Faculty of Architecture Landscape And Visual Arts

Vertical Gardens

UWA Sustainable Development Summer Scholarship
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ALVA VERTICAL GARDENS
An investigation of the environmental & social benefits of vertical gardening
ALVA
VERTICAL GARDENS

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Executive Summary

The overarching goal was to shade the North and South Social Sciences buildings in order to reduce the cooling loads of each building through the implementation of vertical gardens.

Within the brief, we identified an opportunity to create a sustainable entity that satisfied the university’s basic request, whilst also benefitting the larger student body & ameliorating the problems that currently exist on the allocated site. This report compares the total benefits & costs involved with a typical green wall, and the perceived alternate sustainable opportunity we have identified for this site.

A study of the site and the larger campus illuminated the need to reference the historical merit of the pre-existing architecture. It was decided that the collonade was to be reinterrogated to achieve a contemporary solution in the form of a planted canopy.

In conjunction with the canopy to allow for the usual functions of the thoroughfare, platforms were introduced along James Oval to both ground the canopy and to provide an intimate interaction between the sustainable device and the student body.

This process has resulted in a design governed by the duality of the university’s request to provide tangible energy savings, and the opportunity to activate a functional, sustainable precinct.
Introduction

In this project, we have investigated the potential to build upon the dynamic relationship between the built environment and nature that has existed since earliest civilisation.

We have investigated and extrapolated how the vertical garden transcends the traditional garden in their ability to explore three-dimensional form, enhancing seasonal experiences, and physical and environmental benefits.

We aim not to privilege the built environment or nature, but instead are placing these two elements in tandem to investigate a more permanent and lasting relationship appropriate for a Western Australian setting.

Our aim has been to create a system that transcends a perceived neophilia surrounding the field of sustainable design. It has not solely been an investigation into what is sustainable and fashionable today, but rather an investigation of what has been, and what could remain sustainable and engaging for years to come.

Together, we have designed a system that we believe has far-reaching benefits for the University of Western Australia; by educating its students, for reducing energy usage of the campus, and for the university’s reputation.
The foremost concern of the project was acknowledging and accommodating the pre-existing conditions of the site. From the outset, the form and program of the project was shaped by the climatic, functional and spatial factors of the site.
Locality

The Social Sciences North and South buildings have a central location in the UWA campus plan.

To the east is the social hub of the university; the Oak Lawn, Guild Village and refectory. We wanted to extend the social events and interactions that occurs in these venues to the west along this busy thoroughfare.

To the west is the historic James Oval where many university sports events and training take place. We wanted to activate this residual space between the oval and Social Sciences, which also due to the lack of built form on the oval, is a very unpleasant thoroughfare in summer. We aimed to suggest a design that provides areas that are comfortable and encourage students to watch and participate in the activities of James Oval.

To the north is the university’s largest library, the architecturally renowned Reid library, and to the south the Science library.
Pedestrian and Vehicular Movement

It is estimated that more than 1500 people pass through this thoroughfare during 9am-5pm each weekday. At all stages in our research it was considered important to preserve existing movement patterns on the site.

The thoroughfare is particularly uncomfortable in summer during its peak time, 1pm-3pm due to the low western sun and a complete lack of shade protection.

Due to these issues, we have had to approach the project by elevating the vertical garden from the ground plane. Also during the process the university expressed their concern for vandalism, which was another contributing factor to elevate the planting and infrastructure.
Water, Electrical & Communications Services

The services corridor also follows the same north-south orientation as pedestrian and vehicular movement.

This has allowed us to use the existing irrigation system that runs east-west under James Oval parallel to both Social Sciences buildings.

The existence of services along the corridor made it necessary to leave the majority of the service hatches accessible by elevating the program of the project.
Key Vistas/Views

Throughout the historic campus there exist numerous important vistas that punctuate the thoroughfare which we aimed to both preserve and build upon.

It was important to consider both the view from the thoroughfare at ground level, and also the view from above in the adjacent buildings.

