Exploring the role of governance in supporting urban green infrastructure for sustainability transitions

by

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AUTHOR'S DECLARATION

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

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Abstract

Green infrastructure development in urban areas may be enhanced by governing processes that are collaborative, action-oriented, and strategically organized. Past literature has provided evidence on the performance, purpose, and outcomes associated with green infrastructure development and the individual features (e.g. trees, green roofs) to provide improvements to urban sustainability. This is important because it provides a clear understanding of how green infrastructure works and why it may be scaled to contribute to supporting other urban infrastructure, the form it may take, and the functions and outcomes. Building off this it is also important to bring to light the role of actors, the approaches to embed green infrastructure actions in urban areas, and the construction of experiments to advance development through diverse organizing processes. These three aspects are critical in supporting the application of green infrastructure to potentially guide processes and outcomes for more fundamental change to the structures and function of urban areas.

The dissertation addresses these opportunities by pulling together a research program guided by the conceptualization of governance arrangements supportive of urban sustainability transitions. More specifically this research demonstrates how multi-actor governance for green infrastructure is mediated by direct implementation of interventions and the construction of experiments for a range of actors to navigate installation and future development opportunities. Through empirical research, qualitative content analysis is used to construct and interpret interviews with local government representatives, businesses, business networks, and civil society organizations. Three empirical chapters are included detailing the role of private actors directing the development of green infrastructure; the role of action-oriented development to support system change for green infrastructure development; and the strategic delivery of green infrastructure experiments for improved processes and outcomes. Collectively, these three chapters demonstrate and offer greater insight into the multi-actor and collaborative nature of developing green infrastructure supportive of sustainability transitions.

The first manuscript empirically describes who shapes and guides the development of green infrastructure in urban areas, with a focus on private actors. Examining the multiplicity of actors needed to shape green infrastructure in urban areas requires increased support from civil society organizations, businesses, and business networks. Using their array of knowledge, resources, and skills private actors lead development in urban areas based on core organizational mandates, guide

and support other actors to develop green infrastructure, or align their programs to support local government initiatives. This research offers a better understanding of the roles played by private actors in green infrastructure development.

The second manuscript brings to light the importance of actions and interventions in serving to alter transition agendas and long-term visions, all collectively supporting wider system change for future development trajectories. The findings reveal how diverse green infrastructure actions, such as the installation of specific features or participation in early phase design of green spaces, are critical in providing the necessary understanding, confidence, and experience to more thoroughly advance existing green infrastructure agendas and more widely scope future opportunities to build green infrastructure networks in urban areas. The implication of this research is to suggest that sustainability transitions, as a process of system change, are anchored by the ability of actors to engage with interventions and reproduce and contest the meaning or purpose of specific green infrastructure features.

The final manuscript explores how green infrastructure is implemented through the utilization and framing of experimental processes. The findings show how green infrastructure experiments are strategically applied to navigate urban sustainability action and other constraints. In addition, the experiments provide clear opportunities for learning, multi-actor actor capacity building, and co-designed projects. The implication of this is experiments provide green infrastructure stakeholders with strategies to deploy interventions while preserving connections and applicability to existing urban sustainability programs.

The dissertation emphasizes the importance of actors and the processes utilized to deploy green infrastructure interventions and present green infrastructure more effectively or strategically as a tool well-aligned to the existing objectives of urban sustainability. This work supports theoretical insights into how green infrastructure contributes to change processes in urban areas. Empirically, this work advances understanding of the multiple strategies available for actors to collaboratively shape and guide development processes. Practically, this work provides evidence for diverse green infrastructure practitioners to direct their organizational strengths to deliver tangible results. Overall, this work draws attention to the role of governing with multi-actor arrangements and multiple strategies for pursuing and embedding green infrastructure development in urban areas.

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Table of Contents

List of Figures

List of Tables

Chapter 1
Introduction

1.1 Overview

Governance is a concept that describes how societal decision-making consists of multiple societal actors interdependently collaborating to confront problems and develop solutions (Jessop, 1998; Kooiman, 2003). Diverse governing arrangements (e.g. participatory community planning) are crucial for supporting sustainable urban development in ways that address the multi-dimensional, interrelated, and indeterminate social, environmental, and economic challenges in urban areas (McCormick *et al.*, 2013; Leal Filho *et al.*, 2016; Barnes *et al.*, 2018; Romero-Lankao *et al.*, 2018; Elmqvist *et al.*, 2019). Urban areas are critical spaces within which climate change impacts, such as extreme heat events, intensive storm flooding, and more recently wildfires play out. These events are in turn stressing deeply interconnected social, ecological, and technical systems, which amplify the inadequacy or decline of services, infrastructure, and support programs to address drivers of change and promote resilience (Dodman, 2009; Romero-Lankao and Dodman, 2011).

In this context, understanding the governance arrangements that bring together a heterogeneous mix of actors ranging from local government units, businesses, and community organizations may be studied to understand the support strategies available, deployed, and delivered by different actors to achieve or direct sustainability trajectories. This may help people in cities to rethink the usage of urban spaces; the purpose and operation of urban form; and the functions of the ecological systems which support people's well-being (Romero-Lankao and Dodman, 2011; Satterthwaite and Dodman, 2013).

A set of sustainability solutions that have emerged from such arrangements includes the development and use of green infrastructure (GI) to facilitate changes in the way sustainability is confronted and the construction of urban form and function. Green infrastructure is defined as a suite of tools utilized to design a network of natural, semi-natural and ecological inspired human-made features managed to provided sustainability benefits (Benedict and McMahon, 2002; Matthews, Lo and Byrne, 2015). While much research has focused on assessing the performance and suitability of specific green infrastructure projects such as the outcomes of a bioswale, urban forests or tree trenches, less attention has been paid to the often diverse and multifaceted governance arrangements that support these projects (Mattijssen *et al.*, 2018; Pauleit *et al.*, 2019). A deeper analysis is needed

that uncovers the influence of the diverse actors who participate in directing the purpose of green infrastructure interventions and how these actions alter perspectives and approaches to future development. Understanding these processes for system change may be aided by uncovering how actors coordinate actions (chapter 3), actors facilitate change through action (chapter 4), and actors use experiments to accelerate transitions toward sustainability (chapter 5). Such transition processes will ultimately require both incremental and transformative change and diverse solutions that intersect with multiple domains of society to create new spaces for purposeful actions in support of sustainability (McCormick *et al.*, 2013; Ernst *et al.*, 2016).

Having outlined the broad context of this dissertation the following research questions and research objectives are identified below. Following this, the remainder of this chapter will sketch out a literature review to highlight the main bodies of literature guiding this research program.

Main research question:

The overarching research question that guides the dissertation is: How can green infrastructure development by heterogeneous urban actors support governing arrangements that accelerate sustainability transitions?

Sub-questions

1. How can private actors support green infrastructure development through collaborative governing arrangements in urban areas?
2. How can green infrastructure interventions support the embedding of practices in urban areas to mobilize recursive dynamics to guide sustainability transitions?
3. How can green infrastructure experiments strategically support the embedding of sustainability interventions in urban areas?

This research project explores the role of governance in directing and shaping the purpose, processes, and outcomes of green infrastructure development. Building from the research questions above, the following research objectives are identified:

1. Analytically describe the role of private green infrastructure actors as critical leaders deploying diverse governing modes to support actor engagement or collaboratively steer development in urban areas.
2. Conceptualize the role of transitions practices as mediating long-term visions and short-term agendas to strengthen the green infrastructure development approach in urban areas.

3. Empirically demonstrate how sustainability experiments are strategically mobilized to advance green infrastructure development.

1.1.1 Research context

Sustainability is a complex and indeterminate outcome and process seeking to positively achieve broad or narrow goals related to multi-generational equity and opportunity in multiple societal domains, most notably, social, economic, and environment (WCED, 1987). The notion of positivity certainly brings to light the normative dimensions of change. Sustainability has shifted from focusing on improving the consumption of natural resources through efficiency improvements, conservation, and ecological protection outcomes, to processes enhancing pluralistic understanding of the normative and contextual significance of deep sustainability outcomes and the processes important in connecting to people, places, and cultures (Berke and Conroy, 2000; Kemp, Parto and Gibson, 2005; Gibson, 2006; Kuhlman and Farrington, 2010). Sustainability includes diversity in the design and deployment of solutions, as the inherent problems of resource use and waste generation are deeply subjective and connected to intimate personal and cultural practices, behaviours, and routines (Bäckstrand, 2006). Climate change, for example, has a rather simple solution: reduce the concentration of greenhouse gases (GHGs) in the atmosphere and where necessary prepare for impacts. This, however, has not been easy to accomplish. Instead, a warming planet has challenged people to produce alternative solutions to reduce GHGs, while also preserving high-quality lifestyles and GHG intensive development globally (O'Brien and Leichenko, 2000). The challenge presented (i.e. reduce GHGs while preserving lifestyles and development) will not be solved through improvement in market mechanisms or technical processes alone (O'Brien, 2012). Instead, the problem is far more complex because the goals and ambitions of end-users across the world are diverse and dynamic (O'Brien and Selboe, 2015).

In this context, governance serves as an organizing concept to describe how societal decision-making reflects a process of multiple societal actors interdependently collaborating to confront problems and solutions (Jessop, 1998). Multiple scholars have presented governance as a spectrum to more clearly articulate how actors shape and participate in decision-making (Jordan, Wurzel and Zito, 2005; Driessen *et al.*, 2012; Lange *et al.*, 2013). On one end, government serves as one actor setting policy goals (steering) and implementing or achieving those goals (rowing) (see Jordan, Wurzel and Zito, 2005). On the other end, is a self-organizing set of non-government actors, coordinating or independently rowing and steering. The totality of governance then is a balance between diverse

actors fulfilling organizational priorities and forming networks to ensure a particular set of outcomes beneficial to them and potentially to wider system factors (Jessop, 1998; Lange *et al.*, 2013).

Urban areas are one place where novel governance arrangements are needed to purposefully develop and advance sustainability-oriented action in support of economic growth, community livability, and infrastructure operations. Urban governance has been shaped by broad drivers, most notably globalization, neoliberalism, and state restructuring (MacLeod and Goodwin, 1999; Jessop, 2002; Pierre, 2005; Dean, 2007) which have collectively mediated a reorientation of government responsibility, the role of local government, and the need the for non-state actor participation. Urban areas are increasingly recognized as places where a constellation of actors negotiate and collaborate to achieve competing or congruent goals bringing to light a diversity of perspectives, needs, and uses of infrastructure, space, and commodities (Bridges, 2016; Swann, 2017). Moreover, the problems faced and identifying potential solutions requires the full array of urban actors to share, contest, and collaborate to identify pathways and opportunities forward, because a single actor will be unable to scope, define, and understand all possibilities available (Schroeder, Burch and Rayner, 2013). The shifting governance context in urban areas has elevated the urgency of sustainability-oriented action to alleviate deeply embedded problems that may adversely impact the liveability, form, and function of these areas, requiring interventions that move beyond government-led commands and technology alone.

One urban sustainability solution that has emerged to contribute to the partial alleviation of problems and conditions related to climate change, human health, and community well-being is green infrastructure (Mell, 2008; Pauleit *et al.*, 2019) Green infrastructure is defined as a suite of tools utilized to design a network of natural and semi-natural, man-made features managed to provided sustainability benefits (Benedict and McMahon, 2002; Matthews, Lo and Byrne, 2015). Examples of green infrastructure include urban waterways, urban forests, street trees, green walls, green roofs, and open green spaces such as parks and gardens (Tzoulas *et al.*, 2007; Dvorak and Volder, 2010; Silvera Seamans, 2013). Green infrastructure represents a relatively new term from a long-understood dynamic that has served to benefit humankind through the creative utilization of ecological features (PCSD, 1998; Calfapietra and Cherubini, 2019). As urban areas grow in population, cultural influence, and size the use and integration of ecological features no longer sit on the periphery of cities. Instead, recognition is shifting to maintain and advance urban ecosystems requiring policy and programs similar to other forms of infrastructure. Green infrastructure, then, becomes an important

element in creating cities and urban areas to function efficiently but also provide spaces for people to shape and use. Green infrastructure development is understood here as, the combination of diverse activities such as formulating, designing, delivering, installing, and evaluating green infrastructure as a connected network or as individual features.

Certainly, the varied values and outcomes of nature are understood, however, a complex set of factors converge to make green infrastructure development difficult due to the interactions and interconnections between users and producers, urban form and function, and urban design processes and practices (Faivre *et al.*, 2017; Wamsler *et al.*, 2020). As a result, the search and development of green infrastructure may not follow trajectories utilized for traditional grey infrastructure nor will the assumptions of the benefits of ecological features yield acceptance from all urban actors. Green infrastructure can integrate both technical and non-technical solutions in the design, development, and installation. This then requires innovation, taken here as a broad concept to reference the changes in products, practices, processes, or programs which support the alteration of behaviours, routines, and cultures ideally supportive of sustainability (Westley and Antadze, 2010; Klewitz and Hansen, 2014; Moore, Riddell and Vocisano, 2015). The broad interpretation of innovation is used here to provide a simple conceptual understanding of the breadth of opportunities for changes across various aspects of an organization or society.

As an example, a piece of green space can be used in one manner by people (e.g. green space recreation for improved health outcomes) while simultaneously yielding quantitative technical outcomes (e.g. stormwater capture, and urban cooling). As researchers have argued, it is important to leverage diverse actor constellations as they may provide new urban actors who can demonstrate new green infrastructure development practices, approaches to embedding green interventions, and the approval and acceptance of green features in local communities (Finewood, 2016; Fitzgerald and Laufer, 2017; Mattijssen *et al.*, 2018). In this regard then, green infrastructure development may be advanced by further examining the governing tensions and opportunities available. This may help support a better understanding of how green infrastructure stakeholders and actors, including practitioners, community-based actors, and technical experts navigate the development landscape and reveal alternative governing arrangements supportive of embedding green infrastructure in multiple urban contexts.

One key aspect in understanding the governing arrangements for green infrastructure development is clarifying the role of actors, in particular, the role of the businesses, including social enterprises,

business networks, including business improvements districts (BIDs), and civil society organizations (CSOs), including, community-based groups and charities, here collectively referred to as private actors (see Pattberg and Stripple, 2008; Glasbergen, 2011; Abbott, 2012). Private actors are presented here as a heterogeneous group of non-state actors actively steering and delivering services in urban areas. This is important to study because much scholarship has revealed the importance of these actors to actively direct and shape the policies, programs, and actions necessary to spur sustainability-oriented innovation (Frickel and Davidson, 2004; Schroeder, Burch and Rayner, 2013; McAllister and Taylor, 2015). Private actors are deeply intertwined in developing, delivering, and conditioning policy, programs, and plans in urban areas, such as local or regional economic and social policy (Wolfson and Frisken, 2000; Bramwell and Pierre, 2016). This means that private actors are firmly entrenched in the active steering and rowing of urban development processes, and not simply passive agents fulfilling government mandates or independently conducting programs absent of local contexts. Private actors are experts with interests, specialization, and networks important in directing, shaping, and contributing to sustainability. Chapter 3 uncovers the role of private actors in the implementation and development of green infrastructure to better understand who contributes to green infrastructure development and network building.

Advancing sustainability requires generating a better understanding of the processes of change that underpin active decision-making, intervention design, and action-steering. Transition management (TM) has provided a perspective to integrate organizational management, complex systems thinking, and socio-technical change to suggest deep and fundamental change is driven by a set of multidimensional factors, specifically, the interdependence of structures, practices, and cultures (see chapter 4 for elaboration). These concepts are interpreted and presented broadly by scholars (see Loorbach, 2010; Rotmans and Loorbach, 2010; Grin, 2020) to support the description and categorization of how incumbent actors confront novelty and integrate innovation. Green infrastructure challenges how the ongoing planning and management, form and function, and the production and consumption of a city may become more sustainability-oriented. Critical in pursuing green infrastructure is evidence of actions or interventions in providing the tangible and conceptual underpinnings to better formulate appropriate problems, along with future visions and agendas congruent to the outcomes of an organization. This means that the role of actors and their actions reinforce and provide important signposts for the formulized, routines, and entrenchment of green infrastructure development as a viable policy or organizational priority (see chapter 4).

Realizing the opportunities for sustainability action in spaces where competition for resources and attention is scarce requires the utilization of experimental processes to facilitate the embedding of interventions. Experiments are framed as practical sustainability transitions tools to purposively implement sustainability-oriented actions supportive of learning and knowledge development; underscoring governing and novel actor arrangements; and challenge or reinforce the rules and policy context (Marvin *et al.*, 2018). Experiments for green infrastructure support calls for a better understanding of the gaps in knowledge, skills, and actor arrangements (Raymond *et al.*, 2017). Moreover, experiments are critical in providing the confidence to perform and understand the alternative outcomes, beyond technical and efficiency gains (Longhurst, 2015). Green infrastructure experiments are purposively utilized to simultaneously reorient development pathways for green infrastructure and conform to the policy context that directs the rules or conduct of green infrastructure development in urban areas. As an approach to embed, learn, and act, about green infrastructure, experiments are specific interventions with diverse outcomes connecting to multiple users: facilitating a policy strategy to better navigate development opportunities in urban areas (see chapter 5).

The purpose of this thesis is to examine different governing arrangements to understand how green infrastructure becomes physically embedded in urban areas and contributes to urban sustainability. This research will: analyze how private actors are active agents shaping the purpose or intent of green infrastructure to support and deliver on projects (see chapter 3); examine what societal conditions are altered by actors and actions associated with green infrastructure implementation to better support the development of green infrastructure projects and policy (see chapter 4); and describe how experimental processes are used as mechanisms to support the practical realization of the form and function of green infrastructure (see chapter 5). This research, then, seeks to interpret and construct the meaning of how the green infrastructure stakeholders pursue multiple governing pathways to achieve green infrastructure development. Using semi-structured interviews in two urban-regions, this research explores how green infrastructure is developed in a multi-actor context, supportive of diverse expertise to capture the array of benefits and strategic opportunities to embed interventions. More specifically, this research aims to illuminate how different governing strategies uncover and expose the potential for green infrastructure development, particularly, the role of non-state actors pushing forward innovation; the importance of interventions to support policy development; and the role of experiments as a strategic tool to develop green infrastructure.

1.2 Literature review: Green infrastructure governance and sustainability transitions

Multiple bodies of literature - sustainability governance, sustainability transitions, and urban green infrastructure development - help organize the structure of this literature review. These bodies of literature guide understanding of how sustainability interventions require governing arrangements, broadly understood as organizing structures to understand how actors and organizations, practices and actions, and processes and outcomes are interrelated and facilitate change (Arnouts, Zouwen and Arts, 2012; Lange *et al.*, 2013). Collectively, these bodies of literature are used to help understand how deeply embedded problems in urban areas require an alternative set of practices, infrastructure, and conceptualizations of sustainability solutions. Here the literature on sustainability governance and sustainability transitions serves to provide clear boundaries on examining who is involved, the specific roles they play, and the actions supporting change. Green infrastructure serves as the object of inquiry to help illuminate and offer real-world examples of sustainability-oriented action and better explore the relationships between embedding interventions and governing arrangements utilized and the entrenching of solutions to leverage change. This research integrates and builds on scholarship that gives direction to understand how multiple governing actors support the embedding of green infrastructure interventions for system change. Below, this is discussed by first outlining two bodies of literature, sustainability governance and sustainability transitions in an urban context. Following this, the concept of green infrastructure is examined and connected to these themes to offer a connection to the research questions and objectives identified above.

1.2.1 Governance and sustainability in urban areas

Governance is a process, desired outcome, and analytical framework collectively addressing the changing processes and practices associated with multi-actor societal decision-making (Adger and Jordan, 2009). As an analytical framework, a governance lens may help to understand the complex problems and the challenges inherent in policy development (steering) and action outcomes (rowing). Urban areas have emerged as critical sites to study the shifting contents of governance, as neoliberal and state restructuring has pushed local government to shift from the sole service delivery agent to managers of city services with other actors also delivering services (Rhodes, 1996; Dean, 2007). This has pushed new actors to support local governments in the delivery of services but also facilitated an opportunity for non-government actors, or private actors, including businesses and CSOs, to fulfill government objectives and devise steering strategies (see Glasbergen, 2011; Abbott, 2012).

Urban sustainability fundamentally requires recognition and engagement with processes that leverage actors to direct the intentions of problems and solutions (Schroeder, Burch and Rayner, 2013). As a normative concept, imbued with disparate values, ideas, and needs, sustainability presents a unique insight into how actors navigate urban conditions to seek outcomes important to improve social and ecological systems. Further, multi-actor and collaborative governing processes are necessary to move beyond rigid commands and instead, use the collective experience to better understand how problems and solutions are confronted, constructed, and realized differently (Van der Heijden, 2014). Issues such as climate change and ecological degradation, once seen as problems requiring "better" regulation and technology have shifted to recognize the need for complementary policy tools (e.g. funding mechanisms for programs), governing strategies (e.g. mutually reinforcing networks), and social innovation (e.g. user-based designs) for social and ecological system change or stability (Glasbergen, Biermann and Mol, 2007; Galaz *et al.*, 2012).

These factors, however, are also partially influenced and are shaped by spatial, temporal, and institutional scales. Scales are understood as important analytical aspects supportive of creating a more comprehensive view of contexts and conditions altering the impact of organizations, individuals, and processes (Cash *et al.*, 2006). Scales, then, are important to recognize because the actions taken at urban or city-levels may not significantly alter regional or national outcomes or policies (Cumming, Cumming and Redman, 2006). This does not render actions or policies irrelevant but reinforces a need for a more nuanced understanding of what can be accomplished at each level, particularly at urban-levels because principles of subsidiarity reinforce the intimate and contextually significant opportunities for action at local levels for sustainability-oriented action. In turn, the problems confronted are deeply tied to diverse places and contexts shaped by cultures and values, behaviours and routines, and practices and lifestyles that function and thrive on the resources and ecosystems currently under threat (McPhearson *et al.*, 2016; Elmqvist *et al.*, 2019). This means that a one-size-fits-all regulation or technology-oriented solution will be contested, irrelevant, or ineffective if poorly adopted by those who the actions are intended to influence: ultimately minimizing the reach of regulatory tools alone. A governance framing, then, pulls together streams of thought to articulate global and local changes that redirect power structures and economic flows, bringing to light novel social movements, innovation, and problems (MacLeod and Goodwin, 1999; Jessop, 2002). In urban areas, packed with diverse actors, innovations, and connectivity to specific problems, solutions will be realized through the integration of actors (Ernstson *et al.*, 2010) facilitating insight into the governing arrangements used and potentially needed to further advance sustainability.

1.2.1.1 Sustainability governance

Governance is a lens that can contribute to an improved understanding of who drives societal steering and how actors are included, as well as who is neglected from such processes and potentially why. A governance perspective recognizes that actors beyond the state play an important role in the development and implementation of societal solutions (Rhodes, 1996; Stoker, 1998; Dean, 2007; Westman, Moores and Burch, 2021). Governance framings have been applied to scholarships related to environmental change (Lemos and Agrawal, 2006; Biermann and Pattberg, 2008; Evans, 2012), climate change (Betsill and Bulkeley, 2006; Bulkeley, 2016) and sustainability action (Frisken *et al.*, 2000; Lange *et al.*, 2013).

Sustainability governance is a broad and encompassing term referring to the nature of societal decision-making necessary to alter unsustainable modes of production and consumption (Bulkeley *et al.*, 2013). While connected to climate change governance and environmental governance which are focused on tangible problems and solutions such as reducing GHG's or ecosystem degradation, sustainability governance offers potential for a flexible understanding of diverse problems, from resource efficiency to small business sustainability action (Westman, Moores and Burch, 2021). For example, Driessen *et al.* (2012, p. 144) describe environmental governance as "[society] determines and acts on goals related to the management of the environment." Similarly, climate governance focuses on how various actors navigate or build capacity to mitigate the drivers of or adapt to the impacts of, climate change (Jagers and Stripple, 2003). Governance in these instances serves a more utilitarian structure to organize the management and coordination of society to an end-state. In line with this, sustainability governance offers a more holistic lens to analyze or describe a range of rules, mechanisms, and processes to implement solutions to confront a broad range of problems across social, ecological, and economic systems.

One analytical framework to help support exploring the types of actions and actor constellations is governing modes, a term that describes the "set of tools and technologies deployed…which agents seek to reconfigure the specific social and technical relations with a specific governing purpose" (Castán Broto and Bulkeley, 2013, pp. 94–95). This means that modes of governance are used in elucidating the *actors involved (*e.g. government, civil society*), actor arrangements* (e.g. networks, self-organization), *techniques to direct an action* (e.g. regulation, minimum standards, incentives, information), and *mechanism to act* (e.g. partnerships, voluntary agreements) used for a particular problem, action, or desired outcome (Lowndes and Skelcher, 1998; Treib, Bähr and Falkner, 2007;

Evans, 2012; Wydra and Pülzl, 2013). Authors such as Kooiman (2003) identify modes based on an interpretation of actors and perceived roles in decision making. For example, three common modes are hierarchy (the government is the focus of action), market (the private sector is the focus of action), and interactive (all actors can direct action). Further, authors such as Driessen *et al.* (2012) and Lange *et al.* (2013) extend these modes for sustainability-oriented governing to recognize a distinction between top-down government steering and more devolved and decentralized forms of local government-steering. Moreover, both authors bring to focus the importance of civil society organizations in shaping governing decisions, along with market-based and government actors. This addition becomes critical because it brings to light the importance of more actor arrangements for sustainability-oriented decision-making, whereby increasingly complex problems require further understanding of the change processes directed by a diverse constellation of actors.

The modes of governance framework is extended by Bulkeley and Castán Broto (2011) to understand more clearly how private actors support climate change actions in cities (see chapter 3 for elaboration). The empirically developed framework places private actors at the centre of analysis or as the object of inquiry to better encapsulate how these actors push forward novelty, align with city sustainability-related objectives, or enable partnerships supportive of collaboration. Applying this may allow for a better understanding of how sustainability-oriented action may be deployed, developed, or conceptualized with diverse actor arrangements and an array of tools and processes utilized by private actors. This is important to uncover as sustainability challenges require diverse arrangements, actions, and solutions ideally better connected or contextualized to the needs of more urban actors (Bulkeley and Betsill, 2013; Van der Heijden, 2014). More specifically the modes help in providing directions for action, revealing how actors may lead through organizational mandates, mobilize other actors, or align with local government programs (see chapter 3).

