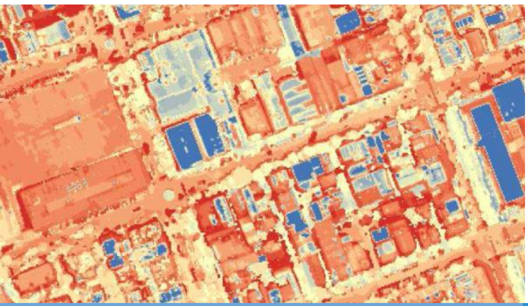
February 2015
Climate Resilience for Decision Makers



Urban Heat Reduction through Green Infrastructure (GI): Policy Guidance for State Government

Policy Brief Executive Summary

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Integrating GI (e.g. street trees, lawns, green roofs and walls) into the urban landscape has the potential to cool the urban microclimate by providing shade and evapo-transpirative cooling whilst also reducing heat retention.

Irrigating GI with safe, sustainable water sources (stormwater, recycled water) will further improve vegetation health and cooling effectiveness. While there are a variety of options available, the effectiveness of each is poorly understood.

This Brief highlights some of the key barriers and enablers for enhancing GI provision in towns and cities, and to sit alongside technical guidance for urban land managers on the selection and implementation of GI elements for the greatest cooling effect.

Findings by Sector

Health

- The Heatwave Plan for Victoria would benefit from the integration of heat reduction measures that target hotspots of existing (and future) urban heat.
- GI not only reduces heat but also provides additional health co-benefits; such as air filtration, promotion of active lifestyles, improved mental well-being, etc.
- GI projects of immediate societal benefit could be implemented using existing data and low-cost technologies, reducing implementation costs and levels of expertise needed.

Transport Planning

- Road networks exhibit some of the highest average surface temperatures across Melbourne.
- Expansion of urban tree cover is limited by a number of barriers that do not currently account for urban heat reduction benefits.
- Enhanced GI encourages use of active transport modes, increases property values, and has been shown to reduce average driving speeds.
- GI can directly reduce the impacts of extreme weather events on transport infrastructure by mitigating both extreme heat and heavy rainfall (through stormwater retention).

Planning and Community Development

- Privately owned GI is shrinking, while access to public green space varies significantly across the city and is reducing on a per-capita basis.
- To reduce the urban heat footprint, incentives and regulations for encouraging private GI implementation should be considered.
- Strategic planning needs to include provisions that allow adequate space and light for street trees and other GI forms to grow.

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Urban Heat Reduction through Green Infrastructure (GI)

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Part I

Whole-of-Government Overview

Melbourne's urbanisation has already resulted in surface temperatures up to 4°C higher than those in surrounding rural areas.

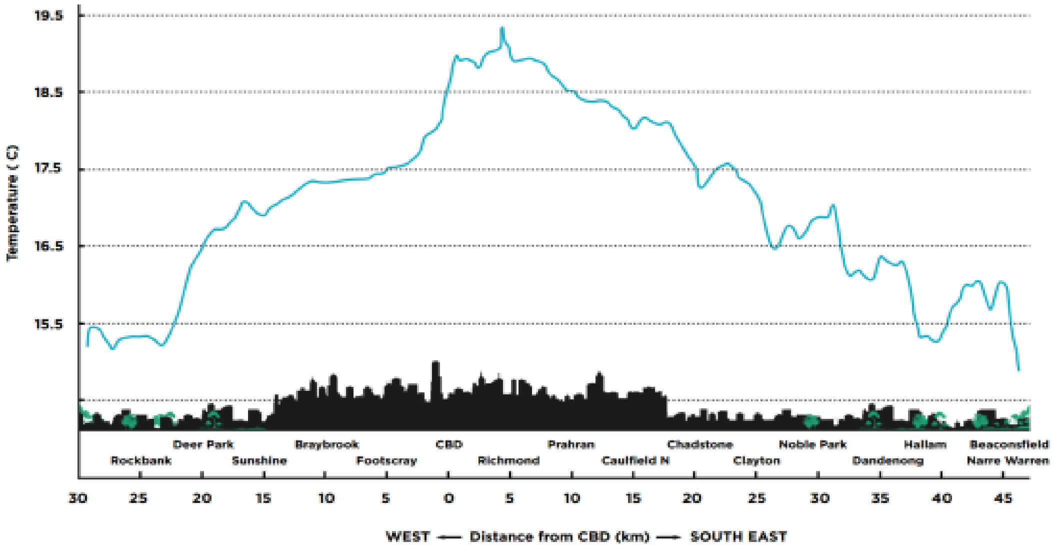
This impact is projected to intensify as the city continues to grow and increase in density; compounding increases in extreme temperatures projected under a changing climate.

