Key Barriers and Challenges to Green Infrastructure Implementation: Policy Insights from the Melbourne Case

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Key Barriers and Challenges to Green Infrastructure Implementation: Policy Insights from the Melbourne Case

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Abstract: Urbanisation has resulted in significant environmental challenges, particularly the phenomenon of urban overheating, with a significant increase in temperatures in urban environments. To tackle the adverse impact of urban overheating, the implementation of green infrastructure (GI) has been considered particularly effective. Although there are various benefits of GI for sustainable urban management, its widespread implementation faces numerous challenges. To effectively scale up the deployment of GI, it is crucial to develop political and institutional frameworks that are both responsive and adaptable to the evolving complexities inherent in human–nature interactions. The barriers to implementation are not merely technical but also embedded in organisational norms, social practices, and governance systems, which makes them particularly difficult to overcome. This paper identifies five key categories of barriers: technical limitations, financial impediments, regulatory constraints, weak political leadership, and governance and coordination challenges. Through a targeted literature review and a detailed case study of Melbourne, the paper explores the city's primary greening initiatives and examines how these barriers have influenced implementation. By linking specific policy responses to each barrier, this study provides new insights into the institutional and policy dynamics affecting GI adoption. The findings offer lessons for other cities seeking to better implement nature-based solutions through integrated and scalable GI strategies.

Keywords: green infrastructure; urbanisation; urban overheating; climate change; sustainable urban management; human–nature interactions; greening initiatives; biodiversity; nature-based solutions; collaborative partnership

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1. Introduction

One of the extensively documented aspects of climate change is urban overheating in urban environments. This phenomenon refers to the increased temperatures observed in urban areas compared with surrounding suburban or rural regions, with empirical data supporting its occurrence in over 450 major cities worldwide [1]. The temperature differential can be as high as 10 °C, with typical values ranging between 5 and 6 °C [2]. Furthermore, research indicates that due to local climatic interactions, the severity of urban overheating is notably exacerbated during heat waves [3].

The consequences of urban overheating are wide-ranging, affecting energy demand, air quality, and public health. For instance, increased urban temperatures contribute to

more energy consumption for cooling, spikes in peak demand for electricity, and elevated concentrations of air pollutants, all of which exacerbate heat-related health issues and increase urban vulnerability [4]. Studies show that for each degree of temperature rise, cooling energy consumption can increase by approximately 0.7 kWh/m^2 of urban surface, while peak electricity demand may rise by around 21 ($\pm$10.4) watts per person [2,5]. The health implications are also significant, with higher ambient temperatures being associated with increased rates of mortality and morbidity, especially in urban areas, in which warmer neighbourhoods have a 6% higher risk of heat-related deaths than cooler ones [6]. The cumulative effect of heat-related illnesses, alongside prevalent conditions including cardiovascular and respiratory diseases, diabetes, cancer, and mental disorders, further escalates the health burden in urban settings, especially in low- and middle-income societies where this burden is expected to grow substantially [7,8].

Various mitigation strategies have been recommended and implemented across numerous initiatives and large-scale projects to combat the adverse impact of urban overheating. These include the use of super-cool and reflective materials, enhancement of urban greenery, implementation of transpiration and evaporative cooling systems, installation of shading devices and solar control systems, and the utilisation of low-temperature natural sinks [9]. Among these strategies, implementing green infrastructure (GI) has been considered particularly effective. As cities worldwide confront the escalating impacts of climate change, GI has become increasingly central to urban sustainability debates, offering multifunctional benefits that span environmental, social, and economic dimensions.

GI is defined by the European Environmental Agency as a strategically planned network of natural and semi-natural areas to improve environmental conditions, support a green economy, create job opportunities, and enhance biodiversity [10]. Connop et al. (2016) describe GI as comprising semi-natural and natural green spaces, such as green roofs and walls, parks, and forests, which offer cost-effective and nature-based solutions [11]. Increasing urban greenery, particularly through enhanced tree cover, is widely recognised for its role in boosting urban resilience. Trees contribute significantly to mitigating urban overheating, improving air quality, sequestering carbon, and managing stormwater through both retention and detention, as well as promoting the health and well-being of urban populations [12,13].

Despite the mounting evidence highlighting various benefits of GI for sustainable urban management, its widespread implementation faces numerous challenges. Apart from the difficulties posed by biophysical factors such as soil characteristics or land topography, extensive research reveals that the most significant barriers to GI implementation are predominantly institutional and political in nature [14–16]. To effectively scale up the deployment of GI, it is crucial to develop political and institutional frameworks that are both responsive and adaptable to the evolving complexities inherent in human–nature interactions. The existing barriers are not merely technical but are also closely reliant on organisational and social norms, processes, and practices, which makes them particularly challenging to tackle and address [17]. This study identifies five categories of barriers to GI implementation—technical limitations, financial impediments, regulatory constraints, weak political leadership, and governance or coordination challenges. These five barriers were derived through a targeted literature review and are used as the analytical framework to examine the case of Melbourne.

This paper provides an overview of the key barriers and challenges that have been identified in the process of implementing GI in urban environments. By conducting a targeted literature review coupled with a detailed case study focusing on Melbourne, the paper explores the primary greening initiatives undertaken in the city and examines the challenges encountered during their implementation. This study contributes new insights

by linking the five key barriers to policy responses, addressing a gap in existing research that often overlooks how institutional settings influence large-scale GI implementation.

2. Key Barriers to GI Implementation in Cities: A Targeted Literature Review

This section presents findings from a targeted literature review focused on institutional, regulatory, and practical barriers to GI implementation in urban contexts. This targeted literature review drew on peer-reviewed articles and policy reports sourced from Scopus and Science Direct. Keywords such as "green infrastructure", "urban greening", and "implementation barriers" were used in various combinations to capture the multidimensional challenges of GI implementation. Through this review, five recurring categories of barriers were identified and used to structure the following analysis. GI in cities faces five key barriers: technical limitations, financial impediments, inadequate regulatory frameworks, low political prioritisation and weak leadership, and governance and coordination challenges. These categories highlight the main obstacles to GI implementation, which will be further elaborated in subsequent sections. While discussed individually, these barriers are often interdependent. For example, weak regulatory frameworks can reinforce financial uncertainty, and fragmented governance can limit both leadership and technical coordination.

2.1. Technical Limitations

One of the main challenges pertains to the level of technical expertise available within institutions tasked with the planning and design, maintenance, and monitoring of GI implementation. Many professionals currently involved in these tasks tend to be more versed in traditional methods rather than in newer GI technologies. This issue is particularly evident in countries with relatively low levels of economic and industrial development, and with a notable scarcity of skilled professionals. The successful design and implementation of GI require a deep understanding of local conditions, so it is difficult to apply knowledge and practices from one region to another without significant adaptation [18].

Considering the multifunctional nature of GI, its successful implementation requires a set of interdisciplinary skills and the involvement of actors capable of integrating various sectors and stakeholders [16]. This often involves systems thinking and active participatory engagement with stakeholders to evaluate ecosystem-wide impacts. Since GI is relatively new and can vary widely across different contexts, compared with more established grey infrastructure, there is considerable uncertainty regarding the performance of GI within larger systems [19]. Additionally, unlike traditional systems like piped stormwater drainage, GI poses challenges in terms of data collection, effectiveness measurement, and recognising its long-term co-benefits, which include environmental, social, and economic advantages such as climate change mitigation, biodiversity conservation, improved health outcomes, and the generation of jobs in the environment, sustainability, and maintenance industries. These technical constraints also affect financial decision-making by increasing uncertainty and reducing confidence in long-term GI investments.

Apart from technical challenges, existing research has highlighted "technocratic path dependencies", which are associated with the prevailing grey infrastructure paradigm that heavily relies on engineering expertise [20]. Engineers serve a pivotal role in the design of both grey and GI systems, particularly for stormwater control and water quality management. However, while grey infrastructure typically compartmentalises water management issues, GI requires a more holistic systems-thinking approach that involves multiple actors in governance. This increased complexity requires multidisciplinary collaboration among environmental management, community engagement, urban planning, and hydraulic

engineering. The complexity of GI often results in longer planning processes, which may not align with the expectations established by grey infrastructure projects. Additionally, the transaction costs involved in gathering, organising, processing, and analysing data can be significant [21]. Sometimes even when relevant data exist, it is frequently not fully integrated into decision-making processes, as exemplified by a case study from Argentina [22]. The rapid pace of urbanisation, together with high levels of vulnerability and informality, places significant pressure on governance capacities in these regions, limiting the ability to explore alternatives beyond traditional grey infrastructure solutions. This risk-averse attitude is also present in the private sector in both developing and developed countries, where uncertainties about innovative approaches may lead to concerns over potential financial risks [23].