1.2.1.2 Sustainability transitions

As urban areas are increasingly confronted by wicked, diverse, and multiscale problems, an emerging thread of research has explored sustainability transitions in urban areas (McCormick *et al.*, 2013; Ernst *et al.*, 2016). Sustainability transitions are defined as "long-term, multi-dimensional, and fundamental transformation processes through which established socio-technical systems shift to more sustainable modes of production and consumption" (Markard et al. 2012:956). Socio-technical systems consist of deeply embedded social practices that do not change easily and quickly, instead change is non-linear and long-term, requiring re-orientation of rules, behaviour, and problem framing

(Rotmans, Kemp and van Asselt, 2001; Geels, 2004). Although much of the work of sustainability transitions is deeply rooted in shifting socio-technical systems; recent contributions have demonstrated perspectives of socio-ecological and socio-institutional systems as equally critical (Loorbach, Frantzeskaki and Avelino, 2017) to support system change. This is important because shifting frames from socio-technical systems - which view change as generally technically guided (Hughes, 1983; Loorbach, Frantzeskaki and Avelino, 2017) - to socio-institutional and socio-ecological frames, supports recognizing the importance of non-technical processes to guide or drive system change. More specifically, creating a fundamental shift in societal systems for sustainability requires challenging and altering existing societal structures, cultures, and practices (Rotmans & Loorbach 2010; cf. Geels 2002; 2006) (see chapter 4 for detailed elaboration).

Multiple framings of the city and transitions towards sustainability position cities as key sites of fundamental change driven by social, ecological, and technical innovations and participatory, user-driven processes of interaction, learning, and knowledge exchange (Ernstson *et al.*, 2010; Antrobus, 2011; Childers *et al.*, 2014; de Jong *et al.*, 2015; Krellenberg, Koch and Kabisch, 2016). Moreover, sustainability transitions in urban areas have advanced to underline the deeply contentious and discontinuous nature of transforming various urban political, technical, social, and institutional systems (Fastenrath and Braun, 2018a; Grandin *et al.*, 2018). This has re-oriented a view of innovation retention that is mediated by selection and variation environments characterized by localized particularities that push or pull innovations to fit into highly specific contexts (i.e. land-use planning and regulations, past experiences, cultural preferences, etc.) (Murphy, 2015).

Though this body of work has significantly advanced discussions of transitions in urban areas, debates continue to be focused on technical infrastructure (Jensen, Fratini and Cashmore, 2015; Fastenrath and Braun, 2018b), exploring various phases of development (Durrant *et al.*, 2018); or rapidly scaling up and scaling out experiments (Peng, Wei and Bai, 2019). An opportunity may be available to explore the local particularities that motivate or guide the application or understanding of innovation. This addition advances description and analysis more supportive of navigating sustainability change and interventions focusing on actors, the perceived conventions of development, and reconceptualization of problems and solutions.

1.2.2 Urban green infrastructure

Green infrastructure is one set of practices that utilize the benefits of nature for human well-being while conforming to the existing structures of a city across scales (Ahern, 2013; Lovell and Taylor,

2013). The European Commission (2013, p. 3) defines green infrastructure as: "a strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services." Also, green infrastructure can be a combination of existing (e.g. natural heritage) or planned natural or semi-natural green (vegetated) or blue (water) spaces (Cirillo and Podolsky, 2011). Examples of green infrastructure include roadside vegetation for stormwater control or pollution control (Saumel, Weber and Kowarik, 2015), urban woodlots and street trees. Thus, green infrastructure increasingly seems like a valuable strategy in cities due to expanding needs related to climate change adaptation and mitigation solutions; and complementing existing structures such as wastewater systems (Hamin and Gurran, 2009; Wamsler, Brink and Rivera, 2013).For this dissertation, the guiding definition of green infrastructure is *a suite of tools utilizing natural, semi-natural features to construct a network of green and blue spaces providing multifunctional benefits for sustainability-oriented gain for people.*

Green infrastructure actions can be multifunctional, adaptive, and multi-scalar creating networks that increase social interaction and biological diversity through redundancy (e.g. planting diverse native species to protect against complete loss of trees) and modularity (e.g. installing multiple bioswales that conform to localized needs) (Gill *et al.*, 2007; Ahern, 2011; Lovell and Taylor, 2013; Demuzere *et al.*, 2014). This does not suggest that green infrastructure is a panacea, instead, it is one set of solutions that fit into increasingly complex and dynamic urban change. Green infrastructure has been applied at multiple scales and levels and across cities. Examples of green infrastructure include community gardens (Bendt, Barthel and Colding, 2013), green roofs (Susca, Gaffin and Dell'osso, 2011), green streets (Walmsley, 2006), street trees (Young and McPherson, 2013), and open green spaces (Liu, Chen and Peng, 2014). Although, these solutions differ in scales (e.g. spatial, temporal, etc.) and levels of application (e.g. building, neighbourhoods, etc.), they all present strategies to address urban heat stress, stormwater control, community development, or climate mitigation, to name a few.

The broad discussion and definition above pull together multiple streams of thought that shape an understanding of how ecological features may be used in urban areas (Sussams, Sheate and Eales, 2015; O'Sullivan, Mell and Clement, 2020). This description may not align with other views that focus solely on specific elements such as low-impact development or sustainable urban drainage management for managing stormwater on-site (Fletcher *et al.*, 2015; Conway, Khan and Esak, 2020). Onsite stormwater capture techniques focus on a very localized level and understanding of how green

infrastructure functions are intended to support the persistence of traditional hard infrastructure for water management (Johns, 2019). As green infrastructure has shifted to reflect a more holistic approach while also continuing to include water management, spaces such as parks and urban forests are leveraged as pieces to promote heat mitigation, recreation, and biodiversity conservation.

The expansion of green infrastructure actions across spatial scales has allowed non-state actors to manage and provide green infrastructure, as opposed to or complementing local government, due to an ability to address financial, knowledge, and jurisdictional issues (Keeley *et al.*, 2013; Chaffin, Floyd and Albro, 2019). Increasingly, the diversity of expert green infrastructure actors is driven by the need for cities to attract people, investors, and employment opportunities (Harvey, 1989; Allen and Cochrane, 2010). Various spaces in the city are increasingly in need of upgrading and thus part of building an attractive city but also contributes to the divergence of who gets to access and use particular areas of the city (Peck and Tickell, 2002; Heynen and Perkins, 2005; Gabriel, 2016). Similarly, even when a more concerted effort is made to develop green infrastructure in less developed areas of a city, the functional benefits of green infrastructure are not always distributed evenly (Heynen, 2003; Miller, 2016; Scott *et al.*, 2016; Anguelovski *et al.*, 2019), reinforcing long-standing disparities associated with class, race, and ethnicity (Heynen, Perkins and Roy, 2006; Carmichael and McDonough, 2019).

On the other hand, green infrastructure has also been used to challenge the purpose of spaces and how those spaces can be used to alter the production of resources at a very localized scale (e.g. guerrilla gardening, pop up spaces) (Tsilini *et al.*, 2015; Spijker and Parra, 2018; Ursić and Krnić, 2018). While green infrastructure is still developed or created in multi-governing contexts, the purpose of greening is used to show residents (and the city at large) how to grow their food, share food resources, and build community networks to maintain gardens (Tornaghi and Van Dyck, 2015; Artmann, Sartison and Vávra, 2020). The actions challenge the logic of growth or alter the understanding of who may be allowed to produce and control local lands and food production (Eizenberg, 2012). Here green infrastructure's powerful ability to not only serve functional technical outcomes, but also empower other actors to take part in activating their local spaces for functional, social, and economic outcomes. Moreover, green infrastructure as a tool is not static, but requires constant revisiting to understanding what can be accomplished, creating new knowledge, actor arrangement, and processes for deployment (Luederitz *et al.*, 2015). Still, caution must be exercised

as it is still unclear how these programs address distributional land disparities and if they alter class and other equity issues (Tornaghi and Van Dyck, 2015; Anguelovski, Connolly and Brand, 2018).

Collectively, the diversity of green infrastructure actions demonstrates the power, conflict, and complexity associated with development. While acknowledging this, there is also research space and opportunity that requires comprehensive attention and a more thorough and focused research program examining diverse actor arrangements and support strategies to develop green infrastructure. Ideally allowing for an improved understanding of how green infrastructure is currently being deployed, who participates and what mechanisms facilitate embedding in urban areas.

Building from this, and connecting to the theoretical scholarship presented above, green infrastructure literature may be advanced to better understand how particular actors use their expertise or creativity to support the deployment of interventions potentially supportive of sustainability action in urban areas (Raymond *et al.*, 2017; Albert *et al.*, 2019). Green infrastructure is not an easily identifiable set of interventions to some (Conway, Khan and Esak, 2020). Indeed, this is because the evolving purpose and the utilization in different contexts reveal the multi-purpose and multi-beneficial outcomes of human and ecological features (Wang and Banzhaf, 2018; Dorst *et al.*, 2019). A community garden can be utilized differently by members of a local community. Technical and efficiency measures of green infrastructure alone will not demonstrate the array of options but are important in building early support for deployment. Improved understanding of how it is deployed and with what intentions are needed to allow a broader set of actors to engage and support interventions that more holistically connect problems and solutions in context.

1.2.2.1 Green infrastructure governance

Green infrastructure development further requires a clear understanding of the support mechanisms and actors pushing or leading interventions and programs. Research has uncovered the role of government-led and directed projects and programs, this has provided clarity on the areas of intervention (e.g. stormwater control or urban forestry) (Chaffin *et al.*, 2016; Dhakal and Chevalier, 2016); the policy tools used by government to guide development (Johns, 2019; Henstra, Thistlethwaite and Vanhooren, 2020); and governing styles deployed by government (Fitzgerald and Laufer, 2017; Chaffin, Floyd and Albro, 2019). Emerging from this are discourses extended to more critically understand how government-directed approaches are contested, siloed, or absent of diverse actor arrangements (Young, 2011; Finewood, 2016). This emerges because green infrastructure is increasingly recognized as a multifunctional tool, extending beyond the control of "experts" and top-

down steering, and - despite the seemingly innocuous benefits of ecological features - diverse opportunities and connections may expose disagreement (Carmichael and McDonough, 2019; Chaffin, Floyd and Albro, 2019) all-important to confront alternative governing arrangements for development. Even with this understanding, it may be valuable to shift the focus from government-led steering to refocus attention to other actors as leaders. The role of private actors - businesses, CSOs, business improvement associations, community-based groups - is then important in urban spaces to expose the diverse needs, resources, and opportunities and connections of green infrastructure development.

Green infrastructure research has demonstrated the role of private actors in participating in shaping projects (see Keeley *et al.*, 2013; Shandas, 2015; Finewood, 2016; Gabriel, 2016; Fitzgerald and Laufer, 2017). However, a gap exists in understanding and generalizing information related to how such actors develop green infrastructure in support of and independently of urban objectives. Green infrastructure implementation is further hampered by a clear understanding of who leads, who participates, relationships between short term design and long-term opportunities, and deployment beyond routine outcomes (Thomas and Littlewood, 2010; Bendt, Barthel and Colding, 2013; Dupras *et al.*, 2015; Luederitz *et al.*, 2015; Riechers, Barkmann and Tscharntke, 2016). To better support understanding of the governing arrangements diverse actor constellations, approaches to development, and exploration of the different uses for green infrastructure should be studied. Underscoring this is the importance of private actors to provide the necessary support to complement government programs (Young and McPherson, 2013), but also reveals the leadership and innovativeness of private actors to design novel green infrastructure or pursue partnerships (Buijs *et al.*, 2016)

Analyzing the supportive or leadership role of private actors enhances understanding of approaches to green infrastructure development. This is valuable to potentially embed green infrastructure that is more inclusive of users, connected to spaces beyond government jurisdiction, and innovative in processes and interventions to use. Further, understanding the approach or the way private actors deploy their resources offers clarity on alternative governing arrangements or the alignment of governing processes currently used. Here a governing modes framework would be appropriate to underscore the multiple pathways deployed by private actors such as their expertise and resources. Paying attention to both the guidance or leadership provided or the supportive functions of private

actors serves to complement and advance green infrastructure development in urban areas (see chapter 3 for details).

1.2.2.2 Green infrastructure transitions and experiments

In the context of sustainable transitions, green infrastructure could be framed as an innovation challenging or complementing existing societal configurations (i.e. structures, cultures, and practices (Markard, Raven and Truffer, 2012). Sustainability transitions is a body of literature concerned with the long-term societal transformation from an unsustainable trajectory to a presumably more sustainable trajectory (van den Bergh, Truffer and Kallis, 2011). Important elements of sustainability transitions are co-evolutionary change between societal structures, cultures, and practices. Structures represent physical infrastructure, economic markets, production and consumption (van den Bergh, Truffer and Kallis, 2011); and institutions such as laws, rules, and regulations (Rotmans and Loorbach, 2010; Ernst *et al.*, 2016). Cultures represent values, norms and paradigms related to shared outcomes, problems, and solutions (Loorbach and Rotmans, 2010). Practices represent the shared understanding of behaviours and routines (Loorbach and Rotmans, 2010; Ernst *et al.*, 2016). Taken together these three societal system parameters shape processes, problems, and actions (see chapter 4 for details).

The green infrastructure development paradigm, takes a rather deterministic approach, whereby building the physical structures alone will precipitate other outcomes (Sussams, Sheate and Eales, 2015; Dhakal and Chevalier, 2017). For example, building a community garden will yield an opportunity for increased ecological biodiversity and food provisions. However, other outcomes such as social interaction between community members, social cohesion, and knowledge of urban agriculture may not follow if people are not engaged and shown how to "do it" (Bendt, Barthel and Colding, 2013; Wolch, Byrne and Newell, 2014). Therefore, a research opportunity is clarifying the potential for green infrastructure development to recognize the interconnection between societal structures, cultures, and practices to extract the full array of benefits, connect benefits to multiple members of society, and ensure short-term experimentation to encourage long-term learning to promote development (see chapter 4 for details). This approach to understanding how practices connect to redirecting agendas and visions relates to the work of governance because it is intimately tied to the action of practitioners and users, their experiences and understanding, and the processes and outcomes related to green infrastructure development and consumption.

Furthermore, green infrastructure acts as a sustainability experiment, serving as a tangible action and space where non-state actors intervene to undertake and confront an issue to further develop knowledge and insight (Bulkeley, Castán Broto and Edwards, 2015). Moreover, the people who conduct these interventions vary greatly, most frequently involving local government (see Bulkeley and Castán Broto, 2013), but also individual or community organizations (see Bendt, Barthel and Colding, 2013; Connolly *et al.*, 2013; Krasny *et al.*, 2014). Experiments, broadly, are described slightly differently by various scholars exploring societal change (see Evans, 2011; Bulkeley and Castán Broto, 2013; Luederitz *et al.*, 2017; Sengers, Wieczorek and Raven, 2019). In general, however, experiments are purposive interventions designed by people and occurring in a specific location to address a problem or build upon past interventions to improve sustainability outcomes while also examining the processes and conditions necessary to further foster change. These experiments it would seem are a form of governance innovation where actors at various scales can intervene and contribute new knowledge or learn about a new way of doing and conducting sustainability actions (see chapter 5 for elaboration). Experiments may be effective to introduce novelty at smaller scales (i.e. neighbourhood or household) and if translated to a higher scale (i.e. county or city-wide) could potentially initiate wider system implementation of that novel practice. Further, exploring green infrastructure experiments may contribute to an alternative method to embed interventions across the city, paying attention to contexts and attempting to better support sustainability objectives but searching for user novelty as well.

1.2.3 Summary of literature review

The literature review has synthesized multiple bodies of knowledge collectively provides a set of ideas that support a conceptualization of how multi-actor processes of societal participation support system change (figure 1.1). Sustainability governance offers insight regarding how the contested realities of sustainability change raise the possibility of conflicting and competing views, solutions, and problems. Sustainability transitions pull in the messy realities of sustainability to categorize the societal dimensions of change and offer clear linkages between actors and innovation steering. Governance literature offers a lens to situate multi-actor decision-making as important in shaping problem guidance and solutions opportunities. Green infrastructure offers an object of focus to understand how actors intervene to potentially redirect systems for more sustainable outcomes. Green infrastructure requires alternative governing actors to direct the purpose or aims of interventions across urban areas. Here actors may lead or conform to the policy context of their

region. Nevertheless, they may expose governing tensions or innovation pathways unique or specific to users and needs. Transitions for green infrastructure may help conceptualize a way for green infrastructure to spread or become further embedded in critical dimensions or steering. The use of experiments may help build evidence of green infrastructure performance but also serves as a tool to deploy green infrastructure.

Two important points must be reflected on before proceeding, first, this thesis does not intend to evaluate whether green infrastructure development is creating a new development pathway for sustainability in cities. Second, it is not the goal of this thesis to confront the issues of power, equity, and access in-depth, which are important and addressed in other literature associated with green infrastructure development (see Wolch, Byrne and Newell, 2014; Anguelovski, Connolly and Brand, 2018; Rigolon and Németh, 2018).

First, it is important to note here that while green infrastructure development and associated terms exploring and encouraging the development of more ecological features in urban spaces continue to be studied, it is still challenging to know whether an alternative sustainability pathway is developed because of green infrastructure (Becker and von der Wall, 2018; van der Jagt *et al.*, 2020). Many factors converge challenging assessment, on one hand, the difficulty of aligning the conceptualization of nature across local government pushes particular green infrastructure features or components (e.g. parks) into compartmentalized units (parks or recreation units) (Bush, 2020; Conway, Khan and Esak, 2020). Moreover, the regulatory tools applied to expand green infrastructure in cities reinforces the dominant agendas associated with units such as spatial planning or water management pushing forward projects and programs that reinforce the status quo or propose green infrastructure for the preservation of economic growth (Maes and Jacobs, 2017; Liu and Jensen, 2018; Davies and Lafortezza, 2019).

While these are both important points to further research, this thesis instead seeks to examine the governing arrangements that unfold with different approaches to deploying green infrastructure. As opposed to offering an assessment of sustainability transition pathways, this thesis explores the processes and actors who may navigate existing urban development patterns to more clearly articulate fit within the existing urban development strategy. This provides an alternative understanding of who develops green infrastructure and with intentions or uses they are deployed for. This may provide seeds of emerging pathways, but will more concretely show how the component pieces, actions, and arrangements may be the ingredients necessary to partially expose the opportunities available to

potentially support various domains and sectors of society in integrating green infrastructure across urban areas.

Second, green infrastructure has been shown to (re)produce power dynamics across a city (Wolch, Byrne and Newell, 2014; Miller, 2016; Anguelovski, Connolly and Brand, 2018; Rigolon and Németh, 2018), reinforcing old injustices of access to quality green spaces and negligence of historic conflict with nature or removal of nature to target particular communities (Carmichael and McDonough, 2019). Further, the siting of new green spaces often benefit those in wealthier communities, either the result of on-property green features or due to location and the availability of historic green infrastructure features and the continued focus in those areas to expand existing green networks (Heynen, Perkins and Roy, 2006; Rigolon and Németh, 2020). While this research does not intend to expose or probe these issues, it is acknowledged that there is potential that the findings in this research have the potential to continue to reproduce these power dynamics. As a reminder, the purpose of this research is to understand how green infrastructure actions have been undertaken by local and regional governments, businesses, civil society organizations, and business networks. These actors provide a partial understanding of how prominent actors understand and deploy green infrastructure.

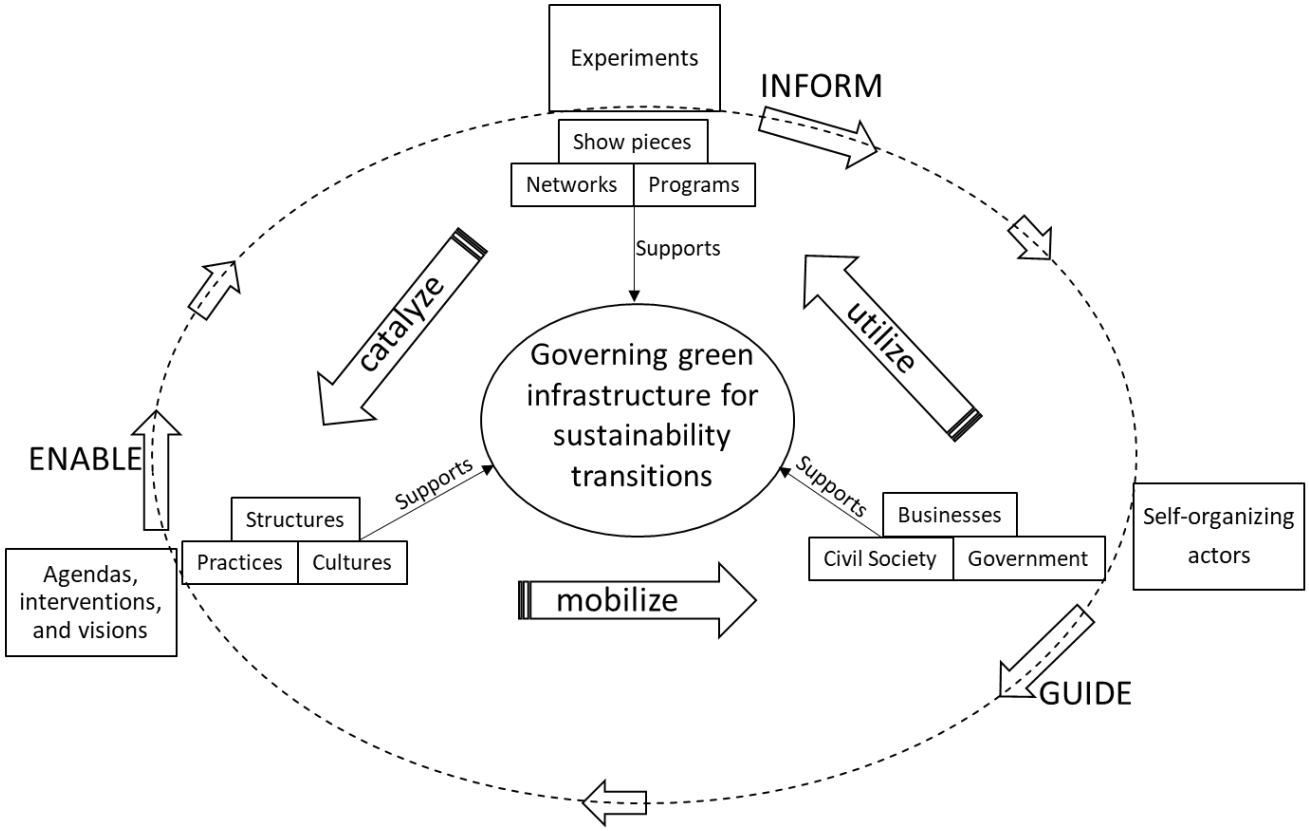

Figure 1.1 Conceptualization of the research program
This figure depicts the conceptual work undertaken in this research project. The relationship between actors, change processes, and experiments are depicted by arrows moving in clockwise and counter-clockwise. The elements of each framework used are placed into rectangles in the dashed oval and are thought to support governing and transition processes.

1.3 Organization of thesis

Following this chapter, the remainder of this document will deliver a deeper and engaging presentation and discussion of the way green infrastructure development has occurred under novel governing arrangements supportive of collaborative processes for sustainability transitions and experiments. First, chapter 2 provides an overview of the research methodology and clarifies the research methods deployed to support answering the research questions. Following this, three manuscripts are presented, each addressing the research questions and objectives highlighted above. Next, chapter 3 uncovers how private actors have supported green infrastructure development and the specific application of expertise necessary to effectively support intervention deployment. Then, chapter 4 explores the potential of green infrastructure development to support sustainability transitions by altering key dimensions for system change. Next, chapter 5 examines the mediating

role of and strategic orientation of green infrastructure experiments as a delivery mechanism. Finally, chapter 6 synthesis of the dissertation, identifies opportunities for future research, and broad reflection of the research program.

Chapter 2
Methodology

2.1 Research design and methodology

The purpose of this PhD research is to explore how green infrastructure development is realized in the context of multi-modal governing processes and arrangements supporting urban sustainability transitions. This section will present the research design by discussing the theory of knowledge and a research paradigm to situate the research program.

A research methodology is the unification of epistemology, ontology, and world views of the researcher (Guba and Lincoln, 1994). This means that what is known and what is desired to be known is tied to the perceptions of the researcher. The researcher is responsible to accurately represent and interpret the issue or phenomena of the study and the subjects who will serve as the data sources (Guba and Lincoln, 1994; Lincoln and Guba, 2000). The ontological foundation, or what can be known, is established through framing and bounding the system or phenomena of study (Kitchin and Tate, 2000; Hoggart, Lees and Davies, 2002). Epistemology is the researcher's ability to further understand, validate, or clarify a phenomenon of interest by asking what are the sources of knowledge (Kitchin and Tate, 2000; Hoggart, Lees and Davies, 2002). Knowledge and sources of knowledge are directly tied to a perspective or philosophical paradigm of the researcher. The constructivist paradigm is used in qualitative research (and in this paper) and suggests that the goal of the researcher is to identify multiple perspectives that can help trace or interpret outcomes that have contributed to the current conditions (Lincoln and Guba, 2000).

In both instances, the purpose is not to seek objectivity, but to trace subjectivity and patterns that can then be interpreted and build a body of knowledge that may aid in improving understanding of a phenomenon. It is important to recognize that knowledge is constructed by people through lived experiences, interactions, and interpretations of their world. Attempting separation between diverse and heterogeneous human agents and their surroundings or "environment" is not independent but it is co-created and reinforcing (Hoggart, Lees and Davies, 2002). Therefore, the methodology will guide attempts to further understand the views of conduct related to how green infrastructure development has occurred and what continues to frame debates and discussions in two cities and amongst multiple practitioners. The data sources will be green infrastructure experts, who have engaged with the development in each urban area or region. To create a deeper knowledge of why green infrastructure

has been developed in this manner the research program will seek to understand how these actors navigate various governing arrangements to lead and guide, undertake actions and interventions, and experiment with and for green infrastructure development.

2.2 Case study research: background and description

2.2.1 Case study methodology

Case study research, as a methodology, provides an opportunity for deep understanding and analysis of phenomena by uncovering contextual factors that have contributed to the significance of an issue (Baxter and Jack, 2008; Yin, 2012). More specifically, and connected to this research, a multi-urban region case study analysis uncovers different governing contexts to better offer prescriptions for improvement with the engagement and implementation of urban green infrastructure development. Case study research affords both breadth and depth to be explored with the area or topic of study (Halinen and Törnroos, 2005). For example, deploying a governance lens in a multi-urban region case study will reveal the diversity of actors participating in sustainability efforts beyond traditional governing actors (i.e. local government, business). Moreover, the case study approach provides (some) generalizable and (mostly) specific information (Stake, 1995; Liamputtong, 2013) with regard to the governance modes utilized to plan, design or implement green infrastructure; the purpose of "doing" green infrastructure; and process of experimentation.

