

Roadmap for green roofs, walls and facades in Australia's urban landscapes 2020-2030

University of Melbourne, UNSW Sydney and Hort Innovation

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This roadmap was developed from the 2019 Green Roofs, Walls and Facades Summits led by Leisa Sargent (UNSW Sydney), Kate Lee (University of Melbourne) and Nick Williams (University of Melbourne) as part of Hort Innovation project GC 16002.

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Authors' Organisations



Executive Summary

Urban green infrastructure is the network of green space in the private and public realm and includes parks, private gardens, street trees, native remnant vegetation and more engineered forms such as rain gardens and green roofs. Increasing the extent, diversity and quality of green infrastructure is vital for ensuring the physical and mental wellbeing of Australia's increasingly urbanised population, and for climate change adaptation. With less ground-level space available in cities to establish new parks, trees and gardens, engineered forms of green infrastructure - green roofs, walls and facades - offer opportunities to grow plants up and on top of built structures; combining grey infrastructure with green infrastructure.

The multiple benefits of green roofs, walls and facades are well documented, but Australian cities are lagging behind many of their international counterparts in the rate and extent of implementation. To explore how uptake could be accelerated we ran Green Roof, Wall and Facades Summits in Sydney and Melbourne in 2019 with representatives from industry, academia, community, local government and state government agencies. Participants worked collaboratively to create a positive vision for greener Australian cities and identify the key actions needed to achieve this. The creation of a roadmap was seen as a critical first step and as a foundation document for other actions.

A series of enabling actions were collectively identified to achieve a flourishing GRWF industry and more liveable future green cities. Actions fall within six overarching strategies:

- 1. Gather and share knowledge**
- 2. Collaborate and advocate**
- 3. Government coordination and national leadership**
- 4. Develop and implement policy mechanisms**
- 5. Enhance skills and expertise**
- 6. Design for success**

This roadmap is a step towards achieving flourishing, sustainable green roofs, walls and facades in Australian cities that contribute positively to human health and wellbeing, support biodiversity and ecosystem services and that are integrated into planning, design and management.

The success of this roadmap relies on the participation and coordination of the diverse range of professions and agencies involved in the design, planning, installation and maintenance of green roofs, walls and facades, along with researchers and the community.



Figure 1. Building Facade. Photograph University of Melbourne

Table of Contents

Aim & Vision	6
Introduction	7
Strategy 1. Gather and share knowledge	8
Action 1.1 Establish a Knowledge Hub	8
Action 1.2 Create opportunities for knowledge exchange	8
Action 1.3 Identify and address knowledge gaps	8
Global Exemplar - Knowledge Hub	9
Strategy 2. Collaborate and advocate	10
Action 2.1 Establish a national body to advocate and educate on GRWFs	10
Action 2.2 Identify champions and encourage leadership	10
Global Exemplars - Collaborate and Advocate	11
Strategy 3. Government coordination and national leadership	12
Action 3.1 A national approach to green infrastructure planning and implementation	12
Action 3.2 Federal and state governments develop the policy framework	12
Action 3.3 Integrate GRWFs in intergovernmental initiatives and arrangements.	12
Action 3.4 Dedicate funds and improve the process for approvals	12
Action 3.5 Governments to lead by example	13
Action 3.6 Invest in research and development	13
Action 3.7 Government support for industry growth	13
Strategy 4. Develop and implement policy mechanisms	14
Action 4.1 Create incentives at a city scale	14
Action 4.2 Establish mandatory regulations	14
Action 4.3 Develop guidelines and standards	15
Action 4.4 Embed GRWFs in design of new developments	15
Action 4.5 Integrate GRWFs into building infrastructure ratings tools	15
Action 4.6 Identify funding mechanisms for GRWFs	16
Global Exemplars - Policy Mechanisms	17

Strategy 5. Enhance skills and expertise	19
Action 5.1 Develop education and training	19
Strategy 6. Design for success - maintenance, function and form	20
Action 6.1 Design for function	20
Action 6.2 Design for maintenance	20
Action 6.3 Adopt an Integrated Water Management approach to planning and design of GRWFs	20
Action 6.4 Use indigenous and native plants	20
Milestones	21
Where to from here?	23
Connecting strategies and actions	23
Starting the process	23
Acknowledgments	24
References	25

Aim & Vision

Aim

The purpose of this document is to help drive greater uptake of green roofs and vertical greening across Australia. It presents a collaborative vision for green roofs, walls and facades for Australia's urban landscapes and the steps needed to achieve this.

Vision

Australian cities have flourishing, sustainable green roofs, walls and facades that contribute positively to human health and wellbeing, support biodiversity and ecosystem services and are integrated into planning, design and management.



Figure 2. Visions for flourishing green roofs, walls and facades (GRWFs) in Australia 2030 as identified in the Green Roof, Wall and Facade Summits (2019).

Introduction

Urban green infrastructure is the network of green space in the private and public realm and includes parks, private gardens, street trees, native remnant vegetation and more engineered systems such as rain gardens and green roofs (Norton et al. 2015). Increasing the extent, diversity and quality of green infrastructure is vital for ensuring the physical and mental wellbeing of an increasingly urbanised population, and to enable Australian cities to adapt to climate change (Shanahan et al. 2016, Hartig et al. 2014). With less ground-level space available in cities to establish new parks, trees and gardens, engineered forms of green infrastructure - green roofs, walls and facades - offer opportunities to grow plants up and on top of built structures; combining grey infrastructure with green infrastructure. The multiple benefits of green roofs, walls and facades are well documented. These include cooling through evapotranspiration and shading (Norton et al. 2015), energy and cost savings for buildings – particularly for summer cooling (Bevilacqua et al. 2016), stormwater control (Bengtsson et al. 2005), enhancement of local biodiversity (Williams et al. 2014), air quality (Yang et al. 2008), higher property values and tenant occupancy (Jones et al. 2018) and increased nature connectivity and the restorative benefits this provides (van den Berg et al. 2007). Combining GRWFs with ground-level green infrastructure can help reduce urban vulnerability to climate change impacts such as increased frequency of flooding and greater temperature extremes (Kohler and Kaiser 2019, Green et al. 2016, Dow et al 2013).

