Title:	**Beyond Skyrise Gardens: The Potential of Urban Roof-Top Farming in Singapore**
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Subject:	Sustainability/Green/Energy
Keywords:	Sky Garden Sustainability Urban Planning
Publication Date:	2011
Original Publication:	CTBUH 2011 Seoul Conference
Paper Type:	1. Book chapter/Part chapter 2. Journal paper 3. **Conference proceeding** 4. Unpublished conference paper 5. Magazine article 6. Unpublished

TS24-02

Beyond Skyrise Gardens: The Potential Of Urban Roof-Top Farming In Singapore

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Biography

Mr Donald Wai is currently the Deputy Director of the Hospital Planning department in Khoo Teck Puat Hospital, Singapore. Trained in mechanical engineering, he is also a qualified Professional Engineer focusing on the building services and facilities aspects of the healthcare industry. He has worked in multiple-roles as a design consultant, hospital planner, facilities manager and biomedical engineering administrator to ensure facility development and management are kept at the fore-front of the local healthcare industry. Most recently, he had worked with his hospital staff, design consultants and contractors to complete the design and construction of the 550-bed acute-care Khoo Teck Puat Hospital from 2006-2010, a relatively short timeframe of four years. In the process, the hospital had won multiple awards, both locally and overseas, in design, sustainability and skyrise greenery.

Abstract

The younger generation of Singaporeans, particularly those born from the 1980s onwards, might not have the opportunity to visit local farms as most of them were gradually reduced over the years. This is because Singapore is a relatively small country where land is highly limited for physical horizontal development. To cope with population influx and economic growth, it was necessary to convert farm lands into vertical infrastructure to meet the nation's emerging industrial and housing needs. The deprivation of real-life experience of farms among younger Singaporeans had not helped the cause of promoting urban farms, much less the idea of skyrise ones. Urban farms would thus see little growth potential unless there are initiatives and other motivational factors such as Government incentives, tangible benefits and residents' support. This presentation investigates the existence of roof-top gardens on public housing, private residents and other buildings as part of urban design in Singapore. Skyrise greenery had evolved over the years to include urban roof-top farming, such as at a hospital and hotel, which is still at an infancy stage locally.

The case study of the new Khoo Teck Puat Hospital (KTPH) had shown that urban roof-top farming beyond skyrise gardens was not merely an accidental venture but had yielded multiple benefits, ranging from organic food production to biodiversity preservation and energy conservation although it carries various difficulties and challenges that need to be overcome. Survey results and interviews at KTPH have provided optimism that skyrise gardens and urban farms will see much growth in future developments to meet the nation's sustainable environment plans. With the support of government initiatives and environmental proponents, urban roof-top farms will have good potential to form part of skyrise greenery plans in future local infrastructure developments, as it is happening in other parts of the world.

Keywords: Urban farming, skyrise gardens, multiple benefits, sustainable environment

1. Introduction

The younger generation of Singaporeans, particularly those born from the 1980s onwards, mostly did not have the opportunity to visit a local farm. Over the years, most farms were gradually reduced due to Singapore's meagre land size of 712.4 km^2 (Singapore Department Of Statistics(1),

2011) which saw the national need to maximize scarce land sources and improve productivity of limited farmland (Agri-food and Veterinary Authority (AVA), 2001) (figure 1). Emerging population influx and economic growth had forced the Government to convert more farmlands into vertical developments for industrial and housing needs, with greater reliance on imported food products.

Figure 1: Typical Singapore farm in the 1960s

The deprivation of real-life experience of farms among younger Singaporeans had not helped the cause of promoting urban farms, much less the idea of skyrise ones. Urban farms would thus see little growth potential unless there are initiatives and other motivational factors such as Government incentives, tangible benefits and residents' support.

2. History

Early civilization had cultivated plants on top of structures, such as the famed Hanging Gardens of Babylon (figure 2) that was recorded by historian Diodorus Siculus (Wellard,1972). During Roman times, elevated terrace of plants were recorded at the Villa of the Mysteries in Pompeii, Italy (Osmundson, 1999).

Figure 2: 16th-century "Hanging Gardens of Babylon" engraving by Martin Heemskerck

Other early records included roof-top gardens irrigated by ox-drawn water wheels in medieval Fustat, Egypt (Behrens-Abouseif, 1992) and roof-gardens around an audience hall in Roman-Byzantine Caesarea, Italy (Littlewood, Henry Maguire and Wolschke-Bulmahn, 2002).