2.2. Financial Impediments

Research has indicated that GI can be as cost-effective as traditional grey infrastructure. However, GI often faces more substantial financial challenges, which are partly due to its relatively new nature [17]. Developing business cases for GI is particularly difficult when trying to achieve multiple long-term benefits because they are often not considered in grey infrastructure planning. Currently, only direct provisioning services are commonly measured, while other additional benefits, such as ecosystem, recreational, cultural, and health impacts, are frequently overlooked. These intangible benefits and outcomes with relevant costs involved do not have sufficient data or clear monitoring devices, leading to a higher perceived risk of GI for decision-makers in both the public and private sectors [24]. As a result, decision-making tends to favour established solutions, making it challenging for innovative approaches to gain acceptance and influence existing criteria. Inadequate regulatory standards can further limit funding eligibility or clarity for GI integration.

2.3. Inadequate Regulatory Framework

Alongside the key barriers in relation to technical limitations and financial impediments, many cities have regulatory frameworks that favour grey infrastructure. Such bias results in difficulty in promoting the implementation of GI for enhanced environmental outcomes or imposing unreasonable liabilities on developers or landowners [20]. Additionally, it is rare to find technical standards for GI as standalone frameworks or within existing policies [18]. Conflicting or confusing provisions' may even occur within the regulatory framework [17]. Other specific issues include inconsistency in regulatory approval processes, unclear property rights, conflicting mandates among organisations, and the lack of power or authority within operational organisations to implement alternative approaches. Different regulatory frameworks associated with GI ranging from landscaping and stormwater management to urban planning and health often have conflicting mandates, or do not cover GI solutions [16]. Moreover, some existing frameworks set inadequate requirements or impose stricter standards than necessary for successful GI implementation [25].

In many Australian cities, there are strong regulatory measures to support GI, but due to the discretionary nature of enforcement mechanisms, regulations, and political will, these measures are not always utilised to their full potential [21]. Although overarching sustainability objectives are developing, the regulatory framework still lags. The lack of legislative mandates tends to privilege existing policy regimes and some unsustainable urban water management approaches, such as maximising impervious areas for parking spaces and road surfacing.

2.4. Low Political Prioritisation and Weak Leadership

To increase the implementation of GI, there is a need for prioritisation and strong support from higher levels of government. However, efforts to improve sustainability outcomes are often overshadowed by other pressing concerns, such as road construction or housing needs. As commented by Brown et al. (2009) [20], stormwater management is a comparatively lower political priority, unless during crisis moments of flooding resulting in harm to people and damage to property. According to a case study in Indonesia, public servants encountered prioritisation challenges, perceiving GI as a dispensable option under the strong pressure to address essential needs and to provide basic grey infrastructure [19]. Although GI is not intended to be a luxury solution, it is hard to appreciate its multifunctionality and long-term benefits compared with traditional or quick-fix solutions to address particular urban issues. Such discrepancy of recognition between long-term sustainability goals and short-term actions is common and represents a major blind spot that needs to be addressed.

In both developing and developed countries, policymakers and political leaders tend to adopt short-term solutions within the terms of their leadership and administration. They often hesitate to offer support for GI because of the uncertainties around measuring associated costs and benefits, its relative novelty, and the potential benefits that may often be materialised in the long term. Referring to a study in Polish cities, financial constraints lead to imbalances in decision-making that favour private development interests, resulting in a lack of support from the public sector for green initiatives [26] When there are conflicting interests with sustainability objectives, the lobbying on leadership may adversely affect the timeline for implementing GI [27]. Weak leadership often exacerbates fragmented governance, which in turn impedes coordinated GI delivery.

2.5. Governance and Coordination Challenges

The design and delivery of GI are often complicated by overlapping and multiple governance challenges, particularly in coordinating the various stakeholders involved. Firstly, issues commonly arise with the engagement and coordination between different divisions of government in terms of communication and resources. The sharing and assignment of duties and responsibilities among various divisions may not be clearly demarcated [23]. Since GI implementation involves the close collaboration between multiple sectors to fully realise its multifunctional potential, the fragmentation of responsibilities within the government creates operational challenges for mainstreaming GI [16].

Additionally, conflicts or inconsistencies may exist between municipal, provincial, and national levels of government. Such coordination among various levels of government can be complicated by power imbalances, different priorities, and funding availability. For example, local government aims to pursue a GI initiative, but higher authorities with financial or regulatory power may operate otherwise under conflicting policy frameworks. This leads to the fragmentation of resource management across various government levels.

Moreover, there are challenges associated with non-government stakeholders in the design and implementation process of GI. The existing governance is mainly centralised and exclusively technocratic, catering to grey infrastructure, but does not favour the decentralised approach of GI, requiring the involvement of various stakeholders [17]. The governance gap related to GI implementation can largely be attributed to the need for close coordination and engagement among diverse stakeholders to plan, develop, implement, and maintain multifunctional solutions [28]. Previous studies indicate that the active involvement of both non-government stakeholders and civil society in sustainability planning arouses awareness, fosters trust, and facilitates behaviour change towards sustainability

outcomes, including the willingness to allocate necessary resources and funding to cover the costs involved [29].

In addition to the challenges of engaging non-government stakeholders in mainstreaming GI design and development, there are also difficulties in acknowledging the existing non-government advancements in GI implementation. The positive impacts of self-initiated actions and movements in civil society contribute to significant change, as exemplified in Brazil and South Africa, where governance structures may struggle to include diverse voices and dissent [30]. Compared with the conventional top-down approach, these self-initiated bottom-up approaches offer an alternative option for addressing flooding, stormwater management, and issues related to urban green spaces.

Last but not least, the engagement with communities and developers on GI poses specific challenges, especially concerning the knowledge gaps about perceptions of environmental disservices and potential environmental services. Experiential and cultural factors may trigger individuals' negative perceptions of interactions between humans and nature. Such negative perception is particularly prevalent in developing countries in Africa, Latin America, and the Caribbean, where there are higher risks of environmental disservices, including flooding, seawater infiltration into freshwater reserves, insect infestations, waterborne diseases, and contamination, particularly among vulnerable populations. In these contexts, communities tend to prefer risk mitigation, such as draining streams to reduce maintenance needs and to remove tree hazards [26].

3. Greening Infrastructure Planning Instruments in Melbourne: A Policy and Practice Review

This section presents a policy and practice review of Melbourne's GI planning instruments, structured around five categories: policies, strategies, programs and initiatives, guidelines, and tools. These categories are not mutually exclusive but reflect different functions and governance levels in supporting GI implementation. Policies offer formal statements of intent; strategies articulate long-term plans; programs and initiatives focus on implementation and delivery; guidelines offer technical and practical advice; and tools provide accessible digital or material resources to support GI uptake. The purpose is not merely to describe these instruments but to analyse how they have collectively shaped Melbourne's GI landscape and addressed key barriers identified in the previous section.

This section draws on a targeted policy and practice review to explore how GI has been implemented in Melbourne. The chosen approach involved reviewing the existing literature to understand global challenges and strategies related to GI implementation, supplemented by an in-depth analysis of Melbourne-specific documents, policy reports, and interviews with key stakeholders. This methodology was selected to provide a thorough assessment of both the measurable impacts of GI and the more subjective, policy-driven factors that influence its implementation in urban settings. By integrating these insights, this study aims to offer a nuanced understanding of the operational and institutional barriers that affect GI deployment, setting a precedent for urban studies globally. After reviewing key barriers to implementing GI in cities, Melbourne was selected as a case study for evaluation due to its exemplary implementation of GI with extensive community engagement.

The GI implementation in Melbourne has been recognised as exemplary with extensive community engagement [31]. Melbourne has been ranked as one of the world's most liveable cities in the world for seven years continuously [32]. As the capital city of Victoria, commonly regarded as Australia's Garden State, Melbourne is situated on the northern coast of Port Phillip Bay, with the central business district (CBD) positioned at the estuary of the Yarra River [33]. The layout of the city extends from the flat plains of the western suburbs to the undulating hills and valleys of the eastern and northeastern suburbs.

These geographic features contribute to a varied microclimate within the metropolitan area [34]. Melbourne's urban form is a blend of historical and contemporary development, characterised by a mix of Victorian-era architecture and modern high-rise buildings [35]. Usually, this dense urban fabric, coupled with a significant amount of impervious surfaces, exacerbates the urban heat island (UHI) effect, where urban areas experience higher temperatures than their rural surroundings [36]. Melbourne's extensive green spaces, including parks, gardens, and tree-lined streets, play a crucial role in mitigating the UHI effect and enhancing urban liveability [37]. However, as the city continues to grow and densify under population growth, the challenge of retaining and integrating GI becomes increasingly complex [38]. Specifically, the city's geographic diversity, ranging from coastal areas to inland hills, requires tailored urban greening strategies to address each area's specific environmental and climatic conditions.

Melbourne has a temperate oceanic climate according to the Köppen climate classification, with hot summers having a 25.3 °C mean monthly maximum temperature and a 40 °C maximum temperature from December to February [39]. Due to the UHI effect, Melbourne has elevated summer temperatures, resulting in its vulnerability to heat waves. These climatic features, with the susceptibility to elevated temperature, increasing occurrences of heatwaves, and amplifying influence of UHI, necessitate adaptable and resilient urban greening strategies to mitigate temperature extremes and enhance urban liveability. The systematic and city-wide implementation of GI in Melbourne is underpinned by policies, strategies, programs and initiatives, guides and guidelines, and tools, which are listed below. The following lists are not exhaustive but highlight key actions for discussion.