Given the multiple benefits they provide, it is surprising that green roofs, walls and facades are not more common in Australian cities. To explore how their implementation could be accelerated we ran Green Roof, Wall and Facades Summits in Sydney and Melbourne in March-April 2019. GRWFs are engineered green infrastructure systems and combine structural and living elements that function at multiple city scales, so achieving greener cities requires collaboration amongst diverse professions, all levels of government and a range of other stakeholders. Lead actors were identified across a number of GRWF sectors and representatives from these groups were invited to participate in the GRWF summits. These sectors are broadly categorised as:

- Building owners and property (facility) managers
- Developers
- Landscape architects, landscape designers and architects
- GRWF suppliers, installers and maintenance personnel
- State and local government – including planning and policy
- Engineering
- Water industry
- Research and education
- Sustainability and environmental professionals.

Over 60 participants worked collaboratively to create a positive vision for greener Australian cities and identify the key actions needed to achieve this. The creation of a roadmap was seen as critical first step and as a foundation document for other actions. In this document, green roofs, walls and facades are abbreviated to GRWFs.

Workshops used an appreciative inquiry approach (Cooperrider & Whitney 2001) to generate collective visions for GRWFs shaping future green cities – how cities might look, be experienced and the benefits that GRWFs could provide. The barriers to the large-scale implementation of GRWFs are relatively well understood and this topic has been the subject of studies in Australia and overseas (Williams et al. 2010, Zhang et al. 2012). Workshop participants identified the critical changes that would be needed to remove some of these barriers.

A series of actions were collectively identified to achieve a flourishing GRWF industry and more liveable future green cities. These actions fall within six overarching strategies:

- 1. Gather and share knowledge**
- 2. Collaborate and advocate**
- 3. Government coordination and national leadership**
- 4. Develop and implement policy mechanisms**
- 5. Enhance skills and expertise**
- 6. Design for success**

Strategy 1 - Gather and share knowledge

There is a significant body of knowledge about the benefits, value and construction requirements of GRWFs in Australia. An online platform to aggregate and share this information is essential for accelerating advances in the GRWF sector. Several knowledge gaps have been identified that could be met through aggregating existing data (e.g. economic costs and benefits (Jones et al. 2018), while new monitoring and research is required in other areas – for example to quantify the thermal benefits of GRWFs in Australian climates (Pianella et al. 2016, Norton et al. 2015).

Technology is critical for both obtaining data and for information exchange. Cities are increasingly ‘data-driven’, and digital technologies are tools that can improve the delivery of green infrastructure benefits (including GRWFs) and increase stakeholder participation and engagement (Nitoslawski et al. 2019).

Action 1.1 Establish a Knowledge Hub

- Establish a Knowledge Hub for Green Roofs, Walls and Facades - an online portal for sharing research data, case studies, ideas and resources that is accessible to practitioners, government, researchers and the community.
- Identify an independent host organisation to support the Knowledge Hub. The host should be able to communicate across professional disciplines, have a strong profile and be able to promote effectively. Establish a process to determine the site’s scope and structure and identify the resourcing needed for establishment and ongoing maintenance.

Action 1.2 Create opportunities for knowledge exchange

Creating opportunities for knowledge exchange may be driven by the national body for GRWFs, or through collaborative activities amongst diverse stakeholders. Forums would allow stakeholders from different disciplines to share expertise, experiences and innovative approaches.

- Run a national conference or symposium to bring stakeholders together.
- Draw on knowledge and experiences from all sectors and share ‘lessons learned’; share intellectual property knowledge to grow the market.
- Use pilot projects and demonstration sites in the private/public space to gather data, create opportunities for learning and raise the profile and understanding of GRWFs.
- Create opportunities to bring together decision-makers from diverse sectors.
- Create communities of practice.
- Use media to inform and educate the community.

Action 1.3 Identify and address knowledge gaps

- Identify the economics of health/wellness from GRWFs
- Collectively identify existing knowledge gaps across industry, government, community and academia that are current barriers to uptake of GRWFs in Australian context. Prioritise research needs.
- Address knowledge gaps through drawing on existing data and information and/or new research projects or monitoring programs. Share outputs on the GRWF Knowledge Hub and through other knowledge exchange pathways.

Global Exemplar - Knowledge Hub

C40 Knowledge Hub

A Knowledge Hub is a way for networks to exchange information, ideas and experiences and store and retrieve data and other media, building a body of knowledge to advance understanding, inform policy and planning, and progress a particular sector.

Knowledge hubs are often accessed through an online portal with different levels of public/private accessibility. They may also bring together people in the real world from businesses, research organisations, government and community to share information and build new knowledge and skills. An effective knowledge hub is more than a simple online repository for storing reports and other media – ideally it should also provide a dynamic way to correspond with other members, to problem solve and exchange ideas and information.

One example of a comprehensive online portal that includes many of these features is the C40 Knowledge Hub. C40 Cities is a partnership amongst 94 global cities to act against, and build resilience towards, climate change. Mayors of the C40 cities (representing 700 million citizens) are working to deliver goals of the Paris Agreement at the local level.

The Hub offers both knowledge (extensive suite of resources comprising different media) and forums for discussion and is a central portal that simplifies information sharing across multiple stakeholders (cities). Features include access to webinars and the opportunity to ask an expert. It has good searchability and is freely accessible.

