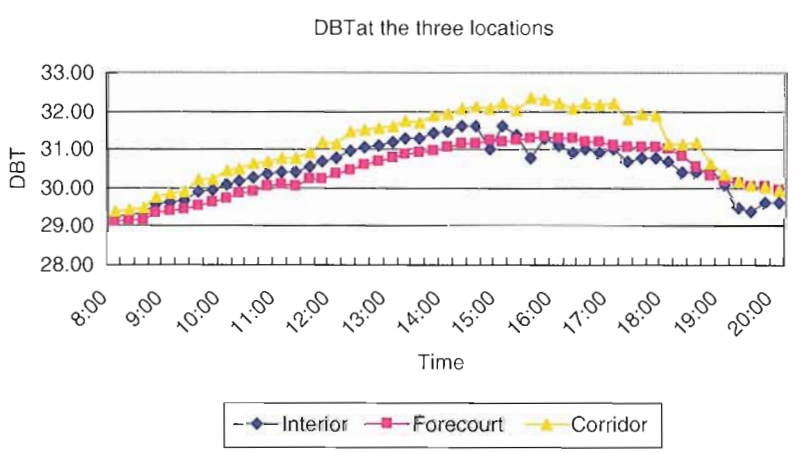
interior rooms. The average radiant temperature measured for the forecourts was generally much lower than that measured for the external environment outside the apartment block and slightly higher than the interior of the apartments.

Liang (2005) argues that wind and solar radiation are the critical factors that affect the thermal comfort, compared to the interior spaces. Therefore the prediction model for thermal comfort of the interior of high-rise tropical housing in Singapore (Wong et al., 2002) cannot be used effectively for the predicting comfort votes for the semi-open forecourts. He surveyed and measured the semi-open forecourts, and adjacent corridors of apartment units of Bedok Court Block 1 (Figures 5.3, 5.7 and 5.8) to study the relative effects of wind and solar radiation on the thermal comfort votes of the residents.

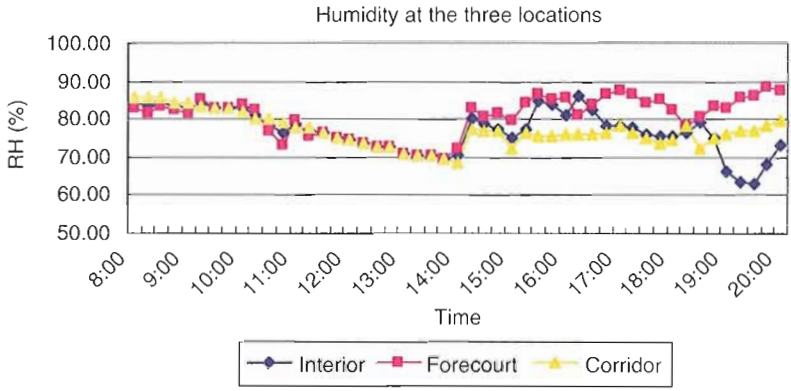
5.3.1 Combined effects of wind and solar radiation

Liang's study shows that there are dramatic differences of the average DBT and average Relative Humidity of the apartment interiors compared to the averages in the forecourts (veranda) and the corridor spaces throughout the day (Figures 5.11 and 5.12). The intensity of solar radiation rose dramatically higher for the narrow corridors at around noon compared to the large and well-shaded forecourts (courtyard) (Figure 5.13). The wind speeds are much stronger at the corridors throughout the day (Figure 5.14).

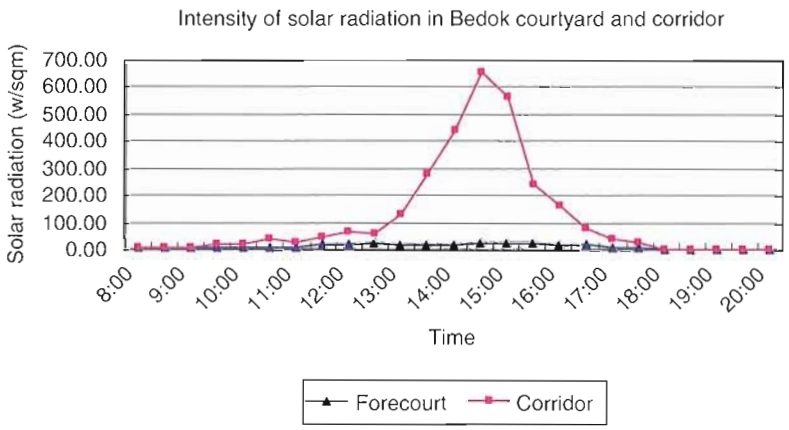
Even though the wind speed in the forecourts (verandas) are lower, the combined effect with the lower solar radiation due to substantial shading results in many of the comfort votes from slightly warm (+1 to −2 in Figure 5.15). In the tropics it is better to feel slightly cool on the warm side. In the corridors, where the solar