The balcony of Social Sciences north is accessed by a post-graduate/teacher lounge and a computer lab. The view from this position figured strongly in the design process, as well as the visual corridors created by the adjacent buildings.
Solar & Wind Considerations

Perth’s climate renders the western orientation of the facades undesirable for implementation of typical vertical gardens.

To construct a vertical garden on one of these blank walls, shading would need to be provided. For this reason we designed a canopy that would shade the facades of the buildings and the thoroughfare.

By using a canopy, we were able to explore the opportunity there exists for different summer and winter experiences. Deciduous trees and creepers allow for the garden to become more heavily planted to provide shading, and in winter allow the softer sun to penetrate onto the thoroughfare and green wall.

The canopy also provides wind protection through creating a buffer, which will provide significant shelter from the south-west.
Informed by the historical context of the university, namely the iconic collonades which frequently appear across the campus, the vertical garden aims to recontextualize the arch.
Concept

The project was concerned with the creation of an engaging and widely accessible sustainable system, rather than something by which the sole benefactor would be the adjacent building and its users.

Instead of designating spaces for walking or seating which would upset the existing movement pattern, we want to suggest spaces for people to pass through or to rest in.

A series of ‘floating’ platforms are arranged along the perimeter of James Oval that facilitate student needs and amenities, whilst also engaging passersby with a sustainable microcosm. Opportunities and experiences that previously did not exist are created by means of these platforms informed by the site.

From looking at the site plan, either side north and south of the thoroughfare, there exists vast planting of large trees and hence comfortable thoroughfares. We aimed to replicate this condition along the length of the unprotected thoroughfare; an extension of a pre-existing canopy.

The canopy structure became the bridging element between the built form and the site, metaphoric of our intentions. The transition as one moves from inside Social Sciences to the expansive oval and footpath is made less abrupt through the creation of an intermediary, sheltered zone.

Our intention was to reference the university’s architectural legacy by reappropriating the collonade form. The creation of a series of abstracted colonnades constructed of steel and draped in greenery.
Drawings

* 1:500 Site Analysis Model + Plan
View from South approach
View from staff/post-grad balcony
*Unvegetated
System and Construction

Strategy

A system of construction was chosen to reference both the permanency of the pre-existing built elements, and the dynamic nature of the planting.

As a structural measure and a reference to the pre-existing built form, the cables are attached to the existing column grid of Social Sciences north and south.

Each cable alternates between fixing to the first floor and second floor slabs, which in conjunction with alternating tower heights, forms a parabolic canopy. The parabola, a naturally occurring and strengthening form, was employed to act as a canopy, and metaphorically as the arch of the colonade.

Pre-cast concrete towers are inherently strengthened through their reinforced joints and triangulated forms, providing ample infrastructure for the cable network.

These strong structural statements provide the necessary framework for the future growth of the canopy planting.
View of unvegetated canopy structure
Platform Detail 1:50

Lightweight Steel Pergola
refer to S.E. details
Platform Detail 1:50
Platform Detail 1:50

- Reinforced Concrete
  - refer to S.E. Details
- Mid Level Planter Box
  - refer to S.E. Details
- Concrete Footings
  - refer to S.E. Details
Connections

**Tower:** Major cables are attached to steel fixing plates which are precast into the concrete panels off site. The plates are structurally tied into the concrete reinforcement.

**Ground:** Three steel fixing plates anchor several light weight cables to the ground to provide linkage from ground garden beds to the higher reaches of the pergola structure.

**Social Sciences Floor Slabs:** The cable network is aligned with the column grid (which we assumed to be at 3m intervals) and attached to the 1st and 2nd floor slabs of both buildings. A partial course of brickwork is removed and steel fixing plates are attached to the floor slabs by chemical anchors.
Green Wall

Construction

*Elmich* Green Wall systems come in pre-made modules of dimensions 560mm (H) x 500mm (W) x ≤ 250mm (D).

To create the suggested green wall area to obtain the energy savings as calculated in section 7b, 1530 modules would need to be installed.

Due to the construction of Social Sciences North and South buildings, the modules would sit 40mm out from the facade on a steel structure. As a result of the disparity between the module dimension and the column grid, a free-standing steel structure with added support to reach 3 storeys in height is necessary.

