Realising transformative agendas in cities through mainstreaming urban nature-based solutions

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ABSTRACT

Cities are at the forefront of sustainability agendas, especially as places to implement the solutions needed to address key sustainability challenges. City-level governments have responded in diverse ways to these challenges, including adopting and implementing a mix of policies to improve resilience and liveability that address issues including heat mitigation, water security, and climate risks. To support such sustainability strategies, we argue that mainstreaming, as a process of embedding novel thinking and solutions into governance and practice, urgently needs to be comprehensively understood and leveraged. Therefore, drawing on a mix of empirical and theoretical research and focusing on the mainstreaming of nature-based solutions in urban planning, we examine and systematically conceptualise mainstreaming as a governance and planning process. Drawing on a recent case study of urban forestry governance across metropolitan Melbourne, Australia, we show how the identified drivers and mechanisms of mainstreaming can be successfully applied. The resulting framework emphasises the need for a dynamic understanding of mainstreaming processes and what ensures they can be enabled and accelerated in the governance and planning of cities. Further, this framework may be applied for mainstreaming urban nature-based solutions as well as other sustainability innovations.

1. Introduction

To address coupled climate change and biodiversity loss crises, there is a need to fundamentally transform the trajectories of urbanisation (Pörtner et al., 2021; IPCC, 2022). In this study, we focus on the concept of mainstreaming, as a governance and planning process, and as a vehicle for change. The aim is to add much-needed conceptual depth and richness to the way that mainstreaming is understood, to bolster the capacity to amplify and accelerate paradigmatic shifts in how we govern cities. As a starting point, we define mainstreaming as a transformative agenda to move systems toward sustainability as a norm in urban planning and governance. This draws on emerging insights in the sustainability transitions literature (Xie et al., 2022; Adams et al. 2023).

We argue that new urban trajectories require changing the way we govern urban space, and for the purpose of this study, especially the way that urban nature is governed and planned for (Duvall et al., 2018; Pineda-Pinto et al., 2023). Therefore, a critical examination of urban

planning responses is required to better account for, mitigate, and adapt to the pollution, loss of biodiversity, and consumption of resources cities are responsible for (Grimm et al., 2008; Elmqvist et al., 2021). We specifically examine a place-based case study of urban forestry to gain a deeper understanding of the governance and planning processes that can foster such changes, focusing on local government initiatives.

In this paper, we use urban forestry as an example of urban nature-based solutions (NBS), as a specific sustainability solution to examine mainstreaming as a governance and planning process of change. NBS are "actions to protect, sustainably manage and restore natural or modified ecosystems, which address societal challenges (e.g. climate change, food and water security or natural disasters) effectively and adaptively, while simultaneously providing human well-being and biodiversity benefits" (Cohen-Shacham et al., 2016: xii). NBS are important sustainability solutions for cities because they can produce multiple co-benefits in these inter-linked systems (Frantzeskaki et al., 2019b), however, to maximise their potential, a paradigm shift in planning away from a focus

on techno-centric solutions is required. Urban NBS have been employed as systemic solutions for the planning of resilient and sustainable cities, which is important for understanding multiple aspects of realising transformative change, such as: how circularity in systems can deliver urban NBS co-benefits (Tsatsou et al., 2023); the role of intermediary actors in facilitating transformative agendas (Frantzeskaki and Bush, 2021), new forms of transformative governance such as metropolitan platforms for cross-sectoral collaboration (Bush et al., 2020; Fastenrath et al., 2020) and co-creation (Collier et al., 2023); as well as mainstreaming processes (Xie et al., 2022; Adams et al., 2023).

We argue that NBS needs to be mainstreamed for urban agendas to enable, pursue, and accelerate transformative and sustainable outcomes. A closer examination of how the mainstreaming of NBS happens in cities is required, i.e., to embed and integrate NBS in urban policy and planning. In this paper we do this from the perspective of mainstreaming as a transformative governance and planning process to inform urban planning practitioners and research for further uptake and adoption of NBS in cities globally. We do this through the lenses of what drives mainstreaming and how mainstreaming efforts can be designed (mechanisms). The drivers and mechanisms, as we conceptualise them in this paper, can help to deconstruct processes of mainstreaming for cities and provide an understanding of the ways in which mainstreaming can be designed to facilitate transformative outcomes.

Specifically, we draw on a mix of theoretical and empirical research to ask critical questions about processes that enable and accelerate transformative change in the way cities plan with and for NBS to achieve sustainability and climate resilience outcomes. In this paper we address the following research question to examine the design of NBS mainstreaming: *What drivers and mechanisms contribute to enabling and accelerating the mainstreaming of nature-based solutions in cities across multi-actor and multi-level governance landscapes?*

For answering our research question, we develop a framework of mainstreaming through which we describe how mainstreaming drivers and mechanisms facilitate the required paradigmatic shifts in urban planning and governance towards more sustainable and resilient cities. We do this through a case study of urban forestry governance across metropolitan Melbourne, Australia. The insights and outputs of this study are intended to be action-oriented and therefore useful for designing NBS mainstreaming in practice.

The remaining sections of the paper are structured as follows: the next section outlines our approach used to develop the processes of mainstreaming framework; the methodology describes the structure of the case study and data analysis; the results present the empirical case study, and the discussion reflects on mainstreaming as a governance and planning process and how it can be applied for city-level governance.

2. Conceptual mapping of mainstreaming drivers and mechanisms

Here, we present the conceptual framing that guided our analysis of mainstreaming as a governance and planning process, from the perspective of social and institutional dynamics and change. We define mainstreaming from the perspective of sustainability transitions, in that it must transform systems towards a new normal (Xie et al., 2022), rather than conflating it with integration (Adams et al., 2023). This is important to clarify, as we consider integration to be only one of several mechanisms of mainstreaming. Thus, we consider mainstreaming to be a transformative agenda to move systems towards sustainability as a norm.