Link: https://www.c40knowledgehub.org/s/?language=en_US

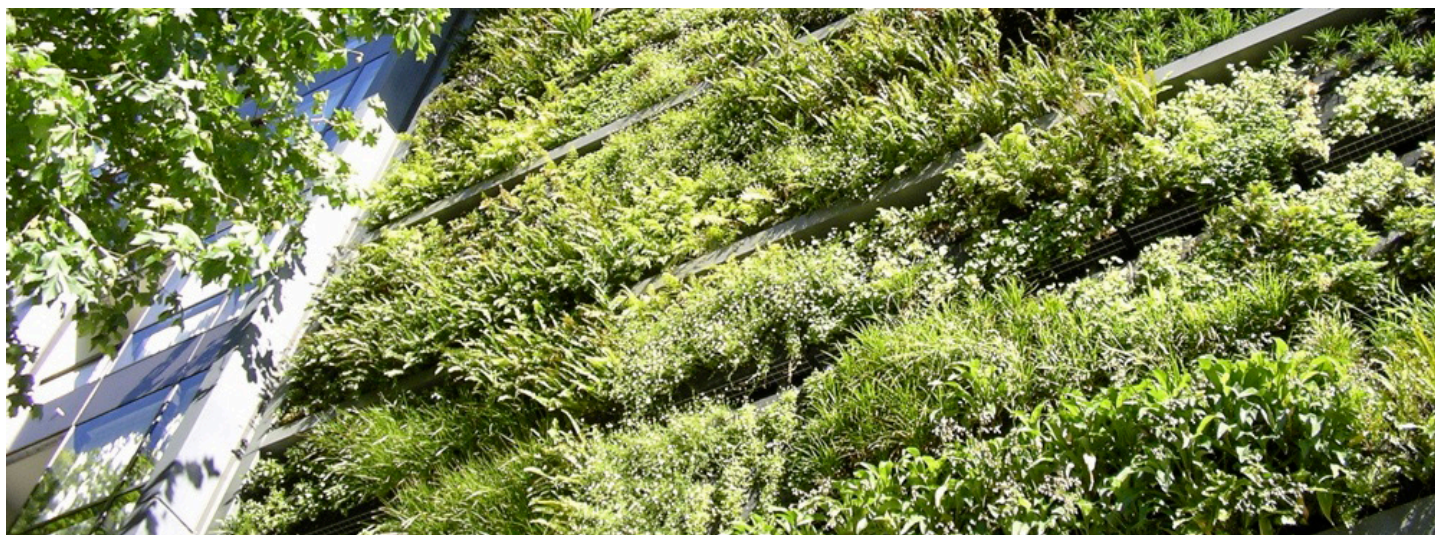


Figure 3. Triptych Apartments Green Wall, Southbank, Victoria. Photograph City of Melbourne

Strategy 2 - Collaborate and advocate

Action 2.1 Establish a national body to advocate and educate on GRWFs

An effective, independent, national advocacy body is needed to drive the uptake of GRWFs across Australian cities. It would have an essential role in advocacy, leadership, education and could assist in developing the requirements in training, accreditation and industry engagement.

- Industry endorsement: Membership should include diverse disciplines from across the industry. It is essential that this body is respected, trusted and valued by its members and advocates to progress the industry. The support from established and related industry bodies and professional associations would be essential in developing this new national body.
- Education and outreach: Education targeting building owners, architects, landscape architects, and policy makers can have significant impact on bringing GRWF technology into the mainstream. The national body should bring industry together for knowledge sharing in forums and conferences and develop a public awareness campaign to effectively communicate the benefits and business case of GRWFs.
- Monitor and report on success of individual and collective projects – using environmental and social metrics. Monitor and report on success of advocacy efforts (e.g. increased awareness in the community; an increase in number of high-quality GRWFs; growth of the industry).

Action 2.2 Identify champions and encourage leadership

Champions and leadership can be highly effective at driving change and are needed from all sectors, both at national level, and for individual projects. Where leaders or champions from multiple sectors come together to support delivery (e.g. from business, government and community) there is usually greater uptake of ideas and actions (Freney et al. 2017). Champions or leaders in industry, government, education, community and other sectors have the capacity to influence others and may or may not have a formal role in promoting GRWFs (Howell and Higgins 1990).

- Identify key stakeholders in state governments and other sectors to drive change.
- Create more formal leadership positions across multiple sectors (e.g. industry, government, education, non-government organisations) that have a dedicated role in the implementation of GRWFs.
- Identify a process for fostering GRWF champions, or emergent leaders (i.e. those who choose to engage in leadership behaviours rather than having a leadership role) (Taylor et al. 2012, Taylor 2009).



Figure 4. Melbourne Quarter Sky Park. Photograph Rachael Bathgate, University of Melbourne



Figure 5. Melbourne Quarter Sky Park. Photograph Rachael Bathgate, University of Melbourne

Global Exemplars - Collaborate and Advocate

Green Roofs for Healthy Cities

Green Roofs for Healthy Cities (GRHC) is a North American (Toronto, Canada) member-based industry association established in 1999. Its aim is to grow the number of green roofs and walls in North America and support the green infrastructure industry. It does this by raising awareness of the economic, social, and environmental benefits of green roofs, green walls, and other forms of living architecture through education, advocacy, professional development, and by recognising 'excellence'. Activities include the Green Roof Professional (GRP) training and accreditation program, development of case studies and industry resources, co-development of standards, an annual conference (CitiesAlive) and smaller, regional symposia.

Link: <https://greenroofs.org/>

Scandinavian Green Roof Institute

The Scandinavian Green Roof Institute (SGRI) promotes itself as a 'knowledge centre for blue green infrastructure' - a platform for sharing knowledge, gaining inspiration and creating collaboration.

SGRI was established in 2000 by the Scandinavian Green Infrastructure Association (SGIA), a non-profit organisation comprising academia, municipal departments, green roof entrepreneurs, architects, developers and other organisations with an interest in green roofs and urban green infrastructure. SGIA's vision is 'a Scandinavia where buildings and nature are combined – where green roofs and walls create living, livable and resilient cities.'

SGRI is open to global participants and runs guided tours, courses and lectures on green roofs and walls, urban ecosystem services, green infrastructure for climate adaptation and stormwater management. The institute works collaboratively with a number of EU, Swedish and local government agencies, undertaking research and development projects. They also act as consultants, supporting SGIA members and industry development. Examples of outputs and tools include the Scandinavian Green Infrastructure Handbook and online e-learning modules showcasing local green infrastructure installations. SGIA runs the annual Scandinavian Green Roof Awards - intended to inspire the Scandinavian green roof market toward excellence and to raise public and professional awareness about the benefits of green roofs.

Links: <https://greenroof.se/en/#services>
<https://green-roof.org/the-scandinavian-green-roof-award-2019/>



Figure 6. Minifie Park Green Roof, Balwyn, Victoria. Photograph University of Melbourne



Figure 7. Augustenborg Botanical Roof Garden, Malmö. SGRI manages guided tours and the development of educational and project activities at the 9,500 m² roof atop a government building. Image SGIA (<https://greenroof.se/en/eco-city/botanical-garden/>)

Strategy 3 - Government coordination and national leadership

Countries and cities that have shown rapid uptake of green roofs, walls or facades are characterised by strong national and/or state government leadership with clear policies and strategies, established funding and a high level of coordination amongst all levels of government (State of Victoria 2014, City of Melbourne 2017, Wilkinson et al. 2017). A national approach is needed to drive the transformation of our current grey infrastructure-dominated urban landscapes into future green cities. There are opportunities to boost greening in cities through arrangements such as ‘City Deals’ - partnerships between the three levels of government and the community to work towards a shared vision for productive and liveable cities (Australian Government 2019).

Action 3.1 A national approach to green infrastructure planning and implementation

Green infrastructure is essential infrastructure for cities. A coordinated, national approach amongst federal, state and territory governments is required to achieve future green cities. Green Infrastructure needs to become BAU (business as usual) rather than an afterthought in strategic planning for cities.

- All levels of government need to collaboratively identify a clear vision for greener capital and regional cities with endorsement from the Minister for Population, Cities and Urban Infrastructure.
- Green infrastructure needs a national strategy formulated by cities and ministers from diverse portfolios, including health.

Action 3.2 Federal and state governments develop the policy framework

Federal, state and territory governments need to lead and provide an integrated policy framework for delivery of GRWFs.

- GRWFs and other forms of green infrastructure should be considered across multiple federal and state government portfolios (e.g. health, education, skills and employment) so that it becomes embedded in policy and ‘mainstreamed’.
- State and territory governments should support and coordinate initiatives and actions amongst local governments.
- Public health policies should highlight the human health benefits of GRWFs and other green infrastructure in cities.
- Develop a policy framework around public health and heat.

Action 3.3 Integrate GRWFs in intergovernmental initiatives and arrangements.

Smart Cities also need to be Green Cities. The Australian Government’s Smart Cities Plan and City Deals need to consider green infrastructure (including GRWFs) as essential infrastructure. City Deals should prioritise green infrastructure projects for funding.

- Link living infrastructure with initiatives such as ‘City Deals’ - partnerships between the three levels of government and the community working towards a shared vision for productive and liveable cities.
- Green infrastructure should be integrated in Infrastructure Australia and green infrastructure projects given priority status.
- Large infrastructure projects should assess the impact on existing green infrastructure and be required to provide additional green infrastructure as part of the project. GRWFs and other green infrastructure should be designed and maintained to meet defined environmental and social objectives.
- Prioritise areas for implementation. Use existing physical and demographic/socio-economic data to identify potential sites – current and emerging, retrofit and new. Prioritise areas where GRWFs would be most effective and where communities are vulnerable (for example, heat vulnerability and lack of social connectedness).

Action 3.4 Dedicate funds and improve the process for approvals

There needs to be coordination amongst all levels of government for funding, applications and approvals. Clear guidelines are needed for permit applicants to help accelerate the implementation of high-quality projects.

- State, territory and federal governments to provide secure, ongoing funding for green infrastructure, comparable with funding arrangements for grey infrastructure (e.g. through City Deals).
- Develop clear national criteria and guidelines against which proposals can be assessed and that are scalable and adaptable (i.e. can be readily applied in the local context).
- Develop state-based funding and approvals processes that have consistent local implementation.
- Build and maintain capacity amongst relevant local and state government departments (e.g. planning) to ensure personnel have the skills and resources to adequately assess proposals.
- Improve the approvals process for retrofitting GRWFs on existing buildings including residential.

Action 3.5 Governments to lead by example

Governments have significant opportunities to integrate GRWFs in new infrastructure projects to enhance greening in cities and to mitigate the environmental and social impacts of urban development. Governments can build demonstration sites that provide a showcase for what can be achieved with GRWFs and encourage uptake by building owners, developers and policy makers (Dvorak and Carroll 2008). Demonstration sites provide opportunities for experimentation and learning – information that can be used to inform the development of guidelines for good GRWF design and management (Tan and Sia 2005).

- Increase community exposure to GRWFs through municipal demonstration projects that identify the benefits and can serve to dispel public misconceptions.
- Government infrastructure should set the standard and lead by example by integrating GRWFs in government buildings - new builds, extensions and retrofits – and other infrastructure projects where practicable.
- Educate and enable communities by bringing them into decision making processes in the planning and design phase of new government GRWF projects.

Action 3.6 Invest in research and development

- Greater government investment is required to support GRWF research and development, including installing trial sites to explore GRWF technologies and applications.

Action 3.7 Government support for industry growth

- Map the potential for GRWF industry development and growth, including new jobs and skilled employment opportunities to sustain the workforce. Identify industry challenges and develop solutions.



Figure 8. Parliament of Victoria Members Annexe Building green roof. Photograph Rachael Bathgate, University of Melbourne

Strategy 4 - Develop and implement policy mechanisms

Policy tools are essential for accelerating the uptake of GRWFs. Cities that have incentives and/or regulation have been shown to have higher rates of green roof installation, particularly when combined with education and advocacy. A recent review of international policy mechanisms suggests that combining incentives and regulation is the most effective way to increase the area of green roofs (and other forms of green infrastructure) and to ensure standards in design, installation and maintenance (Stern et al. 2019, Wilkinson et al. 2017). Incentives are desirable because they are voluntary but compulsory measures can be more effective in some instances (Maddison and Denniss 2013). Incentives encourage voluntary implementation by early adopters and innovators, while regulations have the potential to create the momentum to grow markets and related industries (Coyle 2018, Rennings and Rammer 2011, Rogers 2003). Importantly, tailored policies can encourage and significantly expand particular types of GRWFs to address specific impacts of urbanisation in cities – for example by increasing the number of green roofs that capture stormwater and thereby decrease flooding and polluted stormwater runoff into waterways.

In Australia, local governments and industry groups are investigating how policy mechanisms may advance the GRWF sector and there may be benefits in knowledge exchange and collaboration in this area (Davies 2018, Freney et al. 2017, State of Victoria 2014, Wilkinson et al. 2017). Examples of policies and strategies include the City of Melbourne's Green our City Strategic Action Plan 2017-2021 (City of Melbourne 2017) and the City of Sydney's Green Roofs and Walls Policy (2014).

Action 4.1 Create incentives at a city scale

Grants, rebates, offsets and subsidies can encourage adoption of new products and systems such as GRWFs and drive innovation. Incentives help overcome the initial cost barrier for building owners and developers, where benefits may not be immediate or totally quantified. While projects may be approved at a local government level, in Australia only capital city governments currently have sufficient funds to provide meaningful incentives. Taking a city-wide approach to the implementation of GRWFs that includes the wider metropolitan region requires state government to lead and coordinate with local governments.

- State governments should lead and fund incentives, setting goals to be delivered at a local level by local governments. Local governments to access state/territory and federal funding for delivery.
- Undertake an investigation of options for incentives across the wider metropolitan area that includes GRWFs and all other forms of urban greening.

- Incentives should be geographically targeted and be guided by physical and social-economic considerations to identify optimal sites for GRWF installation that individually and collectively deliver maximum benefits for people and biodiversity at a city/ metropolitan scale.
- Define and set performance targets to ensure that the benefits of GRWFs will be delivered.

Action 4.2 Establish mandatory regulations

Cities around the world have regulations requiring the installation of green roofs, walls and facades on buildings of a certain size and typology to meet their environmental objectives. Regulations can help establish markets by providing certainty and growth to the local industry. This demand can reduce costs of materials and installation and increase the cost-effectiveness of GRWFs (Stern et al. 2019). Codes and standards (plus education and enforcement) ensure minimum sizes and performance of systems, their quality and function over time, and a baseline against which to assess both the GRWF systems and the policies that support them.

The peak body for green roofs in North America suggests that understanding the added value and cost of any regulation is essential to ensure their support and long-term effectiveness, and that this cost/benefit information needs to be based on local conditions and formulated for a range of building typologies (Stern et al. 2019).

- GRWFs should be embedded in regulations and codes including The National Construction Code of Australia (NCC). Including GRWFs in building codes will ensure minimum standards are met and can help reduce the risks and costs of installation and maintenance. Mandatory building codes can help set targets as many overseas cities and countries have done (e.g. Stuttgart and Tokyo).
- GRWFs should be incorporated into state and local planning policy frameworks such as planning schemes.
- GRWFs to be included in assessment tools as part of the approvals process for new builds and developments to ensure minimum coverage and standards of greening. An example of this approach is the Seattle Green Factor - a score-based code requirement that increases the amount, and improves the quality, of landscaping in new development (City of Seattle 2019). A minimum score is required to ensure that greening can deliver all its potential ecosystem benefits. The City of Melbourne has recently taken a similar approach with the development of a Green Factor Tool to help deliver green infrastructure including GRWFs (City of Melbourne 2017).

Action 4.3 Develop guidelines and standards

Guidelines can inform and activate projects and markets. Existing guidelines include the Growing Green Guide (State of Victoria 2014), Green Roofs, Walls and Facades Technical Guidelines (Inner West Council 2020) and Sydney City Council Green Roof Resource Manual (2009).

Well-considered technical standards can help develop the industry, as has been shown in Germany where the FLL green roof standards are seen as a global benchmark. Design standards that meet Australia/New Zealand and International design criteria are needed to ensure the quality and performance of GRWFs, and to create certainty for consumers, which in turn could increase support and implementation.

Standards can also help mainstream GRWFs. They can help to avoid failures that could limit further growth in the Australian green roof and vertical greening market and can provide confidence to property owners. They offer a framework for local governments to assess GRWF applications. Standards should be strongly based on evidence and allow for development and trial of new technical, landscape and horticultural approaches. They should also be flexible enough to take into consideration the physical and climatic variation amongst Australian cities.

- Industry-relevant GRWF guidelines should be produced to assist a wide range of end users including building owners, government, developers and builders, designers and suppliers.
- Develop national GRWF standards that specify design, construction, maintenance and performance requirements. These may include substrate properties, coverage, component types, plant traits, minimum maintenance requirements and leak detection.
- Capital and regional cities to consider local conditions when adopting guidelines (i.e. climate, demographics, plant species). Ensure existing guidelines reflect current knowledge (research, design and maintenance) and update where required.

Action 4.4 Embed GRWFs in design of new developments

- GRWFs should be incorporated into all new developments where the creation of street level green infrastructure is not possible (e.g. planting of trees cannot be undertaken due to space constraints).
- When GRWFs are proposed in new developments they should be integrated at all stages in the design and construction and not treated as an 'add-on' that can be discarded due to budget restraints.
- Integrate plants into the built form and adopt biophilic design principles in building and architecture.

Action 4.5 Integrate GRWFs into building infrastructure ratings tools

- GRWFs to be included in building and infrastructure sustainability rating systems (both voluntary and mandatory) including Green Star, Green Leaf, NABERS (National Australian Built Environment Rating System), BESS (Built Environment Sustainability Scorecard) and Infrastructure Sustainability Council of Australia rating tools.
- Link ratings with incentives (direct and indirect) and provide education on the benefits for accreditors and applicants.