This Policy Brief is for **Victorian State Government departments.** It aims to inform state-level policy developments that would support local government strategic and long-term planning and implementation of GI.

The brief is presented in four parts. This section outlines the need for cross-departmental co-ordination of actions to support the reduction of urban heat through increased GI. The subsequent sections provide guidance according to three key portfolios:

- Part I: **Whole of Government Overview**
- Part II: **Health and Welfare**
- Part III: **Transport**
- Part IV: **Planning and Community Development**

Transect of Melbourne's Night-time Surface Temperature UHI



The Urban Heat Island (UHI) effect is created by the built infrastructure absorbing, trapping, and in some cases directly emitting heat. This results in the Melbourne metropolitan area having a climate significantly warmer than its rural surrounds. On clear and calm nights for example, temperatures can be up to 4°C hotter in the CBD; and with ongoing infill and greenfield growth UHI effects are expected to spread and intensify across the wider metropolitan area.

The UHI effect is expected to compound climate change impacts by intensifying heatwaves and extreme heat events. Of particular concern is the nocturnal impact of the UHI, with night-time heat retention strongly associated with deaths during extreme temperature events. Other impacts include: increases in electricity demand; lost workforce productivity; and rail system delays.

Green Infrastructure (GI), defined as living plant matter within the urban environment, is one approach to reducing urban heat. International studies suggest that a 10% increase in GI cover across a city could result in UHI reduction of up to 2.5°C.

It is important to note that green and blue infrastructure are closely inter-linked, with water needed for effective evapo-transpiration and hence cooling potential, while vegetation often acts as an integral component of water sensitive urban design.

GI is of particular value due to its wide range of co-benefits, including: increased property values and urban liveability; as well as enhanced storm-water management, air quality and biodiversity, and CO_2 sequestration.

This brief is presented as a synopsis of key policy issues that may either support or hinder efforts to reduce urban heat through increased GI. It highlights the need for co-ordinated efforts and identifies specific portfolio barriers and opportunities.

Metropolitan Melbourne covers 562,740 Ha, of which only 16% is classified as public open space.

In a 2012 City of Melbourne survey only 18% of businesses believed they were adequately prepared for damage caused by very hot weather.

Strategic Urban Design

As recognised in the *Urban Design Protocol for Australian Cities,* urban form develops through interactions across a number of scales; ranging from federal policies, funding and building codes through to the design choices of individual households and site developers.

State Government is central to this process, providing influential input into federal policies, while also regulating planning delegation to local government authorities. With 81% of public land and road reserves across the metropolitan Melbourne area owned by the Crown, State Government also plays a direct role in shaping Melbourne's urban footprint and the quality and extent of public green space across the city.

In this VCCCAR project, in-depth interviews with key stakeholders such as council staff, developers, architects, and GI industry representatives identified a need for State-level policy to address differing local capacities and contexts. For example, western areas of Melbourne receive half as much rainfall as those in the east and are experiencing annual population growth rates of up to almost 8%. As such, strategic intervention is considered necessary.

Distributed Costs & Benefits

GI has multiple societal benefits that cut across government portfolios. Furthermore, increasing GI in urban environments will require a diverse range of expertise, regulatory functions, and legislative jurisdictions. Therefore, a whole-of-government approach is needed.