To help define our framework that explains mainstreaming as a governance and planning process we argue that city-level governance is shaped by and interconnected with the decisions, policies, and actions at other levels of governance (such as National-level policies). Multi-level governance is a dynamic and overlapping understanding of governance functions (Fawcett and Marsh, 2017; Kay, 2017). This multi-level governance lens provides richness to our mainstreaming framework,

as although we focus explicitly on the actions of city-level government, the multi-level governance landscape has directive, informative, and collaborative impacts on how this city-level governance happens regarding the planning of cities (Adams et al. 2023).

We examine mainstreaming as a transformative governance and planning process from two perspectives: (1) drivers and (2) mechanisms (Fig. 1).

Drivers describe the social-institutional-economic factors that can enable or incentivise decisions and approaches to mainstream urban NBS. Mechanisms describe the design and actions relating to policy and practice, with the aim to mainstream urban NBS.

2.1. Drivers of mainstreaming

We consider the drivers of mainstreaming to be either *relational* or *systemic*.

2.1.1. Relational drivers

Drivers are *relational* when defining what is mainstreamed, who is involved in processes of mainstreaming, and where in the multi-level governance landscape mainstreaming unfolds. This is important for understanding and appreciating the different actors and power dynamics that can drive change (Avelino and Wittmayer, 2016), as well as the roles actors undertake in mainstreaming (Adams et al., 2023). We refer to *relational* drivers in terms of community engagement processes and collaborative approaches across jurisdictions, such as multi-Council projects or metropolitan-wide platforms.

2.1.2. Systemic drivers

The drivers of mainstreaming are *systemic* when relating to how mainstreaming of urban NBS unfolds in practice. It is important to consider the urban infrastructure regimes (i.e., grey toward green) and the opportunities for and barriers to change (Dorst et al., 2021). We refer to *systemic* drivers in terms of the evidence-base and knowledge that is built and used to formulate policy and best practices and the authority and responsibilities of land management, for example public/private land or decisions about land use.

2.2. Mechanisms

We consider the mechanisms of mainstreaming to be those processes that capture and represent the social dynamics at play in the ways of generating transformative outcomes. Therefore, we frame the
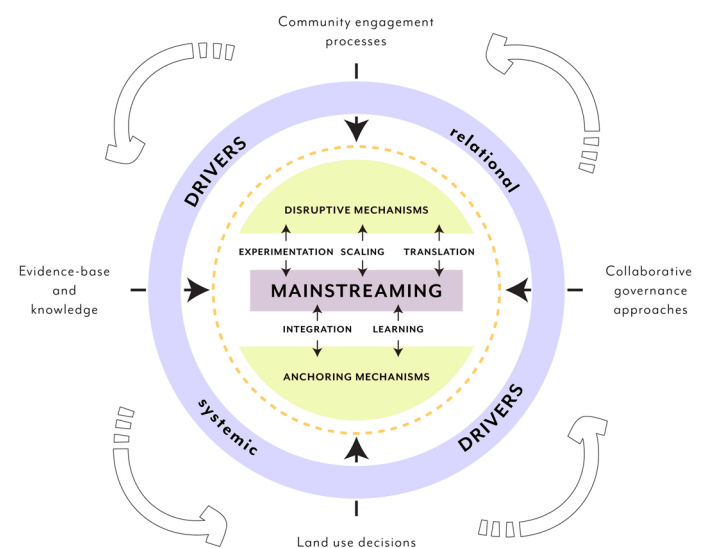

Fig. 1. Mainstreaming framework: drivers and mechanisms of mainstreaming nature-based solutions in urban planning and governance.

mechanisms of mainstreaming that can facilitate transformative change in the governance of urban NBS from two complementary perspectives: *disruptive* mechanisms and *anchoring* mechanisms.

2.2.1. Disruptive mechanisms

Disruptive mechanisms aim to purposefully intervene in business-as-usual (governance) processes to pursue desired change(s) for sustainable and resilient outcomes in planning the city. These mechanisms are 'disruptive' because they are (often) designed, created, or intended to change the fundamental responses, logics, and ways of doing that challenge dominant narratives and actions of urbanism that prioritise economic growth. We conceptualise disruptive mainstreaming mechanisms in reference to experimentation, scaling, and translation.

Experimentation refers to the innovative, bottom-up governance modes, such as urban living labs (Kronsell and Mukhtar-Landgren, 2018), which are important as demonstration projects, for learning and up-scaling the potential of nature-based interventions (Grönholm 2022; Wickenberg et al., 2022).

Scaling refers to the process by which solutions and interventions will cross political jurisdictions and borders (Borgström et al,. 2006; Loorbach et al., 2020). Therefore, this includes diffusion across levels, space, sectors, and from niche to wide-spread adoption (up-scaling) (Fastenrath et al., 2020). Understanding how sustainability solutions are scaled is important to ensure they are contextually appropriate, for example for local and/or regional needs (e.g., Macdonald et al., 2021).

Translation refers to the process of operationalising concepts, knowledge, and best practices for place-based implementation and policy formulation (Wamsler, 2015). This mechanism emphasises the importance of context-sensitive information, knowledge, and practices to enable fit-for-purpose adaptation, i.e., that there needs to be a process of translation rather than transplanting a successful project or program from somewhere else without re-making it for the new context.

2.2.2. Anchoring mechanisms

Anchoring mechanisms, refer to the processes of integration and learning, and are dimensions of urban governance that should be present, regardless of the intention to mainstream NBS. These mechanisms can ensure the persistence and legitimacy of mainstreaming endeavours.

Integration refers to the logic of bringing together sectors and policies to address issues holistically rather than separately. This has been examined in the environmental policy integration literature (Lafferty and Hovden, 2003; Uittenbroek et al. 2016), as well as in city-level adaptation planning (Wamsler et al. 2020).

Learning refers to the evaluative and reflexive processes that build the knowledge and which seek to improve outcomes, such as for systems to be adaptable, flexible, and learn from experiences of implementing urban NBS. Learning is a discursive, iterative process, which includes policy learning (Frantzeskaki and Kabisch, 2016), social learning (Bos and Brown, 2014; Bush et al. 2023), and learning from experimentation (Dunn et al. 2017; Hölscher et al., 2019) or exchange between cities such as through city network platforms (Frantzeskaki et al., 2019a; Ilgen et al., 2019; Oke et al., 2021).

2.3. Towards a comprehensive framework for mainstreaming of NBS

Insights developed from this study build on previous research that conceptualises mainstreaming from a sustainability transitions perspective, which identified roles and mechanisms to better explain the concept (Adams et al., 2023). This paper explicitly focuses on the governance mechanisms to provide deeper understanding of how the mainstreaming of NBS in cities can produce paradigmatic shifts in the way cities are planned. We argue that, taken together, disruptive and anchoring mechanisms enable and accelerate the required paradigm shifts, to promote new ways of thinking and doing to plan, design, and govern cities for transformative sustainability and resilience outcomes. Therefore, the drivers and mechanisms of mainstreaming are

instrumental in facilitating governance and planning processes to mainstream NBS in cities, and in this paper, we provide a new way to explain these processes.

3. Methodology

This paper presents a synthesis of research, based on a case study of urban forestry governance, as an example of urban NBS, in metropolitan Melbourne, Australia.

3.1. Interviews

Semi-structured interviews (n = 32) were conducted in March-May 2022 with participants from two key categories: (1) practitioners working on urban forestry implementation (mostly local government officers), and (2) six academics researching in the field. Interview duration averaged approximately one hour. Out of the practitioners being interviewed, eight were from the City of Melbourne, 17 were from other metropolitan Melbourne Councils, and one was from Living Melbourne. Participants were chosen based on their expertise and experience in academia or practice in relation to urban forestry in metropolitan Melbourne with, on average, around seven years of experience. In relation to the local government participants, they were further selected based on which local government they worked for, i.e., to achieve a representative spatial sample to be inclusive of diverse metropolitan Melbourne Councils (see also Section 3.3). Interviews were conducted in accordance with a Swinburne University of Technology Human Research Ethics Committee approval (Ref: 20225938–9184/20225938–9531). The interview protocol, outlined in Appendix 1, was designed to encourage participants to talk about their experiences with the concept, creation, and implementation of urban forestry in metropolitan Melbourne.

3.2. Analysis process

An analysis process was adopted based on inductive theory-building, that draws on elements of grounded theory (Charmaz and Bryant, 2008). The data was iteratively coded to build our novel framework for designing mainstreaming. New data was used when building on our emerging themes through ongoing research (Adams et al., 2023) with the (re)analysis of empirical data, i.e., to explicitly ground our conceptualisation of drivers and mechanisms in experiences from practice. This process of data analysis refined our conceptualisation of mainstreaming to be applicable and relevant to, and therefore what can be learnt from, our place-based case study.

3.3. Case study context

This research draws on an explanatory qualitative case study (Yin, 2003). The case study is located in the Melbourne metropolitan region which comprises thirty-two local government areas (LGAs or Councils) that range from highly urbanised to peri-urban landscapes and therefore have different pressures and planning needs (Gulsrud et al., 2018; Buxton and Butt, 2020). The case study was designed to include this diversity of experiences and level of engagement with urban forestry, with eighteen Councils participating. Urban forestry strategies have gained prominence in Councils across metropolitan Melbourne as practical and useful plans to address urban climate and biodiversity challenges, especially as it relates to the importance of tree canopy cover to mitigate urban heat island effects (City of Melbourne, 2012; The Nature Conservancy and Resilient Melbourne, 2019). This can be seen in the timeline of urban forest strategy adoption of the included Councils, with several councils adopting early (2010–2015: n = 3), then an acceleration of adoption (2016–2021: n = 11), and recent adoption or with plans in development (2022-ongoing: n = 3). One of the included Councils currently has no dedicated urban forest strategy. Further, a

metropolitan-wide urban forest strategy, Living Melbourne, was adopted in 2019 by partners including all metropolitan Melbourne Councils, the Victorian State Government, and water authorities.

Our chosen case study is important for examining the elements that influence a paradigm shift in the approaches that cities are taking to promote sustainability outcomes and climate adaptation, thus, to understand how mainstreaming happens in governance processes and planning practice. The inclusion of multiple Councils, that have diverse political, economic, and ecological pressures and needs, is important as this will help us to better understand the processes of mainstreaming in more diverse contexts. Specifically, we interviewed participants from the following councils:

- East Metropolitan Region: Maroondah, Monash, and Whitehorse.
- Inner Metropolitan Region: Melbourne and Port Phillip.
- Inner South-East Metropolitan Region: Bayside and Stonnington.
- North Metropolitan Region: Banyule, Merri-Bek (Moreland), Nillumbik, and Whittlesea.
- South Metropolitan Region: Casey, Frankston, Greater Dandenong, and Kingston.
- West Metropolitan Region: Hobsons Bay, Moonee Valley, and Wyndham.

This diversity adds richness to our framework because we have not just focused on a frontrunner Council (City of Melbourne) and what they have done well, but rather we have synthesised trends and actions from Councils with a range of capacity, resources, as well as urban forestry imaginations and narratives.

4. Results

The results presented for this study aim to highlight the drivers and mechanisms that can promote paradigm shifts in the governance of cities, exemplified by the mainstreaming of NBS, a summary is presented in Table 1, with the full table provided in Appendix 2. The analysis and synthesis of interview data, whereby we identify the drivers and mechanisms for (institutional) change, help to deconstruct mainstreaming as a process, which provides insights into how cities can design and implement sustainability solutions.

Table 1
Summary of mechanisms of mainstreaming.

Mainstreaming mechanisms	
Disruptive	**Anchoring**
Experimentation	*Integration*
Innovation in engagement, collaboration, knowledge co-production, and rules for urban forestry. Including citizen science programs, regional metropolitan collaborations, and tree protections.	Transcending silos of operation to allow for whole-of-Council approaches, aligning relevant policies and decisions, and providing opportunities for citizens to be involved in the process.
Scaling	*Learning*
The appropriate scale for intervention and governance within and across multiple scales, to ensure that interventions are relevant to local communities and/or capacity to scale up interventions (e.g., to metropolitan-wide adoption).	Ensuring that mainstreaming efforts are embedded in processes and procedures over time to improve policies and practices, e.g., by reviewing or updating plans.
Translation	
Building and sharing knowledge and best practices of urban forestry within and across local governments, such as through community education programs and practitioner or city networks.	

4.1. Drivers of mainstreaming

The drivers of mainstreaming describe relationships among multiple actors (experts, communities, etc), Councils, and policies, that contribute to establishing and pursuing mainstreaming. From a synthesis of the interview data, we identify two types of drivers that contribute to mainstreaming: relational and systemic. Driving transformative processes and approaches can happen through community engagement processes, collaborative governance approaches, building the evidence-base and knowledge to support policies and practices, and land use decision-making responsibilities. We consider these drivers to be important for elucidating how governance is organised, the constraints or conflicts that need to be understood and addressed, and how transformative ambitions can be enacted. In this paper, we focus on how mainstreaming, through our identified drivers and mechanisms, is happening in practice.

4.1.1. Relational driver 1: collaborating with the community

A key relationship in urban forestry is between citizens and local government. Many interviewees said that crucial stages in the development and implementation of urban forestry is engaging and collaborating with the community. In terms of these relationships, interviewees noted the importance of ongoing community engagement processes such as education and citizen science programs; inclusivity of Traditional Owners' groups; (re)connecting to nature; and encouraging volunteerism. This is particularly important for gaining buy-in from the community in terms of (supporting) what Council is doing around urban forestry and trees. As one interviewee described:

> "making sure that we're able to build on the volunteering mechanisms and community initiatives so that we're not only just increasing trees but also increasing the awareness of the benefits of plants and trees and what they bring to the community and basically bringing the community along with us on the journey of this strategy and the work that we're doing" [Inner South-East Metropolitan Region participant].

Accounting for and engaging with the aspirations of urban communities was thought to provide important grounding, not only in the development and implementation of current strategies and plans but also for the future ambitions and management of the urban forest. This is underpinned, as many interviewees explained, by Council programs that encourage and invite the community to be actively involved in urban forestry. These include things like tree giveaways or home gardening kits, and volunteer tree planting days, to foster positive interactions with urban nature, such as in parks, reserves, or home gardens.

These programs, however, are not achieving the required shifts for tree retention and planting in private spaces or fundamental changes to the approved development types (e.g., subdivisions, building footprint). Nonetheless, the importance of Councils collaboratively engaging with their community to progress urban forestry programs was an aspect that all interviewees emphasised. For example:

> "the public have really powerful voices…if there's enough public sentiment and enough reason to act, particularly in the space of nature-based solutions, it just gives us more and more of a business case to do that" [Inner Metropolitan Region participant].

4.1.2. Relational driver 2: cross-jurisdictional collaboration

The relationality of mainstreaming is also driven by the collaboration and/or co-ordination of multiple Councils, which as many interviewees recounted, is important in terms of managing cross-boundary (jurisdiction) urban greening projects and programs; applying for grant funding; collective advocacy and pooling resources; and sharing knowledge, expertise, and best practice.

Interviewees mentioned many opportunities for multi-Council collaborations and how they can be useful for supporting the delivery of

(local) urban forestry outcomes. Specifically, these can be in the form of Council-to-Council information sharing or joint projects; regional alliances such as Greening the West (for greening projects for the metropolitan Councils in western Melbourne); and working groups (e.g., biodiversity mapping, data collection, and sharing) and projects through the metropolitan-wide platform Living Melbourne. One interviewee described the benefits of these multi-Council collaborations:

> "I'm actually leading an action in Living Melbourne. That's about planning for habitat connectivity across council borders so it's a group of Councils, largely in the eastern region from Yarra Ranges almost into Melbourne itself. And looking at working to collaboratively say, well, how do we plan habitat connectivity across that area, which has seven or eight Councils. So, collaboration's huge in that bigger picture, but each brings their own perspective and needs to those collaborations" [East Metropolitan Region participant].

4.1.3. Systemic driver 1: evidence-based policies and action

Drawing on a synthesis of the interview data, we found that mainstreaming can be enacted by adopting evidence-based policies and actions. Specifically relating to urban forests, this evidence base is related to the health, extent, functioning, and co-benefits of urban forestry. Therefore, this driver is specifically about transforming the information, knowledge, and application of urban forestry as an NBS. Interviewees noted that this can be in the form of what is included in urban forestry policies and how this aligns with broader Council policies and plans (such as health, transport, and land use).

Evidence-based policies and actions rely on developing knowledge and information sharing across multiple actors in practice, policy, and research to effectively implement urban forestry. This may involve data collection about the health and extent of trees in the urban forest (e.g., useful life expectancy assessments), promoting innovative policies and practices in managing the urban forest (e.g., citizen science programs), or creating policies that capitalise on the co-benefits of urban forestry, urban greening, and urban water management.

Prioritising the development and use of evidence when implementing new solutions was thought to be crucial for designing mainstreaming that can deliver best-practice outcomes for the urban forest, as one interviewee stated of the ambition of their Council's urban forestry program:

> "to make sure that it wasn't: Yes, we planted a million trees, but only 10% of them survived after two or three years. We wanted to make sure that 95% of the trees that we planted were surviving" [Inner Metropolitan Region participant].

It was also acknowledged by most interviewees that adopting evidence-based approaches is an ongoing learning process, i.e., that the evidence-base and policies must be reviewed to be flexible to advances in knowledge and understanding (context-sensitive information, processes of policy, and use of knowledge). This includes evidence related to achieving canopy cover targets or understand why targets are not being met; to be time- and context-sensitive to changing community needs and aspirations; and to create, improve, and embed best practices to manage the urban forest. Many interviewees mentioned the necessity of the 'raw' information that is needed to plant and manage the urban forest under current and future conditions, such as species selection and health of trees. This has implications for tree retention, protection, and rules for urban development. It is an ongoing tension between the aspirations of urban forestry and development priorities, which is exemplified by the comments of one interviewee:

> "There are just conflicting needs for space, and I think trees often lose out, so we do need to make sure that there's adequate space being put aside for larger trees in all types of developments" [South Metropolitan Region participant].

4.1.4. Systemic driver 2: shift in priorities for land ownership and management

The powers and responsibilities to make land use decisions are identified as an important driver. Most interviewees noted that urban forestry ambitions are constrained by land ownership, as local governments can only directly control what happens on the land that they own (public land), which across the case study area tends to be significantly less than fifty per cent of all the urban land. Therefore, the consensus amongst interviewees was that urban forestry targets will primarily be met in the public realm, but it will continue to be difficult to mirror these results in the private realm. This difficulty can be attributed to different factors, including population growth and development pressures (approvals processes, design requirements), inefficient or ineffective tree protections (statutory rules, local laws), and some people not wanting certain trees on their private property (community engagement and education). In terms of land management responsibilities, one interviewee stated:

> "At City of Melbourne we've had ten years to establish the work that we're doing on public land and I think we're in a really good space there…We're going backwards on private land and we are increasing on public land, but will never catch up because of the area of influence that we have" [Inner Metropolitan Region participant].

This means that the responsibilities of land ownership are critical drivers for urban forest management, especially in terms of tree and canopy retention and new plantings in the private realm. As many interviewees highlighted, at some point all available and appropriate public land to plant canopy trees will be planted out, and to meet overall canopy targets the next frontier is how to effectively manage the urban forest that is in the private realm. Examples of the emerging tools, statutory rules, and laws that interviewees mentioned include tree protections through Exceptional Tree Registers; development of the Green Factor assessment tool for private development; grants for private projects through the Urban Forest Fund; and community education programs. Overall, it is clear from this study that urban forest in the private realm needs to have better protections and controls. Especially, as it was noted by multiple interviewees, that public land has competing demands from things like green space, bicycle lanes, and recreation. One interviewee explained their Council's competing interests in allocating public land uses:

> "The only problem is in the public space; we would say we're constrained. We have competing demands for our public open spaces. We can't just keep expanding our provision of sporting facilities and keeping on expanding our urban forest. We can't accommodate both land uses anymore because we're becoming increasingly constrained" [South Metropolitan Region participant].

4.2. Mainstreaming mechanisms

We describe five governance mechanisms available to policy and planning actors for designing mainstreaming: integration, experimentation, scaling, translation, and learning and categorise these as either disruptive or anchoring.

4.2.1. Disruptive mechanism 1: urban experimentation and policy innovation

An important disruptive mechanism is urban experimentation, to trial new solutions, and policy innovation, to create policies that challenge the status quo. This is important as a means to encourage new ideas and ways of planning and governing urban nature. This is in relation to their funding, design, knowledges used, and processes of implementation. Interviewees also noted the following interventions that can be considered as disruptive mechanisms: new 'technology' including green roofs, walls, and facades; participatory approaches to build community acceptance or desire for innovation; designing new

tools for the assessment of development (i.e., the Green Factor tool); new funding initiatives to promote more urban forestry on private land (i.e., the Urban Forest fund); and species selection to adapt to changing climatic conditions.

For urban forestry, these types of urban experimentation and policy innovation help to activate innovative and transformative urban policies and practices that target both public and private land. Especially in terms of types of greening and locations of plantings to improve the liveability of cities (e.g., to encourage planting on private land). As one interviewee explained:

> "The Urban Forest Fund has been established as an innovative funding approach. And so, what that does is offer matched funding to people to do greening projects on private land…we know that actually to have an impact on urban heat, we need good stuff to be happening on private property, too. And so, we have to get a bit creative because we don't control that space. So that's more about influencing" [Inner Metropolitan Region participant].

4.2.2. Disruptive mechanism 2: platforms and initiatives for the scaling of governance

The scale at which the governance of urban forestry is implemented has critical implications for the scope and impact of the solution and its benefits. Processes of mainstreaming happen across scales, in that solutions can be applied to different scales such as policies for street trees, action plans for neighbourhoods (e.g., precincts), municipality-wide tree protections, metropolitan-wide strategies (e.g., Living Melbourne), or State-led strategies (e.g., Plan Melbourne). This means that mainstreaming can happen within one of these scales or across these scales for implementing urban forestry, which means governance modes need to be flexible (i.e., enable a process of scaling) to implement solutions at or across the relevant scale(s) as well as understanding how the authority of different actors overlaps and is managed. While we focus on city-level governments in this study, it is important to place this within the multi-level governance landscape of cities.

Issues of scaling for mainstreaming were reflected in the following aspects mentioned by the interviewees: the relationships between Local and State Governments in terms of statutory planning rules and amendment processes; the realities of managing urban environments and ecosystems that cross Council boundaries; and the collection of spatial data about the urban forest.

Many interviewees noted that targeted implementation of urban forestry is critical for management at individual tree, neighbourhood, and local scales, but this is not effectively supported with the State-provided data and slow processes of statutory rule change for tree protections. Further, the multi-level governance of cities is important for embedding metropolitan-scale innovations, which are interdependent and co-evolve with city-level strategies (such as the Living Melbourne network). As one interviewee explained:

> "I think it is also influenced by the other things happening in parallel. Living Melbourne was on the crest of a wave in terms of thinking about urban greening for biodiversity, connectivity, and then urban liveability, that had been happening, particularly in that climate adaptation space" [Living Melbourne participant].

4.2.3. Disruptive mechanism 3: translating and sharing knowledge and best practices

The translation and sharing of knowledge and best practices is important for building on experience, to benefit communities of practice and urban planning. The practitioner, political, community, research, and private sector avenues for translation and sharing are essential to understand for developing and embedding urban forestry as a normal action in cities. Regarding translation, interviewees referred to information sharing; community education and engagement for developing urban forestry strategies and programs; knowledge (co)production with academics, consultants, and the community; sharing through practitioner and metropolitan-wide networks (e.g., for arboriculture); and learning from exemplars, such as the City of Melbourne. These are all important to understand the progress of urban forestry as a discipline and management approach, as one interviewee explained:

> "If we learn something I think it's our responsibility to share that, so that others can continue the journey and not make the same mistakes we have or get a bit of a shortcut if we've figured out a great way to do something" [Inner Metropolitan Region participant].

4.2.4. Anchoring mechanism 1: policy and sectoral integration

Policy and sectoral integration is an important anchoring mechanism for aligning urban forestry objectives in broader planning and climate adaptation goals. To highlight its common recognition amongst interview participants, several made references to the development and implementation of their Council's urban forest strategy as a whole-of-Council exercise, thus bridging organisational silos. Further, the integration of ecological objectives into policies and planning objectives can be seen in the transformation of language being used (e.g., green infrastructure, NBS), as well as in terms of stated ambitions, knowledge, and politics that is apparent around the benefits of urban nature. This allows for designing, formulating, and getting policies adopted that address cross-cutting issues in the development of cities, including greening provisions in development approvals processes. This quote exemplifies the stated need for alignment of Council policies:

> "We cannot just have an urban forest strategy that is totally separate from the public health strategy because they are intertwined" [Inner Metropolitan Region participant].

4.2.5. Anchoring mechanism 2: learning from the implementation of urban forestry

Processes of learning are essential for understanding what has happened, how it happened, and what can be improved, built on, or eliminated to achieve urban resilience and liveability outcomes. Most interviewees alluded to or explicitly explained processes of learning regarding urban forest strategies and implementation. This was in terms of applying new and emerging ecological knowledge, especially as it relates to changing climate conditions (e.g., species selection), i.e., to broaden the plans; improving community education and engagement; learning from implementation and experience, whether their own or from another city; and review processes for new and updated urban forest strategies. Thus, it is critical for mainstreaming to have reflexivity and feedback loops from implementation. Explaining the development of a new iteration of their Council's urban forest strategy, one interviewee said:

> "in the scoping work to develop the new strategy, it's taking a very broad approach to what an urban forest strategy should be. Our current strategy is exclusively around the public realm and public land, and so there's also an acknowledgement that we need more around private land and private development and other non-council land too" [Inner Metropolitan Region participant].

5. Discussion

The aim of this study has been to develop a framework to describe how mainstreaming happens, which is important for describing how new sustainability solutions can be embedded into governance and decision-making. Key findings that we report on in this paper relate to how mainstreaming can be understood as an urban governance and planning process and to explain the drivers and mechanisms whereby mainstreaming can be enabled and accelerated.

5.1. A novel framework for mainstreaming

Mainstreaming, as described in our proposed framework, is a transformative governance and planning process engulfing disruptive and enabling drivers and mechanisms as well as anchoring and embedding mechanisms that create opportunities for transformative change in the way cities are planned.

The mechanisms of mainstreaming explain how mainstreaming is designed and pursued for the practical implementation of sustainability solutions or to design strategies for mainstreaming. Disruptive mechanisms 'push' governance modes to transform by creating opportunities and ways of thinking beyond business-as-usual processes, whilst anchoring mechanisms relate to standard governance practices that allow for embedding new practices into 'a new normal'.

We argue that our insights and findings about the drivers and mechanisms of mainstreaming describe the governance and planning processes for the design and structure of mainstreaming, and its progression over time. The processes that contribute to changing the design and structure of mainstreaming can be explained by the disruptive and anchoring mechanisms to enable, accelerate, and potentially reinforce mainstreaming outcomes.

5.1.1. How to design mainstreaming of nature-based solutions in cities

By designing mainstreaming there is an opportunity to make it more transformative. This relates to shaping experimental or innovative modes of governance that facilitate transformative actions through new ways of organising and planning cities, such as:

- Urban forestry strategies in municipalities and metropolitan-wide strategies (e.g., Living Melbourne).
- Re-imagining processes and initiatives for community engagement (e.g., citizen science programs beyond one-time interventions (Roger and Motion, 2022)).
- Developing new ways of encouraging private realm urban forestry (e. g., through the Urban Forest Fund).

This study has found that drivers of mainstreaming are relational, in terms of community engagement processes and collaborations across Council jurisdictions and systemic in terms of the evidence-base and land ownership of the urban forest. This has three core elements:

- Engagement and collaboration with multiple stakeholders, who manage, use, or benefit from the urban forest, to design context-sensitive projects and programs (e.g., education programs, citizen science programs, local knowledges, cross-jurisdiction greening projects).
- Knowledge about the urban forest and information to design and define targets and actions to plant and manage the urban forest (e.g., health of trees, tree canopy volume, tree loss/retention, human health, and well-being).
- Rules and regulations for growing and protecting the urban forest and the co-benefits it produces on public and private land (e.g., tree protections, design codes and planning rules, economic incentives).

Therefore, to capitalise on mainstreaming as a transformative governance and planning process, we argue that the design of mainstreaming requires the following considerations regarding the scope of mainstreaming. First, how experimentation and innovation is supported in cities, i.e., its capacity to be disruptive. For example, framing urban experimentation as a long-term driver and means of governance (Bulkeley, 2023). This includes trialling new 'technologies' (e.g., green roofs, walls, facades), reforming planning approaches, and designing new policy. Second, how mainstreaming can capitalise on the multi-level governance landscape of cities, i.e., its capacity to be appropriately scaled. For example, to better understand the metropolitan scale (Fastenrath et al. 2020). This means taking into consideration

where mainstreaming happens, and thus for its design to be fit-for-purpose (e.g., place-based, metropolitan-wide, state-wide). Third, how knowledges and practices are embedded within and among institutions and communities of practice, i.e., its capacity to translate to different contexts. This means understanding what knowledges and practices are available and how they are developed, used, and shared. For example, to build on expertise, foster practitioner networks, build a community of practice, such as intermediaries and intermediary organisations (Frantzeskaki and Bush, 2021). Fourth, how integrative approaches emerge and develop within and across levels of governance to support (disruptive) transformation. This means taking into consideration new concepts in use such as NBS or green infrastructure (Baravikova, 2020), policy alignment, and bridging organisational silos for cross-cutting implementation. Fifth, how processes of reflexivity enable social and policy learning to support mainstreaming as a governance and planning process (as outlined in Section 2.2.2). This allows for urban planning to be flexible and adaptable to ensure mainstreaming has cumulative impact for improving stakeholder engagement approaches and inclusivity. For example, online engagement and workshops, applying new (and diverse) knowledges, policy evaluation and review, and learning from other cities.

5.1.2. Implications for urban forest management

The process of mainstreaming can be designed to enable and accelerate transformative governance. In this study we have explored and explained mainstreaming as transformative governance activity from the perspective of urban forests in the Melbourne metropolitan region. In this context, to drive transformative governance outcomes, four key factors need to be considered:

(1) The implications of public and private land ownership and management on successful urban forestry outcomes.
(2) The division and overlap of State and Local Government responsibilities for the urban forest (and urban development).
(3) Ensuring the inclusivity of stakeholders, especially non-government ones, for decisions and management related to the urban forest.
(4) Addressing knowledge deficits and needs to effectively manage and grow the urban forest.

5.2. Implications for the multi-level governance landscape of cities

Change in the institutions, paradigms, and principles that govern, plan, and build cities usually takes a long time to be realised. Norms, rules, and the way we think about urban nature require long-term, strategic, and adaptable processes that are supported by communities and policies across the multi-level governance landscape of cities.

This insight is in part based on the acknowledgement that mainstreaming does not just happen in practice or in policy and it is not just about the actions of a small number of individuals. It occurs across multiple domains, including in the political sphere, and across the multi-level governance landscape of cities. Therefore, mainstreaming is a culmination of numerous actions across the spectrum of public and private actors and/or organisations. Insights in this paper are based on a case study of metropolitan Melbourne, which provided the opportunity to examine the dynamics of mainstreaming in different contexts to build a representative framework for the processes of mainstreaming.

In our examination of mainstreaming as a governance and planning process, we emphasise the importance of a place-based logic to understand how it unfolds. This can be seen in how urban forestry has progressed in metropolitan Melbourne, where the City of Melbourne produced a standard for urban forestry planning and governance, and how other Councils have adapted (translated) this sustainability solution for their own context. However, mainstreaming should not be locked to a single level, instead, as this framework outlines,

mainstreaming is a process that can be adaptable and flexible to allow cross-jurisdictional paradigm shifts in the planning and management of cities, including diffusion into the wider metropolitan region.

To maximise this potential for diffusion, mainstreaming needs to be undertaken with an understanding of where planning powers and responsibilities lie for cities. In other words, what and who determines the authoritative environment. In the context of this case study, this includes the formal structures at Local and State government levels (e.g., statutory planning rules), as well as more informal and collaborative metropolitan platforms (e.g., Living Melbourne, Greening the West).

5.3. Opportunity for generalisation

The proposed mainstreaming framework aims to understand the knowledge, institutions, and practices that support the mainstreaming of NBS in cities, which includes the diffusion of (urban forestry) adoption, i.e., how mainstreaming is enabled and accelerated beyond its original scope. It also emphasises that mainstreaming efforts must always be contextualised to the place and circumstance of implementation. We argue that mainstreaming processes need to continuously adapt to complex social, ecological, political, and economic realities, and therefore need to be integrative, learning-oriented, and innovative to ensure it is fit-for-purpose and transformative in the long term.

The research outputs of this study have three key insights for generalising these findings:

1. Beyond city-level governance scope,
2. Beyond urban forestry as the solution under investigation, and
3. About how mainstreaming processes, as a transformative governance and planning process, can influence broader efforts for promoting transformative sustainability-oriented change.

5.3.1. Beyond city-level governance

As explored in the previous section, the applications of this mainstreaming framework can be beneficial beyond the city-level scope presented in this study, to have the potential to better understand, for example National-level policies and governance of (urban) nature.

5.3.2. On urban forestry and beyond urban forestry

At the core of urban forestry ambitions across metropolitan Melbourne is the awareness and acknowledgment that urban development cannot continue based on business-as-usual practices without adverse outcomes and unintended consequences. Increased adoption of urban forestry is associated with considerable co-benefits, not least to help adapt to the impacts of climate change, by promoting ecosystem health and reducing urban heat. This can be generalised to broader urban sustainability issues in terms of development priorities (e.g., growth areas) of metropolitan Councils in Melbourne, in terms of planning for the rural-urban fringe, development and population priorities and projections, and therefore, ultimately, the urban form that is (re)produced through the decisions and statutory rules in play for continued urban development.

Importantly, the generalisability of this framework can easily be applied beyond urban forestry as a solution; it has obvious potential to be generalised more broadly to (urban) NBS. We argue that there is also potential to generalise our insights into mainstreaming as a governance and planning process to any sustainability solution to better understand how paradigm shifts happen in governance and decision-making. This has important implications for prioritising the required changes towards sustainability and resilience, both within and beyond cities, to confront the climate and biodiversity crises. The insights of this study provide a new way to organise the thinking and actions for enabling and accelerating the transformations that are needed for city and planet liveability and survival.

5.3.3. Towards mainstreaming as a general process for social-institutional adjustment to achieve sustainability goals

Importantly, the understanding of mainstreaming as a process and the associated framework has implications for how strategic urban planning is thought about and implemented, specifically in terms of urban development and regeneration decisions. This means that the framework we have developed can likely be used (subject to further research) also at different levels of government that are responsible for planning cities. However, further research is needed in other sustainability domains to confirm the applicability and usefulness of the framework.

6. Conclusion

The premises of this paper are threefold. Firstly, cities need to change if they are to address urgent sustainability challenges. Secondly, whilst many solutions already exist that could relatively easily be implemented, the main barrier to many of the sustainability solutions that are needed is that current governance and decision-making settings are commonly not yet set up to adopt and support them. Thirdly, we therefore need to understand the social and institutional processes (work) needed to reform institutions and governance to allow sustainability solutions to be adopted and supported into the future. We refer to this as mainstreaming processes.

This study therefore specifically examines what drives processes of mainstreaming and the mechanisms available to design mainstreaming efforts, as a vehicle to promote transformative change that address sustainability challenges. The drivers relate to community engagement processes, collaborative governance approaches, the creation and use of evidence-bases and knowledge, and land use decision-making responsibilities. In terms of the mechanisms, we refer to disruptive mechanisms, i.e., interventions that are deliberately designed to be transformative such as urban experimentation, and anchoring mechanisms which describe how transformative change can be embedded and accepted into the (urban planning and governance) system.

This paper brings together the drivers and mechanisms to produce a framework and language that can help organise and design mainstreaming processes across knowledge, policy, practice, politics, and research to make cities better in terms of liveability, resilience, and sustainability. Our case study of urban forestry governance in metropolitan Melbourne focused explicitly on the local and metropolitan levels of governance and therefore we have proposed how our theoretical output may be generalised to other contexts. However, there are limitations to this study's generalisability such as understanding the role of the private sector in urban forestry and the politics and power in mainstreaming as these issues were beyond our scope. This study also extracts insights on the complex social process of mainstreaming of urban forestry as a case of NBS and even sustainability solutions in general, on the basis a single case study, meaning that different contexts may throw up challenges or complexities not yet uncovered in this study. However, as all knowledge in this field is ultimately based on contextual case study information, this merely shows that the insights here are a step forward in the knowledge of mainstreaming that can be further built upon, in the spirit of inductive theory building.

We embed our findings into a framework which can be applied to transform systems of planning and governance and shift socio-political thinking, awareness, and desirability of nature in cities. This is an important step towards achieving transformational sustainability agendas. In conclusion, the responses of city-level governments require paradigm shifts, not only in terms of knowledge and understanding of the essential benefits of urban nature, but also for understanding how institutional change can be achieved so that such solutions can be adopted and supported.

CRediT authorship contribution statement

Clare Adams: Conceptualization, Formal analysis, Methodology, Visualization, Writing – original draft. **Magnus Moglia:** Conceptualization, Supervision, Writing – review & editing. **Niki Frantzeskaki:** Conceptualization, Supervision, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix 1

Interview protocol
1. How have you been involved in creating or implementing Council's urban forest strategy? / Can you walk me through the steps of how your Council has developed its urban forest strategy?
2. What information do you find important to continue to develop and implement this strategy? (Councils, except City of Melbourne, added for extra context as only one interview was conducted from each of these Councils)
3. Who do you collaborate or partner with to create or implement Council's urban forest strategy? / How is your council involved with regional partnerships or alliances in relation to this strategy?
4. How do you think Council's urban forest strategy encourages other Councils to adopt urban forest strategies? (only City of Melbourne)
5. What influence do State Government policies have on Council's urban forestry strategy?
6. What influence do Federal Government policies have on Council's urban forestry strategy?
7. How does Council's urban forest strategy fit with urban planning priorities? / How well do you find your urban forestry goals are supported or reflected in the planning system?
8. Through the implementation of the urban forest strategy, what change(s) have you seen in the way Council plans the future city? / What changes have you seen in how your Council approaches planning for urban greening, forests, and nature?
9. What impact has Council's urban forest strategy had on broader urban nature objectives?
10. What do you think your city will look like in 10 years?
11. Present emerging role conceptualisation to participant and receive feedback.

Appendix 2

Summary of results to map the identified mainstreaming drivers with the mainstreaming mechanisms. More detailed version of Table 1.

	Relational drivers		Systemic drivers	
	Community engagement processes	Collaborative governance approaches	Evidence-base and knowledge	Land use decisions
Mainstreaming mechanisms				
Disruptive Experimentation				
Description	Innovation in the practice of participatory processes	Innovation in organising cross-jurisdiction greening	Innovation in defining and producing evidence-base and knowledge	Innovation in statutory rules for tree protection and private realm urban forest
Example	**Citizen science**	**Regional groupings**	• Use of spatial data and technology	• City of Melbourne's Urban Forest Fund
	• City Nature Challenge [Noted by three participants]	• Greening the West [Noted by three participants]	• Limited by financial capacity of local government to invest in place-specific data	• Exceptional Tree Registers
	• City of Melbourne's Citizen Forester Program	• Greening the North [Noted by four participants]	• Co-producing knowledge with academia (City of Melbourne)	• Limited by urban development priorities that ineffectively protect trees
	Policy formulation	**Metropolitan-wide platforms**	• City of Melbourne's Green Factor Tool	• State-level slow to commit to reforms local governments are seeking
	• Ranging from traditional consultation processes to co-designing community visions	• Living Melbourne		
Scaling				
Description	The appropriate scale for intervention and governance within and across multiple scales			
Example	Ensuring that interventions are place-based and targeted, i.e., relevant for local community.	Enabling collective action at regional or metropolitan-wide scales to apply for funding and implement projects.	Building and contextualising evidence and knowledge bases around best practices for urban forestry, i.e., community of practice.	Understanding and potentially reforming where the powers and responsibilities for land management are held to better address local, metropolitan, and state priorities.
Translation				
Description	Local government communication and transparency	Sharing and building on knowledge and best practice	Translation and sharing of knowledge, practices, and policies across the multi-level governance landscape of cities	

(continued)

	Relational drivers		Systemic drivers
Example	• Education • Bringing communities along with local government strategies	• Practitioner networks (e.g., Council Arboriculture Victoria) • City networks (e.g., 100 Resilient Cities)	Building on knowledge and best practices to contribute to the discipline and community of practice, i.e., collective knowledge base to inform (contextual) decisions.
Anchoring			
Integration	Transcending silos of operation to allow for whole-of-Council approaches, aligning relevant policies and decisions, and providing opportunities for citizens to be involved in the process.		
Learning	Ensuring that mainstreaming efforts are embedded over time to improve policies and practices, e.g., by reviewing or updating plans.		

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