3.1. Policies

Policies serve as formal instruments issued by government entities to express strategic intentions, legislative frameworks, or operational commitments that guide urban greening at various levels. In Melbourne, both state and municipal governments have introduced targeted GI-related policies that establish a foundation for long-term sustainability and biodiversity enhancement. At the state level, the *Protecting Victoria's Environment—Biodiversity 2037* policy was released in 2017 by the Victorian Government (Table 1). This document sets a statewide vision in which nature is valued, and GI is recognised as vital to mitigating the UHI effect, fostering daily access to nature, and building more liveable, climate-adapted communities [40]. It explicitly supports community groups, Traditional Owners, and non-government organisations in biodiversity planning and response efforts.

At the municipal level, the City of Melbourne has advanced a suite of policies that directly support GI implementation. The *Parks Policy* (1994) provides a long-standing strategic framework for managing and expanding the city's parkland network with an emphasis on biodiversity, community engagement, and sustainability [41]. The *Tree Policy* (2021) highlights the value of public trees, advocating for best practices in maintenance and protection, with defined criteria for pruning or removal and requirements for community consultation [42] (Table 1).

Additionally, the *Community Garden Policy* (2013) aims to facilitate the development and long-term viability of community gardens (Table 1). It promotes local food production, encourages environmental education, and fosters social interaction, contributing to community resilience and urban sustainability [43]. These policies demonstrate Melbourne's layered approach to GI governance—connecting high-level strategic direction with on-the-ground planning. Importantly, they provide enabling frameworks to overcome several of the barriers outlined in Section 2, particularly those related to regulatory uncertainty, political prioritisation, and weak leadership. Their emphasis on biodiversity, public par-

ticipation, and inter-agency collaboration positions GI as an integrated solution to both environmental and urban liveability challenges.

Table 1. List of policies related to GI in Melbourne.

Policy	Year	Key Points
Parks Policy * [41]	1994	• outline the strategic vision for the city's parkland • outline principles of park management and development • recognise conservation, biodiversity, and community engagement • emphasise sustainability and accessibility
Community Garden Policy * [43]	2013	• promote local food production and access to affordable food • encourage environmental education and sustainable gardening practices • provide development principles and support long-term success • foster social interaction and community involvement
Protecting Victoria's Environment—Biodiversity 2037 $^{\Delta}$ [40]	2017	• increase opportunities for Victorians to have daily connections with nature • foster a more liveable and climate-adapted communities • establish sustained funding for biodiversity • support community groups, Traditional Owners, and non-government organisations to participate in biodiversity response planning
Tree Policy * [42]	2021	• recognise the value and importance of public trees • promote the best practice of protecting and maintaining existing trees • define the criteria for public trees may be pruned/removed • ensure community consultation and involvement

Remarks: $^{\Delta}$ By the State Government of Victoria; * By the City of Melbourne.

3.2. Strategies

Strategies are medium- to long-term planning documents that articulate government goals and implementation pathways. In the context of GI, strategies provide structured guidance, vision, and performance targets across multiple agencies and spatial scales. In Melbourne, strategies are issued both at the municipal and metropolitan levels and reflect a growing policy sophistication in responding to climate and urban challenges. The City of Melbourne has demonstrated consistent leadership in this area. For example, its *Climate Change Adaptation Strategy* (2009, refreshed in 2017) was one of Australia's earliest efforts to systematically address risks such as extreme heat and stormwater challenges [44,45] (Table 2). These strategies prioritise heat reduction and urban resilience, two key functions of GI, and serve to embed environmental planning within broader risk mitigation efforts.

Complementary strategies have also been introduced to enhance biodiversity and public space provision. The *Urban Forest Strategy* (2012–2032) focuses on tree canopy expansion and sustainable tree management to mitigate the UHI effect [46]. Similarly, the *Open Space Strategy* (2012; reviewed in 2024) supports equitable and adaptive access to green spaces, ensuring alignment with population growth and community needs [47,48]. The *Nature in the City Strategy* (2017–2027) introduces an ecosystem-driven adaptation model and Indigenous "Caring for Country" principles, reflecting a shift toward holistic, place-based approaches to GI [49]. The *Green Our City Strategic Action Plan* (2017–2021) takes a more targeted focus on vertical and rooftop greening, helping to address technical barriers and urban density challenges through partnerships and planning scheme amendments [50] (Table 2).

Several regional and cross-agency strategies have also shaped Melbourne's GI landscape. *Greening The West*, initiated by City West Water in 2011 and now coordinated by a multi-stakeholder committee, seeks to redress green space inequity in western Melbourne through collaborative funding and implementation [51,52]. Meanwhile, Resilient Melbourne, part of the global 100 Resilient Cities initiative, introduced the *Resilient Melbourne*

Strategy (2016), the first metropolitan-wide urban resilience plan in Australia. Out of 372 applicant cities worldwide, Melbourne was selected as one of the 33 cities to join the global Resilient Cities Network in the first round [53]. One of its flagship outputs, *Living Melbourne: Our Metropolitan Urban Forest* (2019), presents a long-term vision to 2050 for tree planting, biodiversity, and climate adaptation at a metropolitan scale [54] (Table 2). The strategy was developed through a collaboration between Resilient Melbourne and The Nature Conservancy, and it integrates urban greening with public health, liveability, and habitat protection. These strategies collectively help to overcome barriers related to weak leadership, political fragmentation, and governance challenges, as discussed in Section 2. Their emphasis on multi-sector collaboration and regional coherence enhances Melbourne's capacity to mainstream GI through both municipal and cross-jurisdictional initiatives.

Table 2. List of strategies related to GI in Melbourne.

Strategies	Year	Key Points
Climate Change Adaptation Strategy * [44,45]	2009, 2017	• identify climate change risks for the municipality • provide details on strategies to mitigate, neutralise, adapt to, or prevent the effects of climate change, reduce the risk of heatwaves, cool the city and enhance thermal comfort to build the resilience of the municipality
Greening The West Strategy $^{+}$ [51,52]	2011–Present	• support GI to improve health and well-being • maximise urban greening to improve liveability and connectivity • encourage community support and participation • seek funding opportunities through collaborative partnerships
Urban Forest Strategy * [46]	2012–2032	• provide a strategic framework for the evolution and longevity of the urban forest in Melbourne • create healthier ecosystems and mitigate the UHI effect • increase forest diversity and tree canopy cover
Open Space Strategy * [47,48]	2012, 2024	• provide the overarching framework and strategic direction for open space planning in Melbourne • provide recommendations for maintaining Melbourne's liveability through open space provisions and planning • identify new open space priorities to cope with population growth and community needs
Resilient Melbourne Strategy ^{O} [53]	2014–2020	• enable strong natural assets and ecosystems alongside a growing population • develop and maintain the infrastructure that fosters social unity, equal opportunities, and health • reduce the exposure to future heatwave hazards
Green Our City Strategic Action Plan: Vertical and Rooftop Greening in Melbourne * [50]	2017–2021	• improve the quality and quantity of green roofs and vertical greening • develop industry standards for green roofs and vertical greening • promote partnerships with the private sector to co-fund greening • introduce changes to the planning scheme to encourage more GI
Nature in the City Strategy * [49]	2017–2027	• create and maintain a healthy ecosystem and thriving biodiversity within the city • develop a more ecologically connected urban landscape • connect more people to nature to improve health and wellbeing
Living Melbourne: Our Metropolitan Urban Forest $^{\%}$ [54]	2019	• support the vision of healthy people, abundant nature and natural infrastructure • protect and restore species' habitats and improve connectivity • build a toolkit of resources to underpin implementation

Remarks: ^{O} By the Resilient Melbourne Steering Committee; $^{+}$ By the Greening The West Steering Committee; * By the City of Melbourne; $^{\%}$ By the Natural Conservancy and Resilient Melbourne.

3.3. Programs and Initiatives

Programs and initiatives refer to specific actions, campaigns, or localised projects led or supported by governments and stakeholders to operationalise GI strategies. These are often grant-funded, trial-based, or targeted implementations aimed at testing innovative solutions or scaling up community engagement. In Melbourne, these efforts play a vital role in overcoming implementation barriers, especially those related to technical skills, financial constraints, and fragmented coordination.

One of the most prominent programs is the *Grey to Green Initiative*, which began in the mid-1980s and has since transformed more than 80 hectares of underutilised space into green areas, parks, and wetlands [55] (Table 3). This aligns with the *Open Space Strategy* (2012, 2024) [47,48], *Urban Forest Strategy* (2012) [46], and *Nature in the City Strategy* (2017) [49]. By placing greater emphasis on pedestrians, the walkability of the city and the microclimate of urban environments are enhanced.

To foster knowledge sharing and idea exchange, the City of Melbourne has organised the Canopy Green Roof Forum since 2008. Diverse stakeholders, ranging from government, industry, and community sectors to green professionals and academics, were invited as speakers. Throughout the 16 years of delivery, more than 50 events were organised covering various aspects of GI and urban greening [56].

Smaller-scale, highly visible programs like the Streetscape Improvements Program (2011–2016) and the Green Your Laneway Project (2015–2023) showcase how municipal-level interventions can repurpose underutilised urban spaces to increase greenery and improve public amenity [57,58] (Table 3). These projects are not only landscape improvements but also serve as demonstration models to gain public and political support, thus addressing barriers of low political prioritisation and public unfamiliarity with GI benefits.

Based on the *Green Our City Strategic Action Plan* [50], the City of Melbourne has provided matched-funding grants under the Urban Forest Fund Grant to financially support greening initiatives and projects in partnership with the private sector since 2017. Funded projects include community-led greening for laneways, as well as green roofs and green walls with public interests [59]. A key initiative under the *Green Our City Strategic Action Plan* is the Green Our Rooftop Project. This is a collaboration between the City of Melbourne and the Department of Environment, Land, Water and Planning (DELWP) in alignment with the Victorian Government's *Plan Melbourne 2017-205* for increasing the quantity and quality of GI. The existing office building at One Treasury Place in East Melbourne was selected for having a green rooftop retrofit. Although this project was initiated in 2019, there was a delay in the progress due to the coronavirus pandemic. The green roof construction finally commenced in June 2024, was completed in August 2024, and was launched in February 2025 [60] (Table 3).

Programs like the Public Housing Community Garden Program, running since 2002, target social inclusion and food security. By supporting community gardening among culturally and linguistically diverse (CALD) groups, it enhances both environmental and social resilience [61]. Similarly, the Grow It Local platform facilitates grassroots greening through shared knowledge and small-scale food production [62] (Table 3).

Under the *Greening The West Strategy* [51], there are a series of programs and initiatives, including One Million Trees for a Greener West (2014–2017), Greening the Pipeline (2015–present), and More Trees for a Cooler Greener West (2021–present) through the collaboration of local government authorities, the Victorian Government, and the Federal Government together with community groups. One million trees were planted in Melbourne's West between 2014 and 2017 under funding support from the Federal Government [63]. The Victorian Government also provides funding to support the planting of 500,000 trees in Melbourne West since 2021 [64]. The Greening the Pipeline project exem-

plifies multi-stakeholder cooperation by transforming the 27 km-long Main Outfall Sewer reserve into linear parkland, involving authorities like Melbourne Water and VicRoads [65]. This illustrates the potential for infrastructure repurposing and the adaptive reuse of legacy assets. At the national level, the 20 Million Trees Program (2015–2020) contributed to local greening efforts by funding native tree planting across Australia, reinforcing federal commitment to biodiversity and urban sustainability [66] (Table 3).

Table 3. List of programs and initiatives related to GI in Melbourne.

Policy	Year	Key Points
Grey to Green Initiative * [55]	1985–Present	• support the realisation of biodiversity and greening targets • enhance community access to open space and promote a walkable city • address a range of complex and changing social and environmental issues at the city level
Public Housing Community Garden Program $^{\Delta}$ [61]	2008–Present	• offer opportunities for public housing residents to obtain healthy, affordable, and culturally suitable food foster community engagement and social interaction
Canopy Green Roof Forum * [56]	2008–Present	• foster collaboration and knowledge exchange for improving urban greening and sustainability • showcase top Australian urban greening and GI projects, along with their strategies and initiatives
Streetscape Improvements Program * [57]	2011–2016	• enhance the quality and functionality of urban streetscapes • focus on implementing greenery and aesthetic enhancements and promoting sustainable urban design principles create safer and more attractive public spaces
One Million Trees for a Greener West $^{\%}$ [63]	2014–2017	• increase urban greening and improve the amenity of public open spaces through the collaboration among the local, state and federal government with passionate community groups • foster environmental conservation and support local environmental outcomes through community engagement
20 Million Trees Program $^{@}$ [66]	2015–2020	• plant 20 million native trees and understory across Australia to establish healthy, self-sustaining tree-based ecosystems as part of the National Landcare Program • contribute to a reduction in Australia's net greenhouse gas emissions
Green Your Laneway Project * [58]	2015–2023	• transform existing laneways into vibrant green spaces • introduce greenery, art installations and other amenities to enhance laneway aesthetics and functionality • improve air quality, mitigate UHI effect and promote biodiversity through planter boxes, vertical gardens, etc.
Greening the Pipeline $^{\#}$ [65]	2015–Present	• transform the heritage-listed Main Outfall Sewer reserve into a vibrant parkland and green corridor • create green space in western suburbs to connect communities, improve health and wellbeing, enhance active transport
Urban Forest Fund Grant * [59]	2017–Present	• offer matched-funding grants to support greening projects, such as tree planting, green open space, installation of green roofs and walls • form partnerships between government and the private sector to expand greening initiatives beyond the Council's capital works funding
Green Our Rooftop Project $^{\Delta}$* [60]	2019–2025	• deliver a demonstration retrofit green roof in the city through collaboration between the local council and the Victorian Government • demonstrate the benefits of green roofs through research partnerships and innovative research • provide locally relevant education and guidance materials to the public about green roof installation and maintenance

Table 3. *Cont.*

Policy	Year	Key Points
More Trees for a Cooler Greener West [Δ] [63]	2021–Present	• contribute to urban cooling and greening across Melbourne's west by planting 500,000 more trees in urban areas with the lowest tree canopy cover • increase biodiversity by planting a variety of tree sizes/species, and contribute to wildlife corridors • provide more accessible green spaces for recreation and amenity
Grow It Local [&] [62]	2023–Present	• provide an online platform for backyard, balcony, community garden, and windowsill farmers in Australia to connect, share and learn • encourage Australians to plant, share and eat locally grown healthy food

Remarks: [@] By the Australian Government (Department of Agriculture, Water and the Environment); [Δ] By the State Government of Victoria; * By the City of Melbourne; [#] By the Melbourne Water; [%] By the Greening The West Steering Committee; [&] By Grow It Local.

3.4. Guides and Guidelines

Guides and guidelines are operational documents that translate policies and strategies into practical advice, technical standards, and everyday practices. In the context of GI, these resources help reduce technical uncertainties, support community engagement, and clarify implementation procedures, thereby addressing some of the key barriers to GI adoption, particularly technical limitations and regulatory inconsistencies.

The City of Melbourne has been proactive in publishing various GI-related guides and guidelines. The *Sustainable Gardening in the City of Melbourne* guideline was published in 2012 to offer practical advice on gardening in private spaces [67]. This guide supports decentralised, small-scale greening that complements larger municipal strategies. Based on the *Community Garden Policy* [43], *A Guide to Community Gardening in the City of Melbourne* and *Community Food Guide* were released in 2013 [68,69]. These resources support bottom-up greening efforts and address social equity in GI implementation. Besides community gardens, *Street Garden Guidelines* were provided in 2015 to cater for street garden planters, median strips, and roadside planting [70]. These types of tools help address governance and coordination challenges, especially around property rights and community engagement. Under the *Urban Forest Strategy* [46], the *Urban Forest Diversity Guidelines* were issued in 2011 to provide evidence-based criteria for selection of tree species that suit the urban conditions in Melbourne [71]. This contributes to the long-term performance of GI by encouraging resilient and appropriate species choices, tackling a key technical limitation identified in the literature. In line with the *Green Our City Strategic Action Plan: Vertical and Rooftop Greening in Melbourne* [50], two documents—*Valuing Green Guide: Green Roofs, Walls and Facades* and *Guidelines for Biodiversity Green Roof*—were published in 2019 and 2023, respectively [72,73] (Table 4).

In addition to the persistent efforts of the City of Melbourne, the Victorian Government also released the *Growing Green Guide: A Guide to Green Roofs, Walls, and Facades in Melbourne and Victoria, Australia* in 2014 in collaboration with the University of Melbourne and four local government authorities (City of Melbourne, Port Philip, Stonnington, and Yarra) [74] (Table 4). Together, these documents offer both technical and participatory support mechanisms that reinforce broader GI policies and strategies. They play a crucial role in making GI more understandable, implementable, and replicable across a wide range of users and contexts.

Table 4. List of guides and guidelines related to GI in Melbourne.

Guides/Guidelines	Year	Key Points
Urban Forest Diversity Guidelines: Tree Species Selection Strategy for the City of Melbourne * [71]	2011	• develop a scientifically backed set of criteria to identify tree species suited for Melbourne's urban environment, focusing on its adaptability, heritage significance, and character
Sustainable Gardening in the City of Melbourne * [67]	2012	• offer practical advice on gardening in private spaces, such as backyards, front yards, courtyards and balconies
A Guide to Community Gardening in the City of Melbourne: A Companion to the City of Melbourne Community Garden Policy * [68]	2013	• outline factors to consider when developing a community garden • cover the key requirements for submitting an expression of interest to establish a community garden on properties managed or owned by the City of Melbourne • provide the necessary details for submitting an interest in developing a community garden on property managed or owned by the City of Melbourne
Growing Green Guide: A Guide to Green Roofs, Walls, and Facades in Melbourne and Victoria, Australia $^{\Delta}$ [74]	2014	• offer practical advice for incorporating GI into building design and construction • provide detailed instructions on planning, designing, building, installing, and maintaining green roofs, walls, facades, rain gardens, and permeable pavements
Street Garden Guidelines * [70]	2015	• provides residents with straightforward, easy-to-understand information and guidance on gardening within approved municipal areas describes the application process and methods for engaging with neighbours and the local community
Valuing Green Guide: Green Roofs, Walls and Facades * [72]	2019	• summarise the financial benefits of green roofs, walls, and facades using findings from literature reviews and industry reports showing the benefit of green spaces to the environment, health and wellbeing, and the value in protecting and developing GI
Community Food Guide * [69]	2022	• offer information about food access programs and resources, including community gardens • encourage individuals to cultivate their own vegetables and foster social bonds in their local community by using shared planter boxes and communal food garden
Guidelines for Biodiversity Green Roof * [73]	2023	• offer advice on green roof design and construction in Melbourne to provide habitat for biodiversity • provide a list of appropriate plants, focusing primarily on native species, for successful growth on green roofs

Remarks: $^{\Delta}$ By the State Government of Victoria; * By the City of Melbourne.

3.5. Tools

Tools in the context of GI refer to digital platforms, technical toolkits, and data resources designed to guide planning, decision-making, and implementation. These instruments support technical capacity building, evidence-based planning, and public engagement, helping address several of the identified barriers to GI, particularly technical limitations, governance complexity, and regulatory uncertainty.

The City of Melbourne has also collaborated with different partners to develop user-friendly GI-related tools for the public to access practical resources. Through the collaboration with the Australian Institute of Refrigeration, Air Conditioning and Heating (AIRAH) and the independent environmental consultancy, Sustainable Built Environments (SBE), the *Greening Your Building: A toolkit for improving asset performance* was published in 2007 to

offer actionable steps for sustainable practices, including the incorporation of green roofs, walls, and facades [75]. This resource directly supports private sector actors in transitioning from traditional to sustainable design practices. The *Green Factor Tool* was released in 2019 in collaboration with the University of Melbourne [76]. As the first free online tool in Australia for providing evidence-based GI assessment at the building scale, the *Green Factor Tool* facilitates architects, designers, landscape architects, planners, and developers to design new buildings to be environmentally friendly with embedded GI elements [77]. This tool addresses a major technical gap by providing a consistent, evidence-based GI assessment framework, contributing to planning transparency and development accountability. Another freely available online tool is the *Urban Nature Planting Guide*, which offers practical information on selecting appropriate native plants for urban environments in Melbourne [78] (Table 5). By bridging technical knowledge and public application, it helps reduce uncertainties and promotes grassroots greening.

Table 5. List of tools related to GI in Melbourne.

Policy	Year	Key Points
Greening Your Building: A Toolkit for Improving Asset Performance * [75]	2007	• provide practical resources and guidance for implementing sustainable practices in buildings, including green roofs, walls and facades to mitigate the UHI effect and promote biodiversity
Urban Nature Planting Guide * [78]	2018	• assist individuals, community groups and businesses in enhancing green spaces throughout the city • offer practical advice on selecting and nurturing native plants suited to urban environment • promote water-wise gardening practices • provide recommendations for creating vibrant, resilient green spaces
Green Factor Tool * [76]	2019	• assess the effectiveness of greening designs and improve GI in new developments and renovations based on UHI reduction, biodiversity promotion, stormwater management, social amenities, urban food production, and aesthetics
Melbourne's Vegetation, Heat, and Land Use Data $^{\Delta}$ [79]	2019	• measure the area of tree, shrub and grass cover at a land parcel level and track changes over time • provide a visual representation of vegetation cover, land surface temperature and the urban heat vulnerability assessment

Remarks: $^{\Delta}$ By the State Government of Victoria; * By the City of Melbourne.

Additionally, *Melbourne's vegetation, heat and land use data* were released by the Victorian Government in 2019 to record the baseline of urban vegetation cover across Melbourne [79] (Table 5). These data-driven resources allow planners to make informed decisions about where and how to target GI investments, especially in areas most at risk from heat and environmental degradation. The Department of Transport and Planning (DTP) collaborated with RMIT University, the Commonwealth Scientific and Industrial Research Organisation (CSIRO), Melbourne Water, and the Clean Air and Urban Landscapes (CAUL) Hub of the National Environmental Science Program to map vegetation cover, land use, and urban heat across Melbourne and track changes over time by comparing imagery in 2014 and 2018. Such data are useful to have a better understanding of the impact of urbanisation on surface temperature, vegetation cover, and urban heat vulnerability.

Collectively, these tools exemplify the move toward digitally enabled GI planning. They not only fill critical knowledge gaps but also empower a range of users, from urban planners and architects to residents and policymakers, to engage with and act on GI strategies.

4. Discussion

This section revisits the five key barriers identified earlier, technical limitations, financial impediments, inadequate regulatory frameworks, low political prioritisation and weak leadership, and governance and coordination challenges, and assesses how Melbourne's policy responses and initiatives have addressed or exposed these barriers. Drawing from the case study, both systemic challenges and practical opportunities are examined. These responses are discussed in relation to each of the five key barriers, with attention paid to the relative significance of each and the extent to which policy and institutional actions have mitigated or reinforced their effects.

4.1. Challenges in Overcoming the Five Barriers

Despite Melbourne's progressive approach to GI, there are some challenges that hinder the full realisation of these policies. The metropolitan area of Melbourne has a total of 31 local government authorities [80]. Each municipality has its own policies, strategies, and initiatives. Melbourne has been criticised for lacking effective and clear institutional arrangements across its metropolitan area, resulting in a "governance deficit" [81]. The fragmentation of policy implementation across different municipalities may lead to uneven distribution of GI with some areas receiving more attention and resources than others. The planning of Australian cities has also been criticised for being complex and often fragmented across local and state governments under the Federal Government [82].

There have been some regional initiatives that aim at the increase of urban greening. A salient example is Greening the West, which was initially convened by the City Wet Water in 2011. It may be challenging for the leading party to bring different stakeholders together for collaboration and implementation. The City West Water successfully brought 23 partner organisations, including the State Government (DELWP, DHHS, VPA, Parks Victoria, VicRoads), local government authorities, water utilities, and community groups, to address the greening shortfall in Melbourne's West [51]. However, the success of greening initiatives really depends on the support of corresponding local government authorities, so the original leading role of the City West Water has been subsequently shifted to local government representatives.

For successful collaboration among a group of partner organisations, the contribution and commitment of participating members are critical. For some members, it may be their voluntary time investment on top of their regular workload, whereas for others, it may be regarded as part of their regular workload. The contributions from junior staff members may be limited due to their levels of authority and experience. The level of executive support is an influencing factor. For example, the development of the *Living Melbourne: Our Metropolitan Urban Forest* strategy was supported by a high degree of engagement among senior executives throughout the whole process [53]. It has even been described as "an instance of metropolitan governance in action" [83]. Such senior stakeholder involvement was crucial to the success of *Living Melbourne.*

For collaborative partnerships, it is important to have an inclusive participatory network that allows different stakeholders to interact constructively, especially the involvement of local community groups. There can be varying levels of participation and interest among stakeholders with different sociodemographic backgrounds. Effective community communication provides valuable opportunities for harnessing local knowledge and fostering a sense of ownership among participants. For instance, during the process of developing the *Nature in the City Strategy*, the City of Melbourne actively collaborated with Traditional Owners and the local Aboriginal community to duly incorporate "Caring for Country" principles with corresponding ecological practices to inform the management and restoration of Indigenous biodiversity [49].

Throughout the engagement process, it can be challenging to build and sustain momentum. Clear aims and objectives with effective communication and sharing opportunities among participating stakeholders are essential to attract new ideas, to receive contributions from diverse perspectives, and to drive the greening agenda. Long-lasting programs in Melbourne include the Grey to Green Initiative led by the City of Melbourne since 1985 and the Public Housing Community Garden Program funded by the Victorian Government since 2008. The Grey to Green Initiative involves public consultation for converting unused grey areas into vibrant green public spaces and for prioritising pedestrians over vehicles towards the vision of making Melbourne a connected city and a city for people [55]. The Public Housing Community Garden Program encourages local communities to grow their own food and to turn food scraps and waste into nutrients for soil to reduce the landfill amount [61]. Through the establishment and management of community gardens across the city, community engagement is enhanced and a sense of connection to nature is fostered leading to the broader goal of promoting environmental stewardship within the community.

Funding availability is another factor for consideration. For example, the One Million Trees for a Greener West (2014–2017) was funded by the Australian Government's National Landcare Program [63], whereas More Trees for a Cooler Greener West (2021–present) was funded by the Victorian Government [64]. Some programs are co-funded by different stakeholders, such as the Greening the Pipeline initiative (2015–present) has been funded by the Suburban Parks Program of the Victorian Government, the Stormwater Harvesting Partnership Fund of Greater Western Water, the Living Rivers Program of Melbourne Water, and Wyndham City Council. Considering that the Main Outfall Sewer reserve has a total length of 27 km, a 100 m-long pilot project was strategically completed in 2017 as a showcase to demonstrate the desirable outcomes and to attract ongoing funding support from various sources [65]. Sometimes, matched-funding grants are available to support community-led and/or business-led greening. An illustrative example is the Urban Forest Fund Grant provided by the City of Melbourne since 2017 [59]. Since a significant barrier to GI implementation is the high cost of initial investment involved, the matched-funding grants foster community and business-driven greening projects by offering financial support, especially those on privately owned lands and spaces. These practical examples relate directly to the five key barriers, showing how financial mechanisms, collaborative partnerships, and leadership structures have shaped GI outcomes in Melbourne.

4.2. Opportunities and Best Practices from Melbourne

Despite its contributions, this study has several limitations. While Melbourne offers a useful example, generalising the findings to global urban contexts requires caution. After reviewing the challenges involved, the case study of Melbourne illustrates many opportunities available and best practices in place. The City of Melbourne has demonstrated its proactive, persistent, and committed pursuit of GI implementation through a track record of policies, strategies, programs, and initiatives, although challenges relating to fragmented governance and variable funding persist at the metropolitan level. The outcomes generated have been regularly monitored and reviewed, as exemplified by the *Climate Change Adaptation Strategy* and *Open Space Strategy.* This practice of reviewing the current progress against the original goals and specific targets has been highly recommended because many cities have developed climate adaptation or climate resilience plans with ambitious lists of interventions, but it is not common for cities to revisit the plans after years of implementation [45]. Since the launch of the *Climate Change Adaptation Strategy* in 2009, there has been a transformation in Melbourne's contexts due to population growth and the change in global and national policies and regulations, so there is a need to evaluate existing

efforts and identify areas of improvement towards the vision of adapting well to climate change. Similarly, the *Open Space Strategy* (2012) was revisited in 2024 to review completed actions, assess the effectiveness of current provisions, and propose new recommendations to achieve the original vision and goals [48].

Melbourne is one of the cities joining the reputable C40 Cities Climate Leadership Group among 96 member cities worldwide and is committed to confronting the global climate crisis to build sustainable, equitable, and thriving communities [84]. Melbourne has also been selected as one of the 100 Resilient Cities under the initiative pioneered by the Rockefeller Foundation. Through the global network, knowledge and best practices of resilience strategies are shared among member cities, aiming towards a sustainable, resilient, and liveable future for all. Such a knowledge-driven global alliance has brought a new perspective into metropolitan governance in Melbourne with thematically led initiatives on urban greening and nature-based solutions [83]. These collaborations highlight that addressing governance and coordination challenges requires multi-level institutional commitment and frameworks that transcend individual jurisdictions.

Besides international collaboration, strategic partnerships with local universities and research institutes in Melbourne offer opportunities for identifying existing knowledge gaps and obtaining evidence-based findings based on the latest knowledge and practice. For example, *Valuing Green Guide: Green Roofs, Walls and Facades* (2019) was developed further from the report titled *Quantifying the Benefits of Green Infrastructure in Melbourne: Literature review and gap analysis* (2018). Both documents were published by the City of Melbourne in collaboration with the Institute of Sustainable Industries and Liveable Cities of Victoria University and the Green Infrastructure Research Group of the University of Melbourne [72, 85]. The outcomes and effectiveness of *Greening the West* were evaluated by the Centre for Urban Research of RMIT University leading to the release of the report, *Greening the West Case Study Report: Assessment of the functioning and implications of collaborative efforts to achieve urban greening in Melbourne's West* (2017) [51].

In addition to GI-related policies, strategies, programs, and initiatives, different guides, guidelines, and tools have been launched and are freely available to access, which provide opportunities for wider GI implementation. The *Green Factor Tool* (2019) caters for industry stakeholders to enhance greening design for proposed developments [76], whereas *A Guide to Community Gardening in the City of Melbourne* (2013) [68] offers practical advice to community garden groups and interested parties on planning, operation, and management of community gardens. Such user-friendly resources empower practitioners and the general public to engage with GI implementation. Collectively, these tools and resources not only support technical knowledge transfer but also reflect Melbourne's efforts to tackle governance gaps, build institutional capacity, and encourage community involvement, aligning with the five-barrier framework used throughout this study.

Building on these insights and achievements, several implementable recommendations are proposed to inform practice and guide future planning:

- Enhance cross-jurisdictional coordination by establishing dedicated metropolitan-level GI governance bodies to address fragmentation between municipalities.
- Institutionalise review cycles for climate and greening strategies (e.g., Open Space Strategy and Climate Change Adaptation Strategy), ensuring they adapt to emerging challenges.
- Strengthen regulatory mechanisms by embedding enforceable GI targets within planning schemes, supported by dedicated funding and inter-agency accountability.
- Prioritise inclusive partnerships by involving community and Indigenous voices early in strategy development, building on the "Caring for Country" model.

- Support knowledge-sharing across sectors and regions, including tools like the Green Factor Tool and open-access GI performance data.

4.3. Limitations and Future Research

There are some limitations in this study. The lists of GI-related policies (Table 1), strategies (Table 2), programs and initiatives (Table 3), guides and guidelines (Table 4), and tools (Table 5) are not exhaustive. The analysis focuses primarily on the City of Melbourne and does not cover the broader metropolitan area in depth. GI initiatives at the community level across Melbourne's 31 local government authorities warrant further investigation. As such, the generalisability of findings may be limited to urban contexts with similar planning and governance conditions. This study also draws on a targeted literature review and qualitative policy analysis of publicly available documents, without incorporating first-hand perspectives. Future research could benefit from empirical data collection, including interviews, focus groups, or surveys, to capture stakeholder insights and lived experiences.

Although this paper centres on a single-city case study, future research could adopt a comparative approach involving cities with different climatic, geographic, and institutional contexts. While international comparisons were beyond the scope of this study, Melbourne's participation in networks such as C40 Cities and 100 Resilient Cities highlights its global relevance. Lessons from Melbourne, such as cross-sectoral collaboration, inclusive community engagement, and iterative policy review, can inform urban greening efforts globally. A dedicated comparative study would provide further insights into the transferability and scalability of such strategies.

5. Conclusions

GI offers significant benefits in addressing urban challenges linked to climate change, urbanisation, and overheating, helping to mitigate UHI effects, improve air quality, promote biodiversity, and support public health. This paper identified five key barriers to GI implementation: technical limitations, financial impediments, inadequate regulatory frameworks, low political prioritisation and weak leadership, and governance and coordination challenges. Through the case study of Melbourne, the paper explored how these barriers play out in practice and the responses developed to address them. Melbourne has demonstrated leadership through initiatives like the Grey to Green program and adaptive strategies such as the Climate Change Adaptation Strategy. Collaborations with research institutions and global networks further reinforce its position as a leader in urban greening. Nonetheless, persistent challenges remain. Fragmented governance across 31 local authorities leads to uneven GI outcomes, while reliance on short-term funding limits project scalability. Technical skills gaps, regulatory inconsistencies, and variable political will, especially beyond the City of Melbourne, continue to hinder progress. To move forward, unified metropolitan policies can address governance fragmentation, while stable funding and technical capacity-building can support sustained implementation. Raising political commitment and leveraging inclusive community engagement, such as the "Caring for Country" model, will be key to advancing equitable and resilient GI across the city.

The conclusion affirms that the five key barriers to green infrastructure, technical, financial, regulatory, political, and governance-related, persist globally, yet Melbourne offers grounded responses to each. Continued progress will require sustained coordination, inclusive policymaking, and long-term investment in institutional and community capacity.

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Abbreviations

The following abbreviations are used in this manuscript:

AIRAH	Australian Institute of Refrigeration, Air Conditioning and Heating
CALD	Culturally and Linguistically Diverse
CAUL	Clean Air and Urban Landscapes
CBD	Central Business District
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DELWP	Department of Environment, Land, Water and Planning
DHHS	Department of Health and Human Services
DTP	Department of Transport and Planning
GI	Green Infrastructure
NGO	Non-Government Organisation
SBE	Sustainable Built Environments
UHI	Urban Heat Island
VPA	Victorian Planning Authority

References

1. Santamouris, M. Analyzing the heat island magnitude and characteristics in one hundred Asian and Australian cities and regions. *Sci. Total Environ.* **2015**, *512–513*, 582–598. [CrossRef] [PubMed]
2. Santamouris, M. Regulating the damaged thermostat of the cities—Status, impacts and mitigation challenges. *Energy Build.* **2015**, *91*, 43–56. [CrossRef]
3. Founda, D.; Santamouris, M. Synergies between urban heat island and heat waves in Athens (Greece), during an extremely hot summer (2012). *Sci. Rep.* **2017**, *7*, 10973. [CrossRef] [PubMed]
4. Santamouris, M. Recent progress on urban overheating and heat island research. Integrated assessment of the energy, environmental, vulnerability and health impact. Synergies with the global climate change. *Energy Build.* **2020**, *207*, 109482. [CrossRef]
5. Santamouris, M. On the energy impact of urban heat island and global warming on buildings. *Energy Build.* **2014**, *82*, 100–113. [CrossRef]
6. Johnson, H.; Kovats, R.S.; McGregor, G.; Stedman, J.; Gibbs, M.; Walton, H.; Cook, L.; Black, E. The impact of the 2003 heat wave on mortality and hospital admissions in England. *Health Stat. Q.* **2005**, *25*, 6–11. [CrossRef]
7. Van den Bosch, M.; Sang, Å.O. Urban natural environments as nature-based solutions for improved public health–A systematic review of reviews. *Environ. Res.* **2017**, *158*, 373–384. [CrossRef]

8. Vos, T.; Barber, R.M.; Bell, B.; Bertozzi-Villa, A.; Biryukov, S.; Bolliger, I.; Charlson, F.; Davis, A.; Degenhardt, L.; Dicker, D. Global, regional, and national incidence, prevalence, and years lived with disability for 301 acute and chronic diseases and injuries in 188 countries, 1990–2013: A systematic analysis for the Global Burden of Disease Study 2013. *Lancet* **2015**, *386*, 743–800. [CrossRef]
9. Santamouris, M.; Yun, G.Y. Recent development and research priorities on cool and super cool materials to mitigate urban heat island. *Renew. Energy* **2020**, *161*, 792–807. [CrossRef]
10. European Environment Agency. Green Infrastructure (GI): Enhancing Eurpoe's Natural Capital. Available online: https://www.eea.europa.eu/policy-documents/green-infrastructure-gi-2014-enhancing (accessed on 8 March 2025).
11. Connop, S.; Vandergert, P.; Eisenberg, B.; Collier, M.J.; Nash, C.; Clough, J.; Newport, D. Renaturing cities using a regionally-focused biodiversity-led multifunctional benefits approach to urban green infrastructure. *Environ. Sci. Policy* **2016**, *62*, 99–111. [CrossRef]
12. Davies, H.J.; Doick, K.J.; Hudson, M.D.; Schreckenberg, K. Challenges for tree officers to enhance the provision of regulating ecosystem services from urban forests. *Environ. Res.* **2017**, *156*, 97–107. [CrossRef] [PubMed]
13. Jayasooriya, V.; Ng, A.; Muthukumaran, S.; Perera, B. Green infrastructure practices for improvement of urban air quality. *Urban For. Urban Green.* **2017**, *21*, 34–47. [CrossRef]
14. Bettini, Y.; Brown, R.R.; de Haan, F.J.; Farrelly, M. Understanding institutional capacity for urban water transitions. *Technol. Forecast. Soc. Change* **2015**, *94*, 65–79. [CrossRef]
15. Croeser, T.; Garrard, G.E.; Thomas, F.M.; Tran, T.D.; Mell, I.; Clement, S.; Sánchez, R.; Bekessy, S. Diagnosing delivery capabilities on a large international nature-based solutions project. *npj Urban Sustain.* **2021**, *1*, 32. [CrossRef]
16. Sarabi, S.; Han, Q.; Romme, A.G.L.; De Vries, B.; Valkenburg, R.; Den Ouden, E. Uptake and implementation of nature-based solutions: An analysis of barriers using interpretive structural modeling. *J. Environ. Manag.* **2020**, *270*, 110749. [CrossRef]
17. Dhakal, K.P.; Chevalier, L.R. Managing urban stormwater for urban sustainability: Barriers and policy solutions for green infrastructure application. *J. Environ. Manag.* **2017**, *203*, 171–181. [CrossRef]
18. Qiao, X.-J.; Kristoffersson, A.; Randrup, T.B. Challenges to implementing urban sustainable stormwater management from a governance perspective: A literature review. *J. Clean. Prod.* **2018**, *196*, 943–952. [CrossRef]
19. Drosou, N.; Soetanto, R.; Hermawan, F.; Chmutina, K.; Bosher, L.; Hatmoko, J.U.D. Key factors influencing wider adoption of blue–green infrastructure in developing cities. *Water* **2019**, *11*, 1234. [CrossRef]
20. Brown, R.R.; Farrelly, M.A. Delivering sustainable urban water management: A review of the hurdles we face. *Water Sci. Technol.* **2009**, *59*, 839–846. [CrossRef]
21. Mekala, G.D.; MacDonald, D.H. Lost in transactions: Analysing the institutional arrangements underpinning urban green infrastructure. *Ecol. Econ.* **2018**, *147*, 399–409. [CrossRef]
22. Janches, F.; Henderson, H.; MacColman, L. Urban Risk and Climate Change Adaptation in the Reconquista River Basin of Argentina. Available online: https://www.jstor.org/stable/pdf/resrep18470.1.pdf (accessed on 8 March 2025).
23. Kabisch, N.; Frantzeskaki, N.; Pauleit, S.; Naumann, S.; Davis, M.; Artmann, M.; Haase, D.; Knapp, S.; Korn, H.; Stadler, J. Nature-based solutions to climate change mitigation and adaptation in urban areas: Perspectives on indicators, knowledge gaps, barriers, and opportunities for action. *Ecol. Soc.* **2016**, *21*, 39. [CrossRef]
24. Raymond, C.M.; Frantzeskaki, N.; Kabisch, N.; Berry, P.; Breil, M.; Nita, M.R.; Geneletti, D.; Calfapietra, C. A framework for assessing and implementing the co-benefits of nature-based solutions in urban areas. *Environ. Sci. Policy* **2017**, *77*, 15–24. [CrossRef]
25. Abuseif, M.; Dupre, K.; Michael, R.N. Trees on Buildings: A Tree Selection Framework Based on Industry Best Practice. *Land* **2022**, *12*, 97. [CrossRef]
26. Kronenberg, J. Why not to green a city? Institutional barriers to preserving urban ecosystem services. *Ecosyst. Serv.* **2015**, *12*, 218–227. [CrossRef]
27. Runhaar, H.; Wilk, B.; Persson, Å.; Uittenbroek, C.; Wamsler, C. Mainstreaming climate adaptation: Taking stock about "what works" from empirical research worldwide. *Reg. Environ. Change* **2018**, *18*, 1201–1210. [CrossRef]
28. Frantzeskaki, N.; Vandergert, P.; Connop, S.; Schipper, K.; Zwierzchowska, I.; Collier, M.; Lodder, M. Examining the policy needs for implementing nature-based solutions in cities: Findings from city-wide transdisciplinary experiences in Glasgow (UK), Genk (Belgium) and Poznań (Poland). *Land Use Policy* **2020**, *96*, 104688. [CrossRef]
29. Fünfgeld, H. Institutional challenges to climate risk management in cities. *Curr. Opin. Environ. Sustain.* **2010**, *2*, 156–160. [CrossRef]
30. Miraftab, F. Insurgent planning: Situating radical planning in the global south. *Plan. Theory* **2009**, *8*, 32–50. [CrossRef]
31. Gulsrud, N.M.; Hertzog, K.; Shears, I. Innovative urban forestry governance in Melbourne?: Investigating "green placemaking" as a nature-based solution. *Environ. Res.* **2018**, *161*, 158–167. [CrossRef]
32. Wahlquist, C. Melbourne 'World's Most Liveable City' for Seventh Year Running. *The Guardian*, 6 August 2017.

