TOWARDS A FOURTH ECOLOGY: Social and Environmental Sustainability with Architecture and Urban Design

Joo Hwa Bay,[1] Ph.D.

Third Ecology—"What is not yet clearly demonstrated and understood is that the human species, through its ability to alter bits and pieces of the laws which govern the natural environment and its ecology, has in fact created a completely new environment—a man-made one which in complexity and scale of containment is comparable to the natural. This new environment now requires a new ecology of its own order so that it can be fully comprehended: a third ecology within which, with luck, humanity may find a new symbiosis with other living things...the third ecology environment may be described as technological in its production and control processes, but at the same time social in its continuously developing nature. It cannot therefore be uniquely explained in biological or technological terms."

—Serge Chermayeff and Alexander Tzonis 1971[2]

ABSTRACT

The architect has always been interested in the social and cultural dimensions while creating architecture for people to last, with the help of building science and technology. Science could solve some problems, but is yet to solve many of the problems of urbanization in human history. Perhaps many of the problems can only be solved with careful understanding of human behavior, social intercourse, and economics in relation to the urban environments and organizations, and the natural environment simultaneously.

There seemed to be a divide between the way an engineer and an architect think and practice in making a building and a piece of architecture, where the former is highly mathematical, and the latter deals with cultural poetics and a whole range of social and technical issues of which the physics of the environment is but one dimension (Bay and Ong 2006). It may appear natural in this age of environmental crisis and rapid urban development in many cities that the current Ecologically Sustainable Design (ESD) system, which is mainly based on science of the physical world, would be readily accepted by the architect in practice and education.

Many of the current ESD guidelines can contribute to the avoidance of a further decay of the earth, thus preventing droughts and floods, etc., and hope to maintain the status quo of the environment for all the "business as usual" social-economic activities. With more world leaders of the developed world agreeing in principle on the need to address climate change, perhaps a lot more will be done based on the engineering models for ecologically friendly planning, commerce, industry, and design. There could be a cognitive bias[3] *of overconfidence and systemic error that the predominantly engineering focus to keep climate change at bay will solve the problem of sustainability in various parts of the world. The current limited concept of "ecological" or the "green" design does contribute to sustainability, but is quite limited and not the whole picture of sustainability.*

The concept of sustainability involves the dynamic and complex balance of environmental (man-made and natural), economic and social dimensions, from many earlier sources including the theory of the Third Ecology

[1]Joo Hwa Bay, Ph.D. Associate Professor, University of Western Australia; Director, Eco Design Consultant; Philip.Bay@uwa.edu.au; philipjhbay@yahoo.com.

(Chermayeff and Tzonis 1971) about social ecology directly related to the man-made urban fabric, and recently, the much accepted pervasive framework of the Brundtland Commission Report 1987: Our Common Future*, which included more discussions about the interrelatedness with economic equity and the natural environment. Foremost and ultimately it is about promoting and ensuring social quality of living now and sustaining that into the future, for all nations, the rich and the poor, through solving the matrix of social, economic, and environmental problems.*

From the perspective of the theory and practice of architecture, this paper discusses the following issues:

1. *Belief in science, disenchantment, symbol of failure of modern architecture – Pruitt Igoe;*
2. *An anti-thesis to Pruitt Igoe – Bedok Court;*
3. *The cultural concerns and preparametric design thinking process of the architect;*
4. *Architecture, social science, cultural value, social capital, behavior, and ESD;*
5. *A Fourth Ecology, multi-disciplinary research by architects, social scientists, and engineers.*

KEYWORDS

Ecology, sustainability, architecture, Modern Architecture, functionalism, ecologically sustainable design, rating tools, social and environmental, community, social capital, socio-climatic, bioclimatic, human behavior, diversity, human potential

INTRODUCTION

The following sections discuss the issues outlined in the above abstract.

BELIEF IN SCIENCE, DISENCHANTMENT, SYMBOL OF FAILURE OF MODERN ARCHITECTURE—PRUITT IGOE

Before the widespread awareness of the problem of limited resources and climate change, the mistake of thinking and practicing with the assumption that there were unlimited resources was not confined to just the Modern Movement in architecture. It was a mistake committed by all walks of life and with other approaches to architecture, including the Post-Modern and later approaches. So this paper is not contradictory if it is discussing some of the good qualities in the ideals of Modern architecture, if it had considered also the issue of limited world resources and the problems of climate change, and if it has access to current know-how in environmental and social sciences.

Were Le Corbusier's Ideals of Community, Sun, and Garden Wrong?

We all know the story of Modern architecture well; it is about the brave new hope, believing in science and architecture improving the quality of life by promoting community in a healthy environment of sun and garden.[4] Some of these key ideals of Modern architecture were articulated by Le Corbusier.[5]

The Modern Movement was not just based on the ideas of Le Corbusier, but also by many of his contemporary proponents of various functionalist concepts, including new construction materials, ways of building, economy of scale in building repetitive modules, community, climate, gardens, and the concept of Utopia. Le Corbusier's idea of high-rise higher density community and environment was one of the promising highlights and ideals of Modern architecture.

Behling (2000) cited the sunny side of heroic Modernism, referring to several ideas and projects of Le Corbusier. The Radiant City was based on the principles of the heliothermic axis, the quantity and time of insulation each built surface would receive, and solar optimization proposed. The Immenubles Villas were designed to be stacked in blocks on 6 double floors with garden terraces. They were part of the Contemporary City, a model for high-density living in an urban context; designed with the ideal to provide residents with a good quality of life. However, there was much criticism of Le Corbusier's actual projects. Banham (1969) pointed to some of the failures in actual environmental performance of Le Corbusier's projects, while Gehl (1971) pointed to the lack of community life in public spaces in Le Corbusier's utopian housing schemes. The Unite d'Habitation at Marseilles, designed by Le Corbusier in 1953, embodies some of the ideal for modular mass housing and community using an open deck

garden and swimming facilities on the roof, shop, and school in mid-level of the high-rise building. However, these did not work well either, where the school and shop quickly became non-operational, and the large doors to the roof facilities were unused, chained, and padlocked for safety after the initial fad wore off.[6]

Disenchantment with Science, Modern Architecture, and Architectural Theory

In the early 1900s the ideas of a brave new world and of utopia were attractive. After the world wars, there were rapid redevelopments of many cities with a full range of technocratic and large-scale changes to the environment as if it were another world separate from natural ecology, and with poor understanding of the social dimensions in issues of culture, community, psychology, and economy.

Jane Jacob (1962) pointed to the impoverishment in social quality in the highly zoned American cities with huge shopping, sports, business, and housing facilities, lacking the human scale and quaint streets of community life. Others thought of comprehensive *design methods*, theorizing how the designed environment could be a catalyst to community building and social quality. Such writings include *Pattern Language, Community and Privacy, Defensible Space, Shape of Community*, *Ekistics*, and others, where the authors believed in a better functionalism where social science should complement physical and biological science to solve the social-environmental (man-made) problems.

The concept of the Third Ecology, in the *Shape of Community*, Chermayeff and Tzonis (1971) argue from evolutional, economic, psychological, and urban theories that human potential and creation of knowledge can be optimized via improved social concourse and intercourse. They noted that sociological and ecological change move much faster than the biological and psychological changes, and that urban design must be thought in terms of human potential. This parallels the economic concept of social capital (Putnam 2000) that is used quite extensively in contemporary planning, especially in the underdeveloped nations. It was a pity that in architecture, design method could not be easily translated to better practice and the architect needed more understanding and knowledge in real and different social contexts to do so. There was a shift from the period of *design methods* to *critical theories* (Tzonis 2006) to understand cultural issues in different localities, politics, and periods of history. Critical theories never really translate down to practice to solve the problems either (Op. cit.) and the proponents of critical theories themselves concluded the death of theory.

Fetish with News of Demolition, and Icon of Failure—Pruitt Igoe

On one hand is the disenchantment with science and technology in solving the world problem and the belief that a better understanding of human culture and urban design may help but with little practical success. On the other is the strange preoccupation of people around the world in becoming more and more interested in the news of demolitions (Tzonis 2006).

When Pruitt Igoe, the high-rise, high density housing development designed and completed by Minoru Yamasaki in 1955 in the tradition of Modern architecture, was exposed by international press of its poor living conditions with mounting crime rates, and was demolished in 1972, it was deemed an icon of failure to modern housing and functionalism in architecture. Charles Jencks (1984) in his book on Post-Modern architecture wrote that this event marked "the day Modern architecture died." It was a symbol of the failure of mainstream practice of architecture, and was used by various architects to propagandize their lines of architecture as alternative manifestos till today.