3. Environmental Benefits Of Skyrise Greenery

Over the past one hundred and twenty years, factors such as regulatory changes and building façade technological advances had affected how energy is consumed in tall buildings (Oldfield, P., Trabucco, D. and Wood, A., 2009).

Infrastructure developments worldwide had led to contribution of greenhouse emissions, with buildings accountable for 30–40% of all primary energy used worldwide (United Nations Environmental Programme, 2008).

Part of this is due to insolation, where buildings and roads absorb and re-radiate solar heat. One counteractive measure is the use of plants. Plants surfaces transpire by absorbing heat but their surface temperatures do not rise more than 4–5 °C above ambient temperatures (Ong, 2003). Thus, roof-top plantings could reduce surface temperatures and provide resistance to thermal radiation to spaces beneath (figure 3) (Liu, 2002) resulting in a cooler environment.

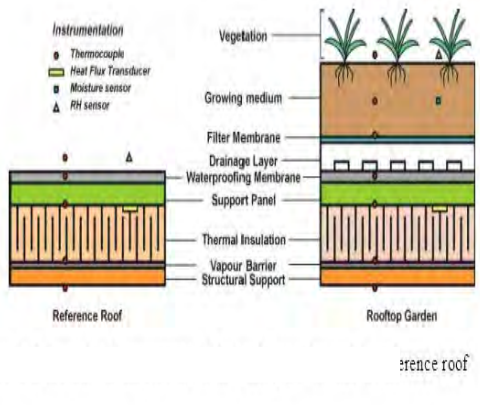
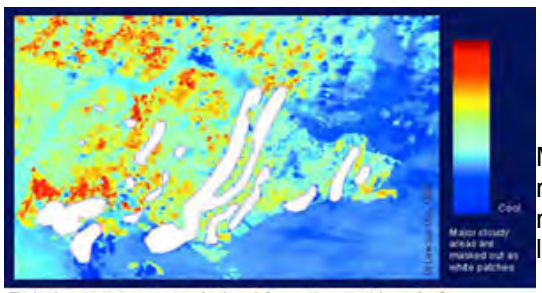


Figure 3: Typical components of normal roof and rooftop garden (Liu, 2002)

This finding is also supported by satellite images from Singapore's Centre of Remote Imaging, Sensing and Processing (CRISP), which showed that surface temperatures of forested regions are generally lower than in urban areas with less greenery (figure 4) (Wong, 2002).



Relative temperature derived from thermal band of Landsat-7 ETM+ image (April 2000).

Figure 4: CRISP images showing Singapore's different surface temperatures

Moreover, on rainy days, roof-top gardens also help to retain rainwater, including the presence of contaminants. This reduces rain run-off from the roof (Liu, 2002) and lower the risk of street-level flooding.

4. Skyrise Greenery in Singapore

Singapore, after gaining independence in 1965 from the British, saw one of its earliest skyrise greenery projects. This was the Bedok Court condominium built in the 1980s (Bay, 2004).

According to Bay, the architect had designed the access to each apartment from a common corridor via a partially covered entrance porch and above-ground garden (figure 5). The above-ground garden acted as a fore- court, similar to one in a Malay kampung house.

Figure 5: Porch and (sky) gardens to apartments at Bedok Court (Bay, 2004)

In 2005, a survey to gauge local residents' response towards skyrise greenery showed that 80% clamoured for more rooftop gardens on urban buildings (Yuen and Wong, 2005). These were requested for leisure, relaxation, aesthetics and biodiversity needs.

In 2008, an Inter-Ministerial Committee on Sustainable Development (IMCSD) comprising of different government bodies was formed to develop Singapore's framework and key strategies for long-term sustainable development. One specific deliverable was to allow residents to have better access to nature and biodiversity through propagation of low-lying and skyrise greenery (Ministry of the Environment and Water Resources and Ministry of National Development, 2009). To soften Singapore's urban developments, skyrise greenery targets of 30 and 50 hectares by 2020 and 2030 respectively were laid down.

Public Housing

This target included 9 hectares of green roofs to be built on Housing and Development Board (HDB) multi-storey carparks. They come in both conventional soil type and modular systems islandwide to provide biodiversity and reduction in ambient temperature and glare to residents (figure 6).

Figure 6: HDB Carpark Roof @ 28 Dover Crescent

National Library Board (NLB) Building

The NLB building in central downtown has over 6,300 m^2 of green spaces acting as sky courts to cushion against solar intrusion (Pomeroy, 2009). A sky garden at Level 5 (figure 7) is designed for poetry readings and book launches while at Level 10, a Wellness Garden with scented herbs and a foot reflexology path to stimulate visitors' senses (NLB, 2005).

Figure 7: Level 5 Sky garden, NLB

Private Developments

An increasing number of private developments have seen the incorporation of skyrise greenery for leisure and beautification, including the luxurious Orchard Residences at Orchard Road (figure 8). It has a 75,000 ft^2 sky garden that replicates the site's heritage as an orchard, supplemented with a green wall system on the building facade.

Figure 8: Orchard Residences

Other private developments include Reflections By the Bay at Singapore's Keppel Bay waterfront that is designed with sky gardens on sloping roof lines (figure 9) as well as The Icon@Tanjong Pagar area (figure 10).

Figure 9: Reflections By The Bay

Figure 10: The Icon @ Tanjong Pagar

Marina Bay Sands

At Singapore's Marina Bay Sands resort, three hotel towers are connected at the roof by a "park-in-the-sky". It spans from tower to tower and cantilevers beyond, with hundreds types of trees and plants to create a green environment (figure 11).

Figure 11: "Skypark" at Marina Bay Sands

5. Urban Roof-top Farms In Singapore

Changi General Hospital (CGH)

The development of urban farms has been gradually increasing over the years. One of the earliest projects was a roof-top farm launched at CGH in 1998 (Greenroofs.com, LLC, 2011).

The atrium roof's concrete flooring was heated up by the sun and reflected heat into the nearby wards. This created discomfort to patients. To partially overcome it, cherry tomatoes and herbs using hydroponics techniques were introduced. It supplied fresh food to patients where in 1998 alone, more than 190 kg of cherry tomatoes were harvested (figures 12 and 13).

This initiative was led by Dr Gregory Chow from Ngee Ann Polytechnic who demonstrated that rooftop farming was already showing viability in the 1990s. Besides food-production and greening of rooftop spaces, it could reduce transportation costs if they were harvested on-site for patients.

Figure 12: Setting-up of CGH hydroponic farm

Figure 13: CGH's commissioned rooftop farm

Swissotel

Singapore's Swissotel ran a Herb Garden on the rooftop of its podium block (figures 14 and 15). The produce from this roof-top farm, such as thyme, parsley, and lemongrass, are used as fresh ingredients for the restaurants' meals (Capitaland, 2010).

Using discarded greens, the hotel also created its own compost that served as natural fertilizers for the plants.

Figure 14: Herb Garden@Swissotel

Figure 15: Sky view of Herb Garden

6. Case Study Of Khoo Teck Puat Hospital (KTPH)

Overview

Khoo Teck Puat Hospital (KTPH), a 550-bed acute-care general hospital serving the northern region of Singapore, is the newest government-funded hospital which opened in 2010. It was the first hospital to win the 2010 International Skyrise Greenery Award (NParks, 2010). A tropical setting was intentionally planned so that any fallen flora would not be easily noticeable but still appear natural, unlike manicured gardens.

It also captured the 2009 Building and Construction Authority (BCA) Green Mark platinum award where the hospital had achieved a Greenery Provision of 6.18, well above the minimum scoring guidelines for this criteria (BCA(1), 2011).

Rooftop gardens and water features provide a healing environment that helps patients recover faster. All patients, whether from the wards or clinics, are offered a refreshing external view. For example, intensive care unit (ICU) patients face large windows that bring in sunlight and colours of nature, instead of recovering in a septic environment (figure 16).

Figure 16: External view from ICU bed

The hospital's linkbridges provide colourful visual connectivities to link different towers. They have built-in planters to contribute to the vista of skyrise greenery (figure 17)

Figure 17: Green linkbridges

Most notably, KTPH had developed 3 pods of intensive urban farms on its roof-top. This was a bold venture beyond skyrise gardens which came with challenges but yielded many fruits of labour.

A) Biodiversity Preservation

These farms function as a living classroom for staff and visitors to learn about the habitats of various life forms and biodiversity, which assesses the health of the ecosystems present (figure 18). They facilitate a myriad of life and food cycles to show how flora and fauna co-exist and compete for survival.

Figure 18: Biodiversity preservation at KTPH's farms

B) Food Sources

Urban roof-top farms optimize otherwise unused roof-top spaces by transforming them into vegetable and fruits production grounds. Many local and regional types of vegetables and fruits commonly found in markets are grown and some are harvested to serve patients. Excess produces are sold fresh to staff. The proceeds are then channelled to a green fund to help maintain the hospital's greenery and urban farms.

These farms offer a good opportunity for crops to be grown organically, without pesticides. When freshly harvested and used, preservatives are also eliminated.

C) Healing Environment

The urban roof-top farms offer colourful sights of the crops and great views of the surroundings to patients and visitors. Some crops also emit fragrant scents which are therapeutic to occupants. In addition, the flora absorbs carbon dioxide and releases oxygen to improve air quality. Thriving birds and insect species provide sounds of nature to patients and staff, which contribute to a healing environment.

D) Work Opportunities

The rooftop farms offer work opportunities to volunteers including retirees and home-makers from the surrounding neighbourhoods. They can utilize their time and agricultural skills fruitfully to generate a multitude of benefits, creating a win-win situation for themselves and the hospital. These farms also provide employment opportunities for gardeners and contractors.

E) Reduction Of Air-Conditioning Load

Past studies on the thermal benefits of rooftop gardens have shown that surface temperatures are lower for roof-top gardens compared to hard surfaces (figure 19) (Wong, 2003). Heat flux into buildings is also reduced by the shading effects of plants on rooftop gardens (Tan, Wong, Chen et al., 2003). The measured reduction of roof ambient temperature is up to 4°C, where solar heat transferred into the spaces below is reduced (Wong, 2002).

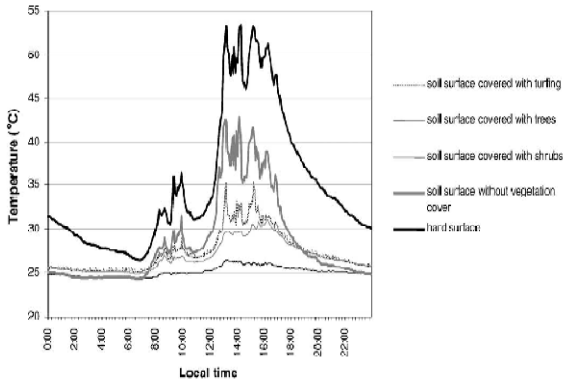


Figure 19: Comparison of measured surface temperatures of roof-top varieties (Wong, 2003)

Measurements of average air-conditioning utilities of clinic spaces directly below the roof-tops have shown that with an almost identical footprint, they are higher for a partial farm plot with a futsal pitch (49.2 kW) compared to one with a full farm plot (39.8 kW) (Table 1). Any utility savings could be passed back to patients through lower bill sizes.

Table 1: Air-Conditioning Utilities Of KTPH Clinics

Monthly And Average Electricity Consumption For Air Conditioning At KTPH Sports Injury And Dental Clinics

Electrical consumption readings / Name Of Clinic	Monthly Electricity Consumption for Nov 10 (kWh)	Monthly Electricity Consumption for Dec 10 (kwh)	Monthly Electricity Consumption for Jan 11 (kwh)	Monthly Electricity Consumption for Feb 11 (kwh)	Monthly Electricity Consumption for Mar 11 (kwh)	Monthly Electricity Consumption for Apr 11 (kwh)	Average Monthly Electricity Consumption From Nov 10-Apr 11 (kWh)
Partial Farm With Futsal Pitch Above Sports Injury Clinic	16,002.69	17,247.36	16,946.73	14,991.18	17,640.82	16,117.49	16,491.05
Full Urban Farm Above Dental Clinic	10,953.44	12,118.62	11,104.34	9,384.30	10,963.74	8,794.36	10,553.13

F) Urban Heat Island Effect

Building developments which replace vegetation and trees, and human activities that generate heat will create the Urban Heat Island (UHI) effect and will see urban temperatures rising higher than in rural areas (figure 20) (Wong, 2009). It also promotes smog formation from vehicular and building pollutants (Gray and Finster (2000)).

Evapotranspiration by the hospital's vegetation and trees help curtails higher urban temperatures. It will improve the air quality, energy use and human health (Wong, 2009).

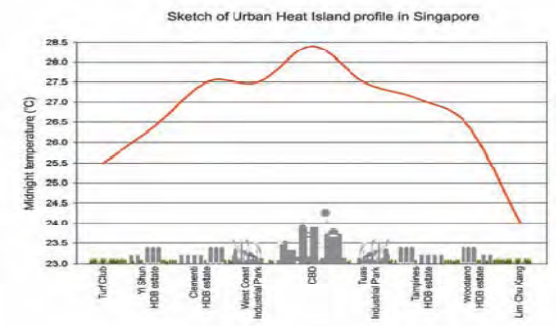


Figure 20: Profile of Singapore showing Urban Heat Island effect (Wong, 2009)

G) Community Spaces

Rooftop farms act as social spaces which allow visitors and patients to enjoy the sight, scent, touch and taste of nature. They also serve as gathering places for community bonding.

H) Concealment Of Mechanical and Electrical (M&E) Equipment

M&E equipment housed at the rooftops, including Air Handling Units (AHUs) and ventilation fans, were purposely sited away from patient areas. This is to allow equipment to be accessed and maintained without causing inconvenience to patients. The rooftop farms provide a naturally-pleasing cover to conceal them. They also partially absorb the mechanical noises generated.

I) Rainwater Collection

The rooftop farms channel rain-water into the adjacent Yishun Pond to be treated for public drinking purposes (figure 21). It is also recycled for irrigating the hospital's landscape, instead of using potable water that will enable considerable savings.

Figure 21: Yishun Pond

7. Difficulties And Challenges

Consultants plan roof-top gardens mainly for beautification and building performance reasons. However, they do not partake in their maintenance as this is left largely to the developers or occupants to follow-up. Urban farms, being relatively labour intensive, need much convincing for the latter to take-up.

Urban rooftop farming is not all rosy and carries various challenges to be overcome for it to be viable. These include:

- Crops are grown mainly for occupants and their acquaintances. It may be insufficient for the neighbourhood. Industrial farms which produce food at larger volumes are still relied upon
- Crops are exposed to vehicular and building-related forms of pollution
- Farm contaminants and bacteria, such as the May 2011 E-coli outbreak in Europe (CDC, 2011), could result in rapid spread of diseases due to quicker distribution among urban consumers.
- High maintenance is needed for urban rooftop farms including stringent waterproofing and drainage needs
- "Spare" urban land areas are needed for farm rest and rejuvenation, which may not be available
- Urban farms will be over-reaped if controlled access is not provided against large urban crowds, as compared to rural farms

8. Potential Of Urban Roof-top Farming in Singapore

Despite the challenges mentioned, the potential of urban roof-top farming looks promising as government initiatives to promote skyrise greenery have been intensifying. Technology for urban farming has also been increasingly developed. Lastly, survey and interviews of people from different walks of life have shown a general positive response although it is still a far cry from fruition.

A) Government Initiatives

Government initiatives include a landscape replacement policy by the National Parks Board called “LUSH” (NParks, 2009) for new developments in Singapore’s Downtown areas, western and eastern regions to ensure equivalent greenery replacements on the developments. Co-funding for green roofs and bonus gross floor area (GFA) for providing rooftop outdoor refreshment areas in downtown areas are other greenery initiatives under LUSH.

Other governmental initiatives include:

1) The Skyrise Greenery Incentive Scheme (SGIS) (NParks, 2011) will provide cash incentives of up to half the installation costs for existing buildings to retrofit green walls on them. NParks would also provide technical advice and literature on vertical greenery technology to assist interested developers and consultants.

2) The BCA Green Mark Scheme was launched in 2005 to promote green sustainable design in the building industry (BCA(1), 2011). The Green Mark award assessment includes greenery provision and green features. Award winners would improve their corporate image and industry standing. Developers may also obtain better leasing and resale value of their buildings.

3) For private developments achieving higher-tiered Green Mark award ratings, the Urban Redevelopment Authority (URA) had introduced a set of Gross Floor Area (GFA) incentives in 2009. This will grant them additional floor area over and above the Master Plan Gross Plot Ratio control (BCA(2), 2011).

4) The Ministry of Finance (MOF) (2009) had directed all government ministries and agencies to comply with more stringent environmental sustainability initiatives. All existing and new public sector buildings were given a timeline to minimally attain a Green Mark Gold^{Plus} and Platinum rating respectively.

5) Community-In-Bloom (CIB) was a program launched to foster a gardening culture among residents (NParks, 2005). The program involved collaboration with Town Councils, HDB, and the private sector to provide a range of gardening support to promote both low-level and skyrise greenery.

B) Technology For Urban Farming

Singapore would need increasing external supplies of greens to satisfy its growing population, given that a paltry amount of about 20,000 tonnes of vegetables in 2009 (AVA, 2011). was grown to feed about 5 million people (Singapore Department Of Statistics(2), 2011).

Technology for urban farming may provide some answers. Professor Lee Sing Kong from the National Institute of Education had developed an urban farming technique called aeroponics in 1997 (Baker, 2009). It involved crops cultivation by suspending their roots in troughs and are nourished by a nutrient spray. This technique required compact urban spaces and trial roof-top set-ups have demonstrated its viability (figure 22).

Similarly in India, successful compact and innovative farming techniques on rooftop spaces have seen the propagation of city farming that has enjoyed great success (Doshi, (undated)).

Figure 22: Rooftop aeroponics @ Tanjong Pagar

C) Survey

A survey at Khoo Teck Puat Hospital was carried out by the author to gauge the future outlook of skyrise gardens and urban farming. It attracted 117 responses from patients, visitors, staff, consultants and contractors, with the response summary listed in Table 2:

Table 2: Survey Results On Skyrise Gardens And Urban Farming

Survey On Skyrise Gardens And Urban Farming		Responses (total = 117)					
S/N	Question	Yes	Yes (%)	No	No (%)	Don't Know / No response	Don't Know / No response (%)
1	Do you find that it is beneficial to provide skyrise greenery and rooftop gardens at our hospital, and not a waste of tax-payers' money?	98	84	18	15	1	1
2.	Do you believe that it is easy to maintain the skyrise greenery and rooftop gardens without being too labour and resource intensive?	52	44	64	55	1	1
3.	Do you believe that it is economically viable to upkeep the skyrise greenery and rooftop gardens, or would not add to the hospital's operating costs significantly?	68	58	46	39	3	3
4.	Do you know of any Governmental incentives or schemes to encourage skyrise greenery or urban farming?	48	41	68	58	1	1
5.	Do you agree our Government is doing a good job to encourage or incentivize skyrise greenery or urban farming?	72	61	44	38	1	1
6.	Do you think that there are other possible benefits from rooftop gardens and urban farms e.g. reduction in indoor temperatures and air-con consumption for the space below?	98	84	18	15	1	1
7.	Have you heard of the Urban Heat Island Effect?	65	56	50	43	2	2
8.	Do you think that having such rooftop gardens and urban farms would benefit the country as a whole to lower the ambient temperatures in Urban areas?	97	83	19	16	1	1
9.	Have you visited a real farm with naturally grown vegetables and fruits?	89	76	26	22	2	2
10.	Do you think that it is possible to generate / harvest sufficient fruits and vegetables for our patients and visitors?	30	26	87	74	0	0
11.	Do you foresee the potential of urban farming on building roof-tops in Singapore, and that this will continue to grow and expand to many other buildings in the near future?	77	66	39	33	1	1
12.	Do you believe that Singaporeans including building owners / private developers will support and help to propagate skyrise greenery or urban farming even though there is a first cost on set-up?	78	67	38	32	1	1

With the exception of 3 of the 12 questions (highlighted in yellow), majority of respondents provided a positive outlook towards skyrise greenery and urban roof-top farming, including its propagation. Most significantly, questions 1, 6 and 8 on generating various benefits garnered an overwhelming 83-84% of affirmations.

D) Interviews

Interviews with staff and visitor have solicited encouraging feedback. They have perceived that skyrise greenery and urban roof-top farms will not only benefit the building users but also the nation as a whole.

They also believe that there is growth potential in this aspect for future building developments.

9. Conclusions

Skyrise greenery in Singapore in the form of high-rise landscaped gardens on public housing, private residents, hotels and other developments has seen its steadfast progress over the years. It has also ventured to become urban roof-top farms, including those at Changi General Hospital and Swissotel.

The case study of the new Khoo Teck Puat Hospital (KTPH) had shown that urban farming was not merely an accidental venture but had yielded multiple benefits, ranging from organic food production to biodiversity preservation and energy conservation. They also measured up against similar conclusions by prominent architect Dr Ken Yeang on improvement of energy consumption, operating costs and micro-climate (Yeang, 2000), although there are various challenges to be overcome.

Survey results and interviews at KTPH have provided optimism that skyrise greenery and urban farms will see copious growth in future developments to meet the nation's sustainable aspirations. Supported by intensifying government initiatives and environmental proponents, urban roof-top farms will have good potential to form part of future local infrastructure developments, as more are mushrooming in other countries.

10. Recommendations

The author recommends that difficulties and challenges related to skyrise greenery and urban farming in Singapore, such as those highlighted in the survey, be further researched into and appropriately managed.

These include:

- Maintenance difficulties which can be overcome by adopting low maintenance growing techniques and selection of hardy crops.

- Lobbying for intensification of government initiatives such as better incentives to help galvanize developers and consultants.

- Use of efficient crop generation techniques such as aeroponics to mass produce food quickly for occupants and urban dwellers to address inadequate food production.

By addressing the various challenges and further promoting their strengths, urban roof-top farms will see much potential growth in Singapore, beyond mere skyrise gardens as the urban environment continuously expands.

REFERENCES

1. Agri-food and Veterinary Authority (AVA) (1) Singapore (2001) Towards New Horizons, AVA Annual Report 2000/01. Singapore: AVA.
2. Agri-food and Veterinary Authority (AVA) (2) Singapore (2011) Publications on Statistics of Farm Production 2009 [online]. Available at: http://www.ava.gov.sg/AVA/Templates/AVAGenericContentTemplate.aspx?NRMODE=Published&NRNODEGUID=%7bF2752F0E-A9A1-4A96-BA40F6843F8CB26A%7d&NRORIGINALURL=%2fPublications%2fStatistics%2f&NRCACHEHINT=Guest#area) [Accessed 28 Apr 2011].
3. Baker, Jalelah Abu (2009) Singapore's Urban Farm Idea Wins Accolade. The Straits Times, 4 February 2009.
4. Bay, Joo-Hwa (2004) Sustainable community and environment in tropical Singapore high-rise housing: the case of Bedok Court condominium. Architectural Research Quarterly 8: pp. 333-343.

5. Behrens-Abouseif, Doris (1992) Islamic Architecture in Cairo. 2nd Edition, The Netherlands: Brill Publishers.
6. Building and Construction Authority (BCA) (1) Singapore (2011) About Green Mark Scheme [online]. Available at: http://www.bca.gov.sg/GreenMark/green_mark_buildings.html [Accessed 10 Jun 2011].
7. Building and Construction Authority (BCA) (2) Singapore (2011) Green Mark Gross Floor Ratio Incentive Scheme [online]. Available at: http://www.bca.gov.sg/GreenMark/gmgfa.html [Accessed 10 Jun 2011].
8. Capitaland (2010). INSIDE Different Geographies: Edible Garden In The Sky [online]. Available at: http://www.capitalandinside.com/ index.php/gourmet/457-edible-garden-in-the-sky [Accessed 5 May 2011].
9. Centers for Disease Control and Prevention (CDC) (2011) Outbreak Notice: Shiga toxin-producing *E. coli* O104:H4 infections in Germany 2011 [online]. Available at: http://wwwnc.cdc.gov/travel/notices /outbreak-notice/2011-germany-europe-e-coli.htm [Accessed 10 June 2011]
10. Doshi, R.T. (undated) What Is City Farming? [online]. Available at: http://www.cityfarming.in/what.html [Accessed 26 Apr 2011].
11. Gray, Kimberly A. and Finster, Mary E. (2000), The Urban Heat Island, Photochemical Smog, and Chicago: Local Features of the Problem and Solution [online]. Available at: http://www.epa.gov/heatislands/resources/pdf/the_urban_heat_island.pdf [Accessed 11 Jun 2011].

12. Greenroofs.com, LLC (2011). The Greenroof Projects Database – Changi General Hospital [online]. Available at: http://www.greenroofs.com/projects/pview.php?id=565 [Accessed 28 Apr 2011].
13. Littlewood, Antony Robert, Maguire, Henry and Wolschke-Bulmahn, Joachim (2002) Byzantine garden culture. Washington D.C.: Dumbarton Oaks.
14. Liu, Karen (2002) Energy Efficiency And Environmental Benefits of Rooftop Gardens. Ottawa, Canada: National Research Council Canada.

15. Oldfield, P., Trabucco, D. and Wood, A. (2009) Five Energy Generations of Tall Buildings: An Historical Analysis of Energy Consumption in High-Rise Buildings. The Journal of Architecture 14(5): pp. 591-613.
16. Ong, Boon Lay (2003) Green plot ratio: an ecological measure for architecture and urban planning. Landscape and Urban Planning 63 (4): pp. 197-211.
17. Osmundson, Theodore (1999) Roof gardens: history, design, and construction. 1st Edition. New York: W. W. Norton & Company.
18. Pomeroy, Jason (2009) The Skycourt – a comparison of four case studies in the context of Corporatised square and Arcade. Council of Tall Building and Urban Habitat (CTBUH) Journal 2009 Issue 1: pp. 28-36.
19. National Library Board (NLB) Singapore (2005). Terraces From "Welcome To The Virtual Tour Of The National Library Building" [online]. Available at: http://virtualtour.nlb.gov.sg/static/ terrace.htm [Accessed 15 May 2011].
20. Ministry Of Finance (MOF) Singapore (2009) Finance Circular Minute No.M8/2009 [Mf B015.080.2838. V1] "Public Sector To Take The Lead On Environmental Sustainability - Additional Measures". Singapore: MOF.
21. National Parks Board (NParks) Singapore (2005) Community In Bloom – Singapore's National Gardening Movement [online]. Available at: http://www.nparks.gov.sg /cms/docs/CIB/cib.pdf [Accessed 10 Jun 2011].
22. National Parks Board (NParks) Singapore (2009) A Lusher and Greener Singapore (URA and NParks introduce schemes to promote Skyrise Greenery) [online]. Available at: http://www.nparks.gov.sg/cms /index.php?option=com_news&task=view&id=145&Itemid=50) [Accessed 6 May 2011].
23. National Parks Board (NParks) Singapore (2010). Skyrise Greenery Awards 2010 [online]. Available at: http://www.skyrise greenery.com/index.php/home/awards/skyrise_greenery_awards_2010 [Accessed 7 May 2011].
24. National Parks Board (NParks) Singapore (2011) Skyrise Greenery Incentive Scheme [online]. Available at: http://www. skyrisegreenery.com/index.php/home/incentive_scheme/about/ [Accessed 10 Jun 2011].
25. Singapore Department of Statistics(1) (2011) Singapore Statistics on Demography and Population, [online]. Available at: http://www.singstat.gov.sg/stats/themes/people/hist/popn.html [Accessed 1 May 2011].
26. Singapore Department Of Statistics(2) (2011) Singapore Statistics On Key Annual Indicators [online]. Available at: http://www.singstat.gov.sg/stats/keyind.html#popnarea [Accessed 1 May 2011].
27. Tan, P. Y., Wong, N. H., Chen, Y., Ong, C.L., Sia, A. (2003) *Thermal Benefits of Rooftop Gardens in Singapore.* Proceedings for Greening Rooftops for Sustainable Communities. 15 May 2003, Chicago, Illinois, United States of America.
28. The Inter-ministerial Committee on Sustainable Development, Singapore (2009) A Lively And Liveable Singapore: Strategies For Sustainable Growth. Singapore : Ministry of the Environment and Water Resources and Ministry of National Development.
29. United Nations Environmental Programme, (2008) UNEP Background Paper On Green Jobs. Nairobi, Kenya : United Nations Office at Nairobi, Publishing Services Section (UNON).
30. Wong, Nyuk Hien (2002) Urban Heat Island Effect: Sinking the Heat. The Innovation Magazine Volume 3 Number 2. Singapore: National Technological University (NTU), National University of Singapore (NUS) and World Scientific Publishing Co.
31. Wong, Nyuk Hien (2003) The effects of rooftop garden on energy consumption of a commercial building in Singapore. Energy and Buildings 35: pp. 353-364.
32. Wong, Nyuk Hien (2009) The Urban Heat Effect. The Innovation Magazine Volume 9 Number 1. Singapore: National Technological University (NTU), National University of Singapore (NUS) and World Scientific Publishing Co.
33. Wellard, James Howard (1972) Babylon. 1st American Edition. New York: Saturday Review Press.
34. Yeang, Ken (2000) The Ecological (or Green) Approach to Design. Council on Tall Buildings and Urban Habitat (CTBUH) Journal 2000, Issue 1: pp. 7-15.
35. Yuen, Belinda, and Wong, Nyuk Hein (2005). Resident perceptions and expectations of rooftop gardens in Singapore. Landscape and Urban Planning 73 (4): pp. 263-276.