Each module can contain up to 16 plants which must be preplanted in a nursery before installation. A lightweight growing media has been developed to minimise loads on the support structure, even when saturated.

A drip watering system must be installed at appropriate levels. For the 3 storey wall areas, a minimum of 3 drip systems would be required.
Chosen Vegetation

Strategy

The planting strategy was conceived of as a linkage element between the two distinct built elements of the project.

A robust plant choice was required because of the harsh weather conditions that the West facade is subject to. Vines and climbing plants were chosen to minimize the amount of space needed at ground level, and to maximize coverage over head.

At its base, any garden should behave as nature intended it to behave. As seasons change, plants change. Whether it be through the flowering of a vine or a deciduous tree shedding its leaves. It is this basic natural phenomenon that we aim to capture and in doing so hope reinvigorate the ‘natural element’ of the vertical garden. It is for this reason that we chose a combination of partially and fully deciduous vines. The deciduous planting also enables the facade and people to receive sun in winter, and to be shaded in summer.

A plant that does not rely on constant watering (ie. one suited to the Western Australian climate) or replacement is a plant that is sustainable. The image of the pristine and lush green wall that is so often touted in the world of contemporary ‘green design’ is essentially impossible for the chosen location if it is to exist as a sustainable entity.
Positioning of Garden Beds
It was important to create opportunities for the growth of the chosen planting at various levels along the vegetated wall to ensure a dense green mass. For this reason concrete towers (or planter boxes) of various heights were introduced to provide elevated garden beds. In conjunction with the planter boxes substantial ground level garden beds were also introduced along the ovals edge.

Engaging with the Planting
In order to bring the university’s populous closer to the greenery, the essence of the project, generous elevated decks were introduced along the perimeter of James Oval. This provided a shaded versatile threshold for engaging passerbys with the project and the spirit of sustainable design as a whole.

Creation of Intimate Spaces
One of the perceived problems with the site as it exists today is how vast, open and empty it feels. For this reason a pergola was implemented about the platforms (also to be covered in greenery) in order to to acheive more densely green, shaded and intimate spaces between the planter boxes.

Linking of Planter Boxes
The pergola network is linked to the top of the planter boxes via cables both for structural reasons, and to provide a linkage route for the growth of the bougainvilleas.

Creation of Density
A cable and mesh network was introduced between the ground beds, pergolas, planter boxes and adjacent buildings to provide a framework for growth and to increase the density of the greenery throughout the project.
**Chosen Vegetation**

**Planting Schedule**

- **Bougainvillea**:
  - Planter Box (Top)
  - *(Bougainvillea Glabra)*
  - Partially Deciduous climber
  - Relatively pest free
  - Extremely hardy with a high salt tolerance, drought tolerant; are said to thrive on neglect.
  - Pruning only required to control size

- **Star Jasmine**:
  - Ground Beds
  - *(Trachelospermum jasminoides)*
  - Evergreen vine
  - Grows well in a pot or in the ground
  - Will not strangle other plants (unlike other species of jasmine)
  - Perfumed white flowers
  - Suitable to Perth climate

- **Boston Ivy**:
  - Planter Box (Mid Level)
  - *(Parthenocissus tricuspidata)*
  - Deciduous and prolific climber
  - Attaches itself to walls by means of sucker-like discs at the tips of branched tendrils.
  - Deciduous, the leaves are 3-lobed and turn brilliant shades of red, yellow and purple in autumn.
  - Suitable to Perth climate

- **[Pre-Existing] Tree**:
  - Ground Beds
Water

a. Options

The university could water the canopy or a typical green wall system by either;
   i. Rain water harvesting along the roof and all adjacent paved surfaces
   ii. Connecting to the existing irrigation system

It was recognised that there existed potential to use the harvested rain water by passing through a green wall purification system. However, this would require the installation of substantial rain water tanks, in excess of 200 000L. These will either need to be located underground in an area which is already overburdened with services, or above ground where a substantial volume (in excess of 8m in diameter x 1.8m high) would be required.

Because it was determined early that the only viable planting on the west facade are succulents, which require minimal watering, that the capital outlay for a green wall purification system would not be justified. Considering the existing irrigation system and ongoing and set up costs, it would be far cheaper and more practical for a system to be connected to the existing irrigation.

b. Canopy Irrigation system

Due to the sufficient platform and planter box structure we have provided for the canopy, the cheapest and easiest watering option is to connect to the existing irrigation system that runs North-South. This system is low cost and low maintenance, as the planting only needs to be watered as much as residential water restrictions allow, which would be a fraction of the current usage for James Oval.

c. Green Wall Drip Water System

The option of grey water for a vertical garden was ruled out early into the research. A large benefit from vertical gardens is biophilia as the result of people interacting with plants in close proximity. Recycling of grey water is not practical in this situation under the current Western Australia health & regulatory code. Drip water systems become complex at heights of 3 storeys, and are substantially more costly to install than conventional irrigation.
Benefits

The university approached us to research the feasibility of vertical gardens on the Social Sciences buildings to reduce the amount of air-conditioning usage. The university also asked us to compare the capital versus on-going costs.

As the project progressed, it was discussed in meetings that there existed an opportunity to go beyond the vertical garden and utilise the residual space between the oval and Social Sciences.

We have researched both the benefits of placing vertical gardens, versus our canopy design to demonstrate to the university the different environmental and social benefits from each.

The green wall acting as the second skin to the built form contributes many benefits for the occupants indoors, and passers-by in close proximity. However, it does not provide amenity for many passers-by through the thoroughfare.

The canopy provides ‘bioprotection’1 to the West facade of Social Sciences North and South and for pedestrians through the outdoor thoroughfare through mild moderation in temperature and relative humidity.2

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1 Alan Cathersides, Troy Sternberg and Heather Viles, “Evaluating the role of ivy (Hedera helix) in moderating wall surface microclimates and contributing to the bioprotection of historic buildings,” Building and Environment 46 (2011): 293.

2 ibid.
Benefits
(a) Canopy

i. Reduction in wind speed

As discussed earlier, in the afternoon due to James Oval the strong afternoon south-west winds are very unpleasant. The vegetated cable network not only provides extra shading in summer, but reduces the speed of cold wind in winter through the interlacing of the creeper.³

We designed the canopy as a hyperbolic surface that provides stability to withstand the strong south-westerly afternoon breezes. This arrangement of the cables was inspired by the Palio de Bougainvilleas in Puerto Rico, which was designed in a similar manner to withstand hurricane-force winds.⁴

Benefits:

Canopy

ii. Reduced Energy Usage due to Conduction

From a shade projection of the West façade, the amount of shading the canopy provides onto Social Sciences North & South can be estimated.

From this projection, it is possible to compare the tangible benefits of the canopy for west facade. We have used Nyuk Hien Wong et al’s model for calculating reduced mean radiant temperature by percentage of west facade coverage.

This research was carried out on different orientations, so we will apply the results for the West façade. The research was completed in Singapore, and despite having a more tropical climate than Perth, the results apply due to similar temperature ranges. As vertical gardening is a contemporary concept, there is a lack of experiments and results that are directly relevant for Australian cities. However we deemed this model to be quite relevant for Perth’s temperate climate.

Nyuk Hien Wong et al’s model suggests from a TAS simulation that on the west façade, 100% vertical greenery cover on an opaque wall reduces mean radiant temperature by an average of 9°C.

Social Sciences north (SSn) has a west façade surface area of 464m², and Social Sciences south (SSs) has an area of 307.3m². The shading projection shows that 262m² is shaded on SSn, and 155.3m² on SSs. Hence, Social Sciences north has 56.5% shaded west facade, and social sciences south 50.5%. Therefore the average shade coverage for both buildings is 53.5%.

This compares to slightly less then the opaque wall coverage of our proposed green wall system for both buildings at 56.4% (see section 5bi). Hence the added R-value and resistance from heat gain via conduction is 2.9% more effective for the green wall.
Benefits: Canopy

iii. The effect of Solar Radiation on Internal Temperature

The canopy provides shading not only for the west facade but also for the thoroughfare. This reduces heat gain via the west facade for 2 reasons;

a. Reduced conduction from the shaded pavement, and
b. Reduced direct solar radiation through openings.