AN ANTI-THESIS TO THE ICON OF FAILURE IN ARCHITECTURE—BEDOK COURT

Contrary to Pruitt Igoe and many more developments that were demolished, Bedok Court is a high-rise, high density housing development in Singapore rich in qualities of community and environmental sustainability. This project embodies many of the ideals that Le Corbusier had concerning high density, mass repetition, and economy of scale, but above all the ideas of community, sun and gardens in the sky. The Bedok Court case has been thoroughly researched and published. The following sub-section highlights some of the key qualities of

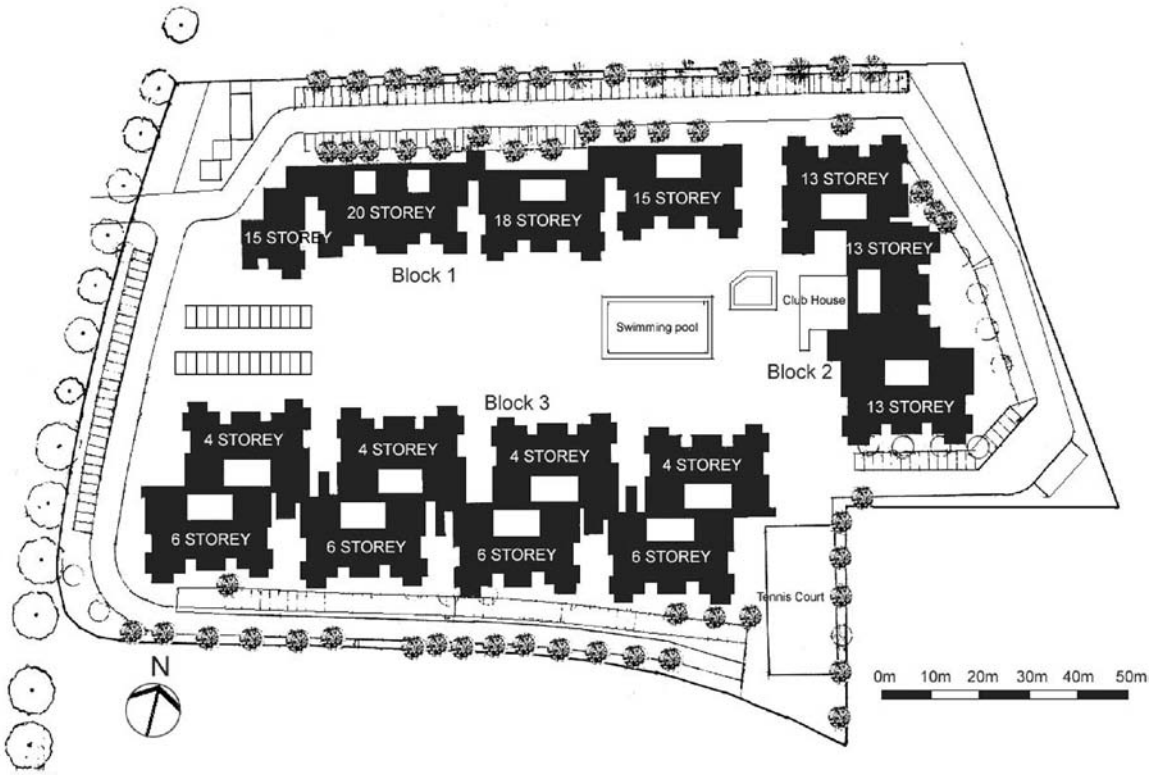
FIGURE 1. Typical public housing blocks near Bedok Court condominium. (Source: Author)

the project[7] and the subsequent sub-sections discuss various angles specific to the trust in this paper.

Singapore is one of the densest cities, and more than 95% of the population lives in high-rise apartments. Housing projects (Figure 1) comprise 85% of the housing stocks, and these were originally inspired by the ideas of Le Corbusier, with most high-rise blocks on pilotis. These void areas on the ground called "void decks" are used for community functions. The openness of the void deck also allows unrestricted visual surveillance from the hundred of apartments above and from the street level. Each apartment is designed with cross ventilation and owners have the freedom to maintain potted plants in common corridors as long as they do not obstruct movement in the corridors. Ten percent of the population lives in private condominium projects, and Bedok Court, designed by Design Link Architects, is one of the least luxurious and least expensive per square foot of these developments. Completed

FIGURE 2. Bedok Court condominium, from left: Block 3, Block 1, and Block 2. (Source: Author)

FIGURE 3. Bedok Court condominium, site plan. (Source: Author, after plans courtesy of Design Link Architects)



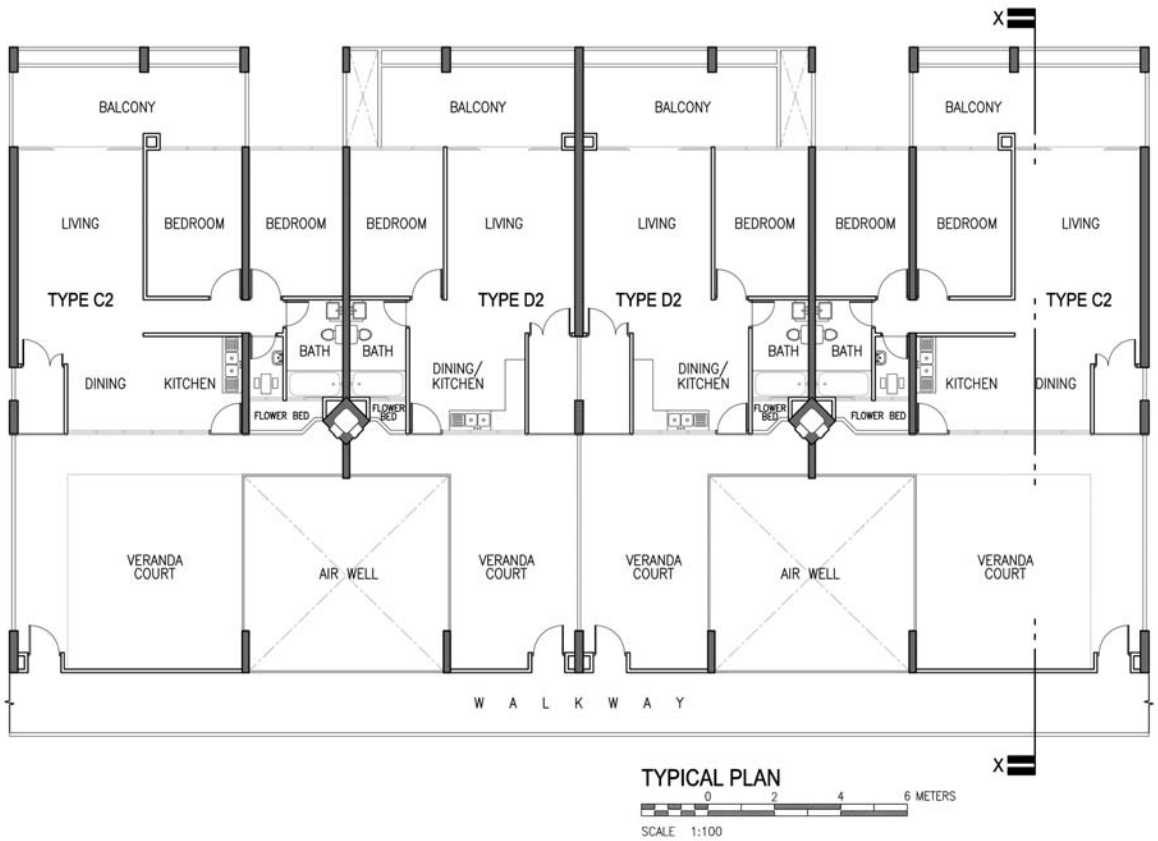
in 1985, it has 280 units of apartment in low-rise blocks that sit on the ground and high-rise blocks on pilotis, with common swimming pool and tennis facilities set in simple landscape gardens (Figures 2 and 3). The void decks are also used for community functions occasionally.

Village and "Land for Gardens" in the Sky

In 1983, Architect Cheng of Design Link Architects was aware of the criticism by Jane Jacobs about the problems of impoverished urban environments lacking the quality of community life, and wanted to create the kumpung (traditional Malayan village) in the sky, as well as land for gardening in the upper levels. He wanted the residents to enter each apartment from the common corridors via a court, which is a semi-open deck for various social activities including gardening (Figures 4 to 6).

FIGURE 4. Bedok Court condominium, Block 1 north façade. (Source: Author)

FIGURE 5. Bedok Court condominium, Block 1 typical floor plan. (Source: Author, after plans courtesy of Design Link Architects)



Similar to the traditional Malayan village house veranda (anjung and/or serambi, Figure 7), this forecourt space is the coolest space with shade and maximum ventilation (Figures 8 to 11), and serves as a privately owned semi-outdoor living space. This is where the residents could see and greet each other frequently, strengthening the sense of belonging through familiarity. All these were achieved with a building technology and architectural styling that is not very dissimilar with those used in the other thousands of housing blocks in Singapore or with those by Le Corbusier and his contemporaries.

