Authors names: Susan Loh and Yael Stav
Email contact address: susan.loh@qut.edu.au and y.stav@qut.edu.au
Theme: Best Practice Bazaar
Category: Refereed paper

GREEN A CITY GROW A WALL

PAPER

As Brisbane grows, it is rapidly becoming akin to any other city in the world with its typical stark grey concrete buildings rather than being characterized by its subtropical element of abundant green vegetation. Living Walls can play a vital role in restoring the loss of this distinct local element of a subtropical city.

This paper will start by giving an overview of the traditional methods of greening subtropical cities with the use of urban parks and street trees. Then, by examining a recent heat imaging map of Brisbane, the effect of green cover with the built environment will be shown. With this information from a macro level, this paper will proceed to examine a typical urban block within the Central Business District (CBD) to demonstrate urban densification in relation to greenery in the city.

Then, this paper will introduce the new technology where Living Walls have the untapped potential of effectively greening a city where land is scarce and given over to high density development. Living Walls incorporated into building design does not only enhance the subtropical lifestyle that is being lost in modern cities but is also an effective means for addressing climate change.

This paper will serve as a preliminary investigation into the effects of incorporating Living Walls into cities. By growing a Living Wall onto buildings, we can be part of an effective design solution for countering global warming and at the same time, Living Walls can return local character to subtropical cities, thereby greening the city as well.

Keywords: Living Walls, greening subtropical cities, climate change, global warming, local character

DISCUSSION

BACKGROUND

Establishment and conservation of urban greenery is a substantial component in sustainable urban development. Natural environment and vegetation in cities contribute to maintaining wildlife, improving well-being and moderating impacts of human activities including global warming. The greening of cities has been traditionally managed through urban parks, green corridors, suburban gardens and street landscaping.

Urban parks have recreational as well as environmental significance and are valued as relaxation and refuge spaces within the city. However, large parks have a sustainability disadvantage of breaking connectivity between different urban functions and therefore increasing car usage (Horsbrugh, 1990). From the ecological perspective, parks are sometimes being criticised as being too artificial (and therefore less sustainable than a wildlife area) and disconnected from the natural environment. In addressing that issue, green corridors were introduced along railways and waterways to allow interconnection of natural spaces and wildlife migration.

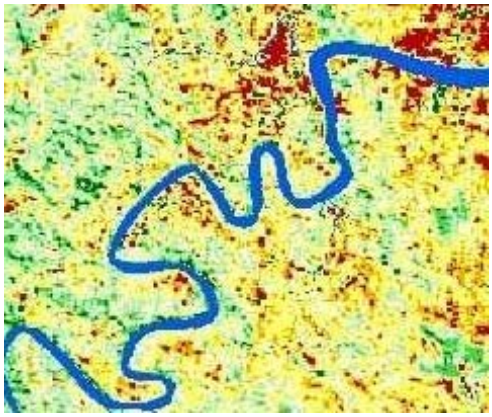
Street trees growing within the city are sometimes called urban forests. One of the advantages of street tree planting is that it requires very little ground space and therefore suitable for high density areas, especially in new developments. Sherlock (1991) advocated spreading greenery through the city with trees on pavements and the use of plots between buildings. The environmental benefits specific to trees are well known (especially their carbon-sinking capabilities)

The "Handbook on Skyrise Greening in Singapore" addresses the greening of one of the densest cities in the world by promoting roof gardens, façade planting and balcony planting on buildings through planning incentives (www.nparksgov.sg). These can be considered modern approaches to greening the city and they are very suitable for tropical and subtropical cities.

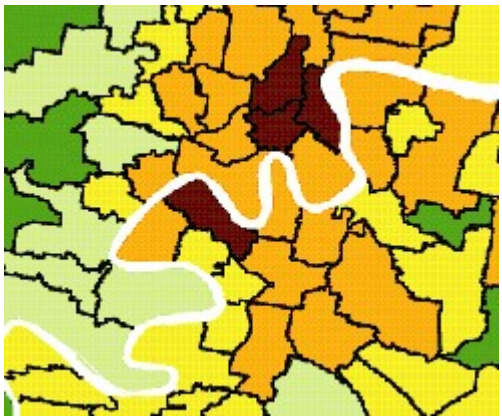
Although green roofs have been part of the vernacular architecture for centuries, the contemporary green roof with the required technology to match modern city buildings, was developed and gained social and political support in Europe, mainly by the German speaking countries in the last 40 years (Dunnett and Kingsbury, 2004). Green roofs with their vegetation and support layers help to lower the Urban Heat Island effect and mitigate stormwater runoff. Green roofs also serve as insulation and perform a cooling effect on the building itself thus saving cooling energy and reducing peak energy demand typical to subtropical cities (Skinner, 2006). Living walls, as discussed in details in the next sections, are a more recent method to incorporate vegetation into the built environment and they are shown to offer similar benefits to those related to green roofs.

CORRELATION BETWEEN URBAN HEAT ISLAND (UHI) IMAGES WITH TREE COVER

The effect of temperature reduction by vegetation and the heat-island mitigation has been widely studied (Rosenfeld et al., 1996). Heat is increased in cities due to the absorption of solar radiation by roads and buildings in the city and the storage and radiation of this heat within the building materials. Even white surfaces can become as much as 10°C warmer than the ambient temperature (Akbari et al., 2001, p. 298). Plant surfaces however, as a result of transpiration, do not rise more than 4–5 °C above the ambient and are sometimes cooler (Jones, 1992).



Landsat Urban Heat Imaging of Brisbane , 1999



Brisbane Tree Cover by Suburb, 2005 (Plant, 2006)

Figure 1: Comparison of Thermal Imaging and extent of Tree Cover[1]

The Landsat-7 satellite thermal map above shows that the warmest areas in Brisbane are the airport, industrial and dense commercial areas (e.g. South Brisbane and Fortitude Valley) which

[1] Thermal and Tree Cover map courtesy of Lyndal Plant, BCC

are over 2°C warmer than the average temperature. The CBD is 1-2°C warmer while the Brisbane river area and the botanical gardens are up to 3°C cooler than the average.

When looking at the tree coverage map, there is a close match between that and the thermal map. The red hot areas are mostly within the suburbs that have low tree coverage (less than 10%) while the cooler greener areas are generally within the suburbs with over 30% tree coverage.

TYPICAL CITY BLOCK IN BRISBANE CBD

In order to examine the interplay of building and vegetation in the inner city of Brisbane, a typical block is chosen – surrounded by Mary, George, Albert and Charlotte streets. The plans and elevations below illustrate the densification of the block in the last 60 years, comparing the same area in the period between 1930 and 2005.

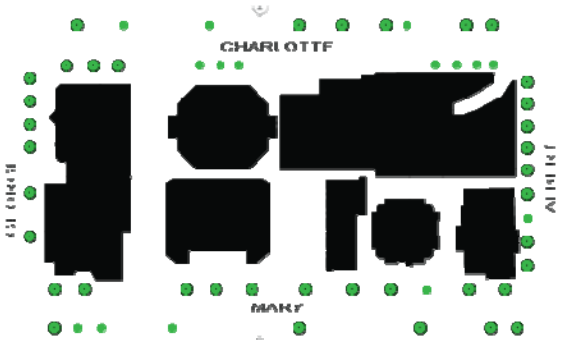
Aerial view 1945

Aerial view 2005

Figure 2
Aerial photographs comparing city block bounded by Mary, Charlotte, George and Albert Streets in the years 1945 and 2005 (retrieved from EBiMap on BCC website)

A snapshot of the city block in 1945 and 2005 as seen in Figure 2 above and in plans below (Figure 3) reveals increased densification of the city with a lack of corresponding increase in tree cover or additional greenery.

Plan 1930



Plan 2005

Figure 3
Plans comparing density of built form within city block bounded by Mary, Charlotte, George and Albert Streets in the years 1930 and 2005 [2]

Photographs of the same street taken 30 years apart (Figure 4) show the extent of increased built form in relation to trees planted on the street.

[2] Plan and elevation information by QUT students N. Schroder and M. Moylan in their paper Urban Morphology - Mapping, 2008. Trees documented by S.A.M. Murray, 2008

Plan 1974

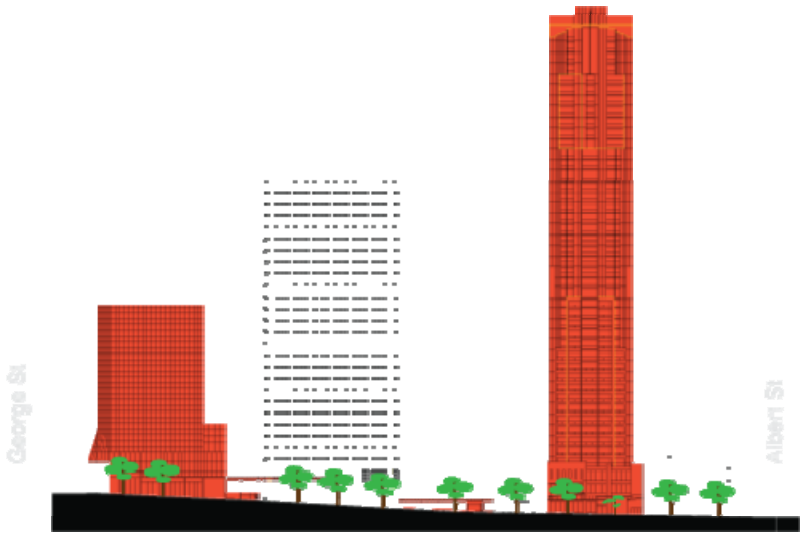
Plan 2005

Figure 4

Photographs comparing density of built form with tree cover on Mary Street in the years 1974 and 2005 [3]

The increase in urban density also occurs on the vertical plane as well as illustrated in Figure 5 below. The street trees are completely dwarfed by the height of buildings on the city block.

Elevation 1930



Elevation 2005

Figure 5

Elevations showing increase of built form within city block bounded by Mary, Charlotte, George and Albert Streets in the years 1930 and 2005 and present tree cover [4]

With the above comparisons of a typical city block on the horizontal and vertical planes, there is a significant increase in urban density, and especially in vertical surfaces, without a correlated

[3] Photographs from BCC archives and by S.A.M. Murray

[4] Plan and elevation information by QUT students N. Schroder and M. Moylan in their paper Urban Morphology - Mapping, 2008. Trees documented by S.A.M. Murray, 2008

increase in greenery within the area. This paper proposes the important part that Living Walls can play as a new technology for greening the city.

LIVING WALLS

Living Walls are also known as Green Walls, Green Facades, Bio Walls or Vertical Vegetation and refer to vegetation that grows directly onto a building's façade or to vegetation that is grown on a separate structural system that is adjacent to the wall and sometimes attached to it. Vegetation grown in planter boxes and trained on a trellis system with mechanized watering is also classified under Living Walls. (Centre for Subtropical Design 2007)

The Centre for Subtropical Design (CSD) proposes that a definition of Living Walls include the fact that they have multi-functional and deliberate environmental benefits to their built surroundings and that Living Walls be clearly identified as designed, built and maintained vegetation elements associated with a building. (Centre for Subtropical Design 2007)

Living Walls can be broadly classified into three systems: Panel System, Felt System and Container and/or Trellis System.

Panel Systems are usually comprised of pre-planted panels that are transported onto the site and then connected to the structural and mechanical watering systems. *Felt Systems* comprise of a layer of felt attached to a waterproofed structural system. Plants are fitted into felt pockets of growing medium and then attached to this felt layered structure. In both the Panel and Felt systems, the panels and felt layers are kept continually wet with water and plant nutrients. *Container and/or Trellis Systems* are used to describe plants grown in containers that climb onto trellises. These planter boxes have mechanical watering systems to control watering and nutrient feeding. *Interior Living Walls* are contained within a building's envelope and are sometimes connected directly to the building's ventilation system to assist in improving humidity and indoor air quality.

BENEFITS

Research shows that incorporation of Living Walls into building design has several benefits:
Thermal benefits: The shading properties of a Living Wall help decrease a building's surface temperature, thereby increasing its thermal performance. This would subsequently lower internal building temperature thus reducing the heating and cooling requirements of a building. Not only does this reduce the costs and amount of energy consumed but it would also reduce urban heat island temperatures of cities and would ultimately lower greenhouse gas emissions.

Research in this area by the National Research Council of Canada (Bass and Baskaran 2003) and Tokyo Institute of Technology (Hoyano 1988) indicates that Living Walls provide climate modification through lowering of building surface temperature by at least 3°C. Wall-climbing vines can reduce summer temperatures on a street by 5%, and reduce household heat loss by up to 30% in winter (Hough 1984)

Positive effects on hydrology: Similar to green roofs, Living Walls can help a city's stormwater management through the use of recycled water or the absorption of rainfall through the Living

Wall. As water percolates and later transpirates, through the Living Wall system, it lowers the amount as well as slows down sudden rainfall discharge to the city's storm sewers.

Some Living Walls use collected rainwater or recycled greywater and blackwater such as the container/trellis system in Melbourne's CH2 building, which plays a positive and active role in sensitive urban water management.

Living Walls have also been shown to *improve air quality, reduce noise, increase urban biodiversity* and *improve our health and social well-being.* (Centre for Subtropical Design 2007)

Though there is no research documenting the direct relationship between Living Walls and workplace satisfaction, we can extrapolate such benefits from associated research that indicates that an improved working environment with the presence of nature translates to lower office absenteeism or more successful patient recovery. (Kellert 2005)

Living Walls can also be an active contributor to the increase of the ecological value of our urban environment. The concept of Living Walls can be expanded to include a range of climatic and ecosystem functions, thereby contributing to net Positive Development. (Birkeland 2007)

In summary, research on Living Walls and related research on greenery indicate multiple benefits. Therefore they should be considered as viable design elements in an urban context.

LOCAL DISTINCTIVENESS AND VEGETATION

The SEQ Regional Plan 2005 – 2026 in section 8.3 identifies that development is to "reflect SEQ's subtropical climate, reinforce local character and achieve design excellence and innovation." (SEQ, 2005) This idea is also reinforced by Brisbane City Council (BCC) in its 15 Principles for Sustainable Development. (BCC, 2005)

Two core values of the urban context as stated in section 8.3 "Urban character and design" of the SEQ Regional Plan concerns character and identity whereby a sense of open and permeable environments is encouraged with the engagement of our natural environment. More specifically, Principle 7 states "use vegetation".

The local distinctive character of Brisbane as a subtropical city is undoubtedly, its direct engagement with the natural environment. With the recent increase in new buildings within the CBD, this close connection to nature is slowly eroded as the ratio between hard surfaces and green areas is being tipped towards more concrete built up surfaces which in turn slowly diminishes the character of the city. However, this defining characteristic of Brisbane can be retained and enhanced with Living Walls as the greenery offered by this system can cover a larger area on the vertical plane where there is scarcity of land on the horizontal plane in such core built up areas. The added greenery can be comprised of indigenous subtropical forest plants, thus recreating lost natural spaces and subtropical habitats.

With the incorporation of Living Walls onto building facades, we envision a viable method of greening a rapidly growing city that would otherwise continue to outpace its ecological footprint.

Living Walls present a useful system to fulfil many principles of the SEQ Regional Plan as they not only help diversify the built environment (Principle 3) and help retain the local character

and design of the city (Principle 4), but they also use vegetation (Principle 7) as a way to green a city. With the use of Living Walls, positive effects on urban hydrology can be achieved, thus acting on Principle 11 – Design for water. Living Walls allow for the enrichment of outdoor meeting places (Principle 13) by being an effective tool for creating green spaces for people to gather in, thereby enabling possibilities for greater social interaction and increasing the well-being of city dwellers or passers-by.

PROPOSAL FOR GREENING THE CITY WITH LIVING WALLS

GREEN NEW FAÇADE

With reference to Figure 4, the facades of buildings on a typical CBD block described above between Mary, Albert, George and Charlotte streets, have been digitally manipulated to demonstrate the possibility of Living Walls growing on the facades of a car park and adjacent high rise residential and commercial buildings. The added vegetation consists mainly of Living Walls but also includes green terraces and planter boxes.

Not only is the added visual amenity a welcome alternative to typical bland looking walls of city buildings, Living Walls also offer significant benefits of cooling the environment and lowering the UHI. While looking good at the same time, Living Walls can also percolate recycled or rain water, thus slowing stormwater runoff; and improve air quality and urban biodiversity.

Façade before application of Living Walls

Façade after with added greenery

Figure 6
Photos showing possible appearance of facades after application of Living Walls

GREEN SURFACE AREA

In order to estimate the amount of greenery that can be added to the city with the use of Living Walls, our investigation considered building envelopes in the identified city block to be covered with plants. Assuming windows account for 50% of the walls' surfaces, and thus will not be covered, we will get more than 30,000 square meters of potential surface for greenery). Even if only half of this area is used for greenery, it will have the potential of restoring greenery that is equivalent to the area of the original block itself. (see Figures 3 and 4 – 1930 and 2005)

Living Walls together with green roofs, street trees and other city greening options will greatly enhance and enlarge the ecosystem of the city block that existed before it was built.

Apart from the aesthetic values and the enhancement of the subtropical character of a subtropical city such as Brisbane, applying this kind of vegetation to the city block will incur the many benefits discussed in the preceding section. Continuing research is being carried out in order to estimate and quantify the added values of Living Walls such as thermal benefit, stormwater management, air quality, etc. (PhD research at QUT by Yael Stav)

GREEN LIVING WALLS

The greening of a city takes place on several levels, from large urban parks to the planting of street trees. The recent use of green roofs and Living Walls technology shows increased understanding of how the greening of a city can also happen on another level – that of a building's rooftop or façade.

One of the reasons that Living Walls is not a common practice yet may be the technical challenges involved in creating and maintaining them. As the technology matures and the amount of commercial activity involved in Living Walls increases, more challenges will be addressed and more architects and planners will feel confident in integrating Living Walls into their work.

The use of Living Walls should not be advocated as a substitute for the loss of green open space due to densification of cities. Living Walls do not offer an alternative green space for children to play in. However, green spaces can be extended by Living Walls when they are used to blanket bare concrete walls of tall buildings and are used creatively when designing gathering spaces for people to socialise within a city block. A public space within a dense urban fabric can be a welcome subtropical oasis if surrounded by Living Walls.

CONCLUSION

The immense usefulness of shade trees is not to be discounted and should be the focus for providing shade, good air quality, carbon storage and sequestration, as well as social health to any city. However, when cities increase their density with infilling of the city core where there is less possibility of providing adequate tree cover due to the lack of opportunity for healthy tree growth on the horizontal plane, then the use of Living Walls on the otherwise un-greened vertical plane would offer an attractive and effective alternative.

This viable alternative to greening a city is due to the many qualities of Living Walls. They help to lower ambient temperatures and urban heat islands through its shading and insulating qualities which leads to increased thermal performance of buildings and the subsequent lowering of the energy consumption of building. This in turn has the spill-over effect of lowering greenhouse gas emissions. The positive effect on hydrology and the improvement of inner city air and noise quality plus the increased urban biodiversity and improved social well being and health of people are also convincing factors for the use of Living Walls on building facades in cities.

Returning local character to subtropical cities such as Brisbane through increased greenery in dense urban centres makes Living Walls an important aspect of greening a city.

This paper serves as a preliminary investigation into the effects of incorporating Living Walls into cities. By growing a Living Wall onto buildings, we can be part of an effective design solution for countering global warming and at the same time, Living Walls can return local character to subtropical cities.

By growing a Living Wall, we green a city.

BIBLIOGRAPHY

Akbari, H., Pomerantz, M., Taha, H., 2001. Cool surfaces and shade trees to reduce energy use and improve air quality in urban areas. Sol. Energy 70 (3), 295–310.

Bass, B. and Baskaran B. (2003) Evaluating Rooftop and Vertical Gardens as an Adaptation Strategy for Urban Areas. http://irc.nrc-cnrc.gc.ca/pubs/fulltext/nrcc46737/

Birkeland, J. (2008) Positive Development: From Vicious Circles to Virtuous Cycles. Earthscan, UK

Brisbane City Council, 2005, Guidelines for Sustainable Development http://www.brisbane.qld.gov.au/BCC:BASE::pc=PC_1870 (retrieved 14th July, 2008)

Centre for Subtropical Design (2007) Living Walls research. http://www.subtropicaldesign.bee.qut.edu.au/LivingWallsResearch.html

Hoyano, A. (1988) Climatological uses of plants for solar control and the effects on the thermal environment of a building. In Energy and Buildings Vol11, Issues 1-3, pp. 181-199

Jones, H.G., 1992. Plants and Microclimate, Second ed. Cambridge University Press, Cambridge, UK.

Kellert, S. (2005) Building for Life: Designing and Understanding the Human-Nature Connection. Island Press, Washington, D. C.

Plant, L. (2005) Brisbane: "Beautiful one day, perfect the next"- is there room for improvement? - Urban tree policy and management challenges for Brisbane,

Rosenfeld, A. H., Akbari, H., Romm, J. J. & Pomerantz, M. (1998) Cool communities: strategies for heat island mitigation and smog reduction, Energy and Buildings, 28, pp. 51–62.

Sherlock, H. 1991. Cities are good for us. London: Paladin.

Skinner, J. 2006, Urban Density, Meteorology and Rooftops, Urban Policy and Research, 24:3, 355 – 367

South East Queensland Regional Plan 2005 -2026, http://www.dip.qld.gov.au/regional-planning/regional-plan-s.html (retrieved 14th July, 2008)