Case study research requires the identification of three factors to thoroughly establish the grounds for inquiry - research questions (see chapter 1), research objectives (see chapter 1), and the case and specific units of analysis (see below). The "cases" to be analyzed are, the Toronto-region, Canada and London-region, United Kingdom (UK) (see Appendix A for reference maps), are each engaging with green infrastructure development. The unit of analysis is multi-actor governing processes, with multiple embedded units of analyses (see table 2.1). Instrumental case studies allow for the pursuit of addressing the unit of analysis but also allow for a narrow focus on embedded issues that reveal specific or general governing processes, the purpose of utilizing those processes, and potential outcomes or directions of green infrastructure development (Stake, 1995).

Table 2.1 Identification of units and sub-units of analysis

Unit of analysis	Embedded unit of analysis	Description	Data Analysis	Sources for data collection
Governing processes for green infrastructure development	Private (green infrastructure) actors and practitioners	People, practitioners, organizations, local government, and regional government engaged with green infrastructure development	Content analysis	Interview transcripts
	Any green infrastructure intervention	Green infrastructure agents, pursuing formal and informal actions to physically implement or establish the rules and direction for green infrastructure development	Content analysis	Interview transcripts
	Green infrastructure experimental conduct (e.g. pilot projects)	Explicit usage of green infrastructure experiments (or related concepts, e.g. pilot projects, test sites, proof of concept) to navigate organizational barriers, encourage learning between and in organizations, shape partnerships and actor networks, , and clarify sustainability solutions	Content analysis	Interview transcripts

2.2.2 Urban areas

Urban areas are described as sites of multiple cities forming networks; where cities are areas that have grown due to increased inflow of capital and technology, and exchange between rural and urban areas (Harvey, 1996). An urban area is not a homogeneous entity, it can potentially contain a core city with peripheral zones such as suburbs or other administrative zones (Muggah, 2012). Other authors describe urban areas as complex systems, shaped by the collective interactions between social, political, technological, and ecological systems (Meerow, Newell and Stults, 2016; Romero-Lankao *et al.*, 2016). Finally, Romero-Lankao *et al*. (2016, p. 2) define cities as "socio-ecological systems (SES) either of interacting biophysical and socioeconomic components, or social and technical components". In this regard, the two cases are being represented as distinct spaces with socioeconomic, technical, and ecological subsystems comprising a larger system. The examination of urban areas, as opposed to cities or other administrative zones, lies in the description provided by Harvey (1996). Urban areas better encompass multiple interacting and interconnected areas forming networks that compete and share resources. The collective examination serves to bridge multiple perspectives on how an urban network organizes modes of production and consumption. The selection of the two urban areas, the Toronto-region and the London-region, are derived from different aspects related to governing structures and experiences with sustainability and green infrastructure (see section 2.2.3).

In London, the formal administrative boundary has developed over multiple decades, with varying levels of formal authority (Sweeting, 2003). The administrative and now formal governing authority help bound the region and provided clarity of the London urban area (Sweeting, 2002). The Greater London region is comprised of 33 government districts and the Greater London Authority, as a spatial planning manager for the whole region (Pilgrim, 2006). The Greater Toronto Area (GTA) or Toronto-region on the other hand, is not a formal administrative area (Williams, 1999). Instead, it is partially derived from the national statistics office, provincial land-use planning bodies, and economic accounting (Frisken *et al.*, 2000). The boundaries of the Toronto-region have expanded over multiple decades, with the current incarnation including the City of Toronto and four outer-borough regional administrative zones, each with additional sub-local cities or towns (Williams, 1999; Frisken *et al.*, 2000).

2.2.3 Case study justification and descriptions

London (UK) and Toronto (Canada) are two distinct urban regions that will be studied for potentially valuable insight into different governing approaches used for the development of green infrastructure in the face of similar urban challenges. A critical sampling method justifies the use of a few cases to draw out similarities, while recognizing the differences, potentially creating generalizability of results and recommendations (Patton, 2002). Both regions are expected to experience an increase in extreme weather events and climate variability in the short and medium terms: examples include extremes in heat and precipitation events (Toronto Environment Office, 2008; Nickson *et al.*, 2011). Also, both are English speaking countries, with neoliberal political systems in the global north (Donald and Blay-Palmer, 2006; Davis, 2019), and both are megacities with strong business and financial profiles and prominent with sustainability engagement (Sancton, 2005; Kübler and Lefèvre, 2018). However, as two distinct urban regions in terms of governing structures (Sweeting, 2002; Winfield, 2012), history of development, and engagement with sustainability and climate change (Edge and McAllister, 2009; Mees and Driessen, 2011) opportunity to explain how different governing contexts require different processes and actors to create similar outcomes (i.e. green infrastructure development) is explored. Dissimilarities at the national and regional levels dictate how governing processes in cities unfold to guide actions related to sustainability, although even here the actors of interest and issues faced at local levels will emerge to reveal similar processes or approaches to green infrastructure development.

Canada is a federalist state, with powers and responsibility divided between national and provincial governments (Mees and Driessen, 2011). Cities are often, and contentiously, referred to as "creatures of the province," whereby authority is devolved to municipalities, though the province will exercise authority when needed (Magnusson, 2005). The United Kingdom (UK) on the other hand, is described as a centralized unitary state where cities are guided by the central government (Ehnert *et al.*, 2018). However, since 1999, the relationship between the central state and London has reflected a "decentralized unitary state" (Harrison and Thomas, 2008; Ehnert *et al.*, 2018). This is because the formation of The Greater London Authority (GLA) has allowed the GLA and its boroughs or local authorities greater autonomy over issues related to taxation and spending, land-use planning and delivery, and community and sustainability planning and development (Tewdwr-Jones, 2009; Coombes, 2013). Since the creation of the GLA in 1999, increasing powers and authority has been given to the GLA to govern local authorities. This power, however, is not reflective of command-and control techniques, nor is it intended to be used as such. The GLA prefer a guiding and facilitator role, local authorities by rule, align themselves to GLA policies and visions for spatial planning (Tewdwr-Jones, 2009).

The purpose of selecting two distinct case-study regions is in the belief or desire to draw out common (literal replication) and different (theoretical replication) (Yin, 2012) lessons for the governance of green infrastructure. This means that while the contexts are different, the object and outcomes of green infrastructure *should* be the same in all places (e.g. trees cool and purify the air). However, urban area actors will have to navigate specific issues to tailor the implementation and development of interventions to address specific problems and satisfy contextual issues. Therefore, the purpose and intentions of green infrastructure development will be different and conform to the needs of the region (e.g. What is the green infrastructure intervention used for? Why do we need or want this?). The motivation for selecting these two urban regions lies in identifying two critical cases that have contributed to green infrastructure implementation or knowledge development locally, regionally, and internationally. Further, selecting two cases with seemingly diverging urban development systems (Hodge, 1985; Heath, 2001; Amati and Taylor, 2010) will enrich our understanding of how sustainability-oriented change can traverse different contexts.

Both regions are leaders within their respective countries. For instance, the City of Toronto was the first city to establish a green roof by-law in Canada (and North America) (Dvorak and Volder, 2010; Loder, 2014), advance municipal urban forestry development (Conway and Urbani, 2007), and

protect and manage natural heritage and natural ravine and water systems using innovative techniques and unique governing arrangements (De Sousa, 2003; Amati and Taylor, 2010). In London, the GLA, multiple local authority governments, and Business Improvement Districts (BIDs) are recognized as leaders for green infrastructure development (see Merk *et al.*, 2012) because of the ability to include local businesses and land development companies as project financiers (Jones and Somper, 2014; Virk *et al.*, 2015). Internationally, the 2012 Olympics in London, provided east London boroughs and neighbourhoods with an opportunity to experiment with green infrastructure projects (Mell, 2016). The Olympic greening process and outcomes are exemplars of how rapid development of housing and infrastructure can integrate green infrastructure (Mell *et al*., 2017). Within North America, efforts in the Toronto-region are recognized as significant for the application of techniques to integrate green infrastructure actions with community members and organizations or collaboratively develop policy (De Sousa, 2003; Wheeler, 2003; Schilling and Logan, 2008). Therefore, neither region is being presented as better or "doing it better than the other"; both regions are leaders and drawing out the different approaches used may allow for generalizability of green infrastructure governance locally and internationally.

The advantage of selecting two different cases is to identify similarities in different contexts. Particularly related to issues of sustainability. Different contexts may be advantageous to draw out multiple and novel insights into practices and processes. While being fully aware of the differences in various aspects such as governing, culture, geography, etc. Nevertheless, similar items emerge in these contexts, such as the presence of nationally recognized civil society organizations (CSOs) or businesses with very similar core functions (e.g. landscape planning, arborists). The purpose is to understand how actors in each region navigate their context and what shapes their ability to develop green infrastructure.

2.3 Methods: Data collection and analysis

2.3.1 Identifying data sources

A list of potential key informants (also referred to as informants) was developed using a purposeful sampling strategy targeting green infrastructure practitioners in each case. This was developed through an informal document review and an internet search of green infrastructure projects, documents, and actors in each case, including local municipalities, local government, and where applicable regional government. This allowed for the collection of names and contact information of

potential key informants, as the broad combination of websites (i.e. government, civil society groups; industry associations, etc.), official documents (i.e. council agendas, public reports, plans, policies, brochures, case study material, etc.), and posted presentations (conferences, symposiums, cross-jurisdictional working meetings, etc.) listed this information. Further, the purpose of this search was to establish an understanding of what each case, as dictated by local and regional governments' identifies as critical issues for green infrastructure to address. Moreover, some of the government documents are produced in partnership with private companies and civil society organizations, this provided an initial start to include private actor key informants.

Identification of private actors occurred through internet searches that selectively queried green infrastructure-related disciplinary fields (e.g. landscape architects, arborists, community gardening, etc.), specific interventions (e.g. urban forestry, low-impact development, green roofs, etc.). Overall, this process provided an extensive list of potential informants to contact along with serving as developing a background understanding of the green infrastructure application in each region and local municipalities or borough authorities. The selection of private actors was conducted using information from websites that indicated relationships built with local government; as well as demonstrable efforts to pursue green infrastructure and sustainability outcomes independently of government. Another source of reliable private actors was to identify databases or members' lists, from credible organizations in each case such as water basin organizations, parks and nature-related groups, and professional organizations and associations. This sampling strategy will miss private actors who do not have a website or if they do have a website and elect not to advertise their relationships with other green infrastructure actors. Further, two additional strategies were used to collect key informants, first snowball sampling was used following interviews, second, when reaching out to potential key informants, a request was made for them to provide a list of other actors they feel would be of value to this research. Ultimately, for this research program, "green infrastructure actors" must meet one of the following three criteria:

1. The key informant is from a specific department, unit or agency at the local, regional, provincial/central level of government, or arms-length government organization;
2. The key informant is a representative of a specific business (including social enterprises), or business association (including Business Improvement Associations or Districts, industry association, other business networks, etc.);

3. The key informant is representative of a specific civil society organization that is involved with green infrastructure development in the urban case study area (including community-based groups, voluntary groups, and charitable organizations).

2.3.2 Contacting key informants and conducting interviews

The purpose of key informant interviews is to collect information and extract expert opinions, (Dangelico and Pujari, 2010; Krysanova *et al.*, 2010). Specifically, to this research program, the goal is to understand the governing processes, experiences, and approaches with green infrastructure development. Key informants were contacted using personal, professional or general email addresses. The invitation email provided a summary of the research program along with an explanation of the informants' role in supporting data collection (Liamputtong 2013; Longhurst 2010). For the informants who agreed to participate an information and consent letter was provided: both documents were approved by the University of Waterloo's (UW) Office of Research Ethics (ORE) (Appendix B). The purpose of the information letter was to provide detailed information on the project, purpose, and contact information of the researcher, researcher's supervisor, and UW's ORE. The consent letter was provided ahead of time for the informant to approve audio recording, use of quotations, and participation.

Interviews occurred from January 2018-June 2018 with 54 green infrastructure key informants through 51 interviews, this occurred because interviews 16.TO had three informants present and interview 11.LO had two informants present, all other interviews were conducted with single informants (see Appendix C). This research program occurred concurrently with the Governing and Accelerating Transformative Entrepreneurship (GATE) project (see Westman *et al.*, 2019). Key informants, identified through GATE, were appropriate to include in this research and were asked ahead of time if they would be able to address questions and themes related to green infrastructure. Appendix C provides a list of key informants and notes those informants from GATE. The selection of green infrastructure informants was identified to gain coverage of multiple actors, local government, regional government, firms, business networks, and civil society organizations (see Appendix D).

Informant interviews followed a semi-structured script, whereby a set of questions and themes were developed to direct the conversation while also allowing for new issues, themes, and questions to emerge during the interview (Longhurst, 2010). The benefit of a semi-structured interview, as opposed to a structured or unstructured interview, is in the opportunity to apply an interview script,

yet ask slightly different questions to different key informants as they emerge during the interview (Dunn, 2005). Table 2.2 presents the list of questions developed, questions bolded were determined to be the most important and essential to address the research questions and objectives for this research, while non-bolded questions served to facilitate additional discussion if time permitted. Interview duration ranged from 45-90 minutes in length, brief notes were taken that captured key points and themes that stood out and seemed like important avenues to pursue immediately or explore later. Active note-taking was purposely avoided since it was crucial to be an active listener, maintaining eye contact, and most importantly building upon informant answers, questions, and comments (Longhurst, 2010; Liamputtong, 2013). The interviews were audio-recorded using a standard recording device. All interviews were transcribed verbatim from July 1st, 2018- August 31st, 2018. Following transcription, the interview transcripts were sent to each informant to provide comments, points of clarification, and adjustment of contents as they felt required.

Table 2.2 Interview questions and relationship to research questions

Research Questions	**Objectives**	**Interview Questions**
Guiding RQ How can private actors support green infrastructure development through collaborative governing arrangements in urban areas? Sub-RQs how can private actors lead green infrastructure development; and leverage their expertise to navigate multiple governing modes?	Analytically describe the role of private green infrastructure actors as critical leaders deploying diverse governing modes to support actor engagement or collaboratively steer development in urban areas.	2. Green infrastructure background a. What is green infrastructure? i. **what documents do you use to guide your thinking of green infrastructure development?** b. **Can you describe (organizations) involvement with the development of green infrastructure projects?** c. What major policies are used to guide GI development? d. What problems do you think GI is typically designed to address? 3. Governing Context: Who participates and decides a. **What role does local government play in guiding your decision-making and action for GI projects?** i How have you seen the interpretation of green infrastructure change between your work with different municipalities/Boroughs? ii. Can you describe how government typically contributes to the development and implementation of projects you are involved with? b. **What role do civil society organizations play in contributing to shaping or implementing your projects?** i. Has the interpretation of GI changed between different organizations? ii. Is it important to include community groups in GI development? What phase are they the most useful? c. **What role do small and medium-sized businesses play in supporting GI development** i. What consultants were used to design major sustainability and green infrastructure related documents? ii. **What other businesses are integrated into project design, development, and implementation?**

		iii. What role do non-consultant businesses play in shaping your GI projects? iv. **Have you seen businesses lead on sustainability or green infrastructure actions?**
<u>Guiding RQ</u> How can green infrastructure interventions support the embedding of practices in urban areas to mobilize recursive dynamics to guide sustainability transitions? <u>Sub-RQs</u> How can green infrastructure development become embedded in societal structures, practices, and cultures? how can green infrastructure practices support the development of agendas and visions?	Conceptualize the role of transitions practices as mediating visions and agendas to strengthen the green infrastructure development approach in urban areas.	<u>2. Green infrastructure background</u> **a. What is green infrastructure?** **i. what documents do you use to guide your thinking of green infrastructure development?** **b. Can you describe (organizations) involvement with the development of green infrastructure projects?** **c. What major policies are used to guide GI development?** **d. What problems do you think GI is typically designed to address?** <u>4. Alteration of structures through green infrastructure projects</u> **a. What Green infrastructure projects stand out as major accomplishments for your organization?** **i. How did the project change interactions of space and people?** 1. How was this measured ii. **What other physical changes occurred that have altered the function of the city or region?** 1. How was this measured? **iii. What policy or by-laws were considered when conducting this project?** iv. Did new by-laws or policies emerge because of projects? v. Did policy require alterations to fit project needs? vi. **Who were the primary people or organizations involved in developing and implementing the project? Who were actors that were not initially considered, but participated?** b. What challenges have green infrastructure projects suffered through at the development, design, or implementation stages? How can these be addressed? i. How were those challenges addressed and overcome?

Guiding RQ How can green infrastructure experiments strategically support the embedding of sustainability interventions in urban areas? Sub-RQ How can experiments be mobilized as a strategic intervention to embed green infrastructure in urban areas?	Empirically demonstrate how sustainability experiments are strategically mobilized to advance green infrastructure development.	5. Experiments and Pilots **a. How do pilot projects contribute to an improved understanding of green infrastructure for your organization? Can you describe at least one project?** **i. What was the purpose of the project?** ii. What did you want to see the project change or respond to? iii. What lessons emerged? How have these been included in efforts since completion? iv. How do you measure this? **v. Who was involved in developing and carrying out the pilot?** b. How have past pilot projects served to improve the delivery of information to municipal/organization decision-makers to get approval for a project or pursue new delivery techniques? 6. Future potential for green Infrastructure a. Do you see green infrastructure as more than complementary to traditional infrastructure? b. Can GI be used to accelerate sustainability change in this City? What is needed to do this?

2.3.2.1 Data saturation

Justifying and understanding data saturation is important for achieving quality of data in qualitative research (Marshall *et al.*, 2013; O'Reilly and Parker, 2013). While a criterion does not exist to assess when a researcher has achieved saturation in interviews (Marshall *et al*., 2013), Saunders *et al.* (2018) identify four models used to support an assessment of saturation. Important for this thesis is the utilization of *a priori thematic saturation* and *data saturation* as both of these models offer alternatives from ground theory models and better support deductive or theory-driven coding saturation strategies (Saunders *et al.*, 2018). First, in *a priori thematic saturation*, predetermined codes are established and are populated with the interview data. Here key informant selection should aim to identify those who can best speak to the phenomena of study. The goal here is not to adhere to simply achieving a set number of respondents but searching for expert opinions and experiences (O'Reilly and Parker, 2013) that can best speak to the topic, research question, and codes. Second, Saunders *et al*. (2018, p. 1897) describe *data saturation* as "the degree to which new data repeat what was expressed in previous data". The goal here is to collect data and assess when similar or repeated codes continue to be expressed in the interviews.

For this research data saturation was assessed during and following the collection of interviews with key informants and connected to the purposive sampling strategy (Saunders *et al.*, 2018). First data saturation followed *a priori thematic saturation* by identifying initial codes that would support

addressing the research questions and research objectives. Informants were identified based on their experiences, engagement with green infrastructure, and connections to the other green infrastructure stakeholders. Informants in this sense possessed deep and rich insight on green infrastructure development in their region. Moreover, informants were representative of their organization because they were either owners or founders, managers of green infrastructure programs in their civil society group, or green infrastructure policy and program managers and land-use planning and development support officers in the regional or local government. Therefore, the informants were connected to key codes such as actor of focus, support in transition agendas, practices and arenas, and engagement with pilot projects (see Appendices E-G). Second, *data saturation* allowed for the assessment of interview data as an ongoing activity with interviews occurring over several months allowing for comparison and identification of data and the ability to follow-up with informants or identify new informants to contact. As well during the interview process interview notes were consulted repeatedly to identify the occurrence when key themes (see table 2.2) were addressed allowing for post-interview reflection and comparison with previous interviews.

2.3.3 Interpreting, coding, and analyzing data

Following the delivery of interview transcripts and approval from informants, data processing and analysis proceeded using qualitative data software Nvivo 12. Qualitative content analysis is suited for this research program because it enables the interpretation of content or data derived from human experiences, providing space to draw out commonalities, differences, tensions, and emergent themes (Dunn, 2005; Elo and Kyngäs, 2008). Although content analysis as a technique for capturing data emerged from quantitative research, qualitative researchers have increasingly utilized this coding and analysis process to move beyond surface-level accounting of phrases and words to offer a more holistic approach to identify and ascribe meaning, intent, and purpose to textual data (Hsieh and Shannon, 2005). Further, as Patton (2002) notes qualitative research is significantly unique and the application of methods will be unique as well. Therefore, the singularity of applied methods and strategies to interpret data will be diverse and overlapping to best support the research inquiry.

Qualitative content analysis was used to analyze the transcript data and later the specific text passages applied to a particular code. Applying rule-based coding operating at both a manifest and latent level gives varying levels of information for deeper analysis or characterizing data. Manifest content is used to note the occurrence or mention of specific terms or concepts (Stake, 1995; Joffe and Yardley, 2004). For example, specific references to legislation, policy, documents, actors and the

names of experiments and on-going projects would be manifest data, which could be used later to understand the most important policy item, projects, or actors and government unit(s). Latent content, in contrast, would provide greater detail in terms of how those policy documents shape the key informant's activities and work; or how those actors re-shape particular policies, projects and subsequent processes and outcomes (Joffe and Yardley, 2004).

The codes were developed through an iterative process of aligning the research questions and the theoretical framing (see chapter 1). Deductive coding phases were applied to sort data then draw out characteristics relevant to each research question. First, theory-driven (Hsieh and Shannon, 2005) and structural coding (Saldana, 2009) was utilized to assign both latent and manifest level text (Stake, 1995). Theory driven coding utilizes themes or codes derived from an existing body of theory, in this case, theory related to modes of governance (see chapter 3), transitions management (see chapter 4), and sustainability experiments (see chapter 5) was used. The theory was used broadly, definitions were wide and encompassing, and concepts covered a range of topics. In line with this, a more exploratory sub-phase of provisional coding was applied. This was suited to this first phase because it provided an opportunity to examine the transcripts broadly, begin to code based on broad theoretical codes, and served as an opportunity to begin memoing, annotating points of interest, and potentially assess the opportunity for inductive coding (Saldana, 2009).

The multiple coding strategies used directed coding (Hsieh and Shannon, 2005), based on theoretical codes, those codes were then refined to maintain the structure and simultaneously support opportunities to flexibly connect codes and subcodes. The coded data from the first phase would support broad interpretations of the theory serving also for the researcher to become familiar with the interviews yet still offer the opportunity to begin initially categorizing data.

The second phase of coding utilized directed coding, with narrower theoretical codes, developed through further refining codes based on literature and the emerging themes drawn out from the first phase. Pattern coding allows for the search for latent meaning of the text, moving beyond simple phrases and offering the opportunity to better connect the subject matter to the research questions (Saldana, 2009). As an example, see chapter 4, moving from broad descriptions of structures, towards a more refined and selective code of "agendas" offered an opportunity to move from what are the rules of the game to better understand how the actors use those rules to frame or guide their conduct in practice. In this regard, directed coding in this first phases focused on both manifest and latent content, then shifted to focusing on latent level data primarily in the second phase (Hsieh and

Shannon, 2005): narrowing codes, but expanding text phrases and chunks to better reflect the sub-research questions and the objectives of each manuscript, with an opportunity to begin to note emerging themes or characteristics. Focusing on latent codes only is justified since the text identified through manifest level coding in the first phase is already narrowed and focused.

Finally, using the coded content from the second phase, a third phase was conducted drawing out the particular characteristic or concepts explaining each code (Cho and Lee, 2014). Saldana (2009) describes axial coding as a technique that pulls together multiple codes or categories to explore the relationships between these categories. This is particularly important as each of the categories (and sub-categories) in the preceding phases are interrelated, such as the relationships between actors, actions, and outcomes. An example from chapter 4, the relationship between those shaping agendas and those designing interventions is rarely separate or independent and will have strong interrelationships. Again, the focus was on latent coding to theme the text phrase (Saldana, 2009) and to capture the narrowest but most descriptive and supportive text phrases in building meaning to present results and elaborate for discussion. Multiphase case coding is intended to support the narrowing and clarifying of interrelated codes to build concepts that support the frameworks used for each empirical section, advancing from theory to more tangible concepts that relate to a concrete expression of the phenomena of study.

2.3.4 Details of phases of research

This research is organized based on the development of three empirical chapters (i.e. chapters 3- 5) each aimed at answering one guiding question (see table 2.2). The empirical contributions aim to understand, who is involved in the development of green infrastructure (chapter 3); how green infrastructure becomes embedded into the societal process of decision-making and action (chapter 4); and how green infrastructure development is accomplished using experiments (chapter 5). Below these points are discussed further describing specific details of the data analysis for each chapter.

2.3.4.1 Part one: Green infrastructure governance

Governance literature has contributed significantly to our understanding of the role of the state in shaping and continuing to assert presence in modern activities of societal steering (see chapter 1). Of particular interest in this portion of the research is developing an understanding of the role of private actors in contributing to the development of sustainability in urban areas. The term private actor is used in this paper to describe non-government actors, specifically, businesses and business-related

organizations and civil society organizations, including community-based, and voluntary or charity organizations (see Pattberg and Stripple, 2008; Glasbergen, 2011; Abbott, 2012).

Green infrastructure serves as the intervention of focus, with the unit of analysis being private actors involved in developing green infrastructure. Interview responses clarified and described the private actors who mediate and facilitate the development of green infrastructure interventions. Furthermore, the interview responses provided either general outcomes (i.e. tree planted; bioswale installed; community forum developed) allowing for identification of how governing actions correspond to outcomes and the implications for future green infrastructure development in each case. This was achieved using multiple coding phases aimed at narrowing the text content of data to better support the opportunity to draw out critical concepts shaping green infrastructure development in the cases (see Appendix E).

The first round of coding used Lange *et al.'s* (2013) categories of sustainability governance modes to aid in broadly coding data through an exploratory phase of structured coding (Saldana, 2009). Here the goal was to become familiar with the data or transcripts, while sorting data based on the actor being discussed, including mentions of state-level actors at all levels as well as private actors. The second phase of coding similarly applied Bulkeley and Castan Broto's (2011) modes of governing framework. Here the goal was to understand the broad set of actions that private actors were engaging with to develop green infrastructure. Therefore, moving from the first round to the second round of coding further narrowed the scope of focus from who is involved, towards what are they doing. Finally, a round of concept building occurred using the coding categories from round two to draw out the actors and relationships, purpose(s) of action, and general (and specific) outcomes of governing action. The purpose of concept building (supported by the previous phases) was to answer the research question: how can private actors support green infrastructure development through collaborative governing arrangements in urban areas?

2.3.4.2 Part two: Green infrastructure transitions

The second portion of the research project analyzed each case to understand the contribution of green infrastructure practices to shape larger societal changes (chapter 4). Using the transition management (TM) framework (see Loorbach, 2010; Rotmans and Loorbach, 2010) served to provide criteria to understand broad and narrow attributes transforming the system of focus. Key informant interviews offer in-depth perspectives related to the alteration in three domains of the TM framework: agendas, interventions, and visions. Here the purpose was to clarify how green infrastructure actions

and decisions were becoming embedded in multiple domains of society. Similar to the previous section two rounds of coding and the third round of concept building were completed here (see Appendix F).