A survey of the residents of Bedok Court shows that a high percentage of interviewed residents (86%) nominated the forecourt/veranda as the most desirable space compared to the interior of apartment, the balcony, the lift, the lobby, the playground, the swimming pool, and the car parking areas (Appendix 1). The forecourt was reported to be the space that afforded the most visual contact with neighbors. 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. Almost none of the residents reported feeling a lack of privacy (90%); most had a strong sense of belonging and ownership (90%); and most felt a high sense of security (96%) (Bay 2004).

While 90% felt a strong sense of belonging and ownership at Bedok Court, about 66% knew neighbors on higher or lower levels intimately. This was largely due to the high spatial permeability afforded

FIGURE 6. Bedok Court condominium, Block 1 typical section. (Source: Author, after plans courtesy of Design Link Architects)

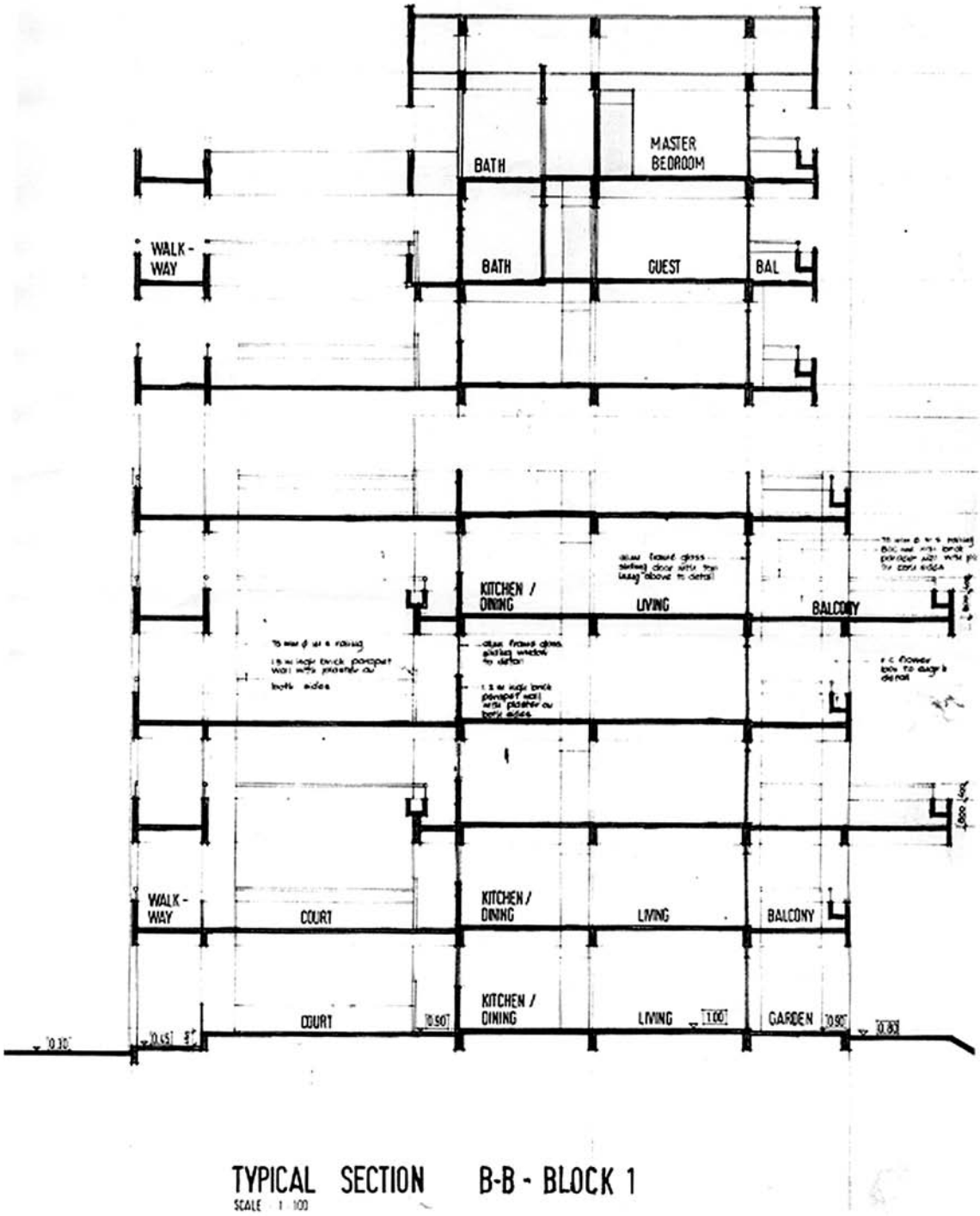


FIGURE 7. Typical semi-open entrance space to each traditional Malay village house facilitates social engagements. (Source: Sketch by Author)

FIGURE 8. Bedok Court condominium, Block 1 17th storey, typical entrance veranda/forecourt. (Source: Author)

by the offset voids, which permitted social intercourse laterally, upwards and downwards from the forecourts, and increased the possibilities for casual encounters and for increased familiarity. This familiarity was not at the superficial level, but involved home visits on a regular basis to neighbors on different floors. By comparison to a typical public housing block, only 65% of the people interviewed felt a strong sense of belonging in the neighborhood, and most relate to an immediate neighbor on the same level. (For more details, please refer to Bay 2004 and Bay et al. 2006).

The empirical measurements and surveys of comfort votes indicate that the physical environment were within the comfort zones most of the time (Appendix 2). Solar radiation being the more crucial effect on comfort was relative low in the court space compared that measured in corridors (Appendix 2 and 3). The comfort votes owing to change in wind speed range from +1 to –2, meaning slightly warm at times, but mostly comfortable or on the cooler side, which is a good thing for the tropical areas (Appendix 3). (For more details and other measurements such as humidity, acoustics, lighting levels, etc., please refer to Bay 2005 and Bay et al. 2006.) Most of the residents with air conditioners find it unnecessary to turn them on except for but a few hours on a few days in a year.

Gardening with potted plants is found in almost all the "courts" at various levels. This, together with the shading and maximum ventilation, provides much coolness not only for the courts, but also for the interior of the apartments (Appendix 4 shows substantial reduction of the temperature with plants in the forecourt). It is also most interesting that these gardens are not maintained by any management groups but by the individuals, which increases the sense of ownership, participation, and diversity of personal expressions.

It was the residents themselves who called their neighborhood a 'kumpung in the sky', where kumpung means the traditional Malay village. They also

FIGURE 9. Bedok Court condominium, Block 1 17th storey, typical corridor adjacent to entrance verandas/forecourts. (Source: Author)

FIGURE 10. Bedok Court condominium, Block 3, typical entrance verandas/forecourts. (Source: Author)

mentioned that they felt as though they were living on the ground where each house has a garden along the streets.

FIGURE 11. Bedok Court condominium, Block 1, typical semi-open forecourt to each apartment unit with views across voids and other forecourts at different levels. (Source: Author)

Socio-climatic Beyond Bioclimatic

The success of Bedok Court is a demonstration of a design that is premised on correlating social with environmental aspects. This is moving beyond the bioclimatic (Olgyay and Olgyay 1963) to a socio-climatic model (Bay 2005). The court caters to the bioclimatic comfort for activities, but also embodies the social dynamics of community building.

If one is to award points for more holistic sustainable design, Bedok Court should receive points for both its social as well as environmental qualities.

Ideas of Community and Privacy Differs for the West and Asia

It is interesting also to note that, while there is a predominant understanding in western and westernized countries that "public and common spaces" provide the realm for community building, Bedok Court and the South-East Asian traditional communities can develop from private spaces that are shared with the communities. This is not to say that there are no communal spaces shared by the community such as the void decks, lift lobbies, corridors, common sports facility, play pools, and garden in the case of Bedok Court, but the same study also showed that the key catalyst for community building was the forecourt-veranda space to each apartment.

Ninety percent of the residents when interviewed expressed that they did not feel a lack of privacy,[8] nor were they particularly disturbed by noise problems. In fact they welcomed the openness of their forecourt gardens that allows personal expression, and rich diversities that they could share with the community.

Traditionally, the semi-open veranda is the living space of the house, and in the case of Bedok Court the forecourt-veranda is very different from the balcony (both categories found in Bedok Court) with regards to social bonding. The balconies are private spaces looking away from the community to distant views, while the forecourts relate to passing neighbors meaningfully.

This category of social space being the "open private" type is not included in the five categories discussed by Newman (1972) in *Defensible Space* or Chermayeff and Alexander (1963) in *Community and Privacy*.[9] This private-open-to-community category is not the only category found in the Asian context that differs from the categories recognized in the West. There is another category that involves small groups of 20 to 30 families that is in a sense private yet common, thus the "small-group-private" category.[10]

Need More Understanding About High-Rise High Density Developments?

For Jan Gehl, "life between buildings" is concentrated in the public realm and on the ground (Gehl 1971, 1987). The whole discourse of urban life, community and character of the city is discussed mainly at the low levels. Bedok Court, however, exhibits much social dynamics in the sky and on the ground, and there is a whole area of discourse and understanding needed in this direction, especially for the needs of the rapidly developing and dense Asia cities.