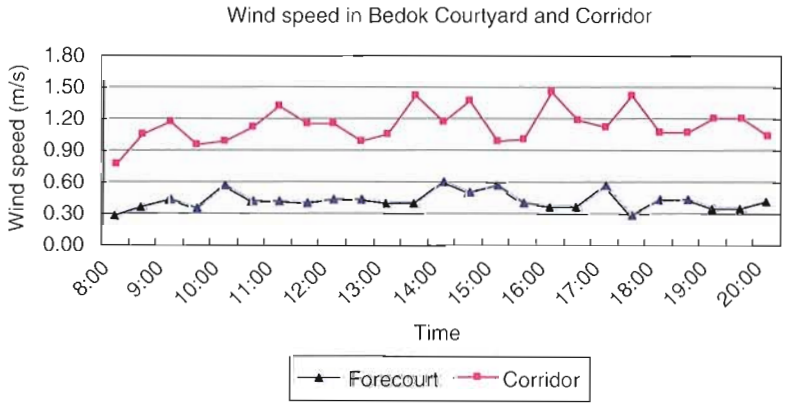
5.11.
Comparison of DBT at the three locations, June 2004, Block 1, Bedok Court. (*Source:* Q. Liang)



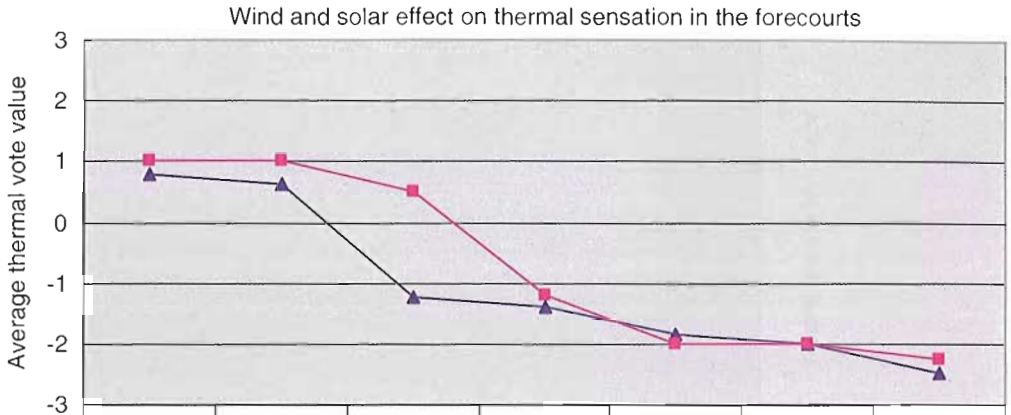
5.12.
Comparison of Relative Humidity at the three locations, June 2004, Block 1, Bedok Court. (*Source:* Q. Liang)



5.13.
Comparison of solar radiation in veranda and corridor, Block 1, Bedok Court. (*Source:* Q. Liang)



5.14.
Comparison of wind speed in verandas and corridors, Block 1, Bedok Court. (*Source:* Q. Liang)



	v<0.2	0.2<v<0.5	0.5<v<1	1<v<2	2<v<3	3<v<4	4<v
SR<50	0.8	0.64	-1.25	-1.4	-1.83	-2	-2.5
50<SR<100	1	1	0.5	-1.2	-2	-2	-2.25

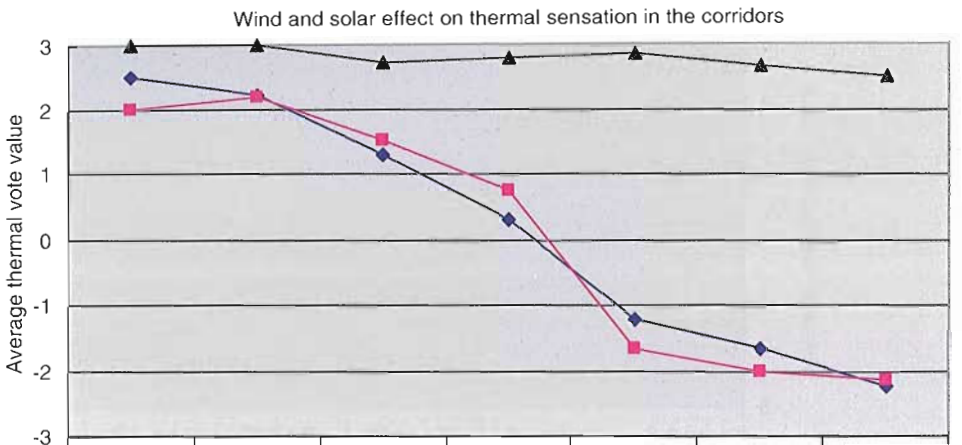
5.15.
Effect of wind and solar effect in the verandas, June 2004, Block 1, Bedok Court. (*Source:* Q. Liang)

radiation is higher, the average votes for comfort rose to very warm and uncomfortably warm if the wind speed drops below 1 m/s.

5.3.2 Solar radiation has stronger effect on thermal comfort votes

The warming effect of solar radiation is therefore more influential in the semi-open space than the cooling effect of wind on thermal comfort. From Liang's study, designers should try to keep solar radiation below 700 W/m^2 for narrow corridor-forecourts to apartment units, where even a low wind speed 0.5 to 1 m/s could still afford thermal comfort vote of slightly warm (Figure 5.16), which would be still acceptable. Measurements of radiation levels of the corridor however show that additional shading devices are needed to keep the radiation below this level for most of the day. For the larger semi-open spaces like the Bedok Court forecourts, measurements of lower than 100 W/m^2 of solar radiation could be achieved with reasonable thermal comfort sensation with minimal wind speed of 0.3–0.6 m/s, and tending towards the cooler side with stronger wind speeds, generally available for the high-rise apartments.

The study shows that the shading of solar radiation provided by the large forecourt is effective and instrumental in the provision of thermal comfort environment in the semi-open spaces in the high-rise housing environment. Before a predictive model is developed



	v<0.2	0.2<v<0.5	0.5<v<1	1<v<2	2<v<3	3<v<4	4<v
400=<SR<600	2.5	2.2	1.3	0.29	-1.22	-1.66	-2.23
600=<SR<700	2	2.17	1.5	0.75	-1.66	-2	-2.15
SR>=700	3	3	2.7	2.79	2.83	2.64	2.5

5.16.
Effect of wind and solar effect in the corridors, Block 1, Bedok Court. (*Source:* Q. Liang)

for semi-open spaces in the high-rise housing environment, Liang's study provides a suitable design guideline for thermal comfort for forecourts and corridors with similar climatic conditions.

5.4 PLANTS, ENVIRONMENT AND SOCIAL ACTIVITIES

Architects, urban designers, and sociologists popularly embrace the concept of gardening as a strategy towards a more humane and comfortable living environment. "Garden City", "City Beautiful Movement",[8] "Corporative Gardens",[9] "Sky-gardens" and other top down green strategies have achieved satisfactory fruits to some extent. However, some the potential owner initiated and maintained green spaces, facilitated by semi-open spaces such as the forecourt, have not received enough attention in contemporary design.

Bay (2004b) survey shows that gardening itself is one of the most popular activities in the forecourt of Bedok Court. Kong (2005) investigated the interrelationships between gardening in semi-open spaces, people and climatic performances with the case of the forecourts of Bedok Court and the corridor spaces fronting apartments of the Jurong West public housing block 510, through surveys and

measurements of the thermal conditions. The main findings are as follow.

5.4.1 Lower ambient temperature with increased planting

Based on the observation of the correlation of lower ambient temperatures readings with greater amount of planting in entrance verandas and corridors, Kong suggested that the plants could create thermally comfortable tropical high-rise dwelling microenvironment, where the more the plant materials the better the environment.

The intensity of plant material determined by volume of leaves, because leaves play a crucial role in shading and cooling effects of plants, which contributes to environmental performance of gardens.

The measurement done in December 2003 in Bedok Court showed that there was not much difference in leaf area index[10] among different plant types cultivated in the semi-open forecourts. The intensity of plant materials was then assumed proportional to the number of plants and the sizes of the plants, which could be easily accounted for. A group of forecourts with the highest range of intensity of plant material (deemed as forecourt with lush plants) is compared to a group of similar forecourts without plants, to observe the differences in the ambient temperature and mean radiant temperature (Figure 5.17).

The ambient temperature in the entrance forecourts with lush plants was 2.3°C lower than those without plants (12:30 P.M. on 16th level) in July, where the spaces enjoyed similar shading and wind conditions. On average, entrance verandas with lush plants

	Ambient Temperature (°C)		Global Temperature (°C)		MRT	
	With lush plants	Without plants	With lush plants	Without plants	With lush plants	Without plants
Jurong_July	28.58	29.36	29.30	30.31	29.78	30.89
Jurong_Dec	26.46	26.80	27.11	27.85	27.78	29.35
Bedok_July	28.55	29.38	29.35	30.60	30.43	32.71
Bedok_Dec	24.84	26.32	25.34	26.94	26.39	29.84

5.17.
Comparison of temperature in corridors and forecourts with and without lush plants.

were 0.65, 0.91, and 0.91°C lower than the ones without plants on the 6th, 12th and 16th levels, respectively during the warm season. In December, the greatest difference in temperature was 2.46°C at 14:30 P.M. on 6th level. On average, the differences of ambient temperature were 1.35, 2.14, and 0.38°C on the 6th, 12th and 16th level, respectively between entrance verandas with lush plants and without plants during the cool season.

The transpiration process of greeneries and the screening of direct and diffuse solar radiation could contribute to lower ambient temperatures and mean radiant temperatures observed. Most of the lower temperatures were observed during the hottest period of the day (from 11:00 to 15:30); thus the plants could increase thermal comfort periods. Plants are also known to absorb carbon dioxide and release oxygen to improve air quality through photosynthesis. Thus as much gardening in the forecourts as possible should be encouraged to improve environmental quality.

5.4.2 Social benefits

The survey shows that residents with more plants in their forecourts tend to know more neighbours, and have a higher sense of community, belonging and security. The activity of gardening in entrance verandas allows residents to know more neighbours in a casual and relaxed manner, and the increase in time needed to tend to more plants would also tend to increase the exposure to neighbours.

Compared with the narrow corridors in Jurong West case (Figure 5.18), the large entrance forecourts of Bedok Court could

5.18.
Semi-open corridor space of Block 510, Jurong West public housing used by more than 50% of residents for gardening activities. (*Source:* Authors)

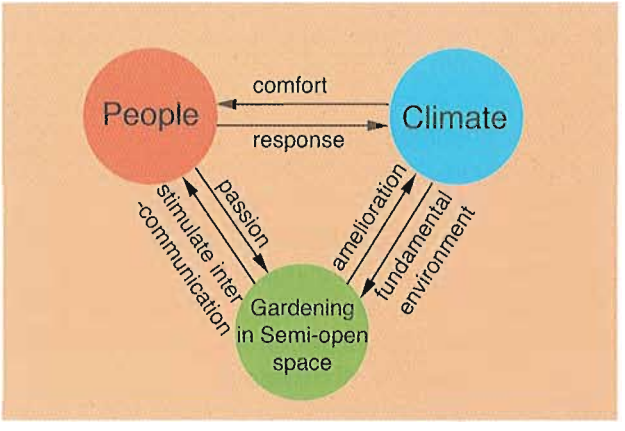
accommodate more plants, where the residents of Bedok Court also reported that they know more neighbours.

Plants afford vivid colours, fresh air and psychological pleasure for the residents, and thus can contribute to improving the environment for socialising. This could explain the correlation of higher intensity of planting with higher numbers of knowing neighbours.

Lewis (1990) asserted that the total physical conditions of a community, including buildings, vacant spaces and streets make an enormous difference in how members of that community feel about themselves. And the collective attitudes create unique community with various characteristic and personality of its own, ranging from vibrant to lethargic. Gardening in entrance verandas contributes physically and psychologically to create desirable environments for a social sustainable community.

5.4.3 Interrelationships

Kong (2005) suggests that gardening, people, and environment form a triangle of interrelationships (Figure 5.19), where one stimulates the other (similar to the interrelationships of social, environmental and spatial described in Bay, 2004a). People play the key role in the triangular relationships. People who love to keep in touch with nature and enjoy outdoor lives tend to desire gardening. The suitable microenvironments afforded by the forecourt and the size, facilitates ample gardening activities. The plants in turn improve the environment, the activity increases, improving the casual knowing of neighbours and sense of community, and thus in turn encourage more interest in gardening.



5.19.
Interrelationships of gardening in semi-open space, people and climate in tropical high-rise housings. (*Source:* P Kong)

5.5 SPATIAL DIMENSION OF FORECOURT AND SOCIO-CLIMATIC THRESHOLD

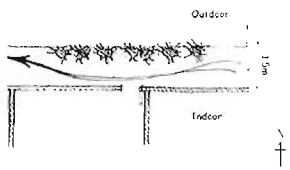
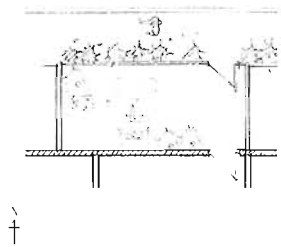
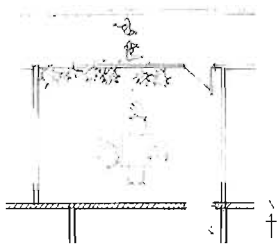
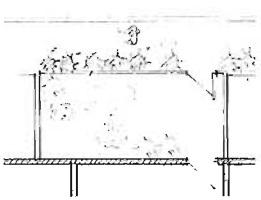
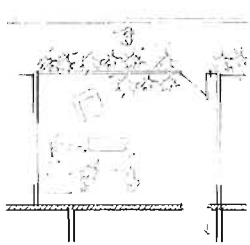
What is the minimal size of a forecourt similar to those of Bedok Court with a similar thermal comfort that can facilitate a minimal set of similar activities? This will be the threshold size of such entrance spaces that can sustain similar social and environmental dynamics and qualities.

Architects tend to think with "preparametric" reasoning (Bay, 2001), where very little mathematical calculations are employed in the process of design thinking. If one could pre-do simulations and analysis the various permutations of sizes and performances of various forecourts, and summarize the results into a "preparametric" format, then it will form a user-friendly design guideline for the architect indeed.

Wang (2005) used the observations of Bay (2004a,b) of the activities of the forecourts at Bedok Court and the corresponding thermal performance as a basis to simulate the quality of smaller forecourts. The quality of smaller size forecourts for facilitating social activities was determined by the ergonomics and space standards. Down to a certain size, the forecourt would fail to satisfactorily support a similar set of activities as observed in Bedok Court. The quality of thermal performance of smaller size forecourts were simulated and plotted against the degree of reduction of solar radiation by shading. As the forecourt size narrows down to a threshold point, the thermal comfort condition deteriorates drastically, rendering the space not conducive for various social activities.

The observations of the study are summarized as a set of design guidelines (Figures 5.20 and 5.21). On the left of the chart, the "poor zone" indicates a space with poor ergonomic and environmental qualities. On the right of the chart, the "good zone" indicates that better ergonomic and environmental qualities can be expected starting from a threshold point of 2 m depth of the forecourt, measured from the corridor. Beyond that size, a semi-open space could provide sufficient shade and facilitate an optimum set of social activities similar to that of Bedok Court.

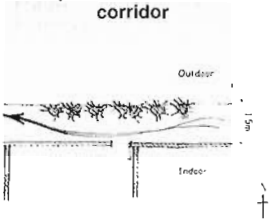
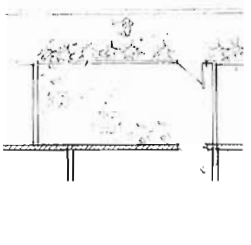
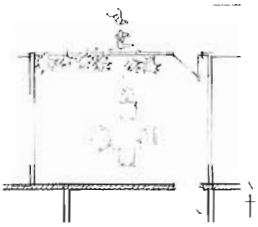
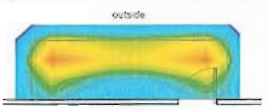
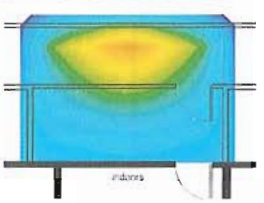
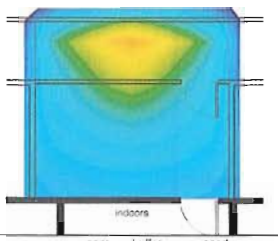
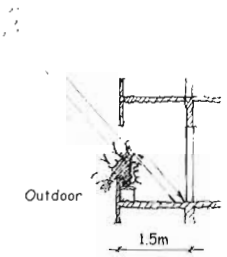
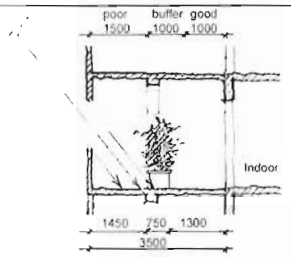
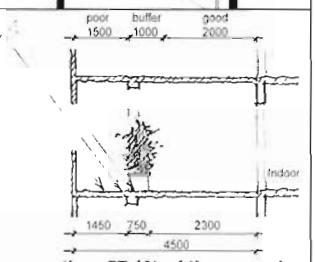
This set of design guidelines is organized and presented using the framework of morphology-operation performance in a given context (Tzonis, 1992), so that designers can easily understand the cause and effect relationships clearly for their design thinking. Morphology refers to the physical configurations. Operation refers to how things work for certain morphology, in this case how each space works ergonomically and in the shading of solar radiation. Performance refers to the possible outcome, such as the possible types of social activities and thermal comfort qualities. The operation column is

	Unacceptable design size	Acceptable design size	
	Poor	Threshold	Good
Possible design configuration (Morphology)			
	0-2m depth of veranda from1.4m corridor 	2m depth of veranda from 1.4m corridor 	Bigger than 2m depth of veranda from 1.4m corridor 
Social aspect			
Possible social activities (Social Performance)	Saying hello to neighbours Gardening	Saying hello to neighbours Gardening Sitting Reading Chatting	Saying hello to neighbours Gardening Sitting Reading Chatting Children's playing Exercising Housework Party, etc.
How it works (Operation)	·Only several pots of plants can be placed at the corridor. And they will make the semi-open space more crowded. ·Residents have little chance to communicate with their neighbours at the semi-open space.	·The maximum number of persons allowed having activities at the veranda at the same time is two. ·Residents have some chances to see and communicate with their neighbours at the veranda. 	·The number of persons allowed having activities at the veranda at the same time is more than 2. ·Residents have many chances to see, say hello to or communicate with their neighbors at the veranda. 

5.20.
Summary of the guideline, morphology corresponding to social benefits and how each works. (*Source:* N. Wang & J.H. Bay)

critical, as it alerts the designer to how things work, and it is not just a matching of sizes of veranda and performances.

This set of design guidelines combines the social and environmental dynamics and thus provide an easily accessible set of "pre-parametric" knowledge for quick design decisions with regard to the design of tropical forecourts in contexts similar to those of Bedok Court.

	Unacceptable design size	Acceptable design size	
	Poor	Threshold	Good
Possible design configuration (Morphology)			
	0-2m depth of veranda from 1.4m corridor 	2m depth of veranda from 1.4m corridor 	Bigger than 2m depth of veranda from 1.4m corridor 
Environmental aspect			
Desired environmental effect (Environmental Performance)			
How it works (Operation)	 ·semi-open space is totally exposed to solar radiation. ·Temperature is high for outdoor activities.	 ·57.1% of the veranda is shaded even without plants. ·Plants can be arranged between the corridor and veranda. They help block the solar radiation and reduce the temperature of the veranda.	 ·more than 57.1% of the veranda is shaded even without plants. ·Plants can be arranged between the corridor and veranda. They help block the solar radiation and reduce the temperature of the veranda.

5.21.
Summary of the guideline, morphology corresponding to environmental benefits and how each works. (*Source:* N. Wang & J.H. Bay)

5.6 DISCUSSION AND CONCLUSIONS

In Singapore, it is timely that the Duxton Plain Housing International Competition organized by the Urban Redevelopment Authority in 2001–2002 encouraged a new debate on the need for community cohesion and environmental sustainability in high-rise dwelling developments in Singapore[11]. There were proposals of large sky

voids, bridges and roofs, facilitating much planting as one of the strategy for sustainability, and serving as public community spaces. In all the schemes from across the world, there were no proposals of schemes similar to those of the Bedok Court forecourts that are almost more personalized and intimate socio-climatic spaces.