33. Visit Victoria. Parks & Gardens. Available online: https://www.visitvictoria.com/see-and-do/nature-and-wildlife/parks-and-gardens (accessed on 18 March 2025).
34. State Government of Victoria. Environment and Weather. Available online: https://liveinmelbourne.vic.gov.au/live/environment-and-weather (accessed on 9 March 2025).
35. Shaw, K.; Montana, G. Place-making in megaprojects in Melbourne. *Urban Policy Res.* **2016**, *34*, 166–189. [CrossRef]
36. Irfeey, A.M.M.; Chau, H.-W.; Sumaiya, M.M.F.; Wai, C.Y.; Muttil, N.; Jamei, E. Sustainable mitigation strategies for urban heat island effects in urban areas. *Sustainability* **2023**, *15*, 10767. [CrossRef]
37. Norouzi, M.; Chau, H.-W.; Jamei, E. Design and Site-Related Factors Impacting the Cooling Performance of Urban Parks in Different Climate Zones: A Systematic Review. *Land* **2024**, *13*, 2175. [CrossRef]
38. Madureira, H.; Andresen, T. Planning for multifunctional urban green infrastructures: Promises and challenges. *Urban Des. Int.* **2014**, *19*, 38–49. [CrossRef]
39. Peel, M.C.; Finlayson, B.L.; McMahon, T.A. Updated world map of the Köppen-Geiger climate classification. *Hydrol. Earth Syst. Sci.* **2007**, *11*, 1633–1644. [CrossRef]
40. State Government of Victoria. Protecting Victoria's Environment—Biodiversity 2037. Available online: https://www.environment.vic.gov.au/biodiversity/biodiversity-plan (accessed on 16 March 2025).
41. City of Melbourne. Parks Policy. Available online: https://www.melbourne.vic.gov.au/parks-policy (accessed on 11 March 2025).
42. City of Melbourne. Tree Policy. Available online: https://www.melbourne.vic.gov.au/tree-policy (accessed on 11 March 2025).
43. City of Melbourne. City of Melbourne Community Garden Policy. Available online: https://www.melbourne.vic.gov.au/community-gardens-and-compost-hubs (accessed on 18 March 2025).
44. City of Melbourne. Climate Change Adaptation Strategy. Available online: https://www.melbourne.vic.gov.au/climate-change-adaptation-strategy (accessed on 16 March 2025).
45. City of Melbourne. Climate Change Adaptation Strategy Refresh. Available online: https://www.melbourne.vic.gov.au/climate-change-adaptation-strategy (accessed on 18 March 2025).
46. City of Melbourne. Urban Forest Strategy: Making a Great City Greener 2012–2032. Available online: https://www.melbourne.vic.gov.au/urban-forest-strategy (accessed on 18 March 2025).
47. City of Melbourne. Open Space Strategy. Available online: https://www.melbourne.vic.gov.au/open-space-strategy (accessed on 14 March 2025).
48. City of Melbourne. Open Space Strategy 2012: Light Touch Review. Available online: https://www.melbourne.vic.gov.au/open-space-strategy (accessed on 14 March 2025).
49. City of Melbourne. Nature in the City Strategy: Thriving Biodiversity and Healthy Ecosystems. Available online: https://www.melbourne.vic.gov.au/nature-city-strategy (accessed on 13 March 2025).
50. City of Melbourne. Green Our City Strategic Action Plan 2017–2021: Vertical and Rooftop Greening in Melbourne. Available online: https://www.melbourne.vic.gov.au/green-our-city-strategic-action-plan#:~:text=The%20four-year%20action%20plan,through%20the%20Urban%20Forest%20Fund (accessed on 13 March 2025).
51. Furlong, C.; Phelan, K.; Dodson, J. Greening the West: Assessment of the Functioning and Implications of Collaborative Efforts to Achieve Urban Greening in Melbourne's West. Available online: https://cur.org.au/cms/wp-content/uploads/2017/10/greening-the-west_online.pdf (accessed on 19 March 2025).
52. Greening The West Steering Committee. A Regional Approach to Delivering Community Health and Wellbeing: Strategic Plan 2020–2025. Available online: https://greeningthewest.org.au/2020/12/greening-the-west-strategy-released/ (accessed on 16 March 2025).
53. Hartigan, M.; Fitzsimons, J.; Grenfell, M.; Kent, T. Developing a metropolitan-wide urban forest strategy for a large, expanding and densifying capital city: Lessons from Melbourne, Australia. *Land* **2021**, *10*, 809. [CrossRef]
54. Nature Conservancy and Resilient Melbourne. Living Melbourne: Our Metropolitan Urban Forest. Available online: https://livingmelbourne.org.au/ (accessed on 19 March 2025).
55. International Association of Horticultural Producers (AIPH). Melbourne, Australia: Grey to Green. Available online: https://aiph.org/green-city-case-studies/melbourne-australia/#:~:text=Initiative:%20Grey%20to%20Green&text=By%20reconfiguring%20sites%20owned%20or,over%20a%2035-year%20period (accessed on 14 March 2025).
56. City of Melbourne. Canopy Green Roof Forums. Available online: https://www.melbourne.vic.gov.au/canopy-green-roof-forum (accessed on 14 March 2025).
57. City of Melbourne. Streetscape Improvements Program. Available online: https://participate.melbourne.vic.gov.au/streetscapes#:~:text=The%20City%20of%20Melbourne%20has,for%20each%20upcoming%20financial%20year. (accessed on 13 March 2025).

58. City of Melbourne. Participate Melbourne: Green Your Laneway. Available online: https://participate.melbourne.vic.gov.au/greenlaneways (accessed on 14 March 2025).
59. City of Melbourne. Urban Forest Fund. Available online: https://www.melbourne.vic.gov.au/urban-forest-fund (accessed on 14 March 2025).
60. City of Melbourne. Green Our Rooftop Project. Available online: https://www.melbourne.vic.gov.au/green-our-rooftop-project (accessed on 18 March 2025).
61. State Government of Victoria. Community Gardens. Available online: https://www.cultivatingcommunity.org.au/publichousingcommunitygardens (accessed on 17 March 2025).
62. Grow It Local. Your Local Grow Community. Available online: https://growitlocal.com/ (accessed on 20 March 2025).
63. Greening The West Steering Committee. One Million Trees for a Greener West! Available online: https://greeningthewest.org.au/projects/one-million-trees-for-a-greener-west/ (accessed on 15 March 2025).
64. State Government of Victoria. More Trees for a Cooler Greener West. Available online: https://www.environment.vic.gov.au/more-trees-for-a-cooler-greener-west/program/about-the-program (accessed on 20 March 2025).
65. Melbourne Water. Greening the Pipeline. Available online: https://www.melbournewater.com.au/services/projects/greening-pipeline (accessed on 14 March 2025).
66. Landcare Australia. 20 Million Trees Program. Available online: https://landcareaustralia.org.au/our-programme/20-million-trees/ (accessed on 15 March 2025).
67. City of Melbourne. Sustainable Gardening in the City of Melbourne. Available online: https://www.melbourne.vic.gov.au/greening-your-community (accessed on 17 March 2025).
68. City of Melbourne. A Guide to Community Gardening in the City of Melbourne: A Companion to the City of Melbourne Community Garden Policy. Available online: https://mvga-prod-files.s3.ap-southeast-4.amazonaws.com/public/SiteCollectionDocuments/guide-community-gardening-city-of-melbourne.pdf (accessed on 18 March 2025).
69. City of Melbourne. Community Food Guide: Supporting People in the City of Melbourne to Access and Grow Affordable, Healthy and Culturally Appropriate Food. Available online: https://www.melbourne.vic.gov.au/community-food-guide (accessed on 18 March 2025).
70. City of Melbourne. Street Garden Permits. Available online: https://www.melbourne.vic.gov.au/street-garden-permits (accessed on 15 March 2025).
71. City of Melbourne. Urban Forest Diversity Guidelines: Tree Species Selection Strategy for the City of Melbourne. Available online: https://www.melbourne.vic.gov.au/urban-forest-strategy (accessed on 18 March 2025).
72. City of Melbourne. Valuing Green Guide: Green Roofs, Walls and Facades. Available online: https://www.melbourne.vic.gov.au/green-our-city-strategic-action-plan#:~:text=The%20four-year%20action%20plan,through%20the%20Urban%20Forest%20Fund (accessed on 13 March 2025).
73. Schiller, J.; Rayner, J.P.; Williams, N.S.G.; Guidelines for Biodiversity Green Roofs. Report for the City of Melbourne. Available online: https://www.melbourne.vic.gov.au/green-roofs-walls-and-facades (accessed on 23 March 2025).
74. State Government of Victoria. Growing Green Guide: A Guide to Green Roofs, Walls and Facades in Melbourne and Victoria, Australia. Available online: https://mvga-prod-files.s3.ap-southeast-4.amazonaws.com/public/2024-05/growing-green-guide.pdf (accessed on 17 March 2025).
75. City of Melbourne. Greening Your Building: A Toolkit for Improving Asset Performance. Available online: https://www.gbca.org.au/docs/GreenYourBuilding.pdf (accessed on 17 March 2025).
76. City of Melbourne. Green Factor Tool. Available online: https://www.melbourne.vic.gov.au/green-factor-tool (accessed on 13 March 2025).
77. City of Melbourne. Virtual Canopy Forum: Green Factor Tool Launch. Available online: https://www.youtube.com/watch?v=yTW5jr_6YcQ (accessed on 13 March 2025).
78. City of Melbourne. Urban Nature Planting Guide. Available online: https://www.melbourne.vic.gov.au/urban-nature-planting-guide (accessed on 13 March 2025).
79. Department of Transport and Planning. Melbourne's Vegetation, Heat and Land Use Data. Available online: https://www.planning.vic.gov.au/guides-and-resources/Data-spatial-and-insights/melbournes-vegetation-heat-and-land-use-data (accessed on 14 March 2025).
80. Only Melbourne. Melbourne Metropolitan Councils. Available online: https://www.onlymelbourne.com.au/melbourne-metropolitan-councils (accessed on 22 March 2025).
81. Steele, W.E.; Gleeson, B. Mind the governance gap: Oil vulnerability and urban resilience in Australian cities. *Aust. Plan.* **2010**, *47*, 302–310. [CrossRef]

82. Adams, C.; Frantzeskaki, N.; Moglia, M. Space for mainstreaming? Learning from the implementation of urban forest strategies in metropolitan Melbourne. *Aust. Plan.* **2023**, *59*, 154–169. [CrossRef]
83. Coenen, L.; Davidson, K.; Frantzeskaki, N.; Grenfell, M.; Håkansson, I.; Hartigan, M. Metropolitan Governance in Action? Learning from metropolitan Melbourne's urban forest strategy. *Aust. Plan.* **2020**, *56*, 144–148. [CrossRef]
84. C40. About C40. Available online: https://www.c40.org/about-c40/ (accessed on 23 March 2025).
85. City of Melbourne. Quantifying the Benefits of Green Infrastructure in Melbourne: Literature Review and Gap Analysis. Available online: https://mvga-prod-files.s3.ap-southeast-4.amazonaws.com/public/SiteCollectionDocuments/quantifying-benefits-green.pdf (accessed on 23 March 2025).