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Biophilic urbanism: a case study on Singapore

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This paper outlines the characteristics of an emerging new planning paradigm called biophilic urbanism by detailing a case study of Singapore, which, over a number of years, has demonstrated how high density does not have to mean reduced natural systems. The paper looks at how biophilic urbanism works to improve natural systems between buildings and on the façades and rooftops of buildings.

Keywords: biophilic; urbanism; Singapore; density

Introduction

Biophilia literally means 'love for our living systems'. It is a term popularised by Edward O. Wilson in his book *Biophilia* (1984), which he describes as an innate affinity that human beings have with nature. He stresses that humans coevolved with nature, so they need it in their daily lives. Tim Beatley has applied the idea to cities and tried to find what he calls a: 'daily dose of nature' (Beatley 2011). The biophilic city, therefore, brings landscaping both into and onto buildings, walls, roads and concrete watercourses to bring nature into every element of the built environment (Kellert, Heerwagen, and Mador 2011; Beatley 2011). The benefits are considered to include the cooling of the city (especially as the urban heat island effect grows with climate change); reduced stormwater surges, as rain slows down in the same way that it does in a forest; reduced energy needs in buildings, due to the mantle of insulation from plant life; improved biodiversity; and improved health.

This paper seeks to answer some questions about biophilic urbanism through examining Singapore and its recent activity in this area. The questions raised are as follows:

(1) Does the density of an Asian city preclude it from bringing nature more intensely into the city or does it help it?
(2) Can a dense city like Singapore make a contribution to local biodiversity?
(3) What kind of urban ecosystems can be imagined developing if biophilic urbanism is taken seriously?

The need for a radically new approach to bringing nature into cities has never been more obvious than in the endless modernist, cookie-cutter high-rise towers of the emerging megalopolises of the world, especially in Asia, where they are usually surrounded by little more than grass and concrete and where biodiversity loss continues apace (UNEP 2012).

Singapore has bucked the Asian cookie-cutter high-rise tower syndrome through its planning over many years, particularly its recent commitment to biophilic urbanism. It now appears to be a leader in this new approach to city building. This paper illustrates biophilic urbanism by highlighting what appears to be happening in Singapore and stresses the planning implications for any city as regards the three questions listed above.

Singapore: background[1]

Since the early days of independence in 1965, Singapore has worked under a vision of creating a 'garden city'. Many campaigns and slogans have been used to educate the public about the importance of keeping their city and the environment clean and green. In 1963, as part of the 'Clean and Green' campaign, then Prime Minister Lee Kuan Yew initiated a tree-planting initiative with the aim of

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Figure 1. Singapore – a city in a garden.
Source: Peter Newman.

improving air quality and marketing a 'garden city' vision (see Figure 2). To demonstrate the significance of this need to be a garden city model in Asia, Lee Kuan Yew made National Parks (NParks) a part of the Ministry of National Development at the heart of the new city-states political agenda. NParks has since been a major source of innovation for the biophilic city in Singapore (National Parks Board 2012b).

As the economy has developed, the people of Singapore's expectations of a better quality living environment with aesthetically pleasing recreational spaces have increased. In addition to this, the increasing awareness of the need for environmental protection has resulted in a rethinking of the 'garden city' model. This has resulted in the 'Singapore Green Plan 2012, beyond clean and green towards environmental sustainability', which shifts the vision from a 'garden city' to a 'city in a garden' (see Figure 3) (Ministry of the Environment and Water Resources 2002).

Figure 2. Tree-planting campaign initiated by then Prime Minister Lee Kuan Yew (1963).
Source: National Parks, Government of Singapore.

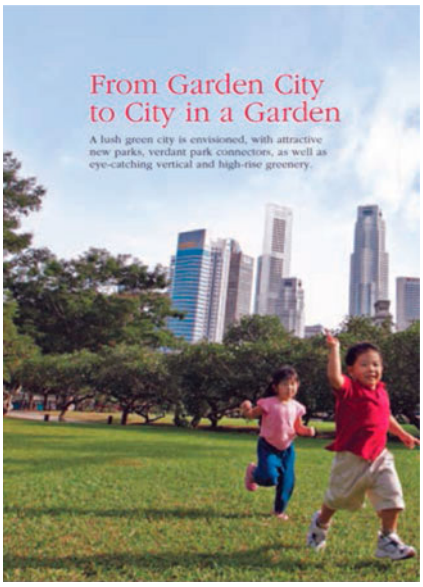

Figure 3. From 'garden city' to 'city in a garden'.
Source: Singapore Government.

At the 2012 World Cities Summit, the Prime Minister Lee Hsien Loong explained what this concept means: 'In the next phase, our aim is to build a "City in a Garden", to bring green spaces and biodiversity to our doorsteps' (SG Press Centre 2012). This seems to be a special feature that goes beyond landscape architecture and planning for parks and reserves: it means that buildings, roads and concrete are all potential sites for landscaping, as well as the usual need to set aside green spaces between buildings.

The Singapore examples of biophilic urbanism set out in this article show that Singapore is engaging in both aspects of biophilic urbanism: creating more natural systems between buildings and also creating natural systems on the façades of buildings. These will be illustrated to provide a better understanding of how some of these biophilic concepts have been attempted in Singapore and are now setting global best practice.

Biophilic urbanism between buildings

Regional plans

The Singapore Green Plan 2012 (Ministry of the Environment and Water Resources 2012), launched in 2002, is a government blueprint setting out Singapore's vision to be environmentally sustainable (see Figure 4). One of its primary components is to conserve nature by replacing natural areas wherever development has disturbed it, providing information on indigenous flora and fauna through biodiversity surveys and creating new parks and Park Connectors (an island-wide net-

Figure 4. The Singapore Green Plan 2012.
Source: Ministry of the Environment and Water Resources 2002.

work of linear parks and walking trails that link major parks and other areas, which will be discussed in more detail). Furthermore, the city has set up a National Biodiversity Reference Centre and, in conjunction with the United Nation's Convention on Biological Diversity, has launched the Singapore Biodiversity Index, which is being used to measure the extent of biodiversity in cities across the world (UNEP 2012).

The rationale behind Singapore's commitment to greater regional natural systems is to improve biodiversity, reduce the urban heat island effect and improve the thermal comfort of the outdoors, water management through reduced stormwater surges and help to reduce energy consumption in buildings (Yok, Yeo, Xi, and Seong 2009).

Streetscape plans

Creating a continuous tree canopy above all major roads is the backbone of the 'city in a garden' vision. The Streetscape Greenery Master Plan (SGMP) is concerned with extending the local identity of an area and its sense of place in the physical landscape to the stretch of road that spans the area, with the aim of creating a 'seamless green mantle' throughout the island. There are five distinctive landscape treatments based on ecosystem types: parkway treatment, gateway treatment, coastal treatment, forest treatment and rural treatment. The SGMP provided planning and design guidelines to achieve variations in the character of Singapore roads and streets. Two of these types – parkway and coastal areas – are illustrated in Figure 5.

The need to conserve some of the more scenic and significant tree-lined roads in Singapore, particularly some of those with mature trees, is expressed through the Heritage Road and Heritage Trees Scheme 2001. The current heritage roads are located in five areas: Arcadia Road, Lim Chu Kang Road, Mandai Road, Mount Pleasant Road and South Buona Vista Road (see Figure 6). There is also the idea of extending the heritage road, like Upper Thompson Road, through boulevards, in order to give it more impact.

Park connectors

The Park Connector Network (PCN) is an island-wide network of linear parks that connect major green areas and destinations (particularly residential locations) around Singapore (National Parks 2009; National Parks Board 2012a). PCNs use an integrated approach of 'greenery, conservation, education and recreation', aiming for a complete network

Figure 5. Before and after images of parkway and coastal area.
Source: National Parks 2009.

Figure 6. Heritage roads. From left to right: Arcadia Road, Lim Chu Kang Road, Mandai Road, Mt Pleasant Road and South Buona Vista Road.
Source: Peter Newman.

of over 300 kilometres of green connectors throughout the whole island by 2015. The plan is to make it possible to walk or bicycle around Singapore by travelling through the parks (see Figure 7). As of 2012, 200km of the PCN had been built (Ministry of National Development 2012), with a massive new north-south connector planned along the old regional rail alignment. This will link the CBD to the main green spaces across the island city.

The PCN optimises the use of under-utilised land, such as drainage reserves, foreshore and road reserves, by turning them into canopy-covered green corridors for recreation and linkage use by pedestrians and cyclists. One such example of these connectors is the

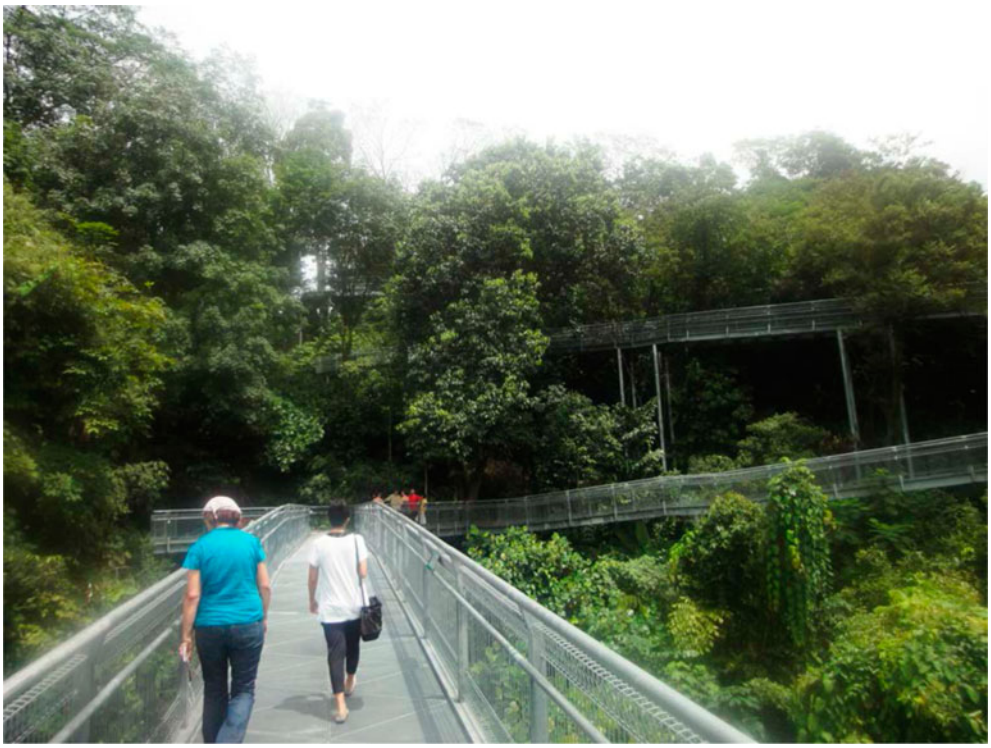

Figure 7. Singapore's Park Connector Network.
Source: Peter Newman.

West Loop Connector Park, which connects eight smaller parks (see Figure 8). The connector parks offer a diversity of recreational activities and significant flora and fauna conservation (for example, 550 species of butterfly and birds have been found there).

The Singapore Botanical Gardens (established by Raffles at the beginning of the colony) is one of the pioneering institutions designed to link parks with people and conserve indigenous and local biophilic knowledge (see Figure 9).

Hort Park biophilic R&D

Horticulture Park, located in Southern Ridge Park, is the first gardening and lifestyle hub in south-east Asia and the only garden-themed park in Singapore. The

Figure 8. West Loop Park Connector.
Source: National Parks 2009.

Figure 9. Singapore Botanic Gardens.
Source: Peter Newman.

park preserves nature, maintains biodiversity and attracts people to engage with nature through recreational, educational, research, commercial and natural developments.

Horticulture Park (Hort Park) has been set up to demonstrate and experiment with green walls and green roofs to facilitate all aspects of biophilic urbanism. The various examples of green walls have become the basis for planners, designers and builders to experiment with how they have demonstrated biophilic urbanism for Singapore (see Figure 10).

Green walls and green roofs, in particular, are being actively implemented throughout the city, with NParks undertaking significant research as to the implementation of these within a Singapore context since 2003 (Yok and Sia 2008).

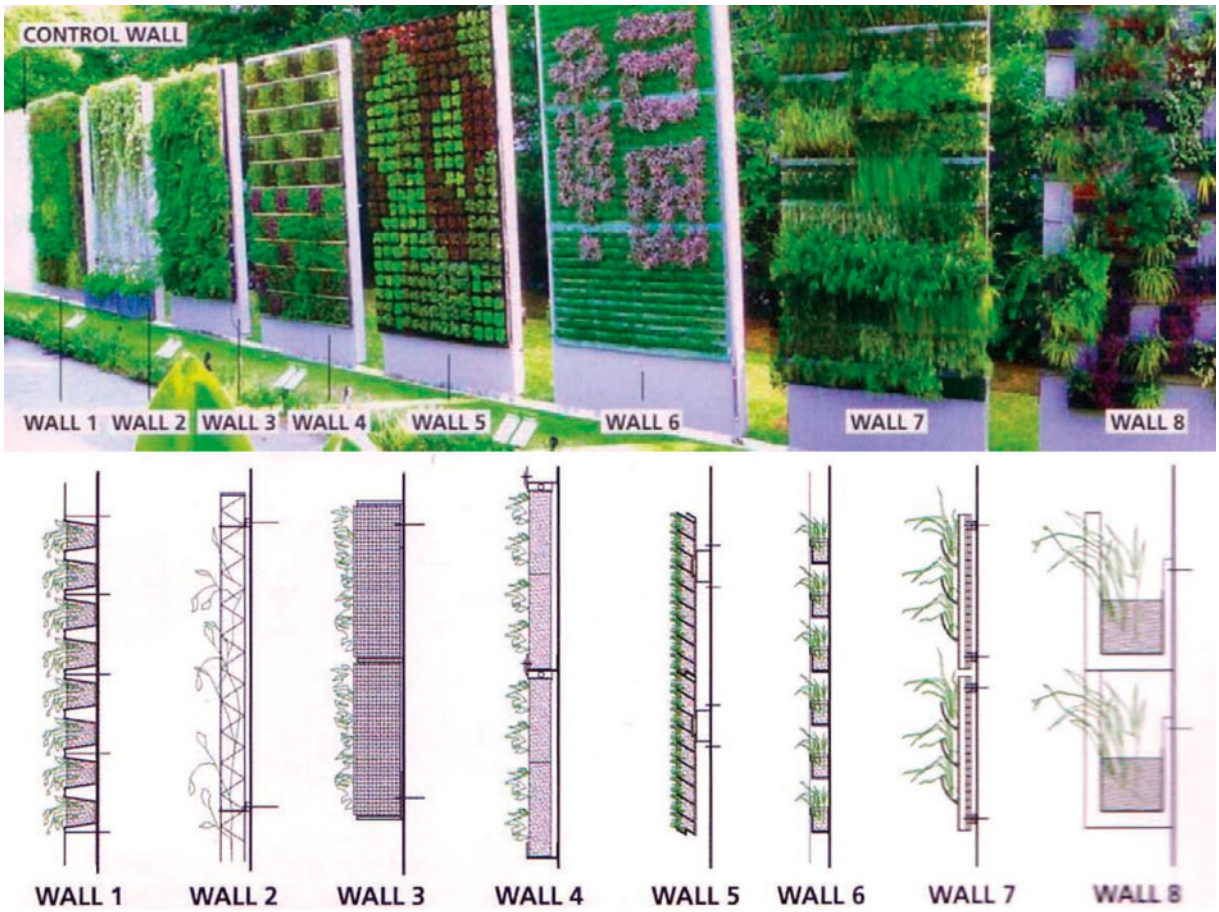

Figure 10. Hort Park R&D facility on green walls.
Source: National Parks, Government of Singapore.

The ABC of water management

The Public Utilities Board (PUB) looks after storm-water and has built concrete canals across the city for this important flood management function. They are now going biophilic by integrating water bodies and canals with parks and green spaces. The ABC (Active, Beautiful, Clean) master plan aims to enable water treatment as soon as the water touches the ground, enabling Singapore's water catchments, waterways, wetlands and man-made bio-swales to have good water quality, be aesthetically beautiful, attract people and enhance the community. They also improve biodiversity and are an important biophilic feature.

Part of the ABC master plan is the improvement of Bishan Park – a joint project with Herbert Dreiseitel's group (see Figure 11). It is the first bioengineering project to convert a concrete canal back into a river in Singapore and illustrates how the biophilic city can be achieved through water-sensitive urban design (Mouritz 1987). The combination of plants, landscaping and innovative engineering in a tropical climate is a symbol for Singapore and, indeed, any Asian city, proving that tropical design can be biophilic.

The naturalisation of the concrete canals (see Figure 12) is done by demolishing the boundaries between the canals and the ground, then using scattered concrete as part of the landscaping. Trees are replanted to filter the rainwater, before allowing it to flow into riverbanks. These naturalised waterways provide a water playground for families and naturally slow down the water flow. Emergency lights and sirens attached to a smart control system along the catchment enables clear direction to be given to the public whenever storms threaten to flood the water-way. Significant increases in biodiversity have been measured, and the park receives three million local visitors a year.

Community gardens

The program 'Community in Bloom' was launched in 2005 to help foster enthusiasm by residents, workers and students to contribute towards gardening in their community. Created through the cooperation be-tween town councils, the Housing Development Board, People's Association, National Library Board, non-governmental organisations and the pri-vate sector, Singapore's gardening network comprises community gardening groups in public and private housing estates, educational institutions, organisa-tions, charities, places of worship, community clubs, corporations and hotels.

The program is largely a response to the demand from community groups for a closer daily connection to nature. The NParks staff that set up the groups identifies a champion who can lead the garden group and together they seek the funds and volunteers needed to establish the garden. There are now 480 sites across Singapore. Increasingly, the groups are working on food production, often on the rooftops of buildings.

Figure 11. Bishan Park plan.
Source: PUB 2011.

Figure 12. Concrete from an old canal is recycled into the new Kallang River, Singapore.
Source: Peter Newman.

'Gardens by the Bay'

A new and iconic garden is the development around the Marina Bay Sands development of 'Gardens by the Bay', which features some extraordinary natural systems built with S$1 billion to regenerate a reclaimed foreshore. The 'Super Trees' and display areas are all designed as educational features, which show people how natural systems and cycles work. As a symbol of how nature can be built into a city, they are dramatic (see Figure 13).

How has it all worked out?

The greening of Singapore between buildings can be seen overall by comparing two satellite photos from 1986 and 2007, which show that green canopy cover has increased by 20%, despite a 70% increase in population (see Figure 14) (National Parks 2009a). As with the community gardens, which are moving onto building rooftops, there is an increasing sense that the next major phase in biophilic urbanism in Singapore will be on the façades of buildings: green roofs, green walls and green balconies.

Biophilic urbanism on building façades

Singapore's biophilic urbanism in landscaping buildings is found in both the public and private sectors. This process has been enhanced by the introduction of planning regulations that require greenery in (and on) buildings, the Sky-Rise Greenery Initiatives program that subsidises biophilic urbanism and the BCA Greenmark scheme, which evaluates the sustainability of new developments.

Planning regulations

Singapore has a strong planning system, with a regional structure plan that sets out the park system and creates the park connectors and a statutory scheme for each local area, with guidelines that establish how much greening of buildings must occur. In the central commercial and shopping area, such as Orchard Road, there is now a requirement that new or refurbished buildings must replace the whole footprint or floor plate coverage of a building with green space; this must be done with green roofs, green walls and green balconies. In this way, the whole city is designed to have access to nature, no matter how dense or busy the built environment has become.

Sky Rise Greening Initiative

In order to assist building owners and developers in the early phase of adopting the technology of biophilic urbanism through innovations such as green

Figure 13. Gardens by the Bay, a spectacular $1b park on reclaimed land.

roofs and green walls, the Singapore Government established a Sky Rise Greening Initiative (SRGI). NParks assess any proposal and pay up to half the cost of adding these green initiatives. Fifty-five buildings over the period 2009–2011 were granted subsidies under the SRGI. At the beginning, the cost of greening was around S$150/m^2, but after a period of two years, this came down to around S$100/m^2. Several of the case studies set out in this article on greening buildings have been given the SRGI subsidy.

The Green Mark Scheme

BCA (Buildings and Construction Authority) launched the Green Mark Scheme in 2005 as part of an effort to be green on a building scale. The scheme is intended to direct the construction industry towards more environmentally friendly developments and assesses the construction process, structure, materials used and performance (indoor quality and use of energy) of the building. The Green Mark Scheme encompasses various building-scale projects from residential and non-residential buildings, building renovations, office interiors, new and existing parks, infrastructure, district level and overseas projects. The Green Mark is increasingly incorporating biophilic elements into its assessments.

Case studies of greening buildings

Six Battery Road – existing buildings going green

Six Battery Road is a high-rise office building located in Raffles Place, overlooking the Singapore River. The developer, CapitaCommercial, wanted to enhance the performance of the building to be greener. In order to accomplish this, the developer tried to apply an efficient chiller plant, redesigning the chiller plant room system to achieve 30% improvement in efficiency and a potential improvement of up to 25% in energy efficiency, as well as a self-sustainable green wall. The creation of the iconic 184m^2 green wall was the biggest green wall installed in an office building in Singapore (see Figure 15). The wall utilises a rainwater harvesting system fed to the wall through an automatic irrigation system. The green wall was designed by Patrick Blanc, whose walls in Paris, London, Madrid and Sydney have helped to establish this new biophilic design element. The building utilises wind turbines to produce the energy needed to power the green wall's irrigation pumps and lighting. The building has a system of sensors that monitor carbon monoxide in the car park. This system brings in fresh air when the carbon monoxide levels increase beyond a certain point. Furthermore, the car park utilises natural daylight through the use of solar light tubes and provides special parking spots

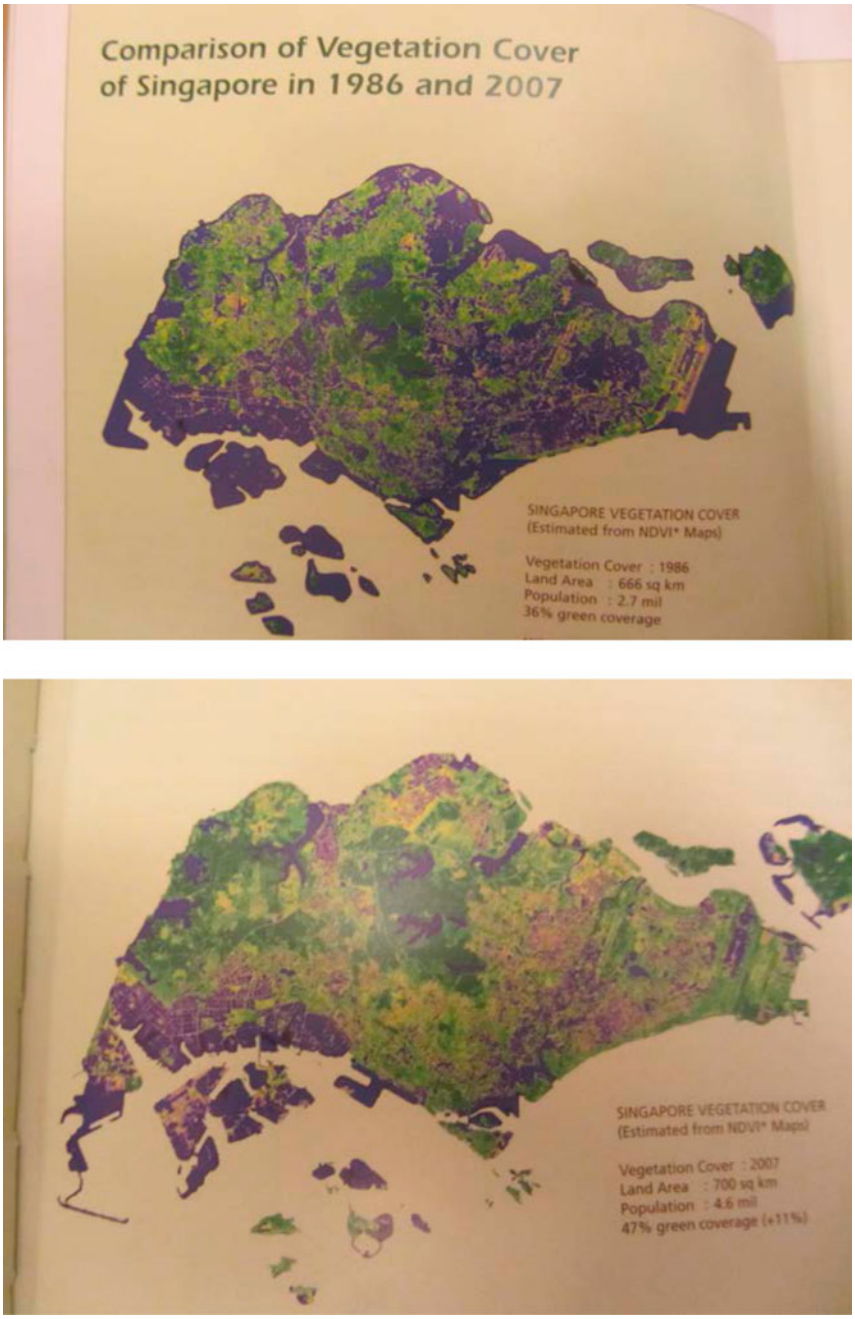

Figure 14. Singapore in 1986 and 2007, showing a 20% increase in canopy cover.
Source: National Parks 2009a.

for hybrid and electric cars. A 'green room' that displays real-time monitoring of the energy and water usage and savings is open to the public and contains an education corner for creating awareness for both tenants and visitors.

Republic Polytechnic – campus in the park

Republic Polytechnic is a development that demonstrates an integration of sustainability from the project's inception to completion (see Figure 16). One aim of the development is to ensure a pleasant environment for present and future occupants to appreciate nature in line with the government's intention to transform Singapore from a 'garden city' into a 'city in a garden'.

The Republic Polytechnic campus was intentionally located adjacent to the regional park in a secondary forest, thus enabling nature to be integrated into the campus. This connection to the

Figure 15. Green wall in lobby area.
Source: Six Battery Road 2011.

regional park on campus is provided through jogging trails and greenery, as well as a soft, but defined, boundary between the campus and regional park.

Other factors at the Republic Polytechnic campus also contribute to the biophilic concept. A compact plan was proposed to maintain as much of the existing greenery as possible. In doing so, 44% of the site surface area is made of greenery. In order to increase and replace the greenery lost, the cleared areas are replanted to integrate the campus with its natural surroundings. The campus also contains a rooftop garden and vertical green wall on the multi-storey car park, which is composed of creepers that grow from vine trays. The development also utilises recycled building materials, including recycled bio-chips for compost. A building management system monitors utility usage and ensures the optimisation of energy consumption. The energy savings of the building over the course of its life cycle is around 175,000kW per year and a photovoltaic energy saving of approximately 11,500kW per year.

Newton Suite

Newton Suite is an example of a high-rise vertical green wall. The building incorporates a lush green environment through the provision of exterior green walls, communal sky-rise gardens and vertical greenery, which extends 36 floors upwards (Chiang and Tan 2009). The design was envisioned by the architects WOHA to be an attempt at advancing the idea of a 'tropical' high-rise residential model (see Figure 17). The greenery becomes a building material. In doing so, the building has a green area that encompasses 130% of its total site area. The devel-

Figure 16. Aerial view of Republic Polytechnic.
Source: National Parks, Government of Singapore.

Figure 17. Exterior view of Newton Suite.
Source: Peter Newman

opment demonstrates the idea of having 'land' and 'green space in the sky' concept living. It was given a Sky Rise Greenery Initiative subsidy and is the winner of the 2008 SIA-NParks Skyrise Greenery Award (Chiang and Tan 2009).

Changi Airport Terminal 3 – architecture of the landscape

Changi Airport is the city's gateway and was seen as a chance to demonstrate biophilic innovation. Changi Airport Terminal 3 reflects Singapore's vision to be a 'city in a garden' by demonstrating an interior architectural landscape environment through the combination of building technology, natural lighting and a living green wall. The terminal features a 15-metre high and 300-metre wide vertical green garden wall, which features 20 different species of climbing plants found in a tropical rainforest that have been grown from planter boxes and mounted on a steel frame (Chiang and Tan 2009; see Figure 18). The wall helps to create living spaces without borders between building and garden, architecture and landscape. The green wall not only 'greens' the terminal, but also adds a unique identity to the place (ARCPROSPECT International Foundation 2011).

KTP Hospital

Khoo Teck Puat (KTP) Hospital in Yishun, Singapore, is a new 550-bed general and acute facility that opened in June 2010. It is the world's first biophilic hospital, built with biophilic features planned from the beginning.

The origins of this brave experiment are in the much older Alexandra Hospital. As the CEO of KTP Hospital, Liak Teng Lit, explains, he was asked to take over Alexandra Hospital, but found the buildings and general environment very clinical, drab and boring. He decided to appoint a chief gardener, Rosalind Tan – an occupational therapist (OT) in the hospital with good community links – and gave her the task of landscaping the hospital using voluntary labour (including a retired Professor of Botany). After three months, the environment was looking more promising, and so the staff, encouraged, began volunteering their time. The landscaping included creating a medicinal garden and fragrance garden, along with water features. Birds and butterflies began returning to the site, and they set a goal of encouraging a total of 100 species of butterflies to return to the site. After three years of landscaping, they had successfully encouraged the return of 102 different butterfly species. As Liak Teng Lit says, it was a transformation from 'this hospital is haunted' to 'this hospital is a butterfly garden' (Teng Lit, personal communication, January 2012).

Figure 18. Images of the green wall at Changi Terminal 3.
Source: Peter Newman

When the Singapore Government began to plan a new hospital, they asked Liak Teng Lit to guide the process and bring some of his 'butterfly magic' to the new site. A young architect – Jerry Ong from CPG – was appointed and although he knew nothing about biophilic design, he quickly learned.

The new KTP Hospital features a green roof that has been built to withstand extra weight and grows vegetables, fruit trees (a total of 140 trees) and spices, which are managed by a local community workforce (see Figure 19). The garden's produce is sold in the hospital canteen to pay for any garden costs.

Jerry Ong responded to the design brief to create a 'hospital in a garden' by building green walls, green balconies and multilevel gardens (including ponds containing 92 different fish species), which means that every bed and office is surrounded by plants with 'healing views' (see Figure 20).

The evidence for improved healing rates is yet to be fully analysed, but all the anecdotal evidence points to the fact that people heal quicker and are happier at KTP. Blood pressure and heart rates are reduced as soon as people enter the tranquil environment (Newman, Beatley, and Blagg 2012).

The hospital is so popular with the general public that they have regular tours for schools and community groups. Similarly, the park-like spaces are used by people who come just to sit and enjoy the space, as well as students who bring their laptops and study there (see Figure 21).

So far, according to CEO Liak Teng Lit, the KTP Hospital has found 32 species of butterflies that have made their home in the green spaces, as well as 24 species of birds. The green roofs and landscaped areas capture and re-use approximately 12% of the rain water run-off. The energy consumption of the KTP is 30% less than comparable new hospitals, saving S$1 million a year. But the health productivity gains from the biophilic elements will greatly outweigh this.

158 Cecil Street

Architect Kelvin Kan from AgFacadesign was faced with a real problem: a 14-storey commercial building in Singapore had failed to attract tenants, as the large façade on the front, which was originally built to reduce sunlight, was ugly and impractical. His solution was to create a green wall, like a 'hanging garden', effectively camouflaging the existing structure and creating natural ventilation for new green spaces on suspended balconies, thus linking offices to the new space (see Figure 22).

The green wall at 158 Cecil Street consists of 13,000 plants in an area of 350m^2, along with a further 70m^2 of hanging plants on balconies. This represents 135% of the building floor plate (not including the hanging plants) (Landscape Forum Nature and Living 2011). The resulting green columns, green walls and green balconies were a stunning success. Not only is the wall home to butterflies and birds, but it is a work of art. Looking from the bottom upwards, the green wall looks like a cathedral (see Figure 23). As soon as tenants began to see the wall being built, they started turning the focus

Figure 19. The rooftop garden at KTP Hospital, Singapore.
Source: Peter Newman.

Figure 20. Green views at KTP Hospital, Singapore.
Source: Peter Newman.

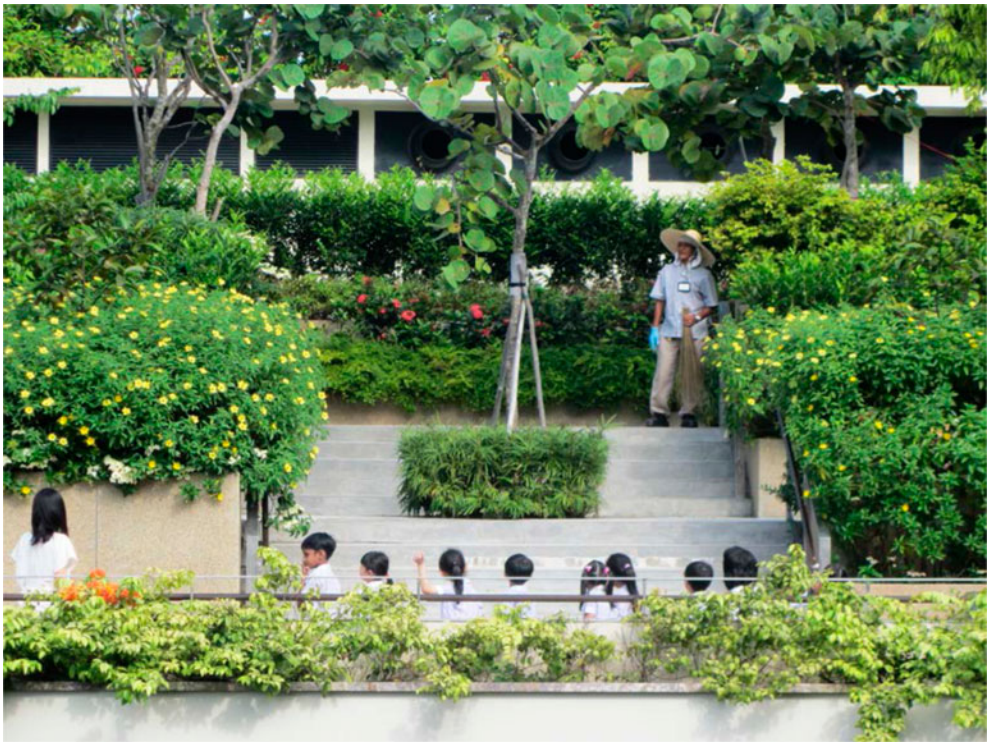

Figure 21. KTP Hospital, Singapore, is popular with school groups.
Source: Peter Newman.

Figure 22. 158 Cecil Street inside the façade.
Source: Peter Newman.

of their offices towards the green space being created. The value of the commercial rental space rose sharply as 'cool' companies chose to relocate to this new 'green' space. Needless to say, the owners of the building were very happy with the rejuvenation of their asset (Landscape Forum Nature and Living 2011; Southeast Asia Building 2011).

One important feature of the design is that every part of the wall is easily accessible, and each plant can be replaced or tended to individually, as they are each grown in separate pots with individual irrigation points. Therefore, maintenance is easy.

Hougang School

Biophilic urbanism needs to infiltrate all parts of the built environment, including institutions like schools, in order to enable them to be models for the future. Hougang Primary School in Singapore shows that biophilic innovation can be trialled by young children at very low cost.

Science teacher Mohan Krishnamoorthy was fascinated by green walls and wondered if he could make one at his school. He travelled to Paris and London to inspect the work of Patrick Blanc. What he found was a simple technique, wherein a wooden base could have a felt cloth cover stapled over the top with slits for soil added and stapled around the edge; plants could then be slotted into these pockets and, with drip irrigation, the wall would start to grow.

After setting up a trial, he was convinced that the students could do it. So, one day in July 2011, his special science CPA class (under his direction) began to build a green wall. The result was the creation of a beautiful and functional addition to the school, which already featured a range of gardens for teaching purposes (see Figures 24 and 25). The students are

Figure 23. The green wall inside 158 Cecil Street.
Source: Peter Newman.

very proud of their green wall, and the school receives many visitors because of it, who leave convinced that they, too, could make one.

The significance of this case study is that it shows how biophilic urbanism is not really difficult or expensive; indeed, it is something that can be done by anyone if they have the necessary mindset and motivation.

Questions

(1) Does the density of an Asian city preclude it from bringing nature more intensely into the city or does it help it?

The importance of Singapore's biophilic urbanism is that it illustrates the possibility of dense cities being able to regenerate natural systems and create far more natural urban systems. It is, in fact, already doing this both between buildings and all over buildings, using the existing structures to create new urban ecosystems never considered possible before. Singapore has demonstrated that density probably helps in two ways: (1) it enables concepts like park connectors and the 'Gardens by the Bay' to be developed, as they need intense land use where distances are short; and (2) it enables the height of buildings to be used to help create a third dimension in an urban ecosystem.

Thus, the positive element of biophilic urbanism is that dense cities with high-rise buildings can perhaps provide even more opportunities to build biophilic urban ecosystems than low-density suburbia, due to their extra habitat opportunities from high walls and flat roofs. This is a big issue, as the global planning world has generally recognised the need for increased densities to prevent car-dependent urban sprawl with all its oil, climate, health and economic implications (OECD 2012; Newman, Beatley, and Bower 2009). However, the need for natural systems to be part of

Figure 24. The green wall at Hougang School.
Source: Peter Newman.

this policy has always been a question that threatens to undermine value in more compact cities (Newman and Kenworthy 1999). Perhaps biophilic urbanism is a way to facilitate green and attractive cities that are also far more efficient in resources? To take away the stigma of density would be a significant planning contribution. This leads us to the next question under consideration:

Figure 25. The gardens at Hougang School.
Source: Peter Newman.

(2) Can a dense city like Singapore make a contribution to local biodiversity?

Singapore's NParks started measuring biodiversity when they began their biophilic experiments. They pioneered the Singapore Biodiversity Index, which has been adopted by many cities around the world (Chan and Dioghla 2009). These data are still inconclusive about whether Singapore's biodiversity as a whole is going up or down. The multiple local examples given above all show rapid increases in bird life and other biodiversity as soon as appropriate habitats are provided, whether they are local species or not. Indeed, many of the tree species used to provide the structures of the urban ecosystems are not native, such as the Rain Trees used to structure canopy cover over roads and parks (because their root systems fit into urban areas). KTP Hospital measures biodiversity in birds, fish and butterflies, and all of these species are increasing in number as their biophilic features mature.

Biophilic urbanism, as demonstrated in Singapore, is unlikely to recreate the pre-urban ecosystem, but nor is this ever claimed as a possible consequence. However, it can do far more to recreate the structure of the ecosystem in any area, as it can use the diversity of a city's built forms and microclimates to create urban ecosystems that are far more biodiverse and complete in their structures than in the one-dimensional urban parks and gardens that we are used to. In this, it is more like the regenerative design paradigm (Lyle 1994; Lacey and Harvey 2011; Newman and Jennings 2008). Finally, an aspirational, future-orientated question needs to be considered:

(3) What kind of urban ecosystems can be imagined as developing, if biophilic urbanism is taken seriously?

As biophilic urbanism in Singapore spreads and matures into a more complete coverage of the urban environment, it can be expected that local biodiversity will rise. Granted, it is not the same as the pre-city rainforest, but it will have many features of a rainforest, with the exception that it will also contain a city full of people. The rapidity with which Singapore has made this transition suggests that any city wanting to make a contribution to biodiversity and create a healthier and more complete urban ecosystem can now do so. The technology needed to create green walls and green roofs is now available and needs to be trialled in as many different urban environments as possible. The results could be a city where a new kind of urban nature develops, which fulfils the functions of the original ecosystem replaced by the city and contributes to local biodiversity improvements.

Conclusion

Singapore is a good example of biophilic urbanism, where the development of green areas and green buildings are being shown as regenerating the natural systems in the city and creating an urban ecosystem similar to the original structure, but with better biodiversity outcomes. The importance of the model of Singapore is that many other Asian cities are beginning to copy their approach and enable their dense urbanity to be expressed in a more natural way. The fact that Singapore has achieved this quite quickly is a tribute to their commitment to innovation in urban planning. They have demonstrated that planning regulations and planning strategies for biophilic urbanism can be delivered cost effectively with strong community support, demonstrations can be quickly mainstreamed, government incentives and R&D are all part of the mix for enabling innovative change and political leadership drives everything. The next stage in the development of biophilic urbanism will be for cities with very different climate conditions to apply the same principles and developed cities, like Singapore, to mainstream the process by evaluating and quantifying the benefits in terms of biodiversity, energy, water, health, aesthetic qualities, human appreciation and economics.

Note

1. This story of Singapore has been made into a film. See Newman, P., Beatley, T., and L. Blagg (2012) *Singapore: Biophilic City*.

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