In the case of Bedok Court, there are both the high-rise, high density and low-rise, high density examples, where the low rise apartments do not experience the winds of higher speeds in the high-rise blocks (Bay et al. 2006). For the high-rise blocks, occupants experienced higher wind speeds more frequently for both the higher and lower apartments. The pilotis create gaps below the high blocks, which cause the winds on lower levels to match the speeds of the winds at the top levels. Whilst for the lower blocks, they could only experience the low speed winds. There was no significant difference observed in terms of social dynamics in the high- or low-rise apartment living.

The Ideals of Le Corbusier Revisited and Updated

One may argue that there should be no high-rise apartments, but low-rise, high density apartments that would be more sustainable, but that is highly debatable and is a separate issue to discuss at length. Owing to the pressing need for land and economic development in many developed and developing cities, where proximity and human contact remain important and desirable for live-work-play processes, it is unlikely that high-rise apartments will go away, but they are more likely to increase ever so rapidly. It is better to understand possibilities and potentials of good designs in the sky and thus create better social-environmental atmospheres for living in both the low- and high-rise cases rather than leaving things to the fate of uninformed practices.

It is sad to witness the declarations of the death of architecture and later the death of theory in architecture. But there are other views that architectural theory is not dead. Bedok Court is an example of an anti-thesis to Pruitt Igoe at two extremes of quality in social and environmental terms, and shows that the ideals of Modern architecture about community, sun, and gardens in the sky are not unrealistic. Ninety-five percent of the 4-million cosmopolitan populations in Singapore live in high-rise

apartments with reasonable quality of life. Unlike Le Corbusier, today we have a lot more understanding and know-how about various social and environmental issues.

There are many other developments in the world showing different degrees of success with more considerations for the social-environmental dimensions, and there are many studies made into the issues of sustainable urban neighborhoods with much emphasis on the social aspects.[11]

There is certainly room for a more critical[12] functionalism that is responsive to specific local microclimate and social context. The question is whether such aspects are carefully integrated into the current theorizing and practice of sustainable architecture and engage the interest of most architects.

ESD IS NOT NECESSARILY A KEY THOUGHT IN THE PROCESS OF THEORIZING AND THE PRACTICE OF THE ARCHITECT

The Camps of Architectural Theories and Practices Are Divided in Approaches to Artistic Expressions with the Design of the Built Environment

In the reflection on a *New Agenda for Architecture,* Kate Nesbitt (1990) brought together in her book several "camps" in theorizing architecture.[13] On one end are those who focus strongly on post-colonial, post-structuralist cultural issues and metaphorism, and on the other the end the push for more environmentally friendly design in the bioclimatic tradition (e.g., McDonough 1996). There is also the proposed approach of Critical Regionalism (Tzonis and Lefaivre 1990), generated from Lewis Mumford's critique (1930s to 1970s) for a more progressive functionalism, sensitive to a region, the people, technology, and the environment.

Considering much critique on the failure of metaphorism, there is a belief that there would be a shift to ecological functionalism (Pallasmaa 1993). There are those that continue the furtherance of understanding more about the architectural expression of the environmental control systems (e.g., Hawkes 1996, Biard 2001), and Susannah Hagan proposes that the architect ought to subscribe to a new contract between architecture and nature (Hagan 2001).

Yet there are those that are still preoccupied with mainly the concerns of the cultural dimension. In "Ethics and Poetics in Architectural Education," Pérez-Gómez, who like many other writers has always been critical about the limits of science[14] and banality in practice, proposed that the architect's duty is in engaging the cultural dimension of society, but make no reference to the duty of the architect to the environmental crisis. Despite the differences, each attempts at arriving at a certain argument for a language, a poetic statement, a way of artistic expression with the design of the built environment.

The Design Thinking Process of the Architect is Preparamatric

The other aspect about the design thinking process of the architect is that it is preparametric (Bay 2001), in the sense that it is reasoning by analogy and graphical manipulation mainly with little mathematical computation. When the architect refers to environmental design books, she would look at the rules, principles, and quantitative guides, and use them by analogy or approximation. For instance, she would be looking at the proportion of the roof to the walls for shading, or the angle, but would not be using calculations or simulations to predict the performances like the engineers would.[15]

An industry-wide survey of practicing architects in Singapore regarding their design process in relation to environmental design showed that there was hardly any inclusion of parametric environmental design methods or use of simulations in the initial design stages (Wong et al. 1999). The architect would have finished her concept and sketch design development by the time the mechanical and electrical engineer received the plans for analysis, thus leaving little practical time for major changes to the design since the client would be in a hurry to build.

How to Seduce the Architect to Love Engineering ESD?

There may be more architects today who are more inclined to consider ESD with the help of the engineers if the client can afford the extra time and fees, but there may not be many. Even if compliance to current engineering ESD requirements becomes compulsory in many countries for each building project, the architect may not warm up to it naturally.

The architect, whose design thinking process is predominantly preparametric, is chiefly concerned about social-economic issues and the poetics of architecture, may continue to do so, relegating the task of compliance to standards of energy use and emissions, etc., to the engineer to resolve or give advice for the last minute architectural intervention after the design has been conceived.

It would be a cognitive bias to assume that all architects are interested in ESD in this time of environmental crisis. Even the writings on a theory of architecture based on its relationship with the environment such as that of Susannah Hagan are about persuading the architect to have a contract between architecture and the natural environment, which may bring it closer to the engineering slanted ESD.

The current architectural education, theorizing, and practice are about so many things that may or may not include part of the current ESD thinking and practices. However, if rating systems begin to acknowledge more and more of the social-environmental dimensions, the interrelatedness, where the concept of "green" is enhanced or expanded with issues of the human social-cultural-economic nuances to be more comprehensive and holistic, this may increase the interest of more architectural theorists, students, and architects to invest more time and effort with sustainable design strategies in the initial design process and in education.

SHADES OF SOCIAL-ENVIRONMENTAL CORRELATIONS

Ideally and theoretically, sustainability can be understood as balancing and maintaining ever evolving tradition with social-cultural diversity, economic choices on building projects, and considerations on the impact on the natural environment (Williamson et al. 2003, p. 85). The following subsections consider the limits and potentials of including various aspects of social dimensions in research and practice, in the discourse toward a more holistic model of sustainability for research and practice.

Behavior, Cultural Value, Social Capital, and the Physical

Human behavior is governed by cultural bends, economic attitudes, and choices, and will affect the degrees of responsiveness to environmental ethics, and thus the level of efforts invested in making sustainable building projects. Human habit may also frustrate the efforts of supposedly good environmental control systems in the sense that the users do not normally act the way the designers think they ought to in relation to using the physical environment to save energy, for instance.

Another important social dimension is the aspect of social capital[16] that contributes to the economic sustainability, which is achieved through promoting social-cultural diversity and connectivity. This aspect is particularly acute in the needs and levels of productivity of the poor and developing places in the world. The appropriate planning and design of the built environment can promote social capital as well as minimize impact to natural environment. This is certainly in the interest of any city authorities to encourage the planning, organisation, and design for such qualities. Potential for higher productivity for a commercial development can also be an incentive for the developer who wants a more saleable or rentable product.

There is also another angle to cultural values that is ascribed to traditional urban fabrics that may not be easily replaced if destroyed in redevelopments. The disruption of traditional urban conditions and the defacement of the character of the place can impact on the existing dynamic social networks and sense of place and belonging, and may also affect tourism and in turn affect the social-economic sustainability of the place.

LEED and Limits in Assessing Social Dimensions Contributing to Sustainability in Quality of Life

Does any current ESD system guarantee better social quality of living now and into the future?

Even if we agree that the holistic sustainability model is a balance of the social and environmental dimensions, we are not sure of the weighting of importance of each dimension for a rating system to fairly reflect the contribution toward sustaining better quality of life now and into the future. Green design rating systems were initiated and developed mainly with engineering methodologies, but some systems do account for aspects of the social dimensions in limited ways, and much more consideration is needed. The provisions for

assessing and weighting of contributions in social sustainability remain very low.

There are an increasing number of suggestions in many international conferences and journals to include more social-environmental dimensions into the ratings systems.

Ong and Cam (2006) examined the lack of considerations for social dimensions in many rating systems, and demonstrated examples of how social-economic behaviors and habits in the high density context can make the environmental design intended to lower the carbon footprint ineffective.

The Journal of Green Building itself has published many papers that argue for more inclusive and holistic approaches.

In the case of the design for social sustainability at Seattle's Central Library (Athens 2007), the author commented on the limitation of the LEED rating system to account for various social dimensions such as public good, health, well-being, quality of life, diversity, and equity related to social capital. Only 28% of the 69 total possible credits directly benefit people, meaning 72% relate to the non-socially related issues. There is a possibility to include issues such as: design to encourage social interaction, accessibility, economic development, cultural arts, and improved staff efficiency and ergonomics.

Let us for the sake of discussion assume an equal weighting for social sustainability as well as environmental sustainability, in the holistic model of sustainability. The Seattle Central Library would then be credited with far more points than 34 points for a Silver status. Athens (2007, p.5) suggested a scenario of possible LEED credit points for the benefits in the social dimensions. Points were given for the reduction in embodied energy for using local materials, but there are no points for the economic contribution in support of local suppliers. Points were credited for provision for cycling that reduce the use of cars, and points for improving the health of people could also be awarded. If LEED does not just give points for reduction in embodied energy for instance for using local materials, but awards points also for the economic contribution to local suppliers, etc., there would be a fairer recognition of the contribution to a better quality of life.[17]

It is also heartwarming to read how historic W. P. Fuller Pain Company building was rehabilitated and awarded 39 LEED points (Young 2008), and that it is possible to get sufficient credits with old buildings even with the existing criteria sets available. It was also cheaper to recycle the building rather then to build anew. The project would have received even more points if the social-cultural-economic value of the historic building that would have contributed to social sustainability were accounted for.

It is interesting to note the Australian Green Star is dubbed the "LEED's Australian Cousin" (Bondareva, (2007). It too has its limits in considering the social dimensions. The Melbourne Council House 2 (CH2) has won the highest 6 Green Star status in green design effort in Australia. There was consideration for the social well-being and productivity of the people in terms of better air quality, lighting ambience, views, indoor plants, and breakout spaces. An independent assessment of the building after the first year of operation showed that staff productivity gained by 10.9%, more than double the forecast of 4.9%.[18] There was also a great annual cost savings, reducing the payback period from 10 to 7 years. While the benefits from social well-being and productivity remain the main incentive for potential new building owners, developers, and designers, the credit for the design aspects that contributed greatly to social sustainability was not adequately accounted for. These statistics of the benefit may provide the basis for awarding more points for social-economic sustainability for future projects.

Athens (2007, p. 19) also acknowledges that assessment of credits for individual building site is more limited when accounting for urban neighborhood projects. She suggested that they can be more success with the pilot LEED for Neighborhood Development tool, which considers compactness, comprehensiveness, connectivity, "walkability," health, diversity in jobs opportunities, housing types and affordability, community public spaces, outreach, and participation.

There are also the arguments of greater resource savings and social benefits in understanding the limits and potentials of the networked cities and conventional compact cities and neighborhoods, which would be a challenge to account for in a green credit system. Worthington (2009) in "Urban Form for a Sustainable Future: How Sustainable is Distributed Working in the Networked City?" discussed the

balance of building and organizational design, how humans work optimally with maximum resource savings in the context of the networked city. Yoko (2008) discussed the issue of work-life communities by "telework" and urban socio-economic issues. There are interesting problems in balancing the issues of human behavior, economic means, time, energy, and resource savings, and the perennial need for appropriate physical social spaces balanced with networking—challenging the current urban models and sustainable design assessment models.

This is encouraging. However, the ideas of social behavior, social capital, and cultural value may not be readily acceptable to the assessors whose frames of mind are predominantly trained to see parametric engineering contributions more readily and thus judged as more important. This is a typical systemic error of judgment owing to the heuristic bias of availability (Bay 2001). Also, in the practical sense, they do need help from other experts to supply the methodologies of weighting and assessing the various non-engineering aspects of design. Part of the problem is the difficulty of quantifying social qualities for numerical ranking and comparisons as opposed to the physical parameters in environmental science. More research and understanding is needed to inform the relative weighting of each design contribution.

Advocacy and Community on Sustainability

Credit points can be considered for contribution to advocacy and helping the social process of learning about sustainability, including exhibitions and computer information counters with connections to sustainable design sites and Internet communities involved in promoting sustainable living and designs. One cannot underrate the importance of this social process and perhaps more points can be awarded.[19]

Cultural Values and Social Capital in Developing Cities and Villages

Sustainability must be discussed on the urban scale (Lehmann 2007), and there are great urban issues, particularly in the developing cities. Many cities that are rapidly developing and suffering from cultural decay and environmental problems are also in the tropical regions[20] around the world (Bay and Ong 2006). Current ESD rating systems are not only inadequate in accounting for the value of existing urban fabrics and social structures, but are also inadequate for assessing designs in the tropical regions.

Many government agencies in developing nations adopt systems used in developed nations and apply them almost directly to their local cities and villages. The top-down approaches disregard multiple layers of social issues for sustainable developments in India, for instance (Mathur 2008). There is also the issue of affordability of housing that will affect social sustainability. The issue of sustainability in the context of China in a specific province with a historic site again renders arguments for more consideration for the social dimensions, warranting a bottom-up "Living Heritage Approach" as opposed to the top-down conventional approach to conservation (Kong 2007).

Bulldozers were razing down 10 historic districts in Singapore in the early 1980s. Through the campaigning by a radical group of students led by an architect,[21] the city realized the value of these districts, stopped the bulldozers, and guarded these districts by law as conservation areas. The regular rating system such as the LEED system might give some credit to regenerations of brown sites based mainly on the possible savings in embodied energy. This may account partially for the amount of energy and material needed to rebuild if demolished, but there is no mechanism to award points for the socioeconomic values (and the time and effort needed to reclaim the loss) that are directly related to the environment that contribute to a more holistic sustainability.

The world is full of such environments that need redevelopment, where accounting for the physics alone of an individual building will not reflect the actual contributions toward holistic sustainability. There must be new models to discuss these urban social-environmental correlations.

Social Capital and the Developed Cities

In proposing new types of housing (2004–2005) for a population of 35,000 people from around the world in *one north,* a new hub for technology, business, and the arts in the developed nation of Singapore,[22] it would be careless to avoid engaging the issues of

diversity, connectivity and choice, social capital, the creative class, recognition of the individual and personal expressions, and the socio-climatic approach for high density living in the tropics;[23] the holistic multi-dimensional approach.

In the theory of the "Third Ecology," the way the city is planned and designed with consideration for social, psychological, and economic aspects, travel time and opportunities for human diversity, contact and exchange can affect the human potential, where people are valuable resources, creative and productive (Chermayeff and Tzonis 1971), and affect the sustainability of social quality (Tzonis 2006). There are observations of creative people who would move from highly top-down planned cities with strict zoning to smaller spontaneous towns with much diversity, choice, recognition of the individual, and personal expression, just as people would move out of Pittsburgh to Greenwich in the past threatening the social-economic sustainability of Pittsburgh (Florida 2002).

Social capital is equally important for the developed and the underdeveloped worlds. Robert Putnam (2000) argued that, "Whereas physical capital refers to physical objects and human capital refers to the properties of individuals, social capital refers to connections among individuals—social networks and the norms of reciprocity and trustworthiness that arise from them. . . ." A society with a dense network of reciprocal relations is rich in social capital, while one with isolated individuals may not be that well off.[24]

Demand and Supply of Places Rich in Potential for Building and Sustaining Social Qualities

Places[25] rich in potential for diversity of personal expression and rich community network in a well tempered physical environment in the high-density context such as that in Bedok Court are rare. Places like the pedestrianized districts of Copenhagen and Melbourne, with *life between buildings*, are rare.[26] But if they remain rare, they can become victims of the capitalist system, and may not be sustainable.

Greenwich was a spontaneous town when it all happened in the 1970s. However, it was so successful that almost all of it was bought up by the rich and the creative class would have taken flight to other places. If many more towns of a city have the capacity to promote the right mixture and integration of social-environmental qualities, then such places would not be a rare commodity and become expensive. As supply and demand matches, it would become affordable and more people would benefit, and a city with such offerings would be more sustainable.

The dynamic social-economic changes of the urban context of the empirical cases discussed above may be far more rapid than the natural ecological changes, and affect more immediately the provision and the sustainability of quality of life for the richer and the poorer, the more temperate and the more tropical regions. Yet the current green systems of assessing sustainable designs reward mainly contributions to the engineering aspects of sustaining the environment. A new way of addressing this matter is needed.

CONCLUDING DISCUSSIONS—FOURTH ECOLOGY, MULTI-DISCIPLINARY RESEARCH AND MULTI-DISCIPLINARY TEAM FOR GREEN SYSTEMS

Is the Concept of a Fourth Ecology Needed?

Sustainability involves the social, economic, and environmental dimensions (built and natural). Community, diversity, harmony, and connectivity are fundamental for social sustainability and can be facilitated with appropriate architecture and urban designs. Human behavior and habits can enhance or frustrate environmental sustainability efforts in the reduction of carbon footprint, indoor air quality, emissions, and impact to the natural environment. There are potentials in sustaining and regenerating social-cultural values in various historic districts, traditional villages in rapidly developing or redeveloping cities, and towns that suffer dramatic economic changes such as industrial towns.

Organizations such as the United Nations and UNESCO have always taken more holistic approaches to sustainability, placing *social capital* as a valuable resource and pivotal to sustainability alongside the provisions for adequate management, healthy built environments, and balance with natural ecology.