The first and second rounds served to narrow data towards addressing the second research question: how can green infrastructure interventions support the embedding of practices in urban areas to mobilize recursive dynamics to guide sustainability transitions? The purpose of the first round was to broadly categorize text into three codes allowing for familiarity with the data and removing text passages less relevant to this phase, thus the utilization of rule-based and structured codes. Here the codes were directly adopted from the TM framework, specifically the definitions given by Loorbach (2010). The second round of coding applied narrower codes that addressed specific aspects of the previous codes. Here the aim was to understand the actors that direct, perform, and reinforce green infrastructure development in each case while paying attention to the role of broad agendas or framing devices for green infrastructure; the specific actions and interventions including pilot projects, capital and operational projects, and localized green infrastructure projects. Finally, the third round of coding used the coded categories from round two to draw out concepts to answer the research question. The data was further scrutinized to identify characteristics that provide meaning to the data, more specifically, explaining the transformative nature of green infrastructure as dictated by the formal procedures, practical actions, and visions of green infrastructure's purpose and potential.

2.3.4.3 Part three: Green infrastructure experiments

The final phase of research analyzed the data to underscore how green infrastructure-related experiments were an important contribution to green infrastructure development in the cases (see chapter 5). The purpose of conducting experiments is for improving sustainability solutions, as opposed to understanding sustainability problems (see Caniglia *et al.*, 2017 for clarification). The selection for experiments - including terms such as pilot project, demonstration project, proof of concept, and test project - was derived by the explicit articulation by respondents using the term "experiment" (and related concepts). Further, through coding, green infrastructure experiments also included non-routine novel practices aimed at redirecting normal governing, operations, management, and implementation procedures and are carried out by state or private actors with the desired or stated purpose of:

- Improving baseline understanding of a green infrastructure intervention (Luederitz *et al.*, 2017; Bulkeley *et al.*, 2019); or

- facilitating learning-by-doing or doing-by-learning using green infrastructure intervention (Nevens *et al.*, 2013); or
- Explicit improvement of actor arrangements with green infrastructure intervention; or
- Explicit improvement of green infrastructure development protocols (Luederitz *et al.*, 2017).

Using Caniglia *et al.'s* (2017) typology served to help construct codes with an explicit aim of sustainability experiments as solutions, broadly supportive of providing a better understanding of the processes to deploy experiments; provide prescriptions offering guidance into preferable options connected to visions or goals; and supports the synthesis of options for improved conformity. The key informants, in the cases, identified experiments they have engaged with or stand out as examples locally and regionally. Further, key informants were probed to identify the purpose or benefits available when using an experimental framing to deploy green infrastructure. Collectively, the data supported an understanding of the way green infrastructure experiments are used as strategic tools to enhance or further embed interventions in urban areas.

Two rounds of rule-based structured coding were applied (Saldana, 2009) and a third round of concept building was conducted (see Appendix G). The first round of coding was designed to support initial coding strategies to become familiar with the data, but still categorize data based on the underlying processes, actions, or outcomes of experiments. Saldana suggested that process coding is useful for sifting through data and capturing short phrases that describe outcomes or actions. Although short text pieces were scanned for, the preceding and succeeding text chunks were captured and coded for. This provides rich descriptions of those actions and outcomes for the next coding phase, along with manifest content, such as the name of an experiment or the broad purpose (i.e. stormwater control). The codes focused on understanding the actors involved, the tangible product, the way experiments are supported or resourced, and finally any opportunities to understand how experiments may be evaluated or measured for success (and failure).

Following this the second phase of structured and axial coding (Saldana, 2009), guided by the framework of Caniglia *et al.* (2017) was used to structure the codes and understand the products or physical outcomes of experiments; the processes or conduct of pursuing experiments; and the way experiments are presented to align or offer clear connections to existing contexts. Following this the third phase of concept building was conducted focusing on latent level data to support a clear

opportunity to address the reach question, “how can experiments be mobilized as a strategic intervention to embed green infrastructure in urban areas?”

2.4 Limitations of methodology

The research approach guiding this paper has serval limitations which do not allow for the generalizability of results and finding but provide critical examples and context-specific outcomes that offer space for interpretation and application with caution and awareness of short-comings. Below the shortcomings are discussed further.

2.4.1 Limitations of cases and data sources

The selection of the two case study sites may limit the generalizability of the data, however, the goal of the project was to pick critical cases to compare and offer lessons and outcomes in those unique settings (Patton, 2002). Using two different cases was not intended to offer generalizability for other contexts (Stake, 1995). Instead, the purpose is to study or show how issues or a topic of focus are experienced in these two different cases (Baxter and Jack, 2008) with the intent of providing a selection of topics to further support understanding of green infrastructure (Torrens *et al.*, 2019). Further, two cases were selected due to the limitations of research resources available, this means that the combination of financial resources, time, travelling, and availability of researchers and informants collectively limited the opportunities available (Patton, 2002). Including additional cases would have been a challenge as the current program would have been extended or in the short-term an increased number of researchers to share in conducting interviews and analyzing data may have been needed.

The second limitation pertains to the selection of key informants and may be criticized for the sampling biases of experts and their underlying biases in presenting green infrastructure governing arrangements. However, the purpose of this research was to provide rich descriptions (or answers) and engage in deep conservations with those particularly involved in various aspects of green infrastructure development in each case. Certainly, the role of private citizens who may engage in personal or community programs was missed because only actors from formally recognized organizations were purposefully selected. Combined with snowball sampling it is clear that the selection of actors was narrowly identified and relied on communications or advertising mechanisms encouraging of outreach and engagement with the public. Moreover, institutional memory plays a critical role in advancing on sustainability and green infrastructure-related actions. However, the opportunity to speak to retired champions important in shaping early projects and instilling the

sustainability-orientation in local and regional government, as well as pioneering programs and action undertaken by CSOs and local businesses was missed and unaccounted for. Nevertheless, the aim is to provide information-rich data (Patton, 2002) that allows for a clear understanding and depth of understanding of how these particular actors engage with green infrastructure more recently.

2.4.2 Limitation of the case study approach

It is important to recognize the limitations of the methods used to frame the research activities. First, the use of semi-structured interviews may be critiqued on three grounds. First, local government and government-connected representatives would be unwilling or hesitant to provide complete information when a topic or subject emerged that may have been regarded as controversial, singling out specific actors (e.g. assigning blame), or speculative. Further, private actors similarly may have been hesitant to openly discuss their relationships with other actors, inhibiting a better understanding of how relationships may be hindered. A second shortcoming is the use of semi-structured questions, whereas closed and structured questions are efficient at obtaining information to provide objective facts (Kitchin and Tate, 2000). Semi-structured questions may lead to conversations being overtaken by mundane and irrelevant information. In both instances the answers cannot be measured, therefore all answers must be viewed as relevant and significant, reducing objectivity or the ability to build verifiable facts. Finally, this research is limited because of the use of one data source - transcripts. However, as described in the previous sub-section, the purposive selection of informants was undertaken to identify key actors involved in the development of green infrastructure in each case.

The research intended to enrich understanding of how green infrastructure is undertaken by practitioners, extract deeper meaning and understanding of how practitioners have pursued development and innovation with interventions. This means that their responses were elicited to draw upon the rich expertise across practice, policy, and research in each case. It should be noted, the purpose of this research was to interpret the engagement these experts have had with green infrastructure development, less of concern was the codification of standardized procedures and regulations used to guide development. These items were certainly used to support the researcher in understanding the context and past projects important in facilitating engaging discussion and pushing forward the opportunity to discuss concepts relevant to green infrastructure governance. Further, the importance of guidance, procedural, and regulatory documents are recognized in establishing a foundation and justification for each actor to direct green infrastructure: though the ultimate objective

was to strengthen the voices, actor interactions, development processes, and outcomes of green infrastructure network building.

Another set of critiques relates to the use of qualitative content analysis for data analysis due to the lack of objectivity and replicability in findings and data procurement. First, content analysis has been viewed as a quantitative exercise providing an objective and clear representation of meaning in the text (Hsieh and Shannon, 2005; Cho and Lee, 2014). However, the changing utilization of content analysis provides a qualitative-oriented stream to aid in searching for particular themes or allowing themes to emerge. This may be criticized because interpretative techniques to search for underlining meaning in the text may not be reproducible. Further, the object of inquiry is less bounded when searching for larger text passages as opposed to clearly defined objects of inquiry (e.g. word frequency, similar words). Finally, only one coder was used to scan transcripts and draw out themes and interprets the text. It remains to be seen if an additional coder(s) would have found radically different results.

Chapter 3

Governing with multi-actor arrangements: Developing green infrastructure for urban sustainability in London, UK and Toronto, Canada

Abstract

Green infrastructure is a suite of tools that can be utilized to address multiple urban sustainability challenges. This article demonstrates the role of private actors contributing to and shaping the development of green infrastructure in two urban contexts. Using 51 semi-structured interviews in the Greater Toronto Area (Canada) and Greater London (UK), the study examines the governing approaches used by multiple actors for the development of green infrastructure. Findings indicate that government, civil society, business, and business networks all play a role in the development of green infrastructure, through physical implementation, technology innovation, or capacity and partnerships building. Increasingly, however, private actors are revealing strong independence by actively leading and steering action directly connected to green infrastructure development. This work advances green infrastructure governance literature by offering a cross-case study to extract the approaches that may direct the development of green infrastructure in urban areas by private actors.

3.1 Introduction

Sustainability challenges such as climate change are increasingly exposing the capital, infrastructure, and resource deficits in urban areas. These deficits directly impact social, economic, ecological, and technical systems (McCormick *et al.*, 2013). The solutions to these challenges will require coordination amongst multiple societal actors since no single actor controls decision-making processes, possess all the knowledge, or can identify all viable outcomes (Glasbergen, 1998; Kooiman, 2003). Private actors, such as civil society organizations (CSOs) businesses, and business-related organizations are important because of their ability to traverse contexts, scales, and jurisdictional barriers. Further, these actors may add novel insights and expertise to the ongoing sustainability efforts of public actors such as local government, providing innovation independent of public actor programs (Kundurpi *et al.*, 2021). Private actors (private sector, third sector, etc.) are presented here as a heterogeneous group of non-state actors actively steering and delivering services for government or independently to accomplish organizational mandates (see Pattberg and Stripple,

2008; Glasbergen, 2011; Abbott, 2012 for details). Private actors are important to include in efforts to address sustainability, as multiple urban problems will require innovative tools and practices that are co-designed to better confront the diverse needs of urban agents and expand the portfolio of solutions (Bulkeley, 2016).

Green infrastructure (GI) encompasses a suite of interventions that address many sustainability challenges, while also integrating (when appropriate and required) multiple actors to shape and direct action for improved sustainability outcomes (Faivre *et al.*, 2017; van der Jagt *et al.*, 2019). Green infrastructure is a network of natural and semi-natural features both existing and constructed landscapes (e.g. woodlands, wetlands) and physical elements (e.g. green roofs, street trees), which provide multifunctional services and benefits to human, technical, and ecological systems (Benedict and McMahon, 2002; Angelstam *et al.*, 2013; Lovell and Taylor, 2013; Matthews, Lo and Byrne, 2015). Questions, however, remain regarding the processes and mechanisms used to steer green infrastructure development or more simply, understanding who develops green infrastructure in cities and with what purpose or intention (Buijs *et al.*, 2019). This steering process and the actors that participate is the domain of governance.

Governance is a term used to describe multi-actor coordination and decision-making aimed at solving collective action problems (Jessop, 1998; Newell, Pattberg and Schroeder, 2012). From a green infrastructure perspective this means that government, CSOs, and other actors contribute to some aspects of designing, developing, and implementing green infrastructure in cities (though not always equally) (Young and McPherson, 2013; Carmichael and McDonough, 2019). Governing conditions are largely shaped by local government, planning and development experts, or public utilities dictating the type and degree of green infrastructure required to support traditional grey infrastructure and engineered systems (Carter and Fowler, 2008; Finewood, 2016; Harrington and Hsu, 2018). A more holistic approach, however, is emerging which includes a variety of green infrastructure elements that contribute to improving various aspects of unsustainability, explores the potential for multifunctional benefits, and shifts away from green infrastructure as a grey infrastructure complement alone (Hansen and Pauleit, 2014). In this strand of literature, green infrastructure is presented as an opportunity to actively build green networks that require the inclusion of multiple actors shaping and *using* green infrastructure (Buijs *et al.*, 2019).

Although the literature has significantly advanced the discussion of green infrastructure development in urban areas and started to explicitly address the governing implications, there is an

opportunity to better elucidate the actors that intentionally shape and re-orient urban areas for green infrastructure development. Ultimately, this paper contributes to the research on green infrastructure governance by providing insight into governing modes undertaken by non-state, private urban actors, more specifically, businesses, CSOs including, for example, community groups, and research organizations. This is important to deepen the understanding of how governing processes and action pathways create robust urban governance strategies for further green infrastructure development (see Albert *et al*., 2019). The examination of how urban actors formulate priorities and collectively navigate governing arrangements is important to create a comprehensive understanding of green infrastructure governance.

Using 51 semi-structured interviews with 54 green infrastructure experts (i.e. local government, CSOs, business-networks, and businesses), this paper aims to identify how multi-actor governance addresses green infrastructure development in each urban region. The research question is how can private actors lead green infrastructure development; and leverage their expertise to navigate multiple governing modes? This paper is organized as follows. Section 2 presents a literature overview to understand collaborative governance and modes of governing in practice. Section 3 presents the methods of the research project, identifying the case study selection, utilization of semi-structured interviews, and the coding criteria for analysis. Section 4 provides a concise description of the results, organized by the modes of governance framework identified in section 2. Section 5 explains the relationship between governing modes and green infrastructure development. Finally, section 6 concludes the article and presents future pathways to develop research for green infrastructure governance.

3.2 Literature review: Collaborative governance for shaping urban sustainability governance and green infrastructure governance

3.2.1 Governance, collaboration, and sustainability

Collaborative governance is a deliberative process of shared decision-making among multiple societal actors such as governments, the business sector, CSOs, and citizens (Emerson, Nabatchi and Balogh, 2011). This slightly diverges with other interpretations suggesting collaborative governance as an ideal type of governing (Ansell and Torfing, 2015); exclusive to inter-departmental government coordination (Vangen, Hayes and Cornforth, 2015), or government-led engagement with non-state actors (Ansell and Gash, 2007). Nevertheless, key features reflected through the broad representation

of collaborative governing aim to build governing networks and shape knowledge creation in helping to support alternative government arrangements that better capture the expertise and needs of each actor (Baird, Plummer and Bodin, 2016; Lupova-Henry and Dotti, 2019). Examples of key policy issues that have shifted to reflect the collaborative approach to governing include environmental protection and climate change (Glasbergen, 1998; Bulkeley and Betsill, 2005). In both cases, a greater understanding of problems and solutions have shifted governing from command-and-control styles of decision-making and policy development to multi-actor decision-making and program delivery (Rhodes, 1996; Jordan, Wurzel and Zito, 2005). On one hand, private actors, share in decision-making, navigating their interests to achieve internal organizational goals, while simultaneously (and ideally) contributing to larger societal outcomes (Kaine, Andresen and Haas, 2014). On the other hand, government continues to play a critical role in providing the necessary conditions and support for these collaborative arrangements and engagement in diverse partnerships to advance strategic interests (Bäckstrand *et al.*, 2010).

Private actor governing expose tensions related to unelected and unaccountable organizations shaping policy (Bäckstrand *et al.*, 2010); coalition building and interest-driven processes favouring particular agendas and actors (Jessop, 1998; Kaine, Andresen and Haas, 2014); and the legitimacy to meaningfully integrate multiple actors throughout steering and program delivery processes (Bäckstrand *et al.*, 2010). Two strands of thinking may help alleviate these tensions - first revealing the contribution of private actors in shaping particular issues or participating in solutions may explain why and how they are supporting actions that are well within the institutional boundaries of urban sustainability programs and innovation development. Second, the focus from the national level to urban areas has elevated cities as active agents re-orienting their positions nationally (Pierre, 1999), as sites of entrepreneurship and innovation (Ernstson *et al.*, 2010). The shifting nature of cities is mediated by multiple tensions that emphasize the importance of multi-actor governing arrangements (Pierre, 1999) to address complex and undefined problems deeply connected to (un)sustainability.

The shifting contents of societal decision-making and policy delivery require an examination of who participates and with what purpose. This may contribute to a better understanding of how private actors shape sustainability-related outcomes and uncover novelty in governing systems. Modes of governance are used to analyze the application of techniques to steer outcomes in collective decision making, aiming to identify actors, instruments for steering, and objectives (Castán Broto and Bulkeley, 2013). Concerning private actor steering, Bulkeley and Castán Broto (2011) provide

guidance with three modes of governance to understand how private actors shape and participate in urban climate change mitigation decision making and action (see table 3.1). Using these modes as guidance and adjusting to better align with broader sustainability-oriented solutions may support an understanding of how private actors advance societal outcomes and goals, such as the development of green infrastructure in urban areas.

Although the work of Bulkeley and Castán Broto (2011) is largely rooted in climate change adaptation and mitigation fields, utilizing modes of governance for studies of sustainability may be useful in helping uncover private actor governing. Moreover, the typology presented by Bulekley and Castán Broto diverges slightly, in language, from more familiar modes presented by Kooiman (2003), Glasbergen *et al.* (2007), and Lange *et al.* (2013) all of which default to the nation-state as the object of focus. Certainly, Bulkeley and Castán Broto do not ignore the role of the state, however, non-state, private actors while partially bound to the programs, rules, and structures of state actors, are required to search for mechanisms and define processes and practices that allow them to innovate where state institutions fail or are limited, allowing private actors to address or fill gaps with their strengths and organizational priorities or core mandates. Further, this typology from Bulkeley and Castán Broto seems to reflect interactive governance (see Kooiman 2003; Lange *et al*., 2013) whereby the constellation of actors pursue networks and partnerships to direct decision-making and problem-solving, as opposed to more traditional modes directed by government or market actors alone. The contributions of Bulkeley and Castan Broto's modes offer a flexible lens to view private actors operating dependently and independently of local government, reframing private actors as the object of focus.

Addressing sustainability-related issues requires collective action due to the cross-sectorial, cross-actor nature of the problems that contribute to unsustainability (Bulkeley, 2016). The value of understanding the role of private actors may contribute to elucidating how they direct sustainability programs and contribute to policy outcomes (Mattijssen *et al.*, 2018). Private actors can act across multiple scales (Mell and Clement, 2019), alter community perceptions of sustainability (Bendt, Barthel and Colding, 2013), and complement government programs (Mell, 2014).

Private actors can traverse spatial, institutional, and administrative scales[1] to work across multiple levels (i.e. boroughs, wards, neighbourhoods, etc.) to ensure appropriate application of actions,

[1] Cash et al. (2006) recognize the importance of cross-scale interactions in shaping particular outcomes in ecological systems. More over, they distinguish between scale and levels, recognizing levels as the specific

designing policy, or engaging other stakeholders. Further, they facilitate the improved design of policy and programs that are more attuned to the needs of local community members identifying specific local needs (Kythreotis and Jonas, 2012) and integration of multiple user perspectives (Pauleit *et al.*, 2019). Also, private actors can alter urban sustainability governing by engaging other actors to participate in contributing to developing opportunities for alternative sustainability practices beyond the status quo or normal manner of practice (Eizenberg, 2012). Here, private actors exercise their expertise and leadership to capacitate others, reorienting perspectives and understanding of an issue, utilizing coercion, or using nudging strategies to improve lessons or understanding of how less-connected actors may use spaces and interventions to conform to their needs. Finally, governing is not performed in isolation, but is instead a co-operative, though uneven, processes of societal steering. Working within the lines of governing proposals related to meta-governance (Jessop, 1998), and "shadow of the hierarchy" (Bäckstrand *et al.*, 2010), private actors may be viewed as contributing to complementing local government in their efforts to fulfill programs and objectives. Simultaneously, private actors can align or advance their programs to increase reach and impact. Overall, private actor-led governing balances the opportunity for more actors to share in the development of policy and programs and confront issues that are beyond the remit of the local government. Building off this it may be beneficial to probe deeper to understand how private actors are important in directing the contents of policy issues.

Table 3.1 Private actor modes of governing

Mode	Description	Example	Strength	Weakness
Self-steering How do private actors lead and directly implement GI?	Private organizations use soft policy instruments aimed less at coercion and more on persuasion, such as target setting; benchmarking; to initiate changes to practices in organizations or communities"	Demonstration projects or voluntary target program (i.e. contribution to urban tree canopy); community garden programs;	Private actors lead and demonstrate leadership; can steer outcomes; dynamic and responsive	Does not require participation from other organizations, may result in low visibility
Mobilization How do private actors enable other actors to participate in GI development?	Private actors lead efforts and connect with other organizations (public or private) to develop information or education campaigns or aid in building the capacity for other actors to pursue particular actions.	Community gardening programs; adopt a tree program; support tree planting on high-street	Partnerships allow for an opportunity to scale out tested and understood practices to shift behaviours	Difficulty maintaining momentum; successful outcomes important to sustain interest and promote

units within scales. This means that, spatial scales range from urban city-region levels, to finer neighbourhood divisions.

				future development and participation
Private-Public partnering How do private and public actors collectively implement GI?	Both public and private actors aim to build or provide the infrastructure or services necessary to achieve outcomes or alter practices.	Tree planting on private property to support urban tree canopy targets; devolve responsibility for parks and open space management	The partnership has the potential for high visibility and impact	Potentially limited funding or other resources may not set incremental goals
Adapted from: Bulkeley and Castán Broto (2011)				

3.2.2 Urban green infrastructure governance

The literature on green infrastructure governance is emerging and diverse, with a particular focus on the type of interventions applied to specific problems. Research and studies have uncovered the governing actors and policy tools used to shape and direct green infrastructure development (Finewood, 2016; Fitzgerald and Laufer, 2017; Harrington and Hsu, 2018; Johns, 2019). This strand of literature situates government and associated technical-experts as critical actors implementing green infrastructure, focusing on stormwater management practices (Johns, 2019) or projects related to land-use and green space development from a technical lens (Young and McPherson, 2013). Government across levels, regulate, implement, and enable green infrastructure development physically installing or capacitating others through education, knowledge exchange, and incentive programs (Young and McPherson, 2013; Harrington and Hsu, 2018).

Another set of literature focuses on private actors directing green infrastructure development through a more holistic lens. Here, green infrastructure interventions (e.g. tree and vegetation planting) are used for urban gardening, parks and green space management, and even human-nature (re)-connectivity (Buijs *et al.*, 2019; Pauleit *et al.*, 2019). In these cases, diverse actor groups define problems, develop solutions, and navigate physical-urban spaces to fulfill actions and implement green infrastructure interventions for issues beyond the perceived remit of local government or work to complement local government goals (Spijker and Parra, 2018; Buijs *et al.*, 2019). The inclusion of more actors into decision making and action steering may expose multiple visions of green infrastructure's purpose, application, and implementation.

Another emerging stream of green infrastructure governance literature situates green infrastructure development in the context of specific urban-focused professional disciplines and private sector actors such as landscape planners, urban planners, or landscape architects to articulate key actors

necessary to better shape, define and expand green infrastructure elements and outcomes (Matthews, Lo and Byrne, 2015; Albert *et al.*, 2019; Mell and Clement, 2019). The collective body of green infrastructure governance demonstrates the active role of multiple governors to steer and deliver development for diverse and potentially intersecting outcomes.

Elucidating the actions of private green infrastructure actors may contribute to an understanding of potential pathways for further development. On one hand, core government responsibilities contribute to diverse projects ranging from green space and tree-planting programs to highly engineered stormwater infrastructure collectively expanding the green infrastructure network (Conway and Urbani, 2007; Young and McPherson, 2013; Fitzgerald and Laufer, 2017). On the other hand, private actors contribute to development by working with local government (Buijs *et al.*, 2019), or independently to address gaps in green infrastructure development at multiple spatial scales (Opdam and Steingröver, 2018). Further exploring the governing processes may contribute to opportunities to improve understanding of private actor-led steering outcomes of green infrastructure development. In the sections that follow this paper demonstrates the increasingly powerful role of leadership, steering, and delivery undertaken by private actors to develop green infrastructure interventions in urban areas. More specifically, private actors will be shown to offer expertise and pathway alternatives to government programs, while simultaneously partnering with government (and others) to fulfill urban development mandates.

3.3 Methods

This case study analysis aims to reveal how private actors govern green infrastructure development in urban areas (Yin, 2014). Using an interpretive approach requires understanding multiple private actors associated with green infrastructure development, and the construction of meaning and different experiences (Lincoln and Guba, 2000; Patton, 2002). Further, an interpretive approach is supported through deductive content analysis of empirical data, relying on a theoretical framework to support the search for content, meaning, and perspectives (Elo and Kyngäs, 2008; Cho and Lee, 2014; Finfgeld-Connett, 2014).

3.3.1 Case study overview

The Greater Toronto Area, (Toronto) Canada and Greater London (London), UK were selected for this study because they are two large city-regions that have demonstrated sustainability leadership in areas such as climate change action (Mees and Driessen, 2011) and green infrastructure development

(De Sousa, 2003; Conway and Urbani, 2007; Carter and Fowler, 2008; Spijker and Parra, 2018). Differences exist in governing structures nationally and sub-nationally, economic recognition globally (i.e. London as a global economic hub), and seemingly conflicting urban spatial development goals specifically, urban sprawl focused development in Toronto and urban densification in London (Frisken *et al.*, 2000; Kipfer and Keil, 2002; Tallon, 2013). Nevertheless, these city-regions are the largest by population and share features that have shifted the purpose of urban governance (i.e. entrepreneurialism, investment, and regeneration) (Kipfer and Keil, 2002; Bellas and Oliver, 2016; Fussey, Coaffee and Hobbs, 2016; Davis, 2019). The combination of sustainability leadership and the shifting purpose of each city-region provide an opportunity for comparing each to understand who shapes green infrastructure and through what mechanisms and intent in urban areas.

In the London region, private actors have led efforts for sustainability and green infrastructure policy and practice. Business improvement districts (BIDs) (Jones and Somper, 2014), firms (Hall, 2006; Rydin, 2010) and CSOs including community-based groups (Batterbury, 2003) play a role in shaping, user preferences, policy, and advocacy efforts for sustainability and green infrastructure-related issues. In the Toronto region, private actors such as firms and CSOs play a role in shaping sustainability and green infrastructure trajectories and outcomes (Granek and Hassanali, 2006; Teelucksingh *et al.*, 2016).