Where openings exist on the façade, the effect of reducing indoor temperature is minimised due to solar radiation. In our research, we considered this and because the Social Sciences buildings have many openings, the canopy design prevents heat gain via direct solar radiation.

The pavement in summer would heat up to nearly 60°C, as brick has a high thermal conductivity value. This contributes to a high U-value and low resistivity, which in Perth’s temperate climate means they retain heat for long periods throughout the day in summer.

The canopy acts as a mediator for the brick pavement’s high U-value, by reducing the heat gain of the pavement in summer and hence the Social Sciences buildings via convection and radiation, and protecting the thoroughfare from wind in winter which would cool the bricks.

However, we must also calculate how the canopy prevents heat gain due to solar radiation. Considering the sun’s changing path daily and seasonally, we will say of the area shaded by the heavily planted canopy, heat gain transmitted through direct solar radiation via openings is 2.5%. This radiation amount is small due to windows being shaded, and the shaded footpath.

iv. Estimated Temperature Reduction (Conduction + Radiation)

The recommended internal temperature for a classroom or office is approximately 18°C. Nyuk Hien Wong et al.’s results showed that 100% opaque coverage of the west façade reduced energy usage by 74%, translating to reducing mean radiant temperature inside the building by 9°C. However, for the same 10 storey building when windows were introduced, consisting of 31% of the west façade area, energy usage was reduced by 10% which translated roughly to 1°C.

Hence we can roughly estimate that the canopy that provides 52.2% coverage on a theoretically opaque west wall, which would reduce energy usage by roughly 40-50%. By extrapolating Nyuk Hien Wong et al.’s results, this should reduce the interior temperature of Social Sciences North and South by 6-7°C, which becomes significant in Perth’s high summer temperatures.

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6 *ibid.*, 184.
Benefits: Canopy

v. Low Maintenance Cost

Green wall systems are highly expensive in terms of on-going maintenance costs. The two issues of placing green walls on the large blank wall areas of Social Sciences North and South are:

a. Expensive constant drip watering system contributing to large maintenance costs
b. A 3-storey high green wall is difficult to access for maintenance, for example if the drip watering system was in need of repair.

Our canopy and platform design has a relatively large capital cost (see section 8 for costing). However, maintenance costs are reduced for two main reasons

a. The canopy is more easily maintained as it is not 3 storeys tall. This is because the cables must be attached to a floor plate or column grid.
b. The chosen creepers and planting require little watering. This watering system is connected to the existing irrigation pipes underground which has substantially lower set up costs.

‘The Bougainvillea thrives on neglect’
Benefits: Canopy

vi. Social Sustainability

Where a conventional green wall is a symbol of the contemporary desire for sustainability, we believe there is scope to promote an idea of social sustainability. Our design will both reduce UWA’s energy consumption, whilst also providing social, active spaces in a currently empty and unwelcoming residual space. We feel that by suggesting spaces for movement, socialising and rest, the sustainable message would resonate more with students than a green wall.

The social benefits of our design transform the environmental benefits of the two-dimensional green wall into the third-dimension, into the realm of architecture. Successful architecture is simply about reading and understanding human behaviour, and creating interesting and enjoyable spaces for them to experience personally.
Benefits
(b) Green Wall

i. Reduced Energy Usage due to Conduction

With 100% green wall coverage with no openings on the west facade, Nyuk Hien Wong et al’s model suggests from a TAS simulation that mean radiant temperature is reduced by roughly 70%. The study shows that throughout the day of heat fluctuations between 30 and 34°C on the west facade, the mean radiant temperature inside remained at 24°C.

Where openings exist on the façade, the effect of vertical greenery reducing indoor temperature is reduced due to significant heat gain through solar radiation. In our research, we considered this and because the social sciences buildings have many openings, the canopy design prevents heat gain via solar radiation.

Below is the recommended vertical greenery coverage suitable for Social Sciences north and Social Sciences south buildings at UWA (figure 3).

The appropriate areas for green wall planting, excluding openings, on each façade allows 243.65m² on social sciences north, and 185m² on social sciences south.

Hence, social sciences north has 52.5% green wall coverage, and social sciences south 60.2%. Therefore the average coverage for both buildings is 56.4%.
Benefits
(b) Green Wall

ii. The Effect of Solar Radiation on Internal Temperature

The green wall however, in the areas of opaque coverage, 9.5% of the façade of Social Sciences north is transparent and affected by direct solar radiation and 7.1% of Social Sciences south, an average of 8.3%, which becomes a significant amount of heat gain from the western afternoon sun.

This value compared to the 2.5% estimate for the canopy is significantly larger and would effect the indoor temperature of Social Sciences noticeably.

iii. Estimated Temperature Reduction (Conduction + Radiation)

The reduction in mean radiant temperature is explained by the vertical greenery acting as added insulation, hence increasing the R-value of the wall reducing heat transfer inside via conduction.

However, the larger source of heat gain in Perth’s climate is heat transfer via radiation, which explains why the benefits decline with less vertical greenery, and facades with openings.

However, because 8.3% of the green wall areas consist of windows, the energy usage would be reduced by a less amount, roughly 20-30% correlating to a reduction of interior temperature by only 2-3°C. This heat gain for radiation is not outweighed by the 2.9% higher R-value then the canopy, which effectively reduces temperature inside via the west facade by 6-7°C.

Nyuk Hien Wong et al’s results show that protection from direct solar radiation, provided by the canopy and not vertical gardening, is required in order to significantly reduce the energy cooling load.
**Costing:**

**Platform**

+ **Timber decking**: 179m²
  Standard grade treated Jarrah at $90.80/sqm
  Estimated cost = $16255

+ **Timber structure**:
  - 100 x 45 H3 Treated Pine Joists
    287m @ $23.70/sqm
    Estimated Cost = $6820
  - 150 x 45 H3 Treated Pine Bearers
    169m @ $11.50/sqm
    Estimated Cost = $1945

+ **Uni-Pier (Steel Stumps)**
  - 24 @ $75 each
  Estimated Cost = $1800

+ **Concrete Pad Footings** (Stumps)
  - 1.344m³ @ $360/m³
  Estimated Cost = $485

+ **Concrete Retaining Wall**: 2.3m³
  - $520/m³
  Estimated Cost = $1200

+ **Concrete Strip Footings**
  - 1.5m³ @ $360m³
  Estimated Cost = $540

**Total Material Cost** = $29045

+ **Allowance for Labour and Installation**: $14525

**Total Cost** = $43570

Costing:

Tower

+ **Reinforced precast concrete planter boxes**: 43.1 m³
  - Concrete with reinforced joinery @ $460/m³
  - Estimated cost = $19,826

+ **Concrete footings**: 11.58 m³
  - Footings valued at $360/m³
  - Estimated cost = $4,168

+ **Pergola steel structure**
  - RHS 150 x 50 x 3mm
  - Valued at $7740/t
  - Costing = $11,315

Total Material Cost = $35,309

+ **Allowance for Labour and Installation** = $14,000

Total cost = $49,309

Costing:
Cable Network

Canopy + Mesh Network
- Mesh Canopy:
  - 316 Braid Electro Polished Stainless Steel Woven Mesh
- Heavy duty cables: 400m approx.
- Light weight cables: 146m approx.
  - 600m² @ $415sqm
  - Estimated Cost (Labour + Surface Coating inc.) = $249000

Network Fixings
- Pergola fixing plates:
  - 16 @ $80
  - Estimated Cost = $1280
- Floor Slab Fixing plates
  - 9 @ $80
  - Estimated Cost = $720
- Chemical anchors
  - 16 12 x 160 @ $32.80
  - Estimated Cost = $524
- Ground fixing plates
  - 3 @ $150
  - Estimated Cost = $450

Total Cost installed = $251974

* Figures based on independent quote from specialist supplier. Refer to authors.

Costing:

- **Vegetation**
  - Earthwork
    - Estimated Cost = $12000
  - Bougainvillea
    - Estimated Cost (@ $80 approx) = $720
  - Star Jasmine
    - Estimated Cost (@ $12 approx) = $160
  - Boston Ivy
    - Estimated Cost (@ $12 approx) = $120
  - Grass (Middle platform): 75.8 m²
    - Valued at $6.50/sqm
    - Estimated Cost = $492.70
  - Irrigation
    - Estimated @ $300 per tower
    - Estimated Cost = $2700
  - Backfill (Middle platform) = 21.2 m³
    - Estimated Cost (@ $20/m³) = $424
  - Added soil: 29.22 m³
    - Valued at $58.50/m³
    - Estimated cost = $830

Total Material Cost = $17445
+
Allowance for Labour and Installation = $5000

Total Cost = $22445

Costing:
Green Wall

**Elmich Green Wall Modules**
- Total area of green wall coverage: 428.65m²*
  - *This figure does not entirely cover the West facades of the social sciences building but rather represents a coverage ratio that was deemed necessary to achieve a worthwhile thermal benefit.
  - $1200/sqm (Cost inclusive of modules, growth media, simple steel support frame and fixing. Extra steel support may be required for 3 storeys.)
  - Estimated Cost = $514380

**Succulent planting**
- Modules accommodate 16 plants per module
- 1530 modules required for wall coverage of: 428.65m²
- 24480 juvenile succulent plants required @ 50c each
- Estimated Cost (Planting and Labour inc.) = $24480

**Drip irrigation system**
- Allow $15000

* Figures based on independent quote from Sheoaks Landscape Melville
Costing:

Implementation

We wanted our design to be about process, like that of a tree growing. Instead of erecting a pre-planted mature structure, we believe in the natural gradual process of erecting the infrastructure and seeing the plants grow and transform the space from residual into amenity space. This approach will yield more rewarding and long-lasting results and will also help to minimize costs associated with the purchase of mature plants.

Below is a breakdown of the construction stages their associated estimated time of completion per platform.

**STAGE ONE: Sub-Structure (1 week per platform)**
- Earthworks
- Irrigation
- Pouring of concrete footings

**STAGE TWO: Primary Structure (1 week per platform)**
- Delivery and assembly of prefabricated concrete planter boxes *(The pre-stressed concrete panels that make up the towers are prefabricated off-site resulting in far less interruption onsite during their construction).*
- Erection of primary pergola steelwork
- Construction of timber decking structure

**STAGE THREE: Finishing (1 week per platform)**
- Laying of Jarrah decking
- Arrangement of subsidiary pergola cables
- Erection of main cable network and formation of canopy

**STAGE FOUR: Planting (3 days per platform)**
- Planting of Bougainvilleas
- Planting of mid-level vines
- Planting of ground based vines

In only 3 years, the bougainvillea would reach a very dense growth.

We understand however that the university might express concerns as to how long it will take before the benefits of our project will come to fruition, as it relies mainly on the growth of vegetation. For this reason, we suggest a temporary lightweight shade cloth could be used on the canopy and platform pergola framework to provide shading whilst the plants grow.

We recognise that the construction of the entire proposal is a substantial undertaking financially therefore we have made it possible to construct the platforms as singular entities, grouping the construction of the associated towers into manageable sets of 3. The existing residual space surrounding the site would also render the construction process relatively unobtrusive to the daily operations of the site.

Therefore the final completion time of the entire proposal is estimated to be approximately 10 weeks.
Costing:
Government Funding/Initiatives

To assist with the substantial capital costs of both options and to encourage the university, we believe that the Australian Government would be inclined to provide funding or subsidisation to the University of Western Australia.

All these government initiatives aim ‘to equip all Australians with the knowledge and skills required to live sustainably’.8 The symbol of a university, the highest institution of education, implementing an innovative approach to sustainability and receiving funding would be desirable for the government and would have far-reaching effects for the University of Western Australia’s reputation.

The Australian Government granted funding to the towns of Cottesloe and Mosman Park and the Shire of Peppermint Grove for the new Grove Library. $1,500 000 was donated under the Green Precincts Fund which was announced in the 2008-09 Federal budget.

The Green Precincts Fund is an Australian Government initiative that encourages Australians to manage water and energy usage. They recognise projects that raise community awareness, provide energy savings and encourage and demonstrate innovative design.

The Peppermint Grove Library is the only project in Western Australia to receive funding, and 9 other were elected in Australia. The government selected 10 high-profile demonstrate projects, and we believe a contemporary, innovative design at the University of Western Australia would be considered high-profile.

(For more information, visit: http://www.environment.gov.au/water/policy-programs/green-precincts/)

On a smaller scale, the Australian Government offers sustainability grants under the Education for Sustainability Grants Program to homeowners, business owners or individuals that directly benefit the community and promote energy efficiency. Since 1997, 95 projects have been supported and a total of $3 million dollars donated to national strategic projects that facilitate changes in community attitudes towards sustainability.

(For more information, visit: http://www.australiangovernmentgrants.org/)

Discussion

i. The social, financial and environmental benefits of the canopy scheme illustrate that if built, this scheme would be a positive addition to the UWA campus.

Unlike a conventional green wall, the canopy scheme embodies and embraces the difficulties of the site, rather than ignoring them and attempting to create something that is simply not suited to the harsh conditions.

As calculated in section 7, the recommended green wall system suitable for Social Sciences would correlate to a reduction of interior temperature by 2-3°C. Despite having a higher insulation value than the canopy, due to reduced solar radiation via shading, the canopy was shown to reduce temperature inside via the west facade by 6-7°C.

In our calculations of material and labour costs, the green wall system would be $553 860, whereas the canopy system was costed at $367 298. In addition to these set up costs, maintenance costs of the canopy scheme were far less than a green wall system that would yield comparable thermal benefits.

ii. However, both schemes share a number of benefits.

Sound Insulation
Both act as a noise buffer by reducing noise and vibration from outdoor into indoor spaces due to the density of planting.  

Building Envelope Protection
Both systems contribute to the protection of Social Sciences’ western facades, and research has shown this helps to maintain the building for longer.  

Improved Air Quality
Through the natural process of photosynthesis, both systems effectively convert CO2 into oxygen, cleaning up the air.

Increased biophilia
Biophilia is the positive effect that plants and their qualities (i.e. scent, aesthetics) have on people. It has also been published that seasonally changing gardens are also beneficial.

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10 L. Labaki & D. Morelli, op. cit.
11 Binabid, op. cit.
Discussion

iii.
The relative non-specificity of our design provides further opportunity for the University of Western Australia to continue to research and implement contemporary, ecological means.

Our sustainable framework is both a physical and theoretical ‘platform’ for the University of Western Australia to expand on its sustainable ambitions.

**PV cells**
PV cells are an elegant solution to provide shading whilst absorbing direct solar radiation. Transparent in appearance, they could be used in conjunction with the raised steel pergola’s above the platforms along James Oval.

**Solar energy**
We designed the concrete planter boxes to be tall to provide enough structure for the tensile canopy, but they also provide an excellent opportunity for the placement of solar panels. This could be used in conjunction with another UWA based research project into the feasibility of solar powered bicycles, which could easily be integrated into the platform network.

iv.
We believe strongly that our design is beneficial for the university both tangibly in energy savings, but further in non-physical terms by providing amenity spaces for the student body, and giving the University of Western Australia a reputation amongst a green-minded community.

Everything proposed is justified twofold. The shading device is not solely a shading device. The platforms are not solely platforms. As a whole, the project does not fulfill one sole purpose, but many. This multiplicity of benefits from the canopy scheme simply does not exist with a green wall system.

The scheme offers a vision of sustainability that is not solely focused on saving energy but also preserving and promoting a social sustainability.

We hope that this report has explained the benefits of the canopy scheme that can be appreciated by both the UWA student body, and the senate. If the University of Western Australia is not prepared to build this project, we at least hope that our design and research will guide the university in their future decision in keeping with our idea of social sustainability.
Bibliography


• Lilleyman, Gillian, and Seddon, George. A Landscape for Learning: The History of the Grounds of The University of Western Australia. Crawley, Western Australia: University of Western Australia Press, 2006.