The Third Ecology as defined in *Shape of Community* (Chermayeff and Tzonis 1971) is "The ecology of the man-made environment created by culture and technology" for the realization of human potentials, where technology is defined as ". . . a composite of technical, psychological and economic concepts . . . a social economic structure. . . ." The First Ecology is nature, the Second Ecology is man's built environment with little consideration for nature, human culture, and social-economic structure. The Third Ecology proposed, theoretically, a way of optimizing the human potential by integrating 60 interrelated issues of community, culture, psychological and economic aspects, and the urban built environment[27] with appropriate urban design.

The focus on a Third Ecology in the man-made urban settings without discussing the thorough engagement and correlation human behavior with natural ecology is lopsided, and in a sense suffers a cognitive bias that is similar to focusing mainly on current engineering ESD methodologies to solve the problem of sustainability. Discussing human behavior and carbon footprint without discussing social capital, residual cultural values of urban fabrics, and other social (and economic) dimensions of sustainability is also incomplete. The concurrent slowing down of the effects of climate change and the sustaining of values and efficiency in building and sustaining social-economic qualities in urban fabrics are necessary. In a sense one needs a concept of the "Fourth Ecology," which looks at impacts on social ecology and natural ecology in multiple correlations with the built environment, all at once where possible.

The socio-climatic approach (Bay 2005) demonstrated by the Bedok Court design precedent above is a good example of the possibility to think, design, research, and discuss dynamic multiple correlations. The semi-open forecourt in the high-rise high density development provides the thermal comfort not only for the court, but also the interior of each apartment, reducing the need for air conditioning dramatically, and acts as catalyst for individual expressions, building and sustaining community with a rich sense of belonging and security. The socio-climatic implications of urban canyons of many historic or new districts, satellite town approaches, etc., with diversity, pedestrian, and digital connectivity, in different parts of the world, would also involve multiple correlations.

The concept of the Fourth Ecology would not be objectionable to the architect, since she has always been concerned about both the social and environmental issues. There is hope in the ideals of Modern architecture, which was never divorced from poetics, but embraced the social and environmental dimensions, as discussed above with the dialectical comparison of Pruitt Igoe and Bedok Court in the history and theory of architectural thinking. Besides the public pressure of doing the politically correct, advocacy and education with more multidisciplinary research informing comprehensive design approaches can encourage more architects toward sustainable designs.

Toward a Fourth Ecology with Multi-disciplinary Teams and Research

Top-down rules of design, whether it is broad principles for education and practice, or institutionalized regulations and guidelines, can only be effective if they are developed with a bottom-up understanding. On the ground precedents would by nature be dynamic and multi-faceted, rich in various social and environmental dimensions. Precedent-based studies[28] rich in cognitive knowledge structures can be ideal for multidisciplinary research, as well as informing design thinking.

Brundtland Commission (1987) suggests a sustenance level of quality of living; bearable, just enough in all aspects, embracing the social, economic, and environmental dimensions. In a discussion of a paper at a recent international conference in Bangkok,[29] Brenda and Robert Vale (2009) briefly mentioned the idea of "sufficiency economy" planned by the government of Thailand and their current research on what that may mean in the context of New Zealand, what that may be in both physical and social terms for a sustainable balance between human behavior and carbon footprint.[30] Somehow the minimal need bases for America, Singapore, or Australia would be very different from Thailand and New Zealand.

The justified weighting of relative importance of the social (culture, community, health, and eco-

nomic) and environmental (bioclimatic, climate change, natural ecology) components of sustainability is an interesting area that demands more thought. For a poor nation, social sustainability may warrant a much higher weighting, but for the rich nations, addressing climate change (with current ESD directions and carbon trading policies) and the maintenance of status quo is a bigger issue.

Research centers worldwide have been recognizing the value of multidisciplinary research works. There is a need for more multidisciplinary teams with relevant scientific methodologies (be it physical or social science, etc.) to advise the current green systems toward more holistic approaches.

Can there be scalable ranking and rating systems for the social dimensions of green design in parallel with those for environmental dimensions in energy and carbon footprint? Can there be more ways to rank social-environmental benefits using methodologies from social science, architecture, and psychical science?[31]

Here is a summary of suggestions for further research with multidisciplinary teams of architects, social scientists, and engineers:

1. Exploring the socio-climatic approach, beyond bioclimatic, involving social science, environmental science, and architecture;
2. Noting the limits of public spaces for community building, and understanding alternative working models in many cultural settings for spaces that are catalysts for diversity, flexibility for individual and community expressions and changes;
3. High density urban developments, especially high-rise, high density mixed developments, considering the human scale, movement-time limits for effective communications, and not just as singular buildings;
4. Understanding how digital networking complement the much needed organisation and physical design for face-to-face social intercourse;
5. Relying more on empirical precedent studies with rich bottom-up multiple correlations of the social and environmental dynamics toward more realistic models to inform and revise top-down theories;
6. Developing an understanding of the relative weighting of the social-environmental dimensions for different contexts to better reflect the contributions of each design component or composite whole toward sustaining better quality of life now and into the future; and
7. Developing relative ranking methodologies to improve current green systems in assessing social-environmental designs.

Riding the Green Rating Bullet Train

The bottom line of the capitalist economic system that is prevalent in most societies is to make money, and top-down regulations are necessary to control damages, whether it is about drug abuse or social-environmental abuse. The ESD rating system and carbon trading ideas as a whole are moving rapidly like a bullet train supported by many "city fathers" in the world. We may as well make good use of the momentum, hop on it and make the system more holistic, accounting more comprehensively for both the social and the environmental dimensions simultaneously, working towards an ESD where the "E for Ecology" embraces the first, second and third ecologies, and nuances of a fourth ecology.

NOTES

2. Chermayeff and Tzonis (1971, pp. 39) discuss the theory of the Third Ecology in *Shape of Community.*
3. Cognitive bias in design (Bay 2001) are mental illusions that lead to systemic errors, and telling the people affected that they have such an illusion will not dispel the problem. Amos Tversky and Daniel Kahneman (2002 Nobel Memorial Prize in Economics) had been showing how professional economists suffered from biases and made systemic mistakes in judgment and decision since the 1970s. One effective way to reduce the effects of a cognitive bias in design is to show the rebuttals to the designer's belief and emphasize the truth in the alternative view in order to shift the frame of mind. This paper attempts to show evidence contrary to the subtle belief that current ESD will solve the sustainability problem and emphasize the fuller picture of sustainability. It also emphasizes the difference between the concerns of the architect and the engineer, with hope for collaboration toward more holistic approaches.
4. Of course the belief in science for solving human problems predates the Modern Movement. One can say that it is like the climax or the end of the last hope.
5. Donald Watson (1993, 1995) delineated the precepts of good environmental design as being akin to Le Corbusier's principles of good architecture. The ideals and principles are good, even though when it comes to actual built works, many aspects of Le Corbusier's work including sun-shading did not perform as intended (Banham 1984).

6. In a study trip in early 1980s, the author found a supermarket occupying half the void space of the famous pilotis ground area. There was little visible sign of community life.
7. Unless stated otherwise, the information in this sub-section of the case of Bedok Court is all referenced from Bay 2005 and Bay et al. 2006, based on a completed research project by Bay, 2004, National University of Singapore.
8. They also have their more secluded interior spaces of their interior to retire to for privacy.
9. The five categories being: "urban-public" (or "urban-semi-public" use including civic parks, schools, health facilities, and courts), "group-public" (including garbage collection, mail delivery, and utility control facilities), "group-private" (including communal facilities, circulation paths, lifts and lobbies), "family-private" (including apartment living room, balcony), and "individual-private" (including private bedroom, balcony).
10. One may argue that the Byker Wall project also presents a category similar to that of Bedok Court, but there are major differences. This opens up an interesting area of research. Please refer to discussions that a balcony is not a veranda, small-group-private social spaces, etc., in Bay, J. H. Integrating nuances of local urban environmental characteristics and community for high-rise, high density living. In *Proceedings of mAAN 2nd International Conference: Towards Modern Asian Architecture*, edited by Shiqiao Li, et al. Singapore: Centre for Advanced Studies in Architecture, National University of Singapore. (2002).
11. Populism Tzonis and Lefaivre (1992) have discussed "populism" in the cases of the Byker Wall residential development at Newcastle upon Tyne, England, designed by Ralph Erskine, 1968–74, and the Centraal Beheer Office Building, Apeldorn, Holland, 1968–72, designed by Herman Hertzberger b.v. There is much discourse on urban neighbourhoods by authors such as Rudlin and Falk (2009), etc. There are also many discussions of communities and regenerations projects in Asia such as those in Lau et al. 2008, etc.
12. Critical here is in the similar sense as Tzonis and Lefaivre (1990) as more the Kantian consciousness in Critical Regionalism. Though Critical Regionalism refers to regions, it does allow for the concept to be applied to micro contexts.
13. Please note that in this section it is not possible to survey the entire history and theory publications that have shown the diverse directions of architecture thinking and practice. This is only one of the volumes where many major theories are brought together, and shows the case that there are great divides in the approaches to architecture.
14. Alberto Pérez-Gómez is known as a theorist and a promoter of phenomenology and has been critical of the limits of science, especially in his seminal publication: *Architecture and the Crisis of Modern Science*, 1983.
15. Not surprisingly this heuristic in design thinking is prone to cognitive biases and errors in judgments (Bay 2001). Also, many architectural books on environmental designs are written with the architect's frame of mind, where the author is also subjected to the preparametric heuristics, biases, and errors. One case in example is Robert Powell's writing on the Bishan Institute of Technical Education in Singapore where the writer assessed the success of the building in sun shading and ventilation with preparametric heuristics and wrote that the building performed very well, when in fact in an empirical study with proper surveys by Bay, the building has failed rather badly in these areas. An architect reading this book can learn the wrong thing, resulting in an error transfer from this publication into the design thinking and practice, and other publications referring to this book may continue the error transfer further (Op. cit.).
16. Social capital is an economic concept (Putnam 2000) about trusting and connected community of diversified individuals with potentials that communicate, share, trade, etc., thus contributing to economic sustainability. In the 1970s there were more methodological arguments to substantiate this concept which was around much earlier in history. Organisations like the UN and similar around the world would have adopted the concept of social capital for their planning, organisation, and physical development policies.
17. Please refer to Athens 2007 for a full discussion of the case and suggestions.
18. http://www.greenerbuildings.com.au/case-study/ch2.
19. It is interesting to note also that buildings that are considered "green wash" (Burckhardt 1992) or screen and louver kitsch (Bay 2000) also contribute to advocacy, even if they do not directly contribute to the reduction of carbon footprint. It will be debatable if credit points be given.
20. Tropical regions would include the tropical and subtropical regions, sweeping across the world including China, India, South-East Asia, Africa, Central America, and Australia. If one looks at a map that is not distorted to make Europe look bigger than it should, but the true map, the tropical regions form the bigger part of the world with many rapid developments.
21. The author was among the students in the architectural workshop led by Architect Tay, Kheng Soon, at the National University of Singapore in 1985, who studied and proposed viable regeneration strategies to the 10-shophouse districts in Singapore, and presented the research to the Urban Redevelopment Authority and the Tourist Promotion Board. Singapore was then not considered a developed nation.
22. Design research and proposal by Joo Hwa Bay in 2005 in collaboration with Knight Frank for housing a 35,000 population at *one north*, master-mined and managed by the Singapore JTC Corporation and master-planned by Zaha Hardid.
23. The economic term of "social capital" was and is a common concept discussed since the early 1900s in public and with the grass-root community organizations in Singapore as a vital element for the success of Singapore, even though the concept of the survival of Singapore through community building started in early 1960s, the start of the post-colonial period. "Diversity, connectivity, and choice" was discussed by Alexander Tzonis at the iNTA Conference 2004, based mainly on theories from the Shape of Community. The revised paper was published later by Tzonis (Tzonis 2006 in Bay and Ong 2006). The economic value and problems, of the "creative class," were discussed by Richard Florida (2002). The concept of the "socio-climatic," community and environmental sustainability was discussed by Joo Hwa

Bay (Bay 2002, 2005) based on empirical studies and real design that are multi-dimensional.

24. It is interesting to note that the "Third Ecology" concept discussed human potential with reference to social-economic diversity, connectivity, and harmony in the 1970s and that the concept of social capital has developed out of similar times and with further research with economic studies and methodologies with similar conclusions and messages.
25. "Places" are multi-dimensional with layers of social and physical meanings and potentials, and is very different from "spaces" of the Cartesian length, breadth, and height, and of pure and applied physics.
26. Jan Gehl, *Life between Buildings: Using Public Space*, (1971) translated by Jo Koch, Van Nostrand Reinhold, New York (1987), was influenced greatly by the thoughts of Jane Jacob (1962), who wrote a very important critique on *The Death and Life of Great American Cities*.
27. "In 'Third Ecology' Tzonis presents the actual and symbolic interdependence between the natural world and the man-made world within the ecological system. Return to third ecology status is not a return to some abstract idea but rather a very real and practical plan that incorporates basic design with architectural tools and know-how, a plan that is developed and adapted to our current ecological state of affairs in the world." In the introduction to the symposium: "Identity and Globalization," 27 November 2009, Shenkar College of Engineering and Design, Tel Aviv, Israel.
28. Nang, Fang, *A knowledge-based computational approach to architectural precedent analysis.* The Netherlands: TUDelft Publikatieburo Boukunde (1993), discussed the cognitive structures of precedent knowledge in design thinking.
29. iNTA-SEGA 2009 International Conference, Bangkok, was co-organized by the International Network for Tropical Architecture, Sustainable and Green Architecture, and Kasetsart University, and held in Bangkok, from 2–4 December 2009, with the theme: "Bridging Innovation, Technology and Tradition: Holistic approach to (rapid) sustainable architecture and environment."
30. This is a current research awaiting publication; something to look forward to.
31. The author discussed the possibility of scaling of social qualities into quantitative points at the recent iNTA-SEGA International Conference 2009 based on social science methodologies applied to architectural design. He also announced the forming of the *Social-Environmental Ecological Design International Network* (*SEEDin)* to encourage collaborations on multidisciplinary research works that correlate social, economic, and engineering methodologies.

REFERENCES

Athens, L. 2007. Design for Social Sustainability at Seattle's Central Library, *The Journal of Green Building, Vol. 2, No. 1.*

Banham, R. 1984. *The Architecture of the Well-tempered Environment* (2nd ed.) Chicago: The University of Chicago Press (originally published in 1969).

Bay, J.H. 2001. Tropical Design Paradigms. In Tzonis, A., L. Lefaivre, and B. Stagno (eds.). *Tropical Architecture: Critical Regionalism in the age of globalization,* pp. 229–265. London: Wiley-Academy, sponsored by Prince Claus Fund for Culture and Development, the Netherlands.

Bay, J.H. 2001. *Cognitive Biases in Design: The Case of Tropical Architecture*, Published Ph.D. dissertation as a book, The Netherlands: Design Knowledge System, TUDelft.

Bay, J. H. 2004. Research Report: *Towards more robust and holistic precedent knowledge for tropical design: Semi-open spaces in high-rise residential development.* Research in collaboration with Khee-Poh Lam, Reference Number: R 295-000-034-112, Department of Architecture, National University of Singapore, 2003–2004.

Bay, J. H. 2005. Sustainable community and environment in tropical Singapore high-rise housing: The case of Bedok Court condominium, *Architectural Research Quarterly*, arq, Vol. 8 No. 3/4, September 2005. London: Cambridge.

Bay, J.H., N. Wang, Q. Liang, and P. Kong. 2006. Social-Environmental Dimensions in Tropical Semi-open Spaces of High-rise Housing in Singapore, in Bay, J.H. and Ong, B.L. *Tropical Sustainable Architecture: Social and Environmental Dimensions.* Elseiver Science, London: Architectural Press.

Bay, J.H., and B.L. Ong. 2006. *Tropical Sustainable Architecture: Social and Environmental Dimensions.* Elseiver Science, Architectural Press: London.

Bay, Joo-Hwa. 2008. Architecture of place and cognitive biases, in Guney, A. and Zarzar, K. M. (eds.) *Meaningful Environments, Architectural Precedents and the Question of Identity in Creative Design,* The Netherlands: TUDelft.

Baird, George. 2001. *The Architectural Expression of Environmental Control Systems,* London: Spon Press.

Behling, S., and S. Behling. 2000. *Solar Power: The Evolution of Solar Architecture,* Prestel Publishing.

Bess, P. 1996. Communitarianism and Emotivism: Two Rival Views of Ethics and Architecture, in Nesbitt, K. (ed.), *Theorizing a New Agenda for Architecture*. Princeton: Princeton Architectural Press.

Bondareva, E. 2007. Green Star—LEED's Australian Cousin, *The Journal of Green Building, Vol. 2, No. 3.*

Burckhardt, L. 1992. On ecological architecture: A memo, in Tzonis, A. and L. Lefaivre (eds), *Architecture in Europe: Memory and Invention since 1968*, London: Thames and Hudson, pp. 42–43.

Brundtland Commission. *Our Common Future*, Annex to Report of the World Commission on Environment and Development (WCED), United Nations. (1987)

Capon, A. G., and E. Blakely. 2007. Checklist for Healthy and Sustainable Communities, *The Journal of Green Building, Vol. 2, No. 2.*

Chermayeff, S., and C. Alexander. 1963. *Community and Privacy: Towards a New Architecture of Humanism.* England: Penguin Press.

Chermayeff, S., and A. Tzonis. 1971. *Shape of Community: Realization of Human Potential*. Penguin Books.

Florida, Richard. 2002. *The Rise of the Creative Class.*

Fry, M., and D. Jane. 1956. *Tropical Architecture in the Humid Zone,* London: Batsford.

Fry, M., and D. Jane. 1964. *Tropical Architecture in the Dry and Humid Zone,* London: Batsford.

Gehl, J. 1987. *Life between Buildings: Using Public Space*, (1971) translated by Jo Koch, Van Nostrand Reinhold, New York.

Hagan, S. 2001. *Taking Shape: A New Contract between Architecture and Nature*. Oxford: Architectural Press.

Hawkes, D. 1996. *The Environmental Tradition: Studies in the Architecture of Environment.* London: E & FN Spon.

Hyde, R. 2000. *Climate Responsive Design: A Study of Buildings in Moderate and Hot Humid Climates*, London and New York: E & FN Spon.

Jacobs, J. 1962. *The Death and Life of Great American Cities*, New York: Random House.

Jencks, Charles. 1984. *The Language of Post-Modern Architecture*. New York: Rizzoli.

Kong, P. 2007. *Social Quality in the Conservation Process of Living Heritage Sites,* Published Ph.D. dissertation, The Netherlands: Design Knowledge System, TUDelft.

Lau S. Y. et al. 2008. *Proceedings of ICONUS Conference 2008 on International Sustainable and Urban Regeneration: Case Studies and Lessons Learned*, Hong Kong College of Technology.

Lehmann, S. 2007. Sustainability on the Urban Scale: 'Green Urbanism'—Mark II, *The Journal of Green Building, Vol. 2, No. 3.*

McDonough, W. 1996. Design, Ecology, Ethics, and the Making of Things, in Nesbitt, K. (ed), *Theorizing a New Agenda for Architecture,* Princeton: Princeton Architectural Press.

Mumford, L. 1961. *A City in History: Its Origins, its Transformations, and its Prospects,* Paperback reprint, 1991, Penguin Books.

Mathur, Deepika. 2008. *Interpreting Sustainability: Examining the social approach to environmentally sustainable architecture in India,* Ph.D. Dissertation, Faculty of Architecture, Building and Planning: The University of Melbourne.

Nesbitt, K. (ed.). 1990. *Theorizing a New Agenda for Architecture: An Anthology of Architectural Theory 1965–1995*, New York: Princeton Architectural Press.

Newman, G. 1972. *Defensible Space,* New York: The Macmillan Company.

Olgyay, V., and A. Olgyay. 1963. *Design with Climate: Bioclimatic Approach to Architectural Regionalism.* Princeton: Princeton University Press.

Ong, B.L., and C.N. Cam. 2006. BEAMs and Architectural Design in Singapore Public Housing, in Bay, J.H. and Ong, B.L. *Tropical Sustainable Architecture: Social and Environmental Dimensions.* Elseiver Science, Architectural Press: London.

Pallasmaa, J. 1993. From Metaphorical to Ecological Functionalism, *The Architectural Review*, 193, June.

Pérez-Gómez, A. 2005. Ethics and Poetics in Architectural Education, *Folio 06: Documents of NUS Architecture*. Singapore: National University of Singapore.

Putnam, R. D. 2000. *Bowling Alone*, New York: Simon & Schuster. P. 19.

Rudlin, D., and N. Falk. 2001. Sustainable Urban Neighhourhood: Building the 21st Century Home. Elsevier Science, Architectural Press: London.

Tzonis, A. 2006. Rethinking Design Methodology for Sustainable Social Quality, in Bay, J.H., and B.L. Ong. *Tropical Sustainable Architecture: Social and Environmental Dimensions.* Elsevier Science, Architectural Press: London.

Tzonis, A., and L. Lefaivre. 1990. Why Critical Regionalism Today? in Nesbitt, K. (ed.), *Theorizing a New Agenda for Architecture: An Anthology of Architectural Theory 1965–1995*, New York: Princeton Architectural Press.

Tzonis, A. 1972. *Towards a Non-oppressive Environment,* Boston: Boston Press.

Tzonis, A., and L. Lefaivre (eds). 1992. *Architecture in Europe: Memory and Invention since 1968*, London: Thames and Hudson.

Vale, B., and R. Vale. 2009. The Importance of People and Individual Behaviour in the Move to Sustainability, in *Proceedings of the iNTA-SEGA International Conference, Bridging Innovation, Technology and Tradition: Holistic approach to (rapid) sustainable architecture and environment,* co-organized by the International Network for Tropical Architecture, Sustainable and Green Architecture, and Kasetsart University, and held in Bangkok, from 2–4 December 2009.

Watson, D. 1991. Commentary: Environmental Architecture, *Progressive Architecture,* 3.91.

Watson, D. 1995. Sustainability: The roots and fruits of a design paradigm. In *ACSA Proceedings 83rd Annual Meeting*, (March 1995). Seattle, Washington.

Wong, N.H., K.P. Lam, and H. Feriadi. 1999. The Use of Performance-based Simulation Tools for Building Design and Evaluation: A Singapore Perspective, *Building and Environment.* Vol. 35, Great Britain: Elsevier Science Ltd., pp. 709–736.

Worthington, J. 2009. Urban Form for a Sustainable Future: How Sustainable is Distributed Working in the Networked City?, *The Journal of Green Building, Vol. 4, No. 4.*

Yoko, K. 2008. Work/Life Community By Telework—Possibilities and Issues in the Case of Loma Linda, *The Journal of Green Building, Vol. 3, No. 2.*

Young, R. A. 2008. Striking Gold: Historic Preservation and LEED. *The Journal of Green Building, Vol. 3, No. 1.*

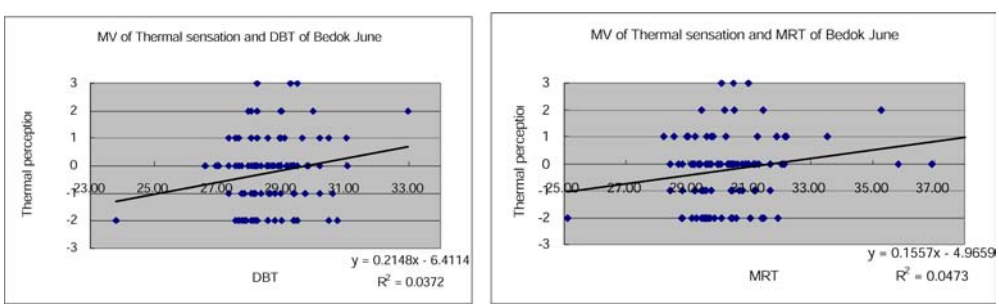
APPENDIX 1

Summary of survey results of human aspects relating to the forecourt spaces at Bedok Court (Source: Author, Bay 2005)

Responses from users on aspects of the forecourt spaces	% of respondents
Conscious of and chose the forecourt as the most desirable designed space compared to the interior of apartment, balcony, lift, lobby, playground, swimming pool, and car parking areas	86%
The forecourt was the space with the highest frequency of seeing other neighbors	80%
Used forecourt more than once a week	86%
Used forecourt as extended living area, including a space for receiving guests	52%
Use forecourt for throwing parties	56%
Use forecourt for gardening	80%
Use forecourt for children's play	72%
Use forecourt for washing and drying clothes	72%
Felt the forecourts well lit, shaded, ventilated with lots of fresh air, comfortable and relaxed, full of lush greens and felt more in touch with nature	80%
Noise level was not a problem	96%
Good environment to bring up children	84%
Greeted each other more than once a week	64%
Did not feel a lack of privacy in the forecourt	90%
Felt a high sense of security	96%
Felt strong sense of belonging and ownership	90%

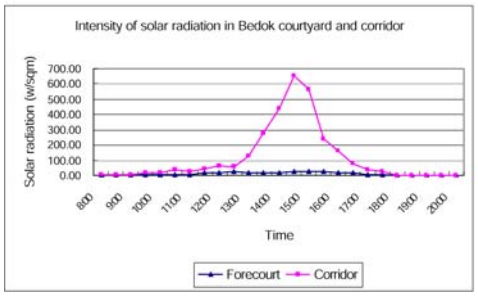
APPENDIX 2

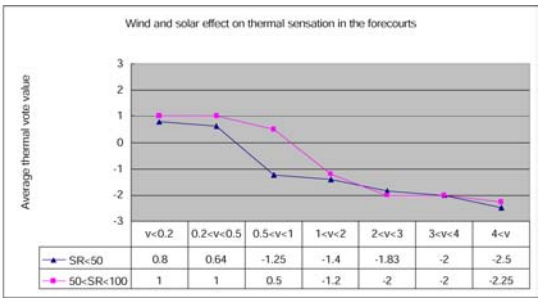
Thermal comfort votes (dots) by residents in forecourts of Bedok Court plotted against mean radiant temperature, June 2003 (Source: Author)



APPENDIX 3

Comparison of solar radiation, and effect of wind and solar radiation in veranda and corridor, Block 1, Bedok Court. (Source: Q. Liang, Bay et al. 2006)





APPENDIX 4

Comparison of temperature in corridors (typical public housing) and forecourts (Bedok Court) with and without lush plants. (Source: K. Ping, Bay et al. 2006)

	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