Action 4.6 Identify funding mechanisms for GRWFs

Funds are required to drive the uptake of GRWFs and support incentive schemes, education and the creation of demonstration sites but there is currently no dedicated national funding for GRWFs. For example, The Australian Institute of Landscape Architecture has recommended a National Living Infrastructure Fund - an investment fund for the implementation of green infrastructure projects across Australia. This would require a percentage of all federal government expenditure on 'grey infrastructure' projects (e.g. roads) to be placed in an investment fund for allocation to state and local government green infrastructure projects.

In Victoria, the Public Open Space contribution is imposed on higher density subdivisions to compensate for the expected increased use of nearby Public Open Spaces (e.g. parks, reserves etc.) caused by the development. Other states have developer contributions for similar green space maintenance or gains. On-ground Public Open Space (managed by government) should remain the priority of these schemes as they allow for equity of use, but a similar approach could be applied to green roofs that provide equivalent benefits in area, quality and access. Freney et al. (2017) detail several options for finance and funding of green infrastructure in NSW that may be applicable to other areas of Australia.

- All levels of government (federal, state and local) should work cooperatively to develop funding models to support the implementation of GRWFs including incentive schemes.
- Expand environmental grant programs (e.g. NSW Environmental Trust grants) to include GRWFs and other forms of urban greening, ensuring new funds are allocated to urban systems with no loss of funds for 'traditional' environmental projects.
- Investigate alternative funding tools for installing GRWFs that have measurable and demonstrable environmental benefits (e.g. stormwater management rebates for GRWFs that reduce stormwater runoff) (EPA USA 2009).
- Investigate the role that green roofs built on private property could play in satisfying the land contribution as an open space contribution (Victoria - or comparable contributions by developers in other states). Suitable green roofs should contribute to a net increase in greening at the city level, see no decrease in the area or quality of ground level greening, and provide comparable social and ecological benefits to on-ground green space.



Figure 9. Green Roof at Yerrabingin Indigenous Rooftop Farm, South Eveleigh, NSW. Photo by Junglify

Global Exemplars - Policy Mechanisms

Toronto, Canada: Mandatory requirements and incentives

Toronto's Green Roof Strategy (2006), Green Roof Bylaw (2009) and accompanying Eco-Roof Incentive Program have stimulated a local green roof industry and created a 'new roofscape' for the city. Toronto was the first major city in North America to implement a mandatory green roof regulation for new buildings (and new additions) with a gross floor area greater than 2,000 m². This regulation applies to all commercial, residential and institutional buildings. Green roofs or cool roofs (using building materials that reflect more sunlight and absorb less heat) are required on all industrial buildings greater than 2,000 m² gross floor area.

The bylaw requires that a minimum of 20% of available roof space must be covered, with the percentage increasing with building size. City buildings require a minimum 50% cover. Developers can provide cash-in-lieu for reduced green roof area which goes to fund the Eco-Roof Incentive Program, which provides grants to owners of existing building and others exempt from the bylaw. These initiatives have seen an increase in green roof area of 500,000 m² (2009-2018) (Wilkinson et al. 2017). The Toronto Green Roof Construction Standard Supplementary Guidelines support the expansion of green roofs along with the Guidelines for Biodiverse Green Roofs developed to assist in the design and installation of green roofs for biodiversity (City of Toronto 2013).

The peak industry body for North American green roofs, Green Roofs for Healthy Cities, has estimated the benefits that these green roofs provide.

Estimated Impacts of Toronto's Green Roof Policies (2009 onwards):

- 222 million litres of stormwater retained annually
- 225 tons of carbon sequestered annually
- 3.2 million kWh of annual electricity savings for the buildings with green roofs
- 1.6 million kWh of annual electricity savings for surrounding buildings due to a reduction in the urban heat island effect
- 1,618 FTE jobs in construction
- 25 FTE jobs annually in maintenance

Source: Stern et al. (2019)

Link: <https://www.toronto.ca/city-government/planning-development/official-plan-guidelines/green-roofs/green-roof-overview/>



Figure 10. Toronto City Hall green roof, constructed 2010 (City of Toronto, 2019)

Stuttgart, Germany: Mandatory requirements and incentives

Stuttgart, a major manufacturing city in southern Germany, has been referred to as the ‘green roof capital of Europe’ because of the expanse of green roofs. Green roofs became a widely implemented tool for combating poor air quality and excessive heat in the city and have been mandated for many buildings since 1986.

The creation and preservation of urban greening in Stuttgart, including green roofs, is regulated by the Federal Nature Conservation Act (BNatSchG), the Nature Conservation Act of the state of Baden-Württemberg (NatSchG), and the federal German building code (BauGB). The building code requires green roofs on all developments with a roof slope of less than 12 degrees.

Incentives (reimbursements) are also offered for existing buildings or new buildings when the construction plan does not already require a green roof. Between 1986 and 2009, 430 projects (66,000 m²) received subsidies covering 50% of the cost of installation and materials. Caveats are that substrate depth must be at least 12 cm deep and roofs maintained for 10 years. A 2014 initiative provides a 50% reduction in stormwater fees for building owners who install green roofs.

These measures have increased Stuttgart’s green roof area from 6 ha to 30 ha by 2015 (Wilkinson et al. 2017).

Stuttgart’s green roof landscape is reflective of a wider national and European expansion of the green roof sector. In 2003, green roofs made up 14% of the total roof area in Germany (Kohler and Kaiser, 2019). A market report by the European Federation of Green Roof Associations estimates that as of 2014 Germany had 86 million m² of green roofs with 8 million m² added each year. Annual sales are estimated to be 250 million euros.

Link: https://efb-greenroof.eu/wp-content/uploads/2016/12/efb-whitepaper_2015.pdf



Figure 11. Green Roof at Bridgepoint, Canberra, ACT. Photo by Jungleyf

Strategy 5 - Enhance skills and expertise

A range of sectors have direct and indirect roles to play in implementing GRWFs and the emerging green roofs, walls and facades industry requires a diverse mix of professions and trades. While some of this knowledge and skill set exists within existing disciplines, at their core green roofs, walls and facades are inherently multi-disciplinary. To enhance skills and expertise in the industry this needs to be acknowledged and new education and training programs developed to create the workforce required to accelerate uptake.

A lack of knowledge of the function, benefits and technical requirements of GRWFs in some sectors is an impediment to their uptake. For example, planners are recognised as central to the delivery to green infrastructure in cities, yet Australian research indicates there is a reluctance in this group to adopt such novel and unfamiliar technologies (Matthews et al. 2015). Education is key to overcoming this barrier.

Enhancing skills and expertise will be assisted by an evaluation of existing education and training programs, both in Australia and internationally, including institutional-based courses, private coursework and training activities and professional recognition/accreditation programs.

The new national project, National Skills Standards for Green Walls and Rooftop Gardens, is a welcome development in the vocational training sector. This project is managed by Skills Impact and overseen by the Amenity Horticulture, Landscaping, Conservation and Land Management Industry Reference Committee. However there remains a gap in any similar development of university/higher education and professional training programs.

Action 5.1 Develop education and training

- Encourage development of education and training programs implemented through institutions and providers at varying levels: higher education, vocational/TAFE, professional and industry training, general public interest activities and short courses.
- Investigate the opportunities for developing industry-based accreditation and training for green roof professionals – similar to the North American Green Roofs for Healthy Cities model.
- Include GRWF content into discipline-based course curricula to increase understanding of GRWFs as living assets beyond the fields of horticulture, landscape architecture and landscape design.
- Increase the availability and access of GRWF demonstration sites for learning, teaching and instruction – including trialing new technologies, materials and plant species.
- Work with existing industries and industry sectors engaged with GRWFs to identify and specify knowledge and competencies needed, contribute to identification of knowledge needs and requirements and adapt training accordingly.



Figure 12. Coromandel Place, Melbourne. Photograph City of Melbourne



Figure 13. Guildford Lane, Melbourne. Photograph City of Melbourne

Strategy 6 - Design for success: maintenance, function and form

The benefits of GRWFs depend on good design and construction, selection of appropriate plant species and long-term maintenance. The failure of GRWFs (e.g. dead plants, poor stormwater retention) is a strong disincentive to their uptake. A lack of understanding by designers and building owners of maintenance requirements (costs and technical aspects) and failure to consult managers or maintenance personnel in the design phase can lead to systems that are hard to maintain or have significant costs in recurrent or reactive maintenance.

Water and irrigation are also critical to the success of these systems, but climate change and growing urban populations are putting significant pressure on potable water supplies (Norton et al. 2015). Taking a water sensitive design approach – by integrating GRWFs into the built environment and using alternative water supplies – is more likely to achieve sustainable, resilient, functioning GRWFs.

Action 6.1 Design for function

Unlike trees and other ground-level greenery that naturally performs a range of ecosystem services, GRWFs need to be designed to achieve their stated function(s) or objective(s). For example, a green roof designed primarily for stormwater control needs an appropriate substrate type and depth that is matched to local rainfall conditions, and an appropriate plant palette, so that the roof is able to retain a high percentage of rainfall and prevent stormwater runoff (Farrell et al 2012). GRWFs may have multiple functions and benefits (Jones et al. 2018).

- Designs should clearly meet GRWF objective(s). Guidelines, standards and information shared through the Knowledge Hub will assist in a best practice approach to design and optimise GRWF performance. Set performance targets in GRWF planning phase, assess as part of management/maintenance plan and report on targets.

Action 6.2 Design for maintenance

- Designers and building owners should document maintenance requirements and costs for each project. Involving end users in the design will help ensure that maintenance can be undertaken safely and efficiently whilst ensuring design objectives can be maintained.
- Adopt innovative technology for maintenance and monitoring (e.g. cloud-based smart irrigation monitoring and controlling systems, drones for visual inspections).

Action 6.3 Adopt an Integrated Water Management approach to planning and design of GRWFs

Irrigation is essential for GRWF plant survival and to achieve cooling via evapotranspiration - particularly over summer. Climate change will both decrease the availability of potable (drinking) water in cities and increase the need for irrigation. GRWFs can be irrigated with alternative water supplies such as captured stormwater and recycled water and thus reduce the demand on drinking water supplies. Along with ground-level forms of water sensitive urban design (e.g. raingardens, swales, stormwater-coupled tree pits) GRWFs – and green roofs in particular - can help to reduce stormwater runoff in cities that can lead to flooding and poor water quality in receiving waters (Schubert et al. 2017, Walsh et al. 2016).

- Integrate GRWFs into water sensitive urban design strategies and plans for cities.

Action 6.4 Use indigenous and native plants

GRWFs have the potential to conserve and protect locally indigenous plants in urban areas from which they have been lost. Use of native species can increase biodiversity by providing habitat and food for fauna, create a sense of place and enhance people's nature connectedness in cities. GRWFs may also serve as urban 'refugia' for native plant species that are vulnerable or threatened in their natural range.

- Use horticultural expertise to identify indigenous and native plant species that can flourish in/on GRWFs and disseminate information on species and ecology.

Milestones

Vision

Australian cities have flourishing, sustainable green roofs, walls and facades that contribute positively to human health and wellbeing, support biodiversity and ecosystem services and are integrated into planning, design and management.

Milestones towards flourishing green roofs, walls and facade industry in Australia were identified by summit participants for short (1-2 years), medium (4-5 years) and long-term (8-10 years) periods.

2020-2022 Milestones	Strategy	Action
Knowledge hub – an online platform for knowledge exchange across industry, government and community	1. Gather and share knowledge	1.1 Establish a Knowledge Hub
New peak industry body formed	2. Collaborate and advocate	2.1 Establish a national body to advocate and educate on GRWFs 2.2 Identify champions and encourage leadership
Policy framework established including incentives and government regulation. Targets identified.	1. Gather and share knowledge 3. Government coordination and national leadership 4. Policy mechanisms 6. Design for success	1.3 Identify and address knowledge gaps 3.1 A national approach to green infrastructure planning and implementation 3.2 Federal and state governments to develop the policy framework 3.4 Dedicate funds and improve the process for approvals 4.1 Create incentives at a city scale 4.2 Establish mandatory regulations 4.6 Identify funding mechanisms for GRWFs 6.3 Adopt an integrated water management approach to planning and design of GRWFs.
Increased public awareness of GRWFs with an emphasis on value and benefits	1. Gather and share knowledge 3. Government coordination and leadership 6. Design for success	1.2 Create opportunities for knowledge exchange 3.5 Governments to lead by example 6.1 Design for function 6.4 Use indigenous and native plants in GRWFs
Development and growth of industry through education and training, creation of national guidelines and standards.	5. Enhance skills and expertise 3. Government coordination and national leadership 4. Use policy mechanisms 6. Design for success	5.1 Develop education and training 3.7 Government support for industry growth 4.3 Develop guidelines and standards 6.1 Design for function 6.2 Design for maintenance
National green infrastructure conference with key stakeholders	1. Gather and share knowledge	1.2 Create opportunities for knowledge exchange

2024-2025 Milestones	Strategy	Actions
National green infrastructure policy in place.	3. Government coordination and national leadership 4. Policy mechanisms	3.1 A national approach to green infrastructure planning and implementation 3.3 Integrate GRWFs in intergovernmental initiatives and arrangements. 4.4 Embed GRWFs in design of new developments 4.5 Integrate GRWFs into building infrastructure ratings tools 4.6 Identify funding mechanisms for GRWFs.
Peak body established and active	2. Collaborate and advocate	2.1 Establish a national industry body to advocate and educate on GRWFs
Knowledge hub active. Project evaluation and success stories shared.	1. Gather and share knowledge	1.2 Create opportunities for knowledge exchange
Accreditation/qualification in GRWFs established focusing on industry and developers.	5. Enhance skills and expertise	5.1 Develop education and training
Demonstration GRWFs in each capital city	3. Government coordination and national leadership	3.5 Governments to lead by example. 3.6 Invest in research and development
2028-2030 Milestones	Strategy	Actions
Industry is thriving: GRWFs normalised across all sectors and targets have been exceeded. Cities are driving progress through “show case” cities.	3. Government coordination and national leadership 4. Use policy mechanisms 6. Design for success	3.1 A national approach to green infrastructure planning and implementation 3.6 Invest in research and development 3.7 Government support for industry growth 4.4 Embed GRWFs in design of new developments 4.5 Integrate GRWFs into building infrastructure ratings tools 6.1 Design for function 6.2 Design for maintenance
Industry development: Widespread adoption of national policies, codes, and standards. Mandatory requirements for new developments	4. Use policy mechanisms	4.1 Create incentives at city scale 4.2 Establish mandatory regulations 4.3 Develop guidelines and standards
Progress and impacts (social, environmental) of GRWFs are measured and reported, improvements are made on these grounds.	1. Gather and share knowledge 2. Collaborate and advocate	1.2 Create opportunities for knowledge exchange 2.1 Establish a national industry body to advocate and educate on GRWFs

Where to from here?

Connecting strategies and actions

While distinct strategies and actions have been identified there is interdependence between these (e.g. government leadership is required to develop policy mechanisms). Some can be undertaken simultaneously while others may need a stepwise approach.

Work is underway on some of these actions. For example, the City of Melbourne and Victorian Department of Environment, Land, Water and Planning will be building a demonstration green roof on a government building in central Melbourne that offers opportunities for research and testing of new systems and plant species. Similarly, Inner West Council, Sydney, have just released technical guidelines for GRWFs. Hort Innovation (the grower-owned, not-for-profit research and development corporation for Australia's horticulture industry) has recently focused on building the evidence-base to demonstrate the benefits of increased urban greening through its Green Cities Fund (e.g. Davies 2018, Wilkinson et al. 2017 and this project). Outreach materials have progressed community and practitioner understanding of GRWFs, for example the Growing Green Guide (State of Victoria 2014), publications by the City of Sydney (City of Sydney 2020) and industry practice notes (e.g. Goddard et al. 2016). There is, however, a lack of overarching coordination of actions and knowledge exchange across Australia, with actions driven largely by local governments and champions within different sectors (e.g. education and research, green roof installation, substrate providers, landscape architects).

A significant body of knowledge exists for GRWFs in the Australian context (e.g. Jones et al. 2018 and references therein) including the barriers and drivers that currently exist (Matthews et al. 2015, Williams et al. 2010). There is a need for better translation of this knowledge for different audiences including industry, the community and federal and state policy makers. There remains an absence of readily accessible information on the state of the Australian GRWF industry itself, no effective industry body and no national strategy for growing the number of GRWFs, despite the importance of greening to city inhabitants.

Starting the process

This roadmap draws on the outputs from GRWF summits attended by representatives from a range of sectors including state and local governments, engineers, the water industry, landscape architects, landscape designers and architects, developers and GRWF suppliers, installers and maintenance personnel. Actors from all sectors are needed to implement this roadmap through a collaborative, coordinated process.

Recommended first steps

1. Establish the Knowledge Hub for Green Roofs, Walls and Facades
2. Set up a stakeholder working group to:
 - a) identify the lead actors for each roadmap strategy;
 - b) develop a timeline for implementation; and
 - c) organise multi-disciplinary/cross-sector forums for each strategy to develop implementation plans.
3. Hold a national symposium on urban green infrastructure with an emphasis on GRWFs
4. Establish an effective national body for GRWFs

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Figure 14. Green Roof, University of Melbourne Burnley Campus. Photograph University of Melbourne.

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