In both regions, local government-led efforts, such as major policies and plans, have supported and created broad visions and guidance for sustainability-oriented actions (Rydin, 2010; Revell, 2013) and green infrastructure projects (Carter and Fowler, 2008; Johns, 2019). Local government in both regions have demonstrated an understanding of the potential challenges emerging within their jurisdiction and have attempted to design policies and plans necessary to alleviate problems and promote solutions for improved sustainability and green infrastructure outcomes (Momm-Schult *et al.*, 2013; Johns, 2019).

3.3.2 Data collection and semi-structured interviews

The unit of analysis for this study are private actors involved in green infrastructure development, specifically leading, mobilizing, or partnering to implement or guide development. Purposive sampling was used to identify "green infrastructure stakeholders" using a web-based search of local government units and private actors (i.e. firms, business improvement districts, CSOs, voluntary organizations, community development organizations, etc.) involved with green infrastructure development (e.g. urban forestry, storm-water management, public realm design, etc.). These actors

were selected as they could provide details of how their organization contributes to green infrastructure development with or as private actors. Snowball sampling was further utilized to obtain contacts of local government and private actors identified as important from interview informants. A total of 51 interviews were conducted with 54 key informants (see Appendix D). In Toronto, a total of 29 interviews were conducted, with five businesses, six civil society organizations, and 18 local government or government-related organizations. In London, a total of 22 interviews were conducted, with six businesses and business-related organizations, eight civil society organizations, and eight local or regional government organizations. Appendix C provides a detailed list of interview key informants. This project has received ethics approval from the University of Waterloo's office of research ethics. Interview informant names and organizational affiliations are not included to protect identities and satisfy confidentiality requirements.

Semi-structured interviews were conducted in-person or telephone from January 2018-June 2018. The structure of the interview questions was designed to probe each informant to think about how their organizations contribute to the development of green infrastructure; their relationship with other green infrastructure actors in their city-region; and the purpose or intention of partnering or coordinating development with other green infrastructure actors. Interview lengths ranged from 30-90 minutes. All interviews were audio-recorded, then transcribed verbatim, and coded using NVivo 12 software.

3.3.3 Deductive framework for analysis

Using the framework discussed in section 2.1, Bulkeley and Castán Broto (2011) use modes of governing to describe how private actors can contribute to the development of infrastructure, services, and policy all critical to shaping sustainability-related actions and decision-making. Green infrastructure is fundamentally related to the construction and physical implementation of interventions (trees, green walls, vegetation, bioswales, retention ponds, etc.). The application of this framework to green infrastructure development in urban areas is used to understand how governing actors utilize various modes to achieve green infrastructure -related outcomes. Further, this framework allows for the emergence of themes that will contribute to understanding the purpose of pursuing green infrastructure actions.

Two rounds of coding were applied to the data, then a round of concept building (see Appendix E). The first round sought to broadly capture and categorize actors based on a traditional understanding of a modes of governing framework developed by Lange *et al*. (2013). Using the five categories

actors were separated based on capturing how actors navigate development independently or collaboratively. Second, using the three modes developed by Bulkeley and Castán Broto (2011) the categories from the previous step were reanalyzed and coding rules adjusted to fit within the context of green infrastructure actions, for example, observing who was involved and their role in pursuing or accomplishing an action. Finally, a step of concept building was applied, to more clearly articulate, who was involved, the purpose of an action, and the outcome of that action for each of the three previous categories. This reflects a more inductive approach, whereby themes emerge, though as an iterative process and structured based on a framework to build out themes and then collapsing or merging themes to create a more refined understanding of green infrastructure development (Elo and Kyngäs, 2008). Collectively, the goals of analysis were to better refine how private actors specifically, are leading, mobilizing, or partnering, and highlighting specific actions that contribute to green infrastructure development (see Appendix E).

3.3.4 Limitation of methods

The limitations of this research are acknowledged based on two broad themes, research conduct (i.e. time and fit) and qualitative research processes. First, research informants had limited time and resources to allocate to this research program, which sought to solely extract knowledge and experience. Recognizing the extractive, unidirectional knowledge exchange, the interview lengths and the data desired had to be respectful of the time allocated and the lack of formal relationship built between researcher and informant (Patton, 2002; Longhurst, 2010). This limits the type of questions asked and the depth of inquiry or at least requires interpretation of non-verbal cues and gestures by the researcher to recognize uncomfortable questions and abandon a line of questioning that may be important (Longhurst, 2010).

Second, using qualitative research methods may be critiqued for the subjective experience, lack of replicability, and struggle for generalization (Kitchin and Tate, 2000; Hsieh and Shannon, 2005). However, the goal of this project was to focus on two leading cases and offer a range of converging experiences. Replicability would not be possible without the same line of questioning with the same set of informants, as this form of research seeks to construct and interpret a range of experiences and voices (Lincoln and Guba, 2000).

3.4 Results

Private actors play a critical role in steering green infrastructure development in both city-regions. When utilizing the private modes of governing framework (see section 3.2.1), it becomes clear that a private actor may be able to traverse multiple roles. First, the category of the self-governing mode reflects organizational alignment (i.e. responsibilities, core mandates, etc.) to lead or leverage other organizations to support development. Mobilization modes describe private actors enabling other actors to develop or interact with green infrastructure through education, capacity building, and incentives. Finally, private-public modes are partnerships between private actors and government aiming at physical development or fostering conditions for green infrastructure development. The remainder of this section presents the results, highlighting the key attributes offered by private actors in steering and delivering green infrastructure development in each city-region.

3.4.1 Private actor-led green infrastructure development

In the Toronto-region, environmental and community CSOs (1.TO; 22.TO; 23.TO), and green infrastructure-oriented firms (9.TO; 28.TO), were viewed as critical actors supporting green infrastructure development in the region (12.TO; 13.TO). CSOs and firms utilize a combination of routine green infrastructure development practices and innovative programs to promote the benefits of urban nature (23.TO; 24.TO; 26.TO). Private actor programs such as tree and vegetation planting (8.TO; 16.TO) and demonstration projects show experts and non-experts alike (e.g. private residents, other organizations, and government) how and why green infrastructure interventions are beneficial. The primary purpose is to build green infrastructure and fulfil organizational and contractual obligations. Interactive opportunities with specific green elements such as parks, gardens, and green spaces further allow private actors to demonstrate their contribution to urban sustainability outcomes (7.TO; 19.TO). Private actors use projects to strategically position their organization as experts, tangibly advertising their capabilities to improve urban outcomes (14.TO; 26.TO; 28.TO).

Also, business improvement associations (BIAs), other CSOs, other businesses, and government were highlighted by private actors as important to leverage for resources, skills, and access spaces (10.TO) and apply innovative techniques (19.TO; 21.TO; 28.TO) to push green infrastructure projects beyond routine and core organizational duties. This is important as it shows how green infrastructure development requires the intermediation of multiple organizations designing and developing to advance programs and processes. This then allows for further evidence and knowledge to support

policy re-development (9.TO; 20.TO; 27.TO), as noted by one Toronto green infrastructure manager regarding the importance of private actor leadership:

> "…he raised the funds and started this huge campaign. Got 21 people to build these rain gardens. He taught them how to do it. He did workshops in the public library. So much of that can be done with these local champions" (25.TO).

In the London-region, CSOs (1.LO; 3.LO; 14.LO), firms (7.LO; 21.LO; 22.LO), and business improvement districts (BIDs) (10.LO; 11.LO; 12.LO) were significant contributors to the development of green infrastructure. CSOs, firms, and BIDs would develop green features on a combination of public and private lands, working with various actors, such as firms (1.LO; 20.LO), residents association (13.LO; 20.LO), estate associations (13.LO; 20.LO), and local government (14.LO; 20.LO) to leverage resources such as knowledge (1.LO), capital (6.LO), labour or volunteers (14.LO), and access to land (6.LO; 7.LO; 14.LO).

Firms, in London, use green infrastructure as community development tools to target youth, immigrants, under-skilled people, and other communities (20.LO; 21.LO; 22.LO). In this case, green infrastructure installation is the mechanism that generates each firm's income. However, the delivery of green infrastructure is also used to promote improvements to the social sustainability of the community (schools, immigrant centres, neighbourhood, borough). Examples of how green infrastructure development contributes to community development can be seen in areas such as the development of skills and training opportunities (7.LO; 21.LO; 22.LO), relationships to foster further green infrastructure development (7.LO; 21.LO), and community well-being improvements through the advancement of individual life skills and employment training opportunities (1.LO; 21.LO; 22.LO).

Business improvement districts (BIDs) have emerged as novel contributors to the development in boroughs in London. The role of BIDs as green infrastructure delivery agent's fits into narratives of place-making; however, this has not limited green infrastructure development to aesthetic-centric features. Innovative measures have been BID-led with collaboration from businesses, local authority, and CSOs to test drainage systems and green walls for example (10.LO; 11.LO; 12.LO). The benefit of BID-led projects is their ability to obtain funding from diverse sources, partner with local government, and contextualize borough specific needs (7.LO; 16.LO; 17.LO), as one London green infrastructure informant noted about the role of BIDs for green infrastructure:

> "And so they [a BID] funded the green infrastructure audit of Brixton. And highlighted an opportunity to build an orchard...those sort of documents and procedures are important" (7.LO).

Across both regions, self-steering still requires partial alignment with other organizations reflective of complementary expertise and resources, as well as familiarity and trust (1.TO; 10.TO; 1.LO; 3.LO). The emerging challenge with private actor-led green infrastructure is the ability (as desired by clients and funders) to provide novelty or capture a well-defined area of expertise, in the context of an oversaturated market of green infrastructure-related service providers (1.TO; 15.TO; 1.LO). Certainly, it is recognized that partnering with others may advance novel interventions (14.LO), however, it is difficult as the outcomes are uncertain and allocation of time and money must be spent and advanced on items to continue operations (7.TO; 3.LO). So, while partnering to advance green infrastructure has been accomplished, private actors continue to primarily pursue green infrastructure development independently, partnering only when a confluence of resources and expertise align and the nature of the project facilitates experimentation, with organizational resources less committed (1.TO; 7.TO; 29.TO; 1.LO; 3.LO; 7.LO).

In both regions, private actors recognize and embrace their role as change agents by innovating and delivering green infrastructure (see table 3.2). Though keen on developing networks and delivering green infrastructure, private actors are constrained by various resources (7.TO; 7.LO), budgetary limitations (29.TO;11.LO), land access (14.TO; 14.LO), and knowledge gaps (27.TO; 10.LO) to consistently pursue risky and uncertain partnerships. Leveraging partnerships certainly presents an opportunity to fill in gaps, however, organizational alignment must be free of risk, open to experimentation, and specific to outcomes and expectations.

Table 3.2 Self-steering mode summary

Description of mode outcome	**Selected examples of GI governing**	**Illustrative quotes**
Private actors use established organizational priorities and missions, to lead by example, installing GI and attempting to promote GI for functional and non-functional services.	<u>Organizational alignment for leadership</u> • Organizations focus resources or obtain funding to develop green infrastructure features (e.g. rain gardens; SUDS; street planting (21.TO; 25.TO; 7.LO; 11.LO; 13.LO). • Private actors use internal organizational mandate or core priorities to design and develop green infrastructure to address deficiencies in existing public sector	"… [21.TO] has been doing this for the last 30 years ahead of anybody else. [21.TO] was designing parking lots…designed it to manage stormwater way back before anybody really thought it was a problem" (9.TO). "I was really keen that we deliver sustainable drainage and be an exemplar scheme... we bid successfully for the GLA's Greener

	development mechanisms (21.TO; 27.TO; 28.TO; 4.LO; 20.LO; 21.LO). • Utilizing green space management programs and services as vehicles to improve urban sustainability outcomes such as employable skills and work to disadvantaged and marginalized communities (29.TO; 20.LO; 21.LO). <u>Steering and program delivery through leadership</u> • Utilizing resources, authority, and creativity to design innovative GI features and leveraging expertise of other organizations to deliver GI (9.TO;10.LO; 20.LO). • Leveraging relationships and contracts with other private actors to implement innovative practices. Using testbeds as an opportunity to integrate other actors (including government) to design projects including, where appropriate, long-term monitoring protocols (21.TO; 14.LO). • Demonstrating the role of private actors as intermediaries for GI development and green space management, linking diverse users, developers, and mangers (1.TO; 10.TO; 15.TO; 17.TO; 18.TO; 1.LO; 7.LO; 13.LO). • Rebuilding and developing housing and estate communities utilizing green infrastructure as an opportunity to improve well-being and integrate community members through engagement, design, and installation (7.TO; 20.LO; 22.LO).	City Fund and that enabled us to pay for the SUDS element. We managed to persuade the council that it'd be great to do SUDS and have a local exemplar project. So we got a SUDS specialists to come in and work with the architects who were already working on this" (10.LO). "A good example is a collaborative greenspace project…taking an underused hydro corridor and transforming it into a linear park that connects communities, builds local habitat, and enhances the local ecological function" (7.TO). "…[We] introduced gardening to these young dads, some of whom had been in jail. And so we started really small. I was doing some private work and the thing that really tickled me, and I felt like it was really making a difference with young dads and young mums. And kids as well" (21.LO). "…let's donate them [extra supplies] to the community garden…we do raised-bed workshops there, we've done composting workshops…a lot of time and energy and expertise to this community garden...That's our way of giving back to neighbours who can't afford our services" (26.TO).

3.4.2 Mobilizing actors for development

In the Toronto-region mobilization modes were carried out in the form of education (7.TO; 23.TO; 29.TO), awareness-raising (7.TO; 24.TO; 29.TO) and advocacy programs and partnerships (7.TO; 10.TO; 29.TO). CSOs and firms (26.TO; 28.TO) attempted to build relationships with multiple actors to push forward opportunities to advance programming aimed at developing green infrastructure with a community focus, such as engaging Indigenous People's, and artistic, youth, or new immigrant communities of Toronto (7.TO; 19.TO; 24.TO; 29.TO). This is viewed as important as non-traditional green infrastructure (and sustainability) actors are included in programing,

confronting historical deficiencies (i.e. Indigenous People's reconciliation) or attracting new actors unfamiliar with green infrastructure or offering new insights.

Further, CSOs and community-based groups have a significant role in guiding municipal efforts to improve public spaces and ensure accountability in terms of how processes of governing green infrastructure are carried out (4.TO; 10.TO; 28.TO). CSOs may lead steering committees focused on advocacy and information sharing, seen as crucial for green infrastructure-related firms (28.TO), CSOs (24.TO), and others to understand what each organization is currently engaged with (18.TO). Finally, CSOs would support businesses and business improvement areas in their efforts to maintain or construct green features (19.TO; 28.TO). Here, then, private actors are coordinating messages, actions, and expanding the gamut of potential actors, actions, and opportunities in the green infrastructure network, as noted by two Toronto-based green infrastructure managers in the CSO sector and business sector respectively:

> "The concept is about arming the community with the tools and resources to animate and activate their common public spaces and parks" (7.TO).

> That committee was committed to making the Don Valley clean, green, and accessible…and so it essentially became the father of all the other stewardship initiatives of the conservation authority as well as the other municipalities around the Toronto area" (28.TO).

In the London-region the mobilization mode was reflected in actions by CSOs and BIDs. The opportunities presented by green infrastructure development included educational (4.LO; 13.LO; 14.LO), awareness-raising (1.LO, 3.LO; 4.LO), program advancement (14.LO; 20.LO), and relationship and community building tools (6.LO; 12.LO; 20.LO). Further, private actors, including, developers and private estate owners, are beginning to understand the value of creating green spaces for amenity value (1.LO), place-making (1.LO; 10.LO), and functional improvements (2.LO; 6.LO). Utilizing partnerships with CSOs, private sector actors can tap into expertise for green space design, land-use planning, and contextually significant attributes (1.LO; 2.LO; 20.LO). In addition, the allure of corporate social responsibility and personal motivation presents valuable opportunities for private organizations to partner with other private actors to implement green infrastructure (3.LO; 20.LO), aid in plan design (1.LO; 12.LO; 13.LO), and offer land or supplies for green infrastructure-related projects (13.LO; 14.LO). Here, a clear expansion of the potential of green infrastructure is revealed

as private actors include more actors into their programs, demonstrating innovative techniques but also important purposes for conducting development.

Across both cases, it is clear that mobilizing efforts expand the nature of green infrastructure development beyond policy prescriptions and push innovative technical and non-technical advancements (see table 3.3). Most significantly, is the clear articulation of green infrastructure's purpose moving beyond traditional prescriptions of water management. Instead, green infrastructure is revealed to facilitate new actor arrangements, expand the inclusion of actors, thus revealing new purposes for application to confront issues beyond water management, climate change, and environmental sustainability.

Table 3.3 Mobilization mode summary

Description of mode outcome	**Selected examples of GI governing**	**Illustrative quotes**
Private actors lead the process of enabling, capacity building, and relationship building to better support other actors to engage with green infrastructure development.	<u>Community consultation</u> • Identifying and collecting data of the diversity of users of green infrastructure spaces (i.e. ravine networks, woodlands, urban parks, etc.) to advance development, protect spaces, or improve the design (23.TO; 29.TO; 14.LO; 3.LO; 4.LO). • Developing committees or advocacy groups to ensure local community expertise and interests are integrated into local government projects (16.TO; 28.TO; 5.LO; 6.LO; 19.LO). • Engaging diverse communities to understand how and why GI is used; or search for opportunities for them to use GI (7.TO; 29.TO; 12.LO; 20.LO). <u>Enabling partnerships for community capacity building</u> • Community-based organizations offer educational resources, training workshop, and small funding grants to other organizations (e.g. neighbourhood volunteer groups) (7.TO; 12.LO). • Long-term engagement with communities, building trust and relationships to collaboratively build or re-purpose spaces with the intent of improving a sense of place and green infrastructure (7.TO; 10.LO; 13.LO).	Our community consultation, community engagement, community connections pieces… I identified an area within the city of people that are within a certain distance from the ravines that would benefit from the use of that space…we've targeted a bunch of different types of audiences" (29.TO). "So, we need to talk to those people… Just talk to them as individuals and get a feel for what they want. It gives them the opportunity to input into the design, give their ideas, but also to let them know about the planting day. (3.LO) "…by offering educational resources, training workshops and small funding grants. Our program works to build community capacity…our staff are working directly with groups and social service agencies to build capacity, engage individuals and strengthen community ties" (7.TO).

3.4.3 Private-public alignment for development

In the Toronto-region, public-private partnerships were utilized by private actors to collaborate with local government to achieve the physical implementation of green infrastructure and build relationships to develop opportunities for future projects. Private actors support the local government as delivery agents of green infrastructure (7.TO; 14.TO; 16.TO); developers of plans, guidelines, and policy (5.TO; 10.TO; 28.TO); procurers of land-use and other green infrastructure-related data (16.TO; 23.TO); and expert reviewers for planning and policy documents (10.TO; 21.TO). This shows how private actors can simultaneously participate in both policy development and service delivery. It should be noted that local government increasingly recognizes the role of private actors in shaping and directing programs, as the relationships have been shaped over years and cultivated towards building understanding and trust of expertise, resources, skills, and delivery of contracts (12.TO; 16.TO; 21.TO) as clearly expressed by a local government green infrastructure manager:

> "Businesses deliver our services, they're actually the ones implementing all these policies for us. As much as we have a contractual relationship, we have a partnership with them…and ultimately how they deliver those services would influence how effective our policies and practices are" (13.TO).

In the London-region public-private provisions are arranged for private actors to participate in the development, maintenance, and improvement of green infrastructure (5.LO; 16.LO; 17.LO), extract benefits of partnering to leverage funding and resources (e.g. BIDs funding green infrastructure audits; CSOs utilizing government funding for air quality, drainage, greening improvements) (4.LO; 6.LO; 13.LO), and navigate land-use barriers (1.LO; 4.LO; 13.LO). CSOs can partner with local government to fulfill community development and information programs through green infrastructure development as explained by a green infrastructure manager in the regional government:

> "So they [CSOs] have a really important role to play in a lot of delivery because they're often the delivery agents for ourselves and the local authorities" (17.LO).

Similarly, firms, BIDs and CSOs can serve government interests relative to urban redevelopment and regeneration (2.LO; 6.LO; 7.LO; 20.LO). Increasingly, local authorities partner with private organizations to address problems associated with disused or underused spaces to serve as opportunities to install temporary green features (7.LO; 10.LO; 12.LO; 20.LO). Further, BIDs, have carved out a role as green infrastructure delivery agents. This arrangement provides private actors with the opportunity to access land to promote their business to the wider community; embeds

physical green infrastructure; and demonstrate the multi-functional benefits of green infrastructure to the local authority and public.

Across both cases, the extension of private actors into the sphere of public services delivery reflects the way more actors shape and direct programs (1.TO;16.TO; 16.LO; 20.LO). Further, the extended network serves to diversify programming expanding the portfolio of goals, better reflecting and connecting the visions of local government with the capabilities of private actors (see table 3.4). However, it is was noted by several local government and regional government informants the difficulty of working with some volunteer groups (23.TO; 19.LO). Through past experiences it became clear that the seemingly innocuous reciprocal agreements for access to land and stewardship of land can result in human-nature conflicts, improper use and damage to natural spaces, and poor application of invasive species management protocols (23.TO; 1.LO). Furthermore, difficulties tended to emerge from a lack of durability in relationships due to these groups acting outside of established protocols (23.TO) or the voluntary groups' lack of commitment to the management of projects (19.LO). In order to more effectively partner, local government seek-out familiar and trusted partners, such as those with well-established reputations, those who have completed projects, and of course building on past relationships (16B.TO; 29.TO; 20.LO).

Table 3.4 Private-public partnering summary

Description of mode outcome	**Common and selected examples of GI governing**	**Illustrative quotes**
Private and local government leverage resources to collaboratively develop green infrastructure	<u>Strategic partnering to enhance GI development and policy</u> • Private and public actors mutual partner to navigate barriers (e.g. regulatory, land access, administrative, financial) (11.LO; 14.LO; 19.LO). • Private actors increasingly serve as service delivery partners, offering to fulfill routine green infrastructure management needs or offering specialized services (13.TO; 16.TO). • Private actors serve as program and policy design specialists, regulatory review partners, and technical experts for guidelines and standards development (12.TO; 16.TO). <u>Complementing urban development goals</u> • Private actors can narrow in on specific issues that are under prioritized by local government such as underused space	"The city has a partnership with the foundation…the foundation has acted, to raise funds for capital projects within parks. We've recently expanded that, we are providing them with funding and they're using that to increase tree plantings. We've increased the urban forest canopy on private lands. So that, that's a huge project" (16.TO). "I think it always works better if you can set up a project with a local authority in partnership because other things come out of that as well; if they've got too of a particular plant, they give it to us and we can sort of spread it around our various networks, across our housing estate land and other parks" (14.LO).

	development, specific neighbourhood level development matters, etc. (21.TO; 21.LO). • Private actors provide extended support aligning programming to address local government priority issues (16.TO; 14.LO; 20.LO).	"[The] Council using section 106 from the sale funds, paid us to come in and build this garden…They [local council) see this as an opportunity to do things better… they are happy for an organization to come in, try and do these things" (7.LO).

3.5 Discussion: Private actor green infrastructure governing

Collaborative modes of governing may serve to enlarge the pool of expertise, spread responsibility, and diversify actions to advance green infrastructure governance in cities. Further, private actors are active leaders spreading green infrastructure development across multiple scales, acting as enablers to reshape the purpose and interactions people have with spaces, and directly shape and contribute to government mandates and programs. In this sense, discussion of private actor modes of governing reveals multiple roles played by private actors (see figure 3.1) serving to advance green infrastructure development while situating their organizational capacities in their local context.

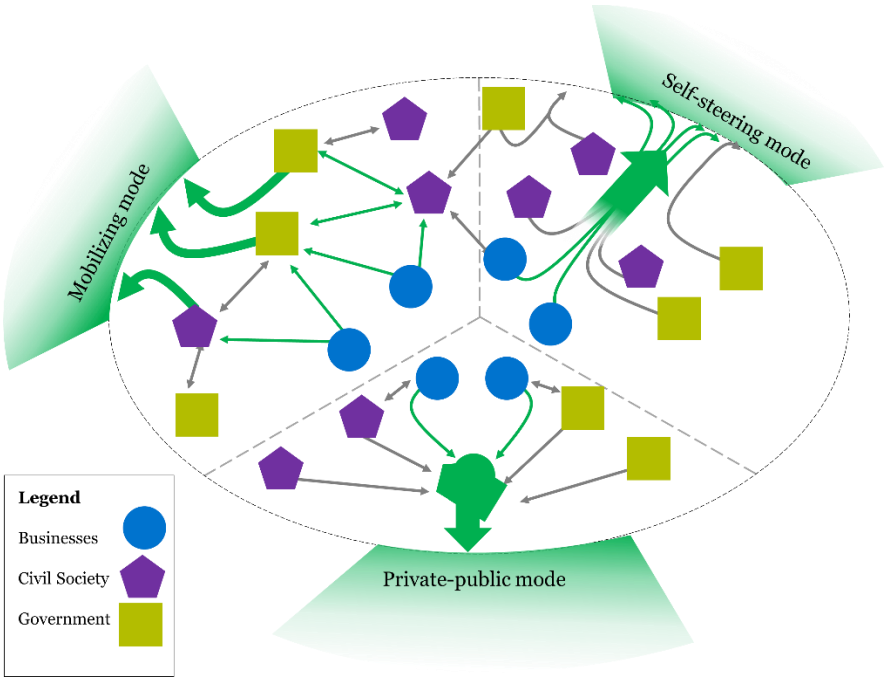

Figure 3.1 Illustration of private actor modes of governing
The figure shows the multiple governing modes private actors traverse and the collaborative nature of mobilizing and private-public modes. Self-governing modes are not absent of collaboration but highlight the interplay between leadership and supportive relationships.

3.5.1 Leadership and networking

The self-steering mode is reflective of strong leadership by private actors pursuing their core or operational priorities to advance the development of green infrastructure. These organizations are increasingly recognizing the importance of spreading green infrastructure across the city, and not simply limiting their activities to routine practices or projects. The scale of applied actions developed by private actors serves the advancement of green infrastructure development beyond government authority, enhancing the application and development of solutions in a multi-actor context. As local governments are increasingly challenged to provide services and programs necessary to improve urban sustainability (McCormick *et al.*, 2013), private actors can support community capacity building, innovative technology and practice development, and access to private and public lands. The ability to traverse multiple scales (i.e. spatial, jurisdictional, and institutional) demonstrates the fluidity by which private actors can navigate green infrastructure development. Certainly self-interested, private actors operate in a context of mutual reinforcement of organizational sustainability, alignment of capabilities with other organizations, and increasing implementation of green infrastructure.