In order to be effective, a strategic approach to reducing heat in the city will require a better understanding of the costs and benefits of GI and how these are distributed between public and private sectors. Intervention costs will have to be shared across engaged Government portfolios.

Extensive and multi-sectoral regulatory reform may be required to achieve this outcome. As an example, the state level *Transport Integration Act 2010* could serve as a useful model for legislative coordination across departments.

Advocacy & Co-ordination

Although the VCCCAR research project identified the *Building Code of Australia* (BCA) as a core regulatory enabler for privately-owned green infrastructure when integral to the building roof and wall design, broader State Government support for GI within the areas of energy efficiency, health, and amenity could significantly increase uptake across Melbourne and other towns and cities in Victoria.

Other opportunities to integrate the urban heat reduction values of GI into sustainability accreditation mechanisms exist in programs such as GBCA's *Green Star* rating scheme and the AGIC *Infrastructure Sustainability Rating Tool*.

Further to inter-departmental co-ordination, exploring linkages with programs such as City West Water's *Greening the West* and the IMAP *Growing Green Guide for Melbourne* would also reduce duplication while supporting enhanced cross-municipality co-ordination and capacity building.

Policy Needs:

- A coordinated framework and position across Government
- Support for integration of GI into the BCA and other suitable initiatives
- Integration of GI principles and objectives into government sustainability programs
- Assessment and exploration of options for the re-distribution and sharing of costs and benefits across Government departments

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Part II

Health & Welfare

The 2009 heatwave contributed to the premature deaths of 374 people, as well as a threefold increase in the number of patients pronounced dead on arrival at emergency departments.

Between 2011 and 2050 the average number of annual heat-related deaths across Australian metropolitan areas is projected to double, based on population growth and ageing alone.

Key Messages:

- The Heatwave Plan for Victoria would benefit from the integration of heat reduction measures that target hotspots of existing (and future) urban heat.
- GI not only reduces heat but also provides additional health co-benefits; such as air filtration, promotion of active lifestyles, improved mental well-being, etc.
- GI projects of immediate societal benefit could be implemented using existing data and low-cost technologies, reducing implementation costs and levels of expertise needed.

Health & Welfare Impacts

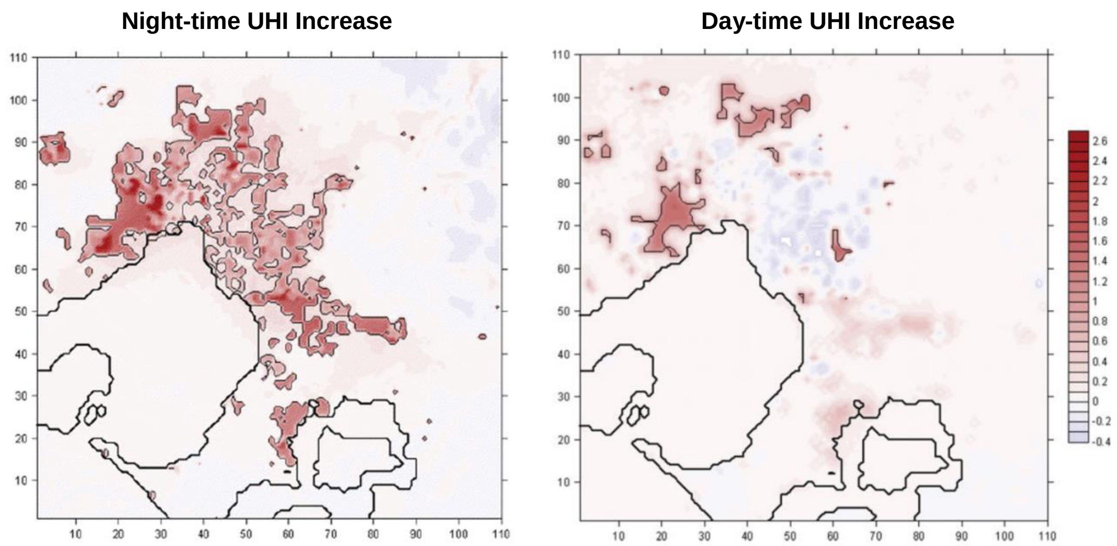
The primary driver in the health and welfare sectors is the link between extreme heat events and excess deaths. As an example, total mortality increased by 62% during Melbourne's 2009 heatwave event. CSIRO modelling suggests that, under a high emissions scenario, the number of consecutive three day periods with maximum temperatures over 37°C is likely to increase from the historic average of one per year to eight by 2100.

Under the same scenario, single days over 40°C are likely to increase from an historical average of 4 to up to 20 per year by the end of the century.

These projected climate change impacts are in addition to the UHI effect, which is also expected to spread and intensify due to the increasing trends of infill and growing urbanisation of greenfield sites.

Currently, urbanisation is estimated to be increasing annual average temperatures by 0.1°C per decade across the city. However, local temperature variations can be much larger, potentially further impacting the health and morbidity of the population. An approximation of the spatial distribution of UHI-based additional warming, under *Melbourne 2030* planning, is shown below.

A recent Commonwealth Government report suggests that the combination of these factors could result in a doubling of annual heat-related deaths by 2050 across Melbourne, with low probability 'super-heatwaves', such as that experienced in France in 2003, potentially resulting in more than 1000 excess deaths in the wider metropolitan area.



Increase in Night-time and Day-Time UHI under Melbourne 2030

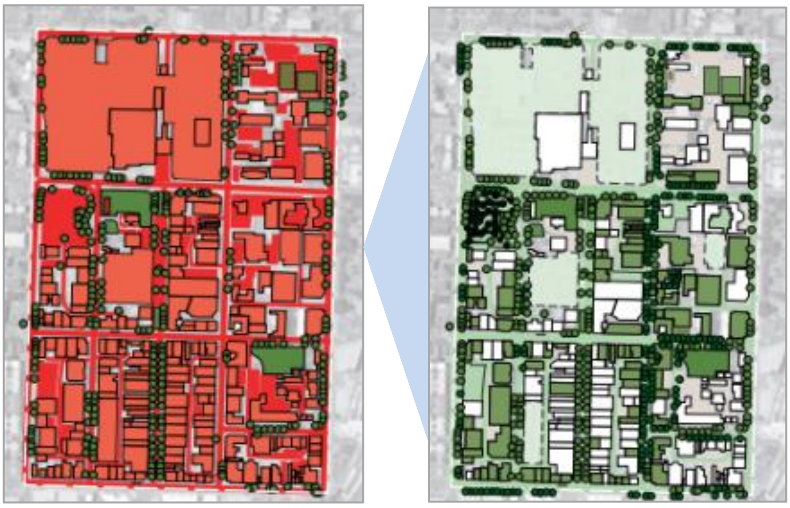
A study in Portland, Oregon estimated that each tree planted across the city removed 92g of PM10 each year, significantly improving air quality.

GI: Health Co-benefits

Various studies have outlined the numerous 'co-benefits' of GI, which include the capacity to:

- Reduce respiratory illness;
- Improve wellbeing and mental health; and
- Encourage active lifestyles and use of alternative transport modes, reducing cardiovascular disease and obesity.

Recent studies into health benefits include the City of Portland's review of 'Health, Energy and Community Liveability Benefits', Forestry UK's 'Benefits of Green Infrastructure' and the European Commission in-depth report into the 'Multifunctionality of Green Infrastructure'.



Existing Conditions   Potential GI Coverage

Liverpool City (Sydney) Case Study: Simplifying Thermal Mapping

Application of an intensive thermal mapping process was found by the project team to be a lengthy, complex and expensive process, requiring high levels of specialist expertise. GI cooling benefits also vary significantly between species, infrastructure type, levels of irrigation, and the type of cooling measured, meaning thermal change through GI implementation can rarely be estimated accurately.

The NSW Government Architect's Office, in partnership with Liverpool City Council, applied a 'low-tech' approach in their demonstration assessment of greening a local activity centre in Liverpool, Sydney, measuring total coverage through a 'green or not' model.

This heat sinking/emitting approach can easily be applied to local activity centres, or vulnerability hotspots identified through socio-economic analysis and/or publicly available city-wide thermal mapping.

Advocacy & Co-ordination

The elderly, the young, and the socio-economically disadvantaged, are groups that have been identified as being vulnerable to heat stress. Integration of GI into existing management and planning for public sector residential services could contribute to reducing their heat exposure, while also reducing their cooling-related energy demands (and costs).

Similarly, integration of GI modules into the *Victorian Prevention and Health Promotion Achievement Program* could provide multiple benefits e.g. supporting active GI implementation in schools and informing the teaching curriculum. The health benefits could also be integrated with the *Victorian Schools' Garden Program*.

There is currently no comprehensive methodology for quantifying GI co-benefits. Although international best practice provides qualitative estimates, local research into quantifying the health and welfare benefits of public green space would assist decision-making, as well as articulating a business case for enhanced GI implementation.

Heat-Proofing Hotspots

The UK's 2009 *Heatwave Planning Guide*, highlighted that best practice heatwave planning integrates urban greening to reduce the frequency at which extreme temperature thresholds are crossed. This practice could be considered in *Victoria's Heatwave Plan*.

In partnership with municipalities, the Victorian Government could support development of GI implementation plans for key activity centres. The Northern and Western Metropolitan Regions could be priority areas due to higher maximum day-time temperatures and lower water availability in this area. Local activity centres also have higher public use during day-time hours, coinciding with maximum temperatures. One 'low-tech' mapping option is currently being assessed for application in Sydney's west (see left).

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Part III — Transport

Crown road reserves make up 45% of total public land. This is in addition to the area directly covered by roads and railway.

Key Messages:

- Road networks exhibit some of the highest average surface temperatures across Melbourne.
- Expansion of urban tree cover is limited by a number of barriers that do not currently account for urban heat reduction benefits.
- Enhanced GI encourages use of active transport modes, increases property values, and has been shown to reduce average driving speeds.
- GI can directly reduce the impacts of extreme weather events on transport infrastructure by mitigating both extreme heat and heavy rainfall (through stormwater retention).

Maximising Public Space Cooling

Public road reserves across metropolitan Melbourne cover 73,000 hectares, while roads and railway cover an additional 9000 Ha. At a local 'micro-climatic' scale (see below); streetscapes represent some of the highest urban surface temperatures across the study area, particularly in the CBD.

Streets are therefore a key area where state and municipal governments could directly develop and implement GI options.

Integration of street tree planning with existing programs and policies, such as Water Sensitive Urban Design (WSUD) and Greening the West could enable optimisation of resources, expertise, and strategies.

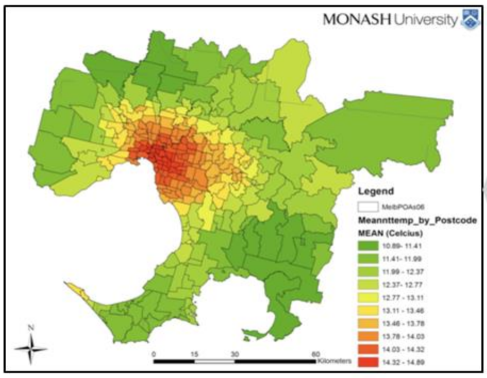
Transport infrastructure will benefit directly from increased GI as it can reduce many extreme heat impacts (such as rail and tram line buckling) through its cooling and shading effects, as well as slowing stormwater.

The values discussed throughout this brief present a key opportunity to account for and incorporate a range of GI benefits, including urban heat reduction, into the streetscape planning processes e.g. recognition of GI in a future policy review of the *Integrated Transport Act*.

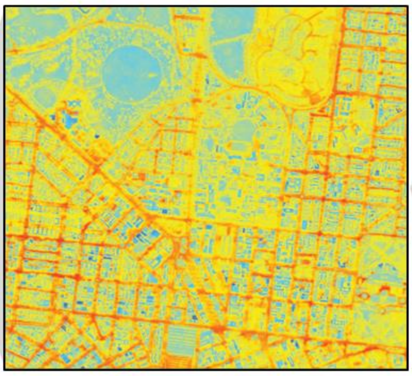
Setbacks & Other Regulations

There are a number of barriers to increasing street tree canopy cover within the existing literature, including research specific to the Melbourne context. In-depth interviews conducted for this VCCCAR study were able to identify a number of barriers specific to Victorian State Government rules and regulations. In particular, the setback requirements set out in the *VicRoads Supplement to the Austroads Guide to Road Design* were commonly cited as a major barrier.

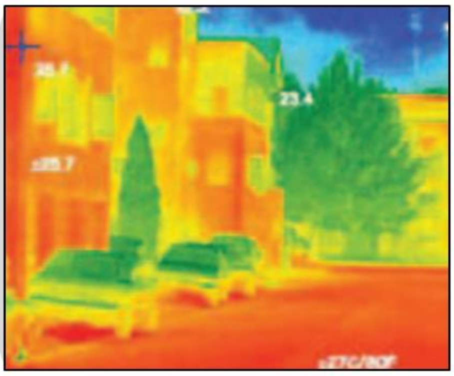
Aerial UHI by Postcode



Localised Aerial UHI



Ground-level Vertical Surface Heat



Different Scales of Thermal Mapping across Melbourne

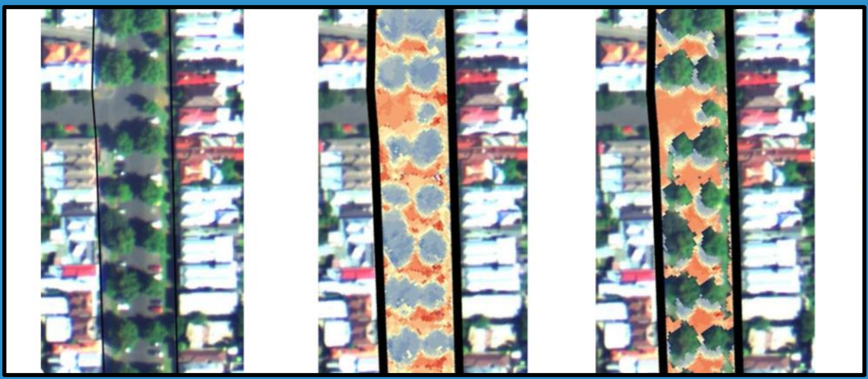
During a driving simulation test participants drove 4.87kph slower in areas with street trees.

Enforcement of current minimum clear zone widths (3m for zones below 60kph) would significantly reduce street tree coverage across Melbourne. Although originally established for 'safety', these setbacks do not reflect studies indicating that suburban street trees can reduce average driver speeds by almost 5kph.

These setback regulations could be re-assessed and provisions made for urban contexts that better support GI and urban heat reduction. Other barriers range from canopy thinning for tram overhead lines through to parking configurations.

Opportunities to support GI through transport planning, policy and practice include:

- The narrowing of streets where tree planting is currently restricted by space (either to minimum lane width provisions or through creation of one-way access);
- Integration of permeable pavement and surface tapering towards tree plantings; and
- Development and communication of guidelines for voluntary resident maintenance and enhancement of kerbside areas.



Street Tree Planting Guidelines for Urban Canyons

In order to maximise cooling through street trees, the following guidelines were developed by the research team:

- Street trees should be prioritised for wide streets with a height-width ratio less than 0.8, where the tree canopy should be maximised on both sides of the street as well as in the street centre.
- For **East-West** streets with a height-width ratio greater than 0.8, street trees should be prioritised on the south side of the street.
- For **North-South** streets with a height-width ratio greater than 0.8. street trees should be prioritised for the centre of the street, followed by the East, and then the West side.
- There is less value in implementing street trees with a height-width ratio greater than 3, however the cooling benefit in these narrow streets is greater for North-South than East-West ones.

Costs of these measures could be minimised by progressive application within ongoing maintenance and resurfacing programs.

Water Retention

A primary factor in determining the cooling capacity of GI, including street trees, is irrigation. For example, areas adjacent to irrigated ovals show up to 5°C differences in surface temperature. Capturing and storing stormwater – including through transport infrastructure surface runoff – is central to enabling and maintaining effective GI-based cooling. This can supplement rooftop stormwater storage in private dwellings.

Annual estimates of urban run-off in Melbourne (453 gigalitres) exceed the region's annual water consumption (412 gigalitres). Retention of this non-potable water would support ongoing maintenance of Melbourne's urban street trees, particularly as rainfall is likely to become reduced and more irregular due to climate change, reducing the need for potable water to sustain vegetation.

WSUD provides a well-established basis for integrating water retention and GI into streetscapes, with engineered designs options already deployed and tested across Melbourne. Numerous councils also have established WSUD implementation programs. Additional state-level support within transport policy and maintenance programs would significantly increase WSUD uptake.

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Part IV Planning & Community Development

Planning Institute of Australia survey respondents identified *'weight, or incentive to consider issues around sustainability, climate change mitigation or environmental issues'* as the 2nd biggest problem they had with the Victorian planning system.

Key Messages:

- Privately-owned GI is shrinking, while access to public green space varies significantly across the city and is reducing on a per-capita basis.
- To reduce the urban heat footprint, incentives and regulations for encouraging private GI implementation should be considered.
- Strategic planning needs to include provisions that allow adequate space and light for street trees and other GI forms to grow.

Valuing Green Infrastructure

Urban greenery is one of the key factors contributing to Melbourne's ranking as the most liveable city. However, as Melbourne increases in density and spatial extent, privately owned green space is reducing, while existing public green space is being used more intensively, with less available per capita.

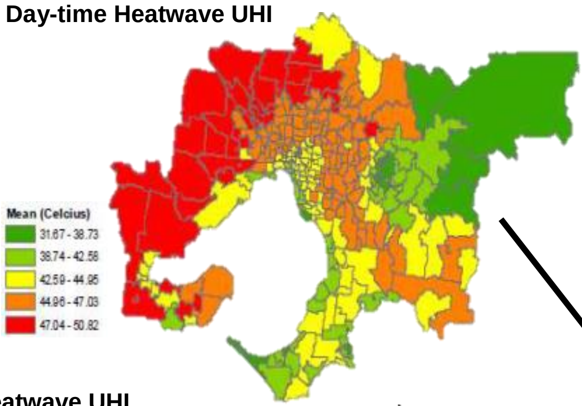
A lack of overarching State Government guidelines was identified by those interviewed as being central to the inability of local government to enforce municipal open space and GI requirements, particularly in western growth areas, which experienced extreme day-time heat during recent heat waves (see below).

International best-practice examples of city-wide GI planning usually include a range of 'carrot' and 'stick' initiatives, including:

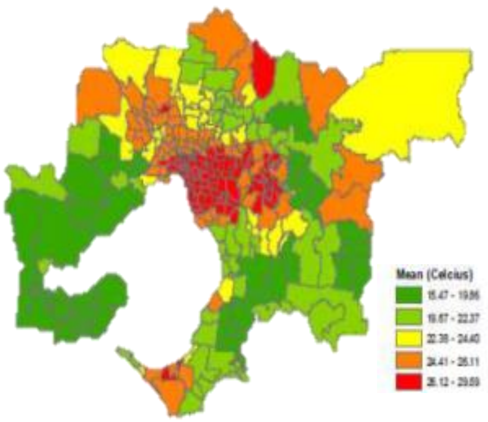
- Compensation or offsetting rates for the development of green space;
- Percentage-based GI coverage requirements for new developments;
- City-wide mapping of GI coverage; and
- One-off tax credits based on stormwater retention potential.

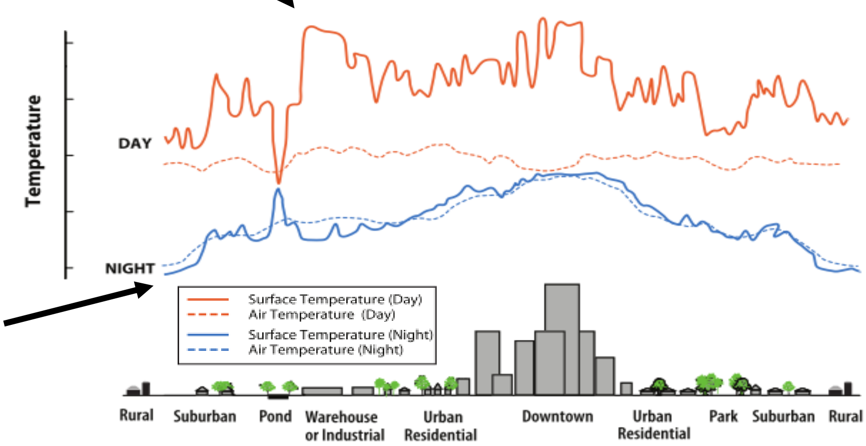
Development of a similar supporting framework for Green Infrastructure implementation within Melbourne's *Metropolitan Planning Strategy* could provide certainty and technical support for municipalities wishing to address urban heat through GI, while also directly enhancing the city's liveability.

Day-time Heatwave UHI



Night-time Heatwave UHI





Transect of Diurnal Differences in UHI Patterns

Privately-owned open space is shrinking: an average Melbourne house built in 2007 covers 34.5% of its allotment, compared to 21% in 1990.

A study by the City of Newcastle found that private green space accounted for more than 48% of the city's GI. Equivalent figures for Melbourne are not currently available.

Private vs. Public

Private land accounts for 84% of the Melbourne metropolitan area. Although no city-wide estimates of private and public GI or open space were available, neighbourhood-level data suggests that private GI across Melbourne has shrunk over recent years due to larger building footprints and ongoing infill. For example, between 2000 and 2009, the number of privately owned trees in the suburb of Balywn declined by 16%.

Without enhancing private Green Infrastructure, improvements on public land are likely to be negated, with the UHI intensifying as a result. Urban Renewal Projects, Growth Area Precinct Structure Plans and Activity Centre re-development programs represent key planning processes that can integrate green infrastructure at an early stage without expensive retro-fitting.

Key principles that could be integrated into these planning processes include:

- Weighting building height restrictions against street level green space, with additional consideration of public access;
- Tiered building set-backs to maximise street tree benefits; and
- Compulsory calculation of proposed GI coverage across the site measured against international best practice.

Linking Co-Benefits

Although urban heat reduction is a significant social benefit of GI, our research identified that in practice GI is implemented for other primary purposes (see diagram, left). As a consequence, urban heat reduction strategies should primarily provide additional support to existing GI programs if they are to be effective.

Public GI projects can reduce stormwater runoff, enhance property values, and increase urban liveability, walkability and amenity. Private GI, however, can significantly increase energy efficiency, improving the long-term affordability of housing stock, while also providing a public good in the form of reduced external heat.

Green roofs have been found to save 15-45% of total annual energy consumption, predominantly due to reduced cooling costs. An American study also found that simply through shading, a single 10 year old tree could reduce energy costs by 8%.

Consideration of these types of benefits – as well as appropriate linkages between GI types, ownership and beneficiaries – should be incorporated into the *Planning and Environment Act 1987*.

Planning for Future Liveability: City of Melbourne Case Study

The City of Melbourne *Urban Forest Strategy* demonstrates a best practice, evidence-based approach for urban forestry. In particular, the strategy focuses on the city's future liveability, taking into account the need for planning green infrastructure 10-20 years in advance to allow for the full benefits of mature GI. The strategy also assesses the interrelationships with other future challenges and drivers, such as urban renewal, population growth and climate change. A similar approach could be taken in addressing urban liveability and GI in planning for the wider metropolitan area.

A full list of references supporting this policy brief is available from the project team. Please contact:
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