It is difficult but one could opt to go back to traditional lifestyle as a way to sustainability, or continue with modern lifestyle and cope with the sustainable issues with more efficient technology.Perhaps, with the forecourts, one could have the modern lifestyle, in reinvented traditional spaces, in the high-rise apartment context and enjoy both sustainable social and environment dimensions. One can view this as a critical sustainable architecture in a similar sense of the 'critical' in *tropical critical regionalism* (Tzonis, 2001).

Bedok Court was designed to work without air-conditioning. Even though residents have fitted their own air-conditioners, they reported that they hardly turn them on, except for a few days in the hot seasons. A separate study can be made to ascertain the extent of cooling afforded by various sizes of verandas to the main building interiors.

The spatial design of the entrance forecourt can also facilitate a synergy of socio-climatic qualities, beyond the bio-climatic. It also gives the Bedok Court a tropical and modern local character of streets in the sky. Perhaps there are other tropical architectural spaces, for example traditional and modern streets, which can be studied as socio-climatic phenomena to understand and hopefully achieve more critical sustainable architecture in the age of globalization.

NOTES

1 For example, Powell (1998), Lim and Tan (1998), and majority of articles on residential projects in the *Singapore Architects,* a journal by the Singapore Institute of Architects, showcase predominantly low-rise living as examples of tropical urban living in Singapore. Powell, R. (1998) *The Urban Asian House: Living in Tropical Cities.* Select Books, Singapore; Lim, William S.W. and Tan, H.B. (1998) *Contemporary Vernacular: Evoking Traditions in Asian Architecture,* Select Books, Singapore.

2 The author of this paper has lived for 19 years in a similar kampong from 1959 to 1978, and empathises with the experience of the architect.

3 Survey by Bay, 2000. "Design for high-rise high-density living: The tropical streets in the sky" in 21st Century QOL, Proceedings of the 2nd International Conference on Quality of Life in

Cities, (March 2000). School of Building & Real Estate, National University of Singapore, Singapore. And surveys in a research project by Bay in collaboration with K.P. Lam, from 2003 to 2004, entitled "Towards more robust and holistic precedent knowledge for tropical design: Semi-open spaces in high-rise residential development", National University of Singapore (Bay, 2004b). Please read this report and Bay (2005) for more details on the methods of study and results.

4 It should be noted, however, that Bedok Court is a gated condominium with controlled access, so that the sky-streets are in a sense only semi-public spaces.

5 Chua (1995), a sociologist, argues that community is formed through the increased familiarity as a result of seeing and meeting each other in everyday routine of movements and activities in and around the apartment buildings.

6 In 1986 the planning control method changed from persons per hectare to total gross area per piece of land, thus limiting Bedok Court type of developments. The author's paper (Bay, 2000) and possible incentives for more semi-open spaces were discussed at the 2nd International Conference on Quality of Life in Cities with planners from the Urban Redevelopment Authority, who were present. From then the planning regulations have been changed to encourage some semi-open spaces. Please refer to Bay (2005) for more on the restrictions and possible improvements, and differential incentives for the forecourt versus other semi-open spaces.

7 It is hardly surprising that Singapore boasts one of the highest per-capita energy consumption of any country in the world, or that one-third of all generated electricity is used for air-conditioning.

8 It was initiated since early twentieth century in U.S.A. led by Daniel Burnham. The movement inherited the idiom of European Beaux-Arts and sought to sweep away social ills through beautification. The first official expression of it was 1901 Plan for Washington, D.C.

9 Corporative gardens programs expressed differently in different states in U.S.A. since the middle of last century, such as neighbourhood corporative garden contest held in New York (1962), and Chicago (1974), and "Greening of Boston" (1987), etc. They achieved great success in revitalizing and beautifying neighbourhood.

10 Leaf area index is taken here as the single-side leaf area per unit ground area as the approximation of relative "denseness" of leaf surfaces available.

11 For example, URA, Jury Comments, News Release, 30 April 2002, report on a public debate in The Straits Times.

Sunday, May 11, 2002, and "Walking the fine line: A review of Singapore's Duxton Plain Housing Competition", by G.D. Robson and J.H. Bay (2002).

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