Discussing the evolving characteristics of private actors, Wilson *et al.* (2017) illustrate four roles of private governors, of importance here, is the role of private green infrastructure actors as network builders. Network builders serve and operate within the established rules and agendas, but tailor organizational character to influence or reorient the context of the system or issue of focus. In this regard, private green infrastructure actors leverage expertise, relationships, or formal policy and legislation to intervene and develop green infrastructure or more significantly redirect the trajectory of the system with the intent of building a network with well-connected, resourced, and skilled actors. In the case of Toronto, the collection of private actors of green infrastructure development is a negotiated balance between independence and network building to leverage resources from private and public organizations. Whereas, in London, the emergence of private green infrastructure actors is a direct result of legislation (i.e. for BIDs to operate) and supportive funding mechanisms to spur green infrastructure development and allow private actors to shape green infrastructure governing networks. These findings support the work on green infrastructure development that has attempted to demonstrate the role played by private actors in leading green infrastructure implementation in cities, in areas such as community or urban gardening (Bendt, Barthel and Colding, 2013); and environmental and land stewardship (Young and McPherson, 2013).

3.5.2 Mobilizing voices

Mobilizing actions are intended to reorient or reshape places by prioritizing or aligning community development initiatives that aim to contribute to place-making - better connecting multiple societal actors to green infrastructure development opportunities and improving social and environmental sustainability. Mobilizing actions show the deep deficiencies of local government to formulate green infrastructure policies and programs inclusive of all possible governing actors. Here private actors can expose the unique configurations of green infrastructure development connected to actors and demonstrate multiple purposes to better address underlying sustainability issues in urban areas. On one hand, private actors can articulate, apply, and extract the functional attributes associated with green infrastructure development (i.e. flood protection, urban heat island reduction, etc.). On the other hand, private actors design green infrastructure programs to provide services, benefits, and experiences that aim to connect diverse users to green infrastructure features. These results conform to the literature that explores the role of green infrastructure as supporting community development (Bendt, Barthel and Colding, 2013), social cohesion (Lovell and Taylor, 2013), and place-making (Angelstam *et al.*, 2013)

Once again, Wilson *et al*. (2017) provide a degree of insight into the character of private actors and their ability to reframe debates and encourage or activate more actor voices. Private actors can work within core interests that simultaneously support and magnify issues of deep concern in local areas. In the Toronto-region organizations utilize public sites to demonstrate or allow public users to engage with nature. The ability to redefine what spaces can do for users or allow them to interact with spaces contributes to allowing users to potentially participate in decision-making and solutions development. Navigating change with an often underused set of actors to educate and build network capacity can create buy-in, motivate further action, and expand the network of participating agents. In London, organizations utilize green infrastructure to confront social sustainability and social development matters. Longstanding issues related to unemployment, space utilization, and community identity are reshaped through reorganizing the relationships between people, space, and nature. In particular, people in the communities become the agents reshaping how and why spaces and nature are needed to work for their benefits. Moreover, across both cases, the active role played by private organizations in developing trust and authority with local communities facilitates deeper and diverse input when designing policies and programs.

3.5.3 Aligning purpose

Finally, the private-public mode highlighted how private actors utilize green infrastructure development to support the delivery of local government mandates by addressing aspects of policy and plans that partially connect or require green infrastructure solutions. For example, climate change adaptation policies may encourage the need for green infrastructure interventions: though green infrastructure may not always be the priority action (Jones and Somper, 2014). As reflected in much of the literature around the public-private modes of governing each actor is committing resources, directing networks, or shaping the intention of actions to conform to their expertise and needs. The cases show how both groups are re-framing organizational understanding of the purpose, opportunities, and arrangement associated with green infrastructure development. Private and public actors pursue active and passive strategies either leveraging the skills, resources, and expertise of each other; or delegating and, to an extent, coordinated devolution of responsibility and authority to achieve green infrastructure development outcomes. This is a process of mutual alignment and relationship building, as each group seeks to identify fit and purpose within the context shaped by their organization's goals and objectives (Jessop, 1998). Combined with local government limitations related to resources and administrative powers, private actors supplement and contribute to government policy development and service delivery. For private actors specifically, this allows for the pursuit of focused projects connected to local or regional goals and visions. This, however, does not limit actions to routine client-vendor outcomes only. Instead, private actors work to demonstrate the powerful role of green infrastructure in redirecting urban form and function, community development actions, and network arrangements.

Examples of private actors serving to complement government programs are seen in London, firms and CSOs are contributing to urban regeneration, air quality improvement, and drainage management. Whereas, in Toronto, the administrative limitations of local government benefit them to support (i.e. funding, organizational resources, and internal advocacy) of private partners conducting programs to advance sustainability goals. Private governors operate within the rules and conditions for green infrastructure development but can flexibly apply and articulate positions to advance delivery, reorient policy, and advance their purpose. In both cases, the conditions of limited spaces and reduced local government budgets have provided many private actors with the opportunity to utilize temporary spaces to implement their interventions particularly aimed at improving community well-being using green infrastructure. In London, the role of BIDs and community-based organizations highlight this arrangement, as the confluence of legislation, local priorities, and creative

organizational tactics have significantly aligned district priorities with local and regional government goals and visions. Overall, the local or regional government, however, is not removed from this process. Once again, the elements of policy steering and service delivery align and overlap with both private and public actor partnering.

Adding to this discussion it is important to recognize the tensions arising from the role of private actors increasingly shaping, guiding, and participating in societal decision-making (Jedd and Bixler, 2015; McAllister and Taylor, 2015). Past literature has thoroughly highlighted the lack of opportunities for accountability, transparency, and responsibility of private actors in relation to the public sector, both broadly in the governance literature (Sending and Neumann, 2006; Vangen, Hayes and Cornforth, 2015; Boschken, 2017) and for sustainability-related action (Khan, 2013; Zeemering, 2016; Hughes and Peterson, 2018). This partially holds true across both cases, specifically the difficulty of maintaining relationships and at times the informality of relationships limiting longevity and coherence between programs for the expansion of green infrastructure. Moreover, the emergence of both formal and informal local voluntary and citizen groups using green infrastructure in urban areas adds to the difficulty in forming and sustaining relationships. As local governments are increasingly stressed financially, the emergence of local voluntary groups to act as green space and biodiversity conservation stewards, or community-gardeners for example, presents an opportunity for partnerships. However, over time competing interests between user groups, and the misalignment between the goals of local government and desired usage of space of voluntary groups emerge. This further highlights the difficulty around sustainability governing whereby the seemingly similar alignment of issues can spur cooperative relationships as well create tensions. However, as McAllister and Taylor (2015) show partnering for sustainability actions may be better viewed on a spectrum of relationships exposing the potential for conflict and mutual alignment simultaneously. This means that in the changing context of urban governing relationships, whereby private actors are needed to provide service delivery both sides need to identify goals, find alignment, and maintain an open dialogue.

Another important point that may require further attention concerning private actor green infrastructure governance is the increasing disparity between access, equity, and use of green infrastructure (Heynen and Perkins, 2005; Rigolon and Németh, 2018). Several terms have been applied to bring attention to the uneven benefits and disproportionate application of green infrastructure in cities, collectively this can be termed “green gentrification” (Gould and Lewis, 2018;

Rigolon and Németh, 2020). Green gentrification brings to light how providing green spaces or other green infrastructure that improves historically underprivileged people will not be experienced by those people, instead new residents or already wealthy areas will gain from the green infrastructure features (Heynen, Perkins and Roy, 2006; Miller, 2016). While green infrastructure research has been shown to offer benefits associated with mental health and human well-being, this may be concentrated to those areas already privileged (with green spaces) that continue to gain the most. Certainly, the field of urban planning has long-standing issues related to directing and reproducing inequality and injustice in cities (Campbell, 1996; Heynen, Perkins and Roy, 2006; Agyeman *et al.*, 2016; Anguelovski *et al.*, 2019).

Private actors may be drivers of green gentrification as businesses including property developers and some civil society groups tend to target spaces and population densities that will provide the most value financially and relative to organizational capacity (Miller, 2016; Anguelovski, Connolly and Brand, 2018; Rigolon and Németh, 2018). Civil society groups, for example, may target private property owners searching for those who have either large spaces available for planting or those neighbourhoods with a history of past success. However, as Carmichael and McDonough (2019) show, history and experiences with nature play a powerful role in the rejection, understanding, and acceptance of civil society groups attempting to re-plant or re-nature predominately African-American neighbourhoods in Detroit. On the other hand, property developers seek out cheap land (e.g. waterfronts, brownfields, underdeveloped neighbourhoods) to build-up and improve, with green infrastructure becoming a key component, either as an on-site function (e.g. water capture, rain gardens) or nearby amenity green spaces (Miller, 2016; Gould and Lewis, 2018).

Collectively then, green gentrification is driven by the interest of those directing and shaping green infrastructure. Collaborative arrangements may serve to highlight how actors require or use green (or other) spaces. Further, this demonstrates the importance of local government as an important partner in ensuring equity in access and availability of green space. Similarly, private actors can expose deep tensions in the urban system, for example, the implementation of green infrastructure to directly benefit those who need skills upgrading. In this regard, equity and access issues may be better addressed through diverse actor arrangements and with greater attention to equity and access moving to the forefront of green infrastructure development (McClintock *et al.*, 2016; Anguelovski *et al.*, 2019; Navarrete-Hernandez and Laffan, 2019).

Collectively, this section has discussed how private actors engage with multiple modes revealing entrepreneurial and independent actions to leverage resources; public-private partnerships facilitating opportunities for access to land; and mobilizing modes to create connections between green infrastructure and broader societal outcomes. In one sense, private actors work on a spectrum shifting from mobilizing community building, to strengthening the organizational reach and redefining government priorities. Recognizing the flexibility to navigate multiple modes shows how private actors are powerful agents of change capable of confronting multiple objectives and urban agendas.

3.6 Conclusion

This paper has demonstrated the role played by private actors in contributing to the development of green infrastructure. Utilizing data collected through semi-structured interviews this paper explored green infrastructure governance, by understanding how private actors- CSOs, businesses, and business networks shape and direct green infrastructure outcomes in urban areas. Private actors contribute to development by navigating multiple scales of space and authority, realign visions of green infrastructure, and supplement government programs. This paper demonstrated how private actors: work across jurisdictional and spatial scales beyond the remit of local government; expose diverse solutions and perspectives in cities creating more opportunities for expanded green infrastructure networks; and serve to enhance local government programs and goals related to sustainability-oriented policy. Future research may benefit from further applying a modes of governing framework that explores the actors, connections, and purposes of acting for green infrastructure development, with a particular focus on diverse actors shaping green infrastructure

Chapter 4

Embedding interventions for green infrastructure transitions in Toronto Canada and London, UK

Abstract

Sustainability transitions are needed in urban areas to reconfigure pathways of unsustainable modes of production and consumption. Critical to mediating transformative change is the simultaneous alteration in societal dimensions including structures (e.g. agendas), practices (e.g. interventions), and cultures (e.g. long-term thinking). Complex problems will not be solved through the application of single technologies or policies, instead, they require multiple interventions across several domains of society. Green infrastructure is one solution that has been mobilized, more prominently in recent years to address multiple urban problems. A gap remains, however, in understanding how green infrastructure becomes embedded into societal processes of urban development, particularly how interventions mediate deeper changes supportive of reconfiguring modes of production and consumption. This is important to understand because both green infrastructure and transitions literature continues to be driven by the allure of policy agendas and development of future visions as motivating change, assuming that interventions for change will follow according to the prescribed agendas and visions. Using 51 semi-structured interviews with green infrastructure stakeholders in local and regional governments, private sector, and civil society organizations, in the case-study urban areas of London, UK and Toronto, Canada this paper illustrates how green infrastructure contributes to sustainability transitions by altering structures, cultures, and practices. The results provide evidence to suggest green infrastructure interventions are the locus for reframing agendas and visions to spur more interventions.

4.1 Introduction

Green infrastructure (GI) has received increasing attention (Zupancic, Westmacott and Bulthuis, 2015; Mell, 2016) as a valuable approach to address a variety of urban sustainability-related matters such as climate change, social and community development, and infrastructure retrofitting (Keeler *et al.*, 2019). Green infrastructure is an interconnected network of multi-functional natural and semi-natural features, intentionally designed or managed to primarily benefit humans (Benedict and McMahon, 2002; Mell, 2009; Matthews, Lo and Byrne, 2015). Examples of green infrastructure are

green roofs, green walls, street trees, parks, urban forests, and water features. Green infrastructure studies often note the valuable addition of specific features to support existing "grey infrastructure" or traditionally engineered infrastructure (Tiwary and Kumar, 2014) such as bioswales to alleviate inflows into treatment facilities (Cettner *et al.*, 2014). Alternatively, research has also revealed a more holistic opportunity for green infrastructure to support sustainability gains beyond technological efficiencies, such as improving green space quality and access to enhance human health and well-being (Coutts and Hahn, 2015). As urban areas are increasingly confronted by short- and long-term tensions, green infrastructure interventions present opportunities for deployment to address diverse challenges and deliver multiple benefits. Missing, however, is an understanding of how green infrastructure practice becomes embedded into multiple dimensions of society (e.g. decision-making, knowledge and technical understanding; community development; and long-term governing) with the purpose of re-orienting urban development trajectories, serving to better align the diversity of green infrastructure solutions to confront urban problems.

The literature on sustainability transitions offers insight for shifting multi-scalar social, technical, and ecological systems towards more sustainable pathways (Loorbach, Frantzeskaki and Avelino, 2017). One framework, transition management (TM), has gained popularity due to its flexibility as a prescriptive and descriptive processes based approach to actively coordinate sustainability shifts in society, industries, and firms or understand on-going or past transitions (van der Brugge, Rotmans and Loorbach, 2005; Lahtinen and Yrjölä, 2019). This paper uses TM (see section 4.2.1 for justification) as a descriptive tool because its power is revealed as "an analytical lens to assess how societal actors deal with complex societal issues at different levels" (Loorbach, 2010, p. 168). This means that TM provides researchers with a strategic manner to outline the nature of change as mediated by the interplay of short, medium, and long-term processes associated with interventions, agendas, and visions. More specifically, the TM framework suggests that three co-evolving societal dimensions – structures (agendas), practices (interventions), and cultures (visions) (see section 4.2.1) advance or reinforce particular sustainability trajectories or opportunities (Loorbach, 2010). However, in the sustainability transitions literature the role of practices is underplayed slightly (Shove and Walker, 2007), neglecting opportunities to understand how sustainability-oriented change is shaped by the acts of doing, that is, interventions and experiments (Longhurst, 2015; Grin, 2020).

The literature on urban green infrastructure is rich with diversity on the barriers, drivers, strengths, and opportunities related to planning and development (Matthews, Lo and Byrne, 2015; Derkzen *et*

al., 2017; O'Donnell, Lamond and Thorne, 2017). Research has focused on clarifying the governing conditions that advance and hinder development (Finewood, 2016; Gabriel, 2016; Fitzgerald and Laufer, 2017; Chaffin, Floyd and Albro, 2019); the technical, performance, and economic factors; and promoting planning (Albert and Von Haaren, 2017), policy, and practitioner guidance. The transitions literature has explored green infrastructure in a fragmented manner offering insight into the role of policy and regulations (Gutiérrez and Ramos-Mejía, 2019); experiments and interventions (Liu and Jensen, 2018; Liu, Fryd and Zhang, 2019); and urban planning and governance drivers (Wamsler, Luederitz and Brink, 2014; Chelleri *et al.*, 2016). In these cases, green infrastructure is adapted to fit into existing policies and urban priorities, ensuring sustainability trajectories do not change or green infrastructure experiments are explored without a clear indication of how outcomes alter existing policy agendas. A gap then exists to better understand how the interventions serve to inform policy agendas and reframe opportunities for more green infrastructure.

This paper explores how green infrastructure development contributes to urban sustainability transitions, by addressing the multidimensional nature of change, mediated by organizing structures, societal practices, and problem framing (Grin, 2020). Using 51 semi-structured interviews with green infrastructure practitioners from local government, civil society organizations (CSOs), business and business-related domains in the case-study regions of Greater Toronto, Canada and Greater London, UK, two research questions are addressed: how can green infrastructure development become embedded in societal structures, practices, and cultures? And second, how can green infrastructure practices support the development of societal structures and cultures? This paper contributes to utilizing the TM framework with empirical insights to show how green infrastructure becomes embedded in societal systems of decision making and long-term action. The results will address how green infrastructure interventions (i.e. transition practices) are the mediating dimension serving to reshape the understanding of green infrastructure as well as the ability to interact with other infrastructure to redirect urban development trajectories (i.e. goals, agendas, and solutions).

4.2 Literature review

This literature review articulates the attributes important in shaping and steering sustainability transitions. The review below describes the theoretical underpinnings guiding system change, specifically, transition management. Next, the review provides emerging research on green infrastructure transitions as a fundamentally intervention-oriented process of designing and implementing natural and semi-natural features.

4.2.1 Sustainability transitions and transitions management

Sustainability transitions scholarship explores the interconnections of multiple systems and explains the "co-dynamics of technologies, institutions, social and economic sub-systems and related conditions in functional domains" (van den Bergh, Truffer and Kallis, 2011, p. 8) to understand how the constellation of rules, artifacts, and actor networks resist or promote change to shift towards sustainability-oriented pathways (Geels, 2004, 2019). Transition management is one framework utilized by transitions scholars to describe past or on-going transitions (Werbeloff, Brown and Loorbach, 2016) or strategically guide current systems towards more sustainable outcomes (Lahtinen and Yrjölä, 2019). As an analytical and descriptive tool, TM is valuable for understanding how and why actors coordinate, design, and utilize innovations, creating a better understanding of what sustainability outcomes have emerged (Lahtinen and Yrjölä, 2019).

Transitions are long-term and on-going change processes. TM allows for process evaluation to reflexively reorient and redirect actions, goals, and desired outcomes (Loorbach, 2010). Though much of the TM literature was originally focused on purposefully examining and reorienting national socio-technical systems, with a focus on national governments (Foxon, Reed and Stringer, 2009; Kemp and Rotmans, 2009), more recent efforts have shifted attention towards utilizing TM at urban and regional scale focusing on firms, users, industries, and sectors (Nevens and Roorda, 2014). To understand how society is shifting (or has "completed" a transition) and the actions utilized towards mediating transitions, TM broadly organizes societal change processes into three co-evolving conceptual dimensions: structures, practices, and cultures - each containing features that reinforce and protect the status quo or embed social and technical innovation in society (see table 4.1 for elaboration and examples) (Loorbach, 2010; Grin, 2020).

In brief, structures are the dominant development agendas and social institutions that steer actors and development trajectories establishing a common purpose, direction, and logic of the system (Loorbach and Rotmans, 2010). Practices, are viewed here broadly - as opposed to narrowly (see Shove and Walker, 2010) - as actions challenging or reproducing structures of the system through actionable and tangible interventions: revealing an opportunity for experiments, routine actions, and reflexive dialogue (Loorbach, 2010; Rotmans and Loorbach, 2010) allowing actors to interpret opportunity, grapple with tensions, and explore innovation. Cultures are conceptualized as spaces to shift the long-term visions and goals of society, offering expert actors an opportunity to engage in strategic discussions to re-direct modes of production and consumption over the long-term (Nevens

and Roorda, 2014) and providing an opportunity for problem definition(s) and projections (Grin, 2020). Taken together these three societal system dimensions organize the sustainability agendas of the system; the actions, interventions, and experiments that will be utilized to advance and achieve sustainability agendas; and the development of long-term sustainability objectives or visions that agendas and interventions should aspire towards. The organization of social patterns in this framework is helpful when studying emergent issues or potential solutions in multi-dimensional systems for identifying particular mechanisms to support the alignment of the three dimensions to leverage a system to change. Understanding deeply intertwined and entrenched institutions, artifacts, and actor networks (Geels, 2004) provides a degree of understanding of the purpose, the direction, and manner of reproduction in a system. Overall, the utilization of this framework aids in establishing a clear picture of the unfolding or potential sustainability transition.

The purpose of selecting the TM framework lies in the utility and flexibility provided to analyze or describe the process dynamics of societal change (Loorbach, 2010; Grin, 2020) when compared to other sustainability transitions frameworks or sustainability transformation concepts. Whereas, other concepts may have explanatory (i.e. multi-level concept) or prescriptive power (i.e. strategic niche management), TM is used here because of the opportunity afforded to better integrate the normativity of sustainability decision-making and process-oriented actions into the analysis. Furthermore, TM is selected when compared to other concepts offering views on fundamental change such as resilience, transformations, and social innovation (Leach *et al.*, 2012; Olsson, Galaz and Boonstra, 2014; Feola, 2015; O'Brien, 2018) because of the conceptual underpinnings and disciplines which partially capture much of the discussion from other fields. Significantly, the evolving discussion of societal transformations, as fundamental change processes, is well embedded in the articulation of system change dynamics offered by socio-technical and TM scholars alike (Geels, 2005; Grin, Rotmans and Schot, 2010; van den Bergh, Truffer and Kallis, 2011; Markard, Raven and Truffer, 2012; Smith and Raven, 2012). The selection of TM, then, pulls together a broad analytical tool supportive of contextualizing multiple pathways for incremental or transformative change.

Conceptual advances in TM have focused on power, agency, and politics associated with normative issues such as sustainability (Smith and Stirling, 2010; Rauschmayer, Bauler and Schäpke, 2015; Gillard *et al.*, 2016) and the gap between theory and practice, particularly, who acts and with what intention (Shove and Walker, 2007; Voß and Bornemann, 2011). However, the focus of these analyses is often aimed at structures (i.e. transition agendas) (Smith and Stirling, 2010) and culture

dimensions (i.e. transition arenas) (Cf. Hölscher *et al.*, 2019). Two gaps remain in understanding how the practice dimension (taken broadly) shapes or reinforces transitions.

First, the role of practices and more specific interventions such as experiments are downplayed and poorly articulated in terms of purpose, outcomes, and actors involved (Rauschmayer, Bauler and Schäpke, 2015). Loorbach (2010) notes that experiments rarely create system change and are often uncoordinated. However, the view from Loorbach (2010) misses the processes, perspectives, and experiences potentially revealed in the practice dimension ignoring an opportunity to better inform structural and cultural dimensions. Second, actor participation is still a blind spot (Cf. Avelino *et al.*, 2016; Hölscher *et al.*, 2019) as the nature of change is mediated by structures and culture (Cf. Loorbach and Rotmans, 2010). This means that the establishment of agendas and long-term visions are driven by a limited number of experts who conform to the status quo, with little opportunity for a reorientation of visions and agendas once they are developed (Smith and Stirling, 2010; Gillard *et al.*, 2016). By advancing on these insights, this paper will aim to demonstrate how the practice dimension (i.e. interventions and experiments), mediate culture and structures, allowing for diverse actor participation and intervention-led change.

Table 4.1 Description of transition management dimensions for societal change

	Description	**Features of change**	**Illustrative Example**
Structures or transition agendas	The dominant tactical patterns that steer organizations, networks, and routines (Loorbach, 2010) or how society is organized (Wolfram, 2016) and how governing, planning and development conditions are realized (McCormick *et al.*, 2013; Ernst *et al.*, 2016)	Policy, regulations, typically established by actors and organizations operating in the domain of concern.	Agendas that describe the purpose of the city (e.g. resilient or low-carbon cities) (Nagorny-Koring and Nochta, 2018); Policy and Regulations that steer green infrastructure protocol (e.g. by-laws, technical guidance) (Drake and Guo, 2008)
Practices or transition experiments	Innovations (social and technical) applied in the short-term that introduce or operationalize novelty in routines and actor networks (Loorbach, 2010). Raising attention to how we are currently living, producing, and consuming (McCormick *et al.*,	Interventions such as experiments and direct implementation of features may require a mixture of established actors and experts working with new actors and actor	The development of small scale stormwater capture and harvesting techniques, that aim to alleviate infrastructure weaknesses of the

	2013; Wolfram, 2016) and highlighting opportunities to do better. Practices emphasize the role and application of interventions, such as experiments and routine actions or procedures.	networks to install physical features or elucidate alternative interactions with features.	traditional stormwater system at local scales (Brown, Farrelly and Loorbach, 2013)
Culture or transition arena	A strategic opportunity for expert actors to rethink modes of consumption and production and envision new pathways towards sustainability over long-term time frames. The concept of the transitions arena is utilized, where a small number of experts discuss long-term visions, engage in strategic discussions of long-term goal setting by outlining problems (Loorbach, 2010; Grin, 2020).	Long-term strategic thinking and vision development; lead by or organized by experts, with forerunner and aspirational attitudes to offer alternative visions and goals.	Inclusion of the construction industry in contributing to the visions and potential outcomes for more sustainable building design (Fastenrath and Braun, 2018a; Helamaa, 2019).

4.2.2 Green infrastructure transitions

In the context of sustainable transitions, green infrastructure could be framed as an innovation that challenges existing societal configurations (i.e. structures, cultures, and practices) (Markard, Raven and Truffer, 2012) to initiate or promote alternative processes of designing and using urban spaces at (Kabisch *et al.*, 2017). Green infrastructure is a concept, as well as a set of tools (Dupras *et al.*, 2015) that utilize the power of ecological features to alleviate a combination of social, technical, and ecological tensions in urban areas, such as flooding (Calderón-Contreras and Quiroz-Rosas, 2017), biodiversity loss (Jansson, 2013), and heat stress (Larsen, 2015). The orientation of green infrastructure to spread across urban areas shifts the urban development framework from single-purpose projects (i.e. condominiums, storm-water pipes) towards a multiple problem-solution-driven framework that potentially integrates more societal actors across multiple private and public sectors and spaces to draw out an understanding of problems and solutions (Albert *et al.*, 2019; Davies and Lafortezza, 2019; Diduck *et al.*, 2020). Although green infrastructure has the potential to confront multi-dimensional urban problems, the diversity of research has yet to explore how green infrastructure supports sustainability transitions.

The emerging literature on green infrastructure transitions is also connected to research on ecosystem services (Wamsler, Luederitz and Brink, 2014) and more recently, nature-based solutions (Maes and Jacobs, 2017; Raymond *et al.*, 2017). Although each of these terms contains unique

attributes that distinguish disciplinary communities, the overall concepts fit together to suggest a fundamental opportunity to utilize existing and new ecological and semi-ecological features to improve multiple domains and sectors of society. Green infrastructure in the transitions literature has been examined in domains such as urban governance (Brown, Farrelly and Loorbach, 2013), societal innovation (Kuller *et al.*, 2017; Liu and Jensen, 2018), user behaviours (Frantzeskaki, Kabisch and McPhearson, 2016), and experimental tools (Chini *et al.*, 2017; Frantzeskaki, 2019). Green infrastructure development in these examples presents pathways for government and private or non-state actors (i.e. CSOs and community-based organizations, businesses, business networks, etc.) to collectively shape green infrastructure for sustainability outcomes. These outcomes may include promoting mechanisms that are participatory and co-created for design and implementation (Bissonnette *et al.*, 2018) and developing both social and technological innovation that is adaptive and place-based (Spijker and Parra, 2018; Frantzeskaki, 2019).

Advancing this research, Bush (2020), Frantzeskaki and Tilie (2014), and others (see Becker and von der Wall, 2018; Diep, Dodman and Parikh, 2019; van der Jagt *et al.*, 2020) have connected sustainability transition frameworks (e.g. transition management, multi-level perspective, etc.) to the development of green infrastructure in urban areas. Through this research, an examination of the barriers such as institutional memory in the planning systems, lack of resources or political support, and land availability and accessibility (Becker and von der Wall, 2018; Davies and Lafortezza, 2019) were identified. Specifically, Frantzeskaki and Tilie (2014) use the TM framework to examine the governing capacity for Rotterdam to manage and advance ecological systems development for urban resilience. The TM framework served as a tool to guide understanding of how each domain partially shapes the (in)ability of city management and governing systems to adequately build a combination of policy, foresight, and interventions. Practices, in particular, were often disconnected, with competing land-use issues, and no strategy for scaling greening efforts coherently put forward.

Building on this, Bush (2020) uses the TM framework to evaluate multiple Australian cities and their policy development processes for green infrastructure integration. The focus was at the policy level aiming to understand how policies are developed and agendas developed and delivered. Practices were limited at the local government level due to resources and land constraints as well as an organizational disconnect to address operational and maintenance issues. In both cases then, the role of green infrastructure practices is limited due to the poorly articulated or understood opportunities available.

Alternatively, then, a line of research is understanding the role of practices shaping green infrastructure development in cities and understanding how interventions may serve to address several policy short-comings and governing tensions. In this sense, we should ask, how has the constellation of deeply embedded social, technical, and ecological systems and sub-systems reorganized to align with green infrastructure interventions? This offers an initial opportunity to utilize examples to articulate how green infrastructure has been embedded into societal structures (i.e. agendas), practices (i.e. interventions), and cultures (i.e. long-term thinking and visions). This is important to understand because it clarifies the potential to strategically navigate green infrastructure development processes to purposefully develop more and potentially re-configure agendas, interventions, and visions related to sustainable urban development.

The remainder of this paper aims to explore the interrelationship between green infrastructure development and sustainability transitions, specifically, understanding the alterations in structures, cultures, and practices. This is an important addition to the transitions literature because it provides an opportunity to strengthen empirical research on multiple patterns of change in an urban context (García Soler, Moss and Papasozomenou, 2018).

4.3 Methods

This research uses two cases to identify and interpret the way green infrastructure development becomes embedded in agendas, practices, and visioning processes, all critical and supportive of facilitating sustainability transitions. The research relies on key green infrastructure informants to support constructing the multiple ways interventions support the reinforcement of agendas and shape visioning processes. Using semi-structured interviews with key informants and qualitative content analysis, interpretations and rich descriptions of the emergent themes were analyzed to better conceptualize the way practices mediate agendas and visions and support the embedding of green infrastructure in urban areas.

4.3.1 Case study selection

Two case-study urban regions, Toronto Canada and London, United Kingdom were selected for this research to explore how similar structures, cultures, and practices can contribute to the development of green infrastructure. Selecting two critical cases is intended to draw out similarities, differences, and may offer a degree of generalizability (Patton, 2002). Exploring two urban regions in different counties, with different governing structures, geographies, and experiences with

sustainability and green infrastructure bring to light innovative actions, processes, and procedures towards deploying and discussing green infrastructure interventions across multiple contexts.

The Toronto-region and the London-region are selected because of their similarities concerning problems confronted at a regional scale, such as climate change, growth, and land-use and space issues, and unsustainability (Williams, 1999; Heath, 2001; Wekerle and Abbruzzese, 2010; Mees and Driessen, 2011). A compelling cross-case analysis will reveal that differences in governing structure (Pilgrim, 2006; Tewdwr-Jones, 2009), experiences with sustainability actions (Granek and Hassanali, 2006; Revell, 2013), and geography serves to enrich understanding of multiple approaches towards implementing similar solutions in different contexts (see Mees and Driessen, 2011; Mell *et al.*, 2017; Ehnert *et al.*, 2018). National level governments are also key drivers, articulating and guiding priority actions, particularly in the United Kingdom (Defra, 2018), whereas, in Canada's federalist system, provincial governments direct municipal governing (*Municipal Act, 2001, c.25.*, 2001). However, in both cases, city-level government maintain strong authority over matters of spatial planning and urban sustainability (Wheeler, 2003; Tindal and Tindal, 2009; Tallon, 2013; Lam and Conway, 2018)

This is a valuable contribution because increasingly literature on sustainability transitions notes the importance of place-based, contextual, and local priorities as important drivers in shaping successful and meaningful change in society (Binz *et al.*, 2020). The literature on green infrastructure is certainly context-driven, as matters such as governance, climate conditions, and past experiences play a critical role in promoting or inhibiting green infrastructure development. However, it is also important to identify cases that provide an opportunity to look across contexts to draw out opportunities to translate lessons across cases (Momm-Schult *et al.*, 2013; Hoyle and Sant'Anna, 2020). It is increasingly important to look at urban green infrastructure across cases to develop a robust understanding of innovation, knowledge development, and action application all contributing to supporting deeper sustainability changes (Wamsler, Luederitz and Brink, 2014; Buijs *et al.*, 2019).

4.3.2 Data collection

Green infrastructure stakeholders were identified using a web-based search of local government units and policy documents (e.g. plans, strategies, programs, regulations) related to green infrastructure development or planning. Those involved with green infrastructure development were selected as these units could provide details of the structures and practices most often deployed to navigate policies to pursue implementation. Similarly, private actors such as companies, business improvement districts (BIDs), and CSOs involved with development (e.g. urban forestry, storm-water

management, public realm design, etc.) were identified through a general web-based search and by consulting local government sustainability, planning, and development documents. Snowball sampling further provided contacts of local government and private actors identified from interview informants. Appendix C provides a detailed list of the interview informants, and Appendix D provides a summary of interview groups based on each case. This project has received ethics approval from the University of Waterloo's Office of Research Ethics. Interview informant names and organizational affiliations are not included, this is intended to protect identities and satisfy confidentiality requirements.

A total of 51 interviews (with 54 key informants) were conducted in-person or telephone, ranging from 30-90 minutes long, occurring from January 2018-June 2018. Interview questions were designed to probe key informants on their city's engagement with green infrastructure actions and projects; the role of policies and regulations in shaping their understanding of green infrastructure; and how their region is guiding future green infrastructure development. All interviews were audio-recorded, transcribed verbatim, and coded using NVivo 12 software.

4.3.3 Data analysis

Directed content analysis using a deductive approach (Hsieh and Shannon, 2005) was applied to organize text content based on structures, cultures, and practices (see section 4.2.1). First, provisional coding (see Saldana, 2009) was used and broadly applied descriptions and definitions of structures, cultures, and practices (see table 4.1 and Appendix F). The definitions allowed the initial sorting of the interview data. Second, theoretical coding was utilized with defined codes (i.e. green infrastructure agendas; green infrastructure interventions, pilot projects, etc.; and processes of developing future visions and long-term thinking). Next, second cycle coding drew out emerging themes categorized based on projects or interventions pursued and their purpose, the types of organizations and actors included, and recognition or mention of long-term drivers or barriers of green infrastructure development. Finally, a phase of concept building was undertaken, working through the text passages from the second phase and further refining them to align with the research questions and maintain alignment with the framework. However, the definitions were further refined to offer a clear understanding of how structures, cultures, and practices are revealed in the delivery and development of green infrastructure in each case and this served as the foundation for presenting the results and organizing the discussion section. Appendix F provides the coding categories and coding rules.

4.3.4 Limitations

Limitations of this research were observed in two areas: first, the reliance on the transition management framework and the articulation of concepts from broad definitions to more narrow codes may have altered the intended meaning or purpose from transition management terms. However, the purpose of using these codes and framework was to flexibly apply them to a context and concept that is itself rather open-ended, abstract, and more clearly understood through the application and practical experience. Criticisms of poor articulation of concepts only serve to underscore the rigidity of frameworks, failing to offer the opportunity to advance socially constructed frameworks built on the co-evolution of practice and theory.

The second limitation of this study is the utilization of qualitative data, particularly semi-structured interviews because they are dependent on key informants and their response biases (Kitchin and Tate, 2000). The underlying assumption by key informants through body language, tonal changes, non-verbal expressions and the like, was missed leaving out key expressions of the governing relationships, desired outcomes of particular projects, and the prospects of future interventions. Only through explicit articulation were these understood and deep probing and building off answers. Further, it may be criticized that researchers are required to interpret meaning based on the verbal responses by a diverse selection of key informants, without clear protocols to control for generalizability. However, the purpose of this research is not to search for generalizable findings, instead, it is intended to construct meaning from valid and multiple perspectives (Yin, 2014) offering the opportunity to search for the multiple purposes for pursuing green infrastructure. The selection of researchers was purposeful and intended to draw on a specific segment of the population, preserving their authenticity and trustworthiness in this field and context (Lahtinen and Yrjölä, 2019).

4.4 Results

This section summarizes the results from the analysis examining how green infrastructure development has become embedded into transition dynamics, namely structures, practices, and cultures. The results indicate that the current agendas of green infrastructure development in Toronto and London are constituted by the mandates of specific local government priorities and the centrality of the core functions of particular units. The practice dimension is understood as the interventions both innovative and routine undertaken by multiple actors in each case. Cultures are shaped in expert-driven transition arenas, forums serving to mediate thinking about long-term development opportunities.

4.4.1 Structures: Agendas and actor networks

Across both cases (see table 4.2), the local green infrastructure-related policies that were identified by respondents as most significant in shaping agendas are clustered into three types: technical guidance, strategic planning, and regulatory development. Policies were developed in coordination with multiple actors, such as firms, civil society organizations (CSO) including community-based, charity and voluntary organizations, and government agencies. Collectively, the breadth of actors provide expertise (28.TO; 17.LO), guidance (17.TO; 9.LO), and perspectives (10.TO; 4.LO; 6.LO), by writing reports and strategic documents (5.TO; 20.LO), commenting and reviewing policy documents (21.TO; 4.LO), and acting as intermediaries between community, experts, and local government (1.TO; 10.TO; 6.LO; 9.LO), as identified by a London-based biodiversity conservation manager:

> "Now parks, public parks, it's a bit more kind of an open battle ground. You can convince a park manager to leave an area wild as long as there's a nice big flat open green bit for people to have their picnics, then negotiate the boundary areas and wilder areas" (1.LO).

Nevertheless, at a local government level, green infrastructure is still viewed primarily as a storm-water and drainage management solution supporting efficient and rapid removal or storage of water from streets and properties to reduce flooding and alleviate pressure on grey infrastructure systems (5.TO; 9.TO; 9.LO; 17.LO) with additional benefits offered as identified by a planner in Toronto and project manager in London respectively:

> "The province defines it as everything…I'm trying to get through that green infrastructure is an infrastructure that has been designed to manage stormwater. Everything else is natural heritage" (5.TO).

> "Green infrastructure needs to provide those additional benefits… and you know, not so blinkered in my thinking that everything has to manage surface water… we need to be thinking about the cooling effects, shading and biodiversity linkages" (17.LO)

As a result of the primarily storm-water driven focus of green infrastructure's purpose, combined with the duty towards spatial and land-use planning, local government green infrastructure priorities are often driven by water management and urban planning units (3.TO; 5.TO; 9.TO; 14.TO; 22.TO; 5.LO; 9.LO; 15.LO; 16.LO; 17.LO; 19.LO).

The power of planning regulation places planning units in advisory and authoritative roles to perform, suggest or require green infrastructure features through project assessments, reviews, and

approvals (2.TO; 3.TO; 22.TO; 9.LO; 15.LO). Water units, particularly related to drainage and storm-water management are critical in guiding development, addressing key issues related to flooding, and grey infrastructure upgrades (5.TO; 6.TO; 9.TO; 13.LO; 17.LO). Other units, however, operating within their core remits, such as urban realm, parks, and forestry, carve out programs and agendas that ensure their priorities are achieved, either exclusively within their unit or in partnership with other units.

Across the analyzed cases, differences emerge that partially re-direct priority issues and connection to green infrastructure development. In London, budgetary cuts across local government, along with streamlined planning processes have adversely impacted the opportunity for green infrastructure development across units (2.LO; 9.LO; 19.LO). Further, drainage management units are similarly under increasing pressure to confront infrastructure performance decline in high impact areas and commercial areas, under tighter financial conditions, forcing green infrastructure projects to be considered less important (17.LO). This gap has provided the Greater London Authority, CSOs including charities, and firms an opportunity to support boroughs in their efforts through funding mechanisms and programs (e.g. Green Fund) (2.LO; 19.LO), expert guidance (e.g. Urban Greening Factor) (5.LO; 17.LO), alignment towards regional outcomes (e.g. air quality and climate change) (8.LO; 16.LO), and network building (9.LO; 16.LO; 17.LO).

Whereas, in Toronto, urban forestry units have long been key actors supporting local green infrastructure development (11.TO; 12.TO; 16.TO). Much of the recent push for urban forest development is the result of significant destruction and loss of urban tree canopy due to Emerald Ash Boer, Asian Long Horn Beetle, and the 2013 Ontario ice storm (8.TO; 12.TO; 13.TO; 16.TO). This has created an opportunity for forestry units to partner across local government units and facilitates cross-project coordination (12.TO; 13.TO; 16.TO; 23.TO) as stated by a forestry department manager in leveraging existing relationships, “I'm going to use that relationship to create further partnerships to increase planting privately” (16B.TO).

Table 4.2 Summary of embedding green infrastructure in structure domain

Structures	Toronto	London

Agendas	Water management is the primary purpose of green infrastructure and must be connected to stormwater management and related issues and regional and local matters (e.g. climate change, ecology, and natural heritage protection). Green infrastructure policies aimed to improve storm-water management, tree protection, street design, parks management, ravine and stream management, and building design (1.TO; 3.TO; 5.TO; 12.TO; 13.TO; 16.TO; 28.TO). Driven primarily by key units (Planning and Water), as well as other units such as parks, forestry, public realm, and ravine systems advise (23.TO; 25.TO).	The purpose is sustainable drainage management and heat island mitigation. Regionally and locally green infrastructure is connected to climate change, biodiversity, air quality, and human health outcomes. Similarly, the borough level aimed at addressing sustainable drainage management, street trees and design, parks and opens spaces, and building design (1.LO; 3.LO; 4.LO; 5.LO; 6.LO; 9.LO; 14.LO; 15.LO; 19.LO; 20.LO). Driven primarily by key units, regional and local issues (e.g. climate change, park protection and access, biodiversity) (5.LO; 19.LO).
Actor networks	Water management and urban planning units, with support from other local government units and private actors, shape green infrastructure development. Urban forestry balances emergent problems, such as tree loss, while expanding tree canopy and urban forests.	Drainage management and urban planning, are supported by other units internally and the GLA and private actors supporting green infrastructure development for borough authorities. Shifting budgetary conditions force planning and drainage management units to under prescribe or under-develop green infrastructure features.

4.4.2 Practices: Innovating with community actors

Across both cases, innovations in the domains of technology, organizational coordination, and multi-actor participation, have emerged as important aspects supporting the development of green infrastructure (see table 4.3). In both regions private (CSOs, firms, BIDs) and public actors (local and regional government, water basin agency) have demonstrated an ability to coordinate unique governing arrangements to test and experiment with green infrastructure for drainage management technologies, on private and public lands (14.TO; 21.TO; 13.LO; 17.LO). These actors are green infrastructure experts, ambassadors, practitioners, and designers navigating development in the region.

In Toronto, green infrastructure technology has provided an opportunity to test and implement new design strategies that have very recently become embedded in local government or private landowner practices (14.TO; 21.TO; 27.TO). In London, Business Improvement Districts (BIDs), for example, utilize public spaces to implement new green infrastructure technology (10.LO; 11.LO), coordinate

partnerships with other organizations to leverage funding and pool resources (12.LO; 14.LO), and organize learning spaces for other organizations (10.LO; 11.LO). Moreover, the importance of practical actions, pilot projects, and completed projects were shown to significantly re-orient local government and other community or green infrastructure organizations perspectives to install more green infrastructure (4.TO; 5.TO; 12.TO; 13.TO; 8.LO; 10.LO; 19.LO) partially due to the tangible and realized benefits that have accrued along with the perceived ability to "do it" (8.TO;1.LO; 5.LO; 13.LO). The shift in organizational perspectives is significant because it facilitates an opportunity for inter-organizational cooperation (8.LO), increased funding and land pools (16.TO; 19.LO), and willingness to attempt larger-scale projects then pursued as a single organization or local government unit (9.TO; 20.LO).

Another similar line of work in both regions is undertaken by firms, community-based organizations, and charity organizations in exposing the importance of green infrastructure to non-expert stakeholders and revealing how community actors are utilizing features beyond the intentions of local government agendas. This is significant because these non-state actors are revealing new and innovative purposes of green infrastructure beyond those discussed in dominant agendas. In both regions, changing demographics (i.e. age and ethnicity) are exposing the importance for community-level programs to allow youth, newcomers, and other members such as the artistic community to share their perspectives of green infrastructure (23.TO; 29.TO; 1.LO; 20.LO; 21.LO). Youth and the arts community explore or use greening for personal growth and connections to communicate the importance of sustainability action in the short and long-term (29.TO; 3.LO). Immigrant groups reveal tensions between perspectives of well-maintained spaces (1.TO; 1.LO) on one hand, yet desire to have spaces to grow fresh food and where appropriate culturally important vegetables (4.TO; 12.LO;13.LO). This opens up programming options for community groups and others to provide growing spaces and foster dialogue regarding the benefits of green infrastructure in confronting multiple urban problems. Green infrastructure, then, serves as an "ice-breaker" for dialogue, cultural learning, and community building (29.TO; 12.LO; 20.LO).

Several differences emerge across the cases. In London, private actors are engaging in projects that reframe the purpose of communities, boroughs, and the region while utilizing green infrastructure as a tool to address social problems (13.LO; 20.LO; 21.LO; 22.LO) (see table 4.3). Government and other organizations address unemployment and local regeneration targeting sustainability-related issues such as local food independence and cultivation (7.LO; 21.LO), housing improvements (20.LO;

22.LO), and public space access and safety (13.LO; 22.LO) as endeavours allowing for disadvantaged groups to develop life skills (22.LO), improve community outcomes (20.LO), shape community relationship-building (20.LO), and redirect personal life trajectories (21.LO; 22.LO). Further, the purpose for "meanwhile" spaces - lands that are currently underdeveloped or disused, often partially leased on short-term contracts to emerging (retail) businesses - is changing to recognize an opportunity to support green infrastructure and environmental sustainability and associated organizations (7.LO; 20.LO). "Meanwhile" green infrastructure spaces have emerged as an alternative avenue for community-based groups (for-profit and non-profit) to demonstrate, test, and experiment with green infrastructure, along with capacitating community actors, and further building local government and regional government collaboration (14.LO; 7.LO; 20.LO). The successful utilization of meanwhile spaces has served to challenge government thinking of the purpose of unused lands, shifting from renting and leasing for profit to allocating and donating land to community-based groups or community-oriented firms (14.LO; 7.LO; 20.LO). This shift, from primarily profit-motivated and tax-generating, to recognizing the opportunity to push forward alternative pathways of urban consumption, has raised awareness of opportunities that support the community and urban development schemes to simultaneously address diverse urban sustainability outcomes.

In Toronto, some government programs engage local community groups to motivate the application of green infrastructure (2.TO; 4.TO; 5.TO; 23.TO;). Local government design programs aim to collaborate with CSOs such as charities and community-based organizations, to acquire or distribute capital (16.TO) attract more volunteers (23.TO; 29.TO) and access or share land and resources for green infrastructure (i.e. city-owned brownfields; trees; material for garden beds) (2.TO; 7.TO; 8.TO). Government programs are varied in their engagement with the local community ranging from hands-on, guided, and persistent (4.TO; 5.TO; 7.TO) to hands-off and supportive, allowing community groups to direct the contents of projects (16.TO). Increasingly, government policy and programs directed at neighbourhood re-development or developing alternative green spaces (i.e. hydro corridors with pathways for walking and biking) require local community and public space users to shape and learn about green infrastructure (2.TO; 4.TO; 5.TO; 25.TO) and allow public input into the purpose of using green infrastructure (5.TO; 7.TO; 23.TO), because "green infrastructure is going to require residents to take an active role and they're going have to see that they are taking an active role" (5.TO) as explained by one city planner.

Deficiencies are experienced similarly across both regions as well, particularly, inadequate formal learning mechanisms and reactionary implementation measures (16.TO; 28.TO 17.LO). The outcome of this has created a slight wedge in the logic of performing green infrastructure actions. Local government and regional government's view failure as a result of unfamiliarity with green infrastructure technology and coordination processes (5.TO; 9.TO; 16.TO; 5.LO; 18.LO; 19.LO). Other actors, on the other hand, suggest failure is the result of local government unwilling to commit the resources to design and install the correct types of green infrastructure, or conduct pre-development scoping exercises (21.TO; 28.TO; 20.LO). As a result, local government is still promoting small-scale pilot projects (5.TO; 19.LO), while private actors are keen to push for larger-scale projects confident in their ability as well as the performance of technology (21.TO; 27.TO; 20.LO).

Table 4.3 Summary of embedding green infrastructure in the practice domain

Purpose of intervention	Description	Summary of outcomes	Illustrative quotes
Process improvements	Integration of novel and routine interventions serving to simultaneously address problems confronted by organization or region. Allows for multi-actor learning related to the purpose of interventions, coordination processes, elucidation of outcomes related to performance and function and coordination.	• Challenge existing processes towards resources management • Alter governing relationships to encourage inter-organizational projects • Clarify conduct or processes with the development approach	"And what we can do is cherry-pick those projects which are either more strategic or better delivering the concept of green infrastructure" (16.LO). "So we said to the City, 'what if we do everything on-site, but we hook into this one manhole that you own and that's the control manual?'…the cities, they love it because they don't own the infrastructure. The owner of the complex has to operate it and maintain it, if not their site floods" (21.TO).
Multi-directional learning	Bottom-up driven green infrastructure development projects or programs aimed at integrating "non-expert" groups. Multi-path learning, as experts and programmers can learn about the problems experienced or solutions devised by people. Further, "non-expert" participants can learn about the role of green infrastructure in urban development.	• Placing agency at the level of the user • Multiple avenues for learning • Realization of alternative practices for green infrastructure development	"What we find when we're working with different partners is that we're that bridge…we have a really strong skill set in community consultation and iterative design and we rely on that quite a lot to actually pull together these different conversations" (20.TO). "So for example, with edible playgrounds, we had a program that we've worked with a group called School Food Matters and a group called Chef's Adopt a School. We were creating the edible

			playground… working with the kids to cook the produce to create beautiful food, and doing the kind of food education and enterprise elements" (3.LO).
Community networking	Organizations direct the development of green infrastructure to support urban development for social sustainability. Provide community members with the opportunity to utilize green infrastructure for work, play, and community outcomes.	• Uncovering new uses for urban spaces • Community network building • New actor constellation	"We got involved with the local kids' group. They didn't know what a trowel was and they'd never seen a worm, but they absolutely loved it and they planted all these plants and they kind of maintain it. So that's the kind of stuff that's really, hard to quantify, but that's kind of stuff that can get people to let you do it again" (13.LO). "But because it's a mental health hospital, people were fearful of using it and felt that they weren't allowed to. So simple planting and landscaping, that gave a kind of unwritten permission to say 'it's okay, you can come and sit here and you can have your lunch here'. We created zones where people could have outdoor yoga or other therapy sessions with the patients" (3.LO). "Incrementally over the years we've implemented little pockets of green. About five years ago, we recruited an apprentice urban gardener to work within our organization to help maintain these sites. And then as that role has grown, in the last two years, we've launched a volunteering initiative where we run free lunchtime sessions where people who work locally can just pitch up and be given some basic tools and basic guidance to kind of help us maintain some of the spaces that we've created" (10.LO).
Community improvement	Community actors participate in shaping and suggesting the purpose of green space utilization. This supports designers, developers, and implementers	• Community inclusion into shaping the traditional development of grey infrastructure	"Building community interest and support for the projects and getting them engaged at the beginning and allowing them an opportunity to animate the space … arming the community with the tools and resources to animate and activate

	with improved understanding of how and why space is used.	• Exposing multi-functionality of traditional features • Adds to the tool box of functions	their common public spaces and parks" (7.TO). "It's urban agriculture, which I think has a lot of connecting power between people and eating what you're growing. It's a pretty simple setup of milk crates in an old parking lot and other areas for people to grow food" (18.TO).

4.4.3 Cultures: Arenas for long-term thinking and visioning

Across both cases, cultures are shifting towards supporting discussions and intention for long-term development aimed at sustained efforts to address long-standing issues (i.e. funding, responsibility, coordination, knowledge) related to preserving and expanding green infrastructure networks (see table 4.4). These on-going discussions are shaped in multi-actor working groups (12.TO; 13.TO; 25.TO; 17.LO), committees (8.TO; 9.TO; 25.TO; 8.LO), and commissions (9.LO; 16.LO) each serving to improve coordination, capacity building, and knowledge generation (10.TO; 19.LO), apply varying degrees of regulatory steering (10.TO; 17.TO; 18.TO; 16.LO; 17.LO) and underscore the resource needs (25.TO; 6.LO) (see table 4.4).

Most significantly, these spaces may offer valuable opportunities for green infrastructure experts and practitioners to openly discuss long-term strategies and perspectives of green infrastructure's potential. These arenas are populated with public and private actors, working across multiple jurisdictions and between public and private domains to initiate discussion to address opportunities towards long-term green infrastructure development, primarily, advancing operational understanding (9.TO; 9.LO), navigating coordination for maintenance (25.TO; 17.LO), and routine monitoring (21.TO; 19.LO). However, problems emerge in these arenas, for instance, disciplinary and professional backgrounds may result in particular views being more accepted than others, often, reverting to simple justifications of cost and performance, and adaptability to existing infrastructure (8.TO; 16.TO; 19.TO; 16.LO; 19.LO).

When analyzing the cases, subtle differences emerge regarding the actors who convene spaces for long-term thinking and visioning. In the Toronto region, conservation authorities (CAs) play a critical role in assembling formal groups comprised of municipalities, businesses, and CSOs aimed at spreading knowledge and experiences of green infrastructure development (8.TO; 12.TO; 17.TO;

18.TO). Recent efforts have focused on supporting municipalities and private actors in better aligning with provincial priorities and organizational issues for improved coordination and long-term development of regional and local green infrastructure networks, as opposed to fragmented and response-oriented approaches for land development (17.TO; 18.TO; 19.TO). The power of CAs combine regulatory duty with credibility and trust built over serval decades, mediating opportunities for multiple green infrastructure actors to discuss long-term issues that impact land-use planning decisions (3.TO; 22.TO), innovative performance and technology (20.TO; 21.TO), and long-term monitoring (21.TO), all collectively critical to the long-term commitment and development of green infrastructure projects (10.TO; 17.TO; 18.TO; 19.TO; 20.TO). Although the CAs were noted as extremely knowledgeable and key actors in the green infrastructure puzzle, an emerging concern was raised regarding non-statutory services offered by CAs (12.TO; 13.TO; 14.TO). CAs are increasingly acting as clients for municipalities and offering services beyond their duties as regional flood managers. This creates slight tensions as they attempt to steer long-term visions and thinking because their areas of expertise may not align with the priorities or visions of municipalities (12.TO) or the expertise of other stakeholders (14.TO; 21.TO; 28.TO).

In London, the GLA formed the Green Infrastructure Task Force which is comprised of "land managers, policy specialists, academics and NGOs" with the intent of "identify[ing] how to encourage a more strategic and long-term approach to green infrastructure delivery and investment" (Green Infrastructure Task Force, 2015, p. 1). The visioning processes resulted in a document offering all stakeholders across the region a *proposed* set of conditions, goals, and outcomes to better integrate common green infrastructure goals into their core functions based on future conditions in London. Aimed at higher level rethinking of purposes, values, and governance from a regional perspective the document reflects on green infrastructure futures and potential, critical to establishing a space for thinking and visioning (9.LO; 16.LO). Through this extended visioning process, other organizations, such as charities, have emerged to support coordinated and long-term guidance for the development of green infrastructure as well (1.LO; 3.LO; 9.LO; 13.LO). These organizations are shaping long-term thinking through programming and planning for London's green infrastructure (3.LO; 4.LO; 6.LO), obtaining funding through national granting organizations (1.LO; 3.LO), and building relationships with international organizations and cities (9.LO; 19.LO; 20.LO). Long-term programming utilizes local organizations such as hospitals, schools, local government, and community groups to extend processes of shifting deeply entrenched behaviours and norms related to green infrastructure usage in London (3.LO; 4.LO; 6.LO). Leveraging funding from national

organizations provides capacity for these organizations to influence long-term thinking of green infrastructure's role at a national and regional scale (1.LO). And finally, connecting with international partners is crucial towards building a better understanding of lessons and examples, serving to establish future possibilities for knowledge sharing and financial resources (9.LO; 19.LO).

Table 4.4 Summary of green infrastructure embedding in the culture domain

Purpose of arena	Outcomes in Arena	Illustrative quotes
Problem-solution arenas	• Narrow in on the opportunities to shape future green infrastructure development utilizing experts at the regional level and local level. • Understand what has occurred in similar contexts to advanced discussions and potential for application. • Long-term thinking and opportunities are dictated by past outcomes and current contexts.	"Our job is to provide advice… help those boroughs who have limited staff resources, to think through the way they might do things more efficiently. So one of the things we're going to do over the next couple of years, is actually set up a commission to help boroughs think about transforming their parks service" (16.LO).
Promotion of experiences for development	• Expert organization(s) direct and coordinate the fragmented approach to better align or bring to light potential priorities that may contribute to the vision of a regional or local network for green infrastructure. • Navigate municipalities' priorities, duties, and needs. • Outline or discuss tensions, priorities, and opportunities as an individual unit, local authorities or organizations.	"we do like to think of ourselves as being influential…part of the reason why we put on these events, is to promote ourselves…people tend to listen to you more…we are much more likely to get the head of planning or the mayor" (14.LO). "It really goes back, when I first started with Metro Toronto in 1991 and the whole idea about ecosystem planning…we gradually morphed into thinking about sustainable design about 2001-2002…from that emerged the work on the Toronto Green Standard, and the Green Roof bylaw…We were really thinking about how can we make what we build better and more sustainable. How can we make our sustainable city happen is kind of the idea" (9.TO).
Awareness for performance	• Bring to light the diversity of green infrastructure intervention options, consider the long-term role of organizations in supporting future development; build a network with actors outside or inside the city-region.	"Whenever we're doing green space stuff now it is also thinking about air quality and planting. Is there opportunity for SUDS? What can we do around climate change mitigation, shade and

	• Build a "database" of information, lessons, and interventions; engage with other cities and associated organizations. • Learn from each other through site visits; leverage national, regional, and continental funding sources to support long-term knowledge development.	other things? Greener living and working is just a real snapshot that's tackling fuel poverty and water stress" (20.LO). "Another program put in a rain garden. So we met with 15 residents, told them about the rain gardens. They'd have to purchase the plants. But we'd come and plant them all fully. We do all the work. We did eight gardens. We went back two years later. Those gardens are a mess. We told them what the gardens were for, what they are going to do, and what they're going to provide. I think the problem - we shouldn't have done it. We should have let them do it. Not us. Maybe they would have bought in more" (5.TO).

4.5 Discussion

Past green infrastructure research has demonstrated several drivers and barriers that coalesce to dictate the magnitude and purpose of a project. The aim now is to expand discussions on the role of green infrastructure in reshaping and becoming embedded in the processes of altering structures (agendas), practices (interventions), and cultures (visioning). Second, the role of practical interventions as guiding agenda development and formulating long-term visions and thinking is examined below (see figure 4.1).

4.5.1 Facilitating green infrastructure development for sustainability transitions

Green infrastructure development is facilitated by structures and cultures in the case study regions. Certainly, both regions are aligning priority issues with green infrastructure solutions, this offers an opportunity to discuss the relationship and role of interventions, agendas, and visioning processes to enrich understanding of how green infrastructure is contributing to sustainability transitions in the urban areas. The co-evolving relationships between actors shaping green infrastructure and urban development occur at the boundaries related to land-use regulation and water management. While, long-term thinking and visioning are shaped in spaces for green infrastructure experts, such as practitioners, local government representatives, and CSO members to articulate future opportunities. Below these points are discussed to further understand potential green infrastructure transitions.

Long-term visions and transition arenas are limited by the actor constellations (i.e. experts, practitioners, etc.) that shape sustainability trajectories. Loorbach and Rotmans (2010) suggest that experts and frontrunners deeply involved in these processes should be free to describe or propose future visions and strategic long-term trajectories for sustainability. In reality, limiting actor inclusion narrows understanding, disciplinary diversity (see Gaziulusoy and Ryan, 2017), and potential for novelty (McGrail, Gaziulusoy and Twomey, 2015). This is a clear outcome of how future visions are rarely designed with an understanding of the future in mind but are readily designed with the present and past limiting creativity - in essence, what has been done and what is the case now will continue to unfold (Kurniawan and Kundurpi, 2019). Visions are in one sense still rooted in managerial processes of system sustainability (e.g. efficiency), with key issues focused on incremental areas of strengthening city management (e.g. operations, maintenance, and monitoring) - although with recognition of the long-term importance of sustainability issues. This process reflects a reproduction (system) dynamic where Geels and Kemp (2007) describe the existing expert groups maintain control of particular rules: working on the margins to alter knowledge, technology, and other actor groups.

Certainly, the green infrastructure arenas developed in the cases reflect early opportunities for long-term steering because of the construction of multi-disciplinary working groups and the presence of powerful regional actors deeply committed to facilitating development and embedding green infrastructure into other domains of society and local government. These actors can confront urban governing tensions, actor responsibility, funding, and other matters that are critical towards shaping long-term green infrastructure issues in each region. As Mccarthy *et al.* (2014) conceptualize using the development of a large regional green belt in Ontario, Canada, visions may support multiple organizations in constructing a common understanding to address the protection of environmentally significant areas. This process will progress from periods of problem framing to articulating land boundaries and formalizing regulatory measures.

However, the "newness" of green infrastructure is overly emphasized at the local government level, serving to temper the ambitions of champions and eager city staff to scale projects. The result is an evaluation of issues on efficiency gains, business-as-usual projections, and cost-benefit outcomes, well attuned towards building grey infrastructure but poorly applied for green infrastructure - a more abstract, flexible concept not easily reducible to a single outcome at a single cost (Elmqvist *et al.*, 2018). As seen, green infrastructure's full potential is often missed at this stage, as discussions are shaped by organizational matters of maintenance, operations, and monitoring. Discussions work at

the margins of its utility failing to explore the multifunctional outcomes: reducing green infrastructure to another operational item at the local government level, caught between disciplinary and governing tensions.

In a similar sense, structures and transition agendas shape and preserve incremental sustainability trajectories, serving to codify commands for developing or addressing issues: certainly useful when planting trees to comply with specifications and by-laws. However, agendas exclusively focused on commands, orders, and routines, will surely miss nuance and creativity, as well as reduce actor participation, both of which are needed when confronting complex sustainability challenges. In this regard, agendas are followed and reproduced by well-connected actor networks and established professionals (see Geels and Kemp, 2007). Reflecting on the cases, change is incremental, with specific actors integrated to strengthen opportunities by injecting their expertise to develop more green infrastructure. Agendas are not necessarily indicative of homogeneous perspectives or obduracy: instead, agendas are selected as a result of, the actors involved, problems defined, and adaptivity to prevailing needs. However, the mere addition of new actors does not necessarily transform the system in the short-term, instead, they serve, in the context of the two cases, as strategic efforts that confront a deficiency in local government or expose an opportunity to install green infrastructure that supports existing programs or objectives.

It is here, presumably, that green infrastructure development, unlike traditional grey infrastructure, is recognized as an opportunity to integrate multiple actor perspectives, exposing a combination of emerging opportunities, alternative expertise and solutions, and unique applications and outcomes (Elmqvist *et al.*, 2018). Unsurprisingly again, the combination of uncertainty, novelty, and abstraction of green infrastructure coalesces to being viewed as a challenge to the existing patterns of organizational processes, outcomes, and purpose, particularly at the local government level. McMeekin *et al*. (2019) and Henderson and Clark (1990) note that motivating fundamental change is in the application and integration of new processes - or more simply, “doing” the proposed and necessary changes.

“Doing”, however, is difficult particularly as a very narrow set of units at the local government level steer and act as authorities on the issue of green infrastructure design. For example, in the cases, water management and land-use planning agendas reinforce prevailing social and technical arrangements. Conversely, with the creation of street tree plantings, expertise for realizing its implementation, are revealed in multiple opportunities related to heat island reduction and shading

(climate change and health), urban realm improvement (neighbourhood identity and culture), and on-site water retention (water management), all (unintentionally) challenge conventional approaches towards urban development (i.e. single infrastructure for single purpose). Despite this, green infrastructure agendas reflect and respond to the priorities of the local government and the historic and past experiences in the regions, whereby, issues of flooding and flood management and space management are prioritized in urban development, but approached from a particular lens of rapid removal of nuisances (Childers *et al.*, 2014; Finewood, 2016). Subordinate units and external actors do not enter discussions to radically alter perspectives or reorient agendas. They fulfill needs and satisfy agendas largely steered by dominant actors (i.e. water and planning units), or when opportunities arise, other units (e.g. forestry) may lead particular agendas to confront immediate and pressing problems.

Collectively, agendas and visions enable incremental and routine change for existing green infrastructure development, largely motivated as authoritative compliance or a response to a sustainability problem. The newness of green infrastructure is not embraced as an opportunity to further explore options. Instead, it is used as a justification to exercise caution and require conformity to existing measures of infrastructure success. It is clear, the discomfort to pursue innovative action will not be the result of more thinking or tweaks in agendas. Instead, more 'evidence' is required before agendas and thinking will change.

4.5.2 Embedding practices in urban areas for green infrastructure transitions

Transitions are mediated by a constellation of actors confronting immediate and critical issues utilizing innovative approaches to alter existing modes of production and consumption (Jalas *et al.*, 2017). As revealed by the results, the practice dimension, specifically, innovation in technology, actor participation, and resources allocation, serves to strengthen agendas and provide impetus towards formulating visions. This is important to discuss, because, by scrutinizing the role of practices as the mediator of change it brings to light important opportunities towards empowering diverse actors, cultivating societal innovation, improving resources allocation, and initiating learning.

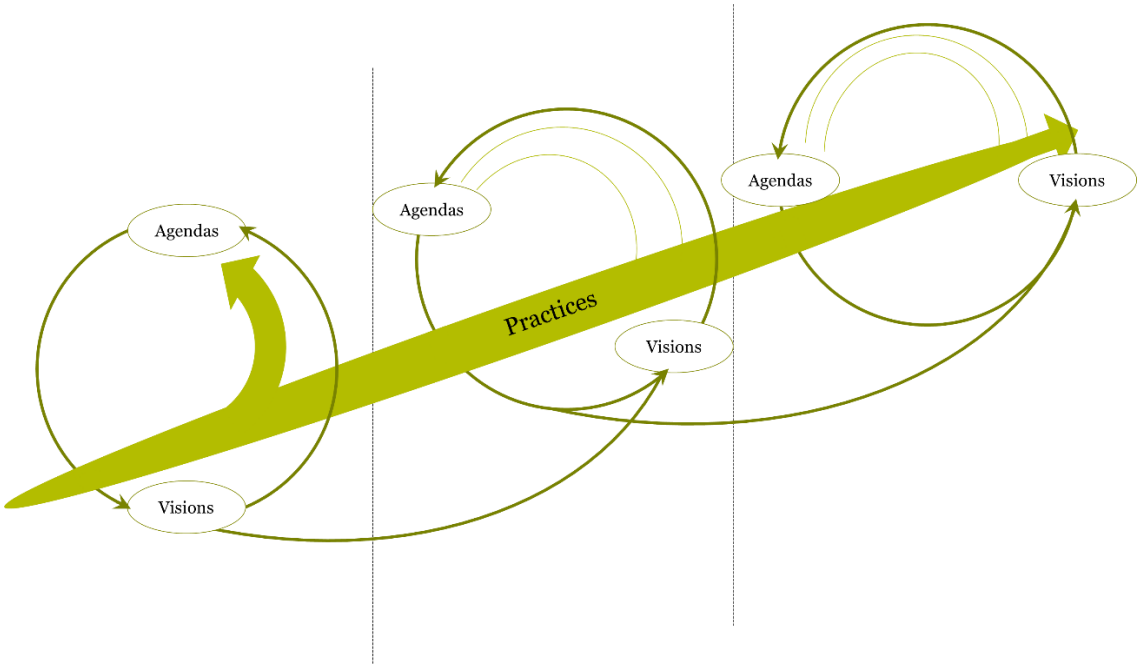

Figure 4.1 Illustration of transitions practices mediating change
This figure depicts the mediating role played by transition practices supporting transition agendas and visions and the recursive nature played through the process.

The role of the practice dimension (e.g. interventions) must be viewed as the critical dimension enriching agendas and visions. By "doing" and "creating work" (Bettini *et al.*, 2015; Grin, 2020) the greatest understanding of processes, outcomes, and benefits is released when tangible actions support intentions or guide the manner to engage with an issue. Indeed, the practical engagement with green infrastructure has advanced knowledge and learning as well as inspired confidence to install or interact with green infrastructure. The inspiration for practices should not be ignored as trivial, as Longhurst (2015, p. 190) notes regarding diverse worldviews and rationalities for the development of sustainability actions "it creates the socio-cognitive space for experiments to emerge by stretching the socially accepted (and constructed) boundaries of possibility". This suggests the role of experiments is purposefully oriented in the direction of attempting to proceed outside the norms, rules, and behaviours sign-posted to guide actions. The agendas and visions are simply (yet important and powerful) active milestones, as Westley and Folke (2018) argue, symbolic or iconic images can spur innovation and transformative change inspiring breadth of opportunity across diverse actor groups. Experiments or other interventions can potentially move well beyond milestones to challenge what can be achieved and extending the possibilities of sustainability beyond narrow goals, agendas, and

visions. Elmqvist *et al*. (2018) broaden this perspective to explore how green infrastructure "tinkering", can precipitate multidimensional changes in the urban system to spur new knowledge flows, space and system reconfiguration, and objectives and goals.

In the case-study regions, green infrastructure was utilized to confront social issues, environmental problems, and neighbourhood redevelopment. Through the installation of green infrastructure innovative actor constellations were formed, serving to leverage expertise and resources, along with serving as demonstration sites or reconfiguring the purpose of spaces and functions of green infrastructure. In this regard, practices are revealing transition dynamics whereby reorientation of urban development trajectories are challenged, revealing new opportunities to address deep tensions in the system (see Geels and Kemp, 2007).

The types of actions are moving from routine practices towards innovative practices that reveal new outcomes or objectives for green infrastructure, in terms of who is involved, how it is managed, and the functions. As an example, actors in both cases are utilizing innovative technologies, governing arrangements, and tools directed at reorienting the purpose of drainage management systems at multiple levels of the region. Geels and Kemp (2007) use the term "transformation" to describe this dynamic; innovation-oriented actors in the cases, reshape how projects and interventions are completed revealing creative and innovative practices and solutions to navigate bureaucratic inertia and protectionism over natural assets. This reveals that experiments and interventions do not simply occur in uncoordinated ways (see Loorbach 2010). These interventions are designed to address deeply embedded tensions that foster unsustainability (see Elmqvist *et al*., 2018).

Green infrastructure interventions provide various actors opportunities to selectively learn and bring to light important questions to re-purpose land and community relationships. In London, this was revealed through the utilization of temporary spaces. Local governments may have been unable to design agendas or project future opportunities for these spaces without the practical implementation of green infrastructure and the subsequent outcomes associated with the achievement of community development goals (e.g. local food security). Moreover, green infrastructure interventions offer confidence in pursuing more interventions because the experience of "doing it" exposes the governing opportunities, relative to creating space for green space users, local community members, and other stakeholders to shape green infrastructure. In a study exploring the relationship between the artistic community and scientists to confront local social and ecological issues, Hawkins *et al.* (2015) note the importance of integrating diverse actor groups in stimulating experimentation

and thinking, while also exposing new perspectives and actors to participate in transformative change processes. This perhaps speaks to much of what Longhurst (2015) suggest as an "alternative milieu" for opening up spaces for different forms of knowledge and knowledge development to playout and attempt new sustainability actions.

Conversely, "milieu's" may be limited, yet powerful: operating under the guise of traditional routines, as was seen in both cases, whereby, water management practices were used to challenge urban development practices and organizational knowledge. Here, Turnheim and Geels (2019) give a perspective where infrastructure projects can contribute to creating alternative ambitions and produce radical innovation. Incumbents are not enemies of experimentation and interventions, instead, they provide a degree of consistency in performing green infrastructure actions. Whereas, the alternative actors reshape and reveal opportunities for actions that expose a completely new constellation of practices, actors, and outcomes for sustainability-oriented development.

In sum, green infrastructure interventions support evidence of form, function, and outcome to navigate the advancement of agendas and visioning. TM would benefit from a broad reconceptualization of the role of practices (see Shove and Walker, 2010; Jalas *et al.*, 2017) enriching and providing confidence for agendas and visions development. It may be more prudent to recognize that deep changes are the result of improved knowledge shaped by doing and performing sustainability actions to capture the depth and breadth of application across societal domains. Relative to green infrastructure development this means that pursuing interventions or experiments must be recognized as more than standalone projects. Instead, projects feed into reorienting the intent of an organization and the purpose of the city.

4.6 Conclusion

The development of green infrastructure is shaped by the interplay and connection between agendas, interventions, and visioning. Certainly, it is critical to recognize the intersection of various processes occurring over multiple time frames (e.g. short-term planting programs, long-term objective embedding, and partnership building). Nevertheless, TM, rooted in structuralism and technocratic agendas, perceives experiments specifically, and short-term innovation broadly as haphazard and emergent and not the locus of transformative change. This means that change in behaviours, knowledge, and institutions is better understood to be impacted by policymaking and regulation along with expert-driven perspectives connecting current conditions to future system trajectories. It may be

more beneficial to alter this perspective and view practices as the locus of transformative change because the possibilities of processes and outcomes are tangible and experienced.

Practices occur through interventions conducted by a constellation of actors, confronting immediate and critical issues. Green infrastructure may offer opportunities to test innovative approaches of technology, alternative governance arrangements, and expose tensions in urban and community development while revealing alternative sustainability outcomes. The interventions initiate rethinking of the long-term purpose and outcomes inherent in green infrastructure and simultaneously have the capacity to re-orient policy, programs, and agendas to better conform to available opportunities and benefits of green infrastructure.

Chapter 5

Mobilizing green infrastructure experiments for sustainability transitions in Toronto, Canada and London, UK

Abstract

Green infrastructure has emerged as a key opportunity in urban areas to support sustainability through experimental processes. In this context, green infrastructure experiments represent a suite of tools that, when deployed deliberately, can support the infrastructure and design of cities through the creation of networks of green and blue spaces that help to address climate change, human well-being, and community development. Previous research has illustrated how individual green infrastructure experiments can help achieve different outcomes, such as learning, governance, and policy development. Yet, it is unclear how the public sector, private sector, and civil society organizations can approach and systematically implement experiments in ways that collectively support and reinforce such efforts. This study responds to this gap by carefully examining how urban actors can pursue experimental strategies to develop and deliver green infrastructure. Using comparative case study design, 51 semi-structured interviews with green infrastructure practitioners was conducted in Toronto (Canada) and London (UK) to identify the different roles experiments play in supporting green infrastructure development. The results demonstrate that green infrastructure experiments can serve as opportunities to showcase specific interventions (e.g. green roofs and green walls); improve relationships among diverse actors; and support framing green infrastructure in ways that help to achieve existing policy objectives (e.g. tree canopy targets). This study offers an understanding of how practitioners navigate competing urban sustainability priorities and realize green infrastructure experiments despite the perceived lack of resources, knowledge, and experience. The use of experiments as a strategic tool allows for an exploration of creative opportunities to promote diverse sustainability outcomes as well.

5.1 Introduction

Green infrastructure (GI) - the utilization or development of ecological features to design natural or semi-natural networks (Benedict and McMahon, 2002; Matthews, Lo and Byrne, 2015) - provides numerous benefits such as flood attenuation and temperature moderation (Farrugia, Hudson and McCulloch, 2013). Green infrastructure experiments have emerged as a critical strategy to better

support the delivery of sustainability actions through the testing and piloting of specific interventions and actions aiming to better understand a combination of performance and operational factors. Green infrastructure experiments, however, are still largely approached as a technical exercise to understand the quantifiable outcomes (Matsler, 2019) for example, the water retention capacity of a bioswale (Beecham and Razzaghmanesh, 2015). While these technical functions are important, green infrastructure is qualitatively different from traditional hard or grey infrastructure (e.g. roads, buildings, etc.), allowing for multiple uses and outcomes (Ahern, 2011). The intent of green infrastructure experiments has typically been presented as an opportunity for improving and validating technical performance (Collins, Schaafsma and Hudson, 2017), yet an alternative set of factors (e.g. policy, governance, and learning) may be deployed to further develop green infrastructure network expansion (Dignum *et al.*, 2020; Zuniga-Teran *et al.*, 2020). This is important to understand because it frames experiments as an open-ended and strategic tool to navigate urban sustainability development beyond performance and efficiency criteria alone (Ansell and Bartenberger, 2016).

This then opens up space for broader urban sustainability experiments, which seek to introduce novelty beyond technical innovation (Hodson, Evans and Schliwa, 2018) at local scales and may support inclusive and alternative governing arrangements (Bulkeley and Castán Broto, 2013). Experiments may be strategically used to promote innovation in social, material, and cultural dimensions of cities, bringing into view the messy politics and contested realities of societal decision-making associated with complex problems (Bulkeley and Castán Broto, 2013). In this regard, experiments are used for multiple learning outcomes shaped by processes that support a better understanding of innovation deployment including techniques, actions, and protocols for urban sustainability solutions (Caniglia *et al.*, 2017; Luederitz *et al.*, 2017). Learning is used in this paper broadly, to express how a combination of formal and informal processes, practices, and actions may create new knowledge and information or improve knowledge on routine practices and processes in use (Pahl-Wostl, 2007; Armitage, Marschke and Plummer, 2008; van Mierlo and Beers, 2020). Further, learning may occur from both successful and failed projects and interventions spurring an opportunity to reframe problems and solutions, approaches to address sustainability, or improve actor arrangements (Brown *et al.*, 2003). Finally, learning may be undertaken by individual actors or whole organizations, through internalized exercises or collaboratively with program and project partners, and applied to institutional (e.g. multi-actor governing), policy (e.g. Green roof by-law), and social (e.g. access to green space) outcomes (Pahl-Wostl, 2009; van Mierlo and Beers, 2020). An

opportunity then exists to collectively understand how green infrastructure experiments clarify policy fit and objectives, facilitate improved governing interactions, and support knowledge development (Raymond *et al.*, 2017).

Pursuing the above opportunity is a valuable area of study because it draws attention to green infrastructure experiments as critical in providing interventions that will have a deep and sustaining impact (O'Brien, 2012; Elmqvist *et al.*, 2019). As discussed by Blythe *et al.* (2018) and others exploring the nature of transformative change (Gillard *et al.*, 2016; Romero-Lankao *et al.*, 2018), the status quo may be reinforced when searching for technology improvement and efficiency glossing over the need to challenge and alter problematic behaviours, cultures, and politics associated with sustainability. Using the lens of sustainability experiments (see Luederitz *et al.*, 2017; Sengers, Wieczorek and Raven, 2019), then, offers space and practical opportunity to bring to light the messy realities of how producers and consumers of urban areas and spaces navigate, contest, and cooperate to design and implement interventions (Bulkeley and Castán Broto, 2013; Grin, 2020). Green infrastructure experiments create two important outcomes. First, and obvious, experiments provide physical interventions that can be seen and interacted with contributing to a better understanding of the purpose and outcomes of a green infrastructure feature. Second, and less tangible is the novelty in approaching governing, design, and learning to support more durable outcomes for pursuing and steering sustainability change.

This chapter will offer a better understanding of how green infrastructure experiments are leveraged as showpieces for building momentum for future development; expanding urban governance processes and building community relationships; and innovative policy tools suitable for integration into existing organizational objectives. Using the Toronto, (Canada) and London (UK) urban regions as the cases, a total of 51 semi-structured interviews with local green infrastructure experts were conducted to answer the following question: how can experiments be mobilized as a strategic intervention to embed green infrastructure interventions in urban areas?

The chapter is organized as follows, section two presents a literature review of sustainability experiments and green infrastructure development. Section three describes the methods used to undertake this research and an overview of the cases. Section four presents the results of the paper highlighting the three key aspects used to develop green infrastructure experiments in urban areas. Section five utilizes the results to expand on a discussion and presents critical lessons that must be

considered, advancing the literature on sustainability experiments for green infrastructure. Finally, section six presents a conclusion summarizing the findings of the paper.

5.2 Literature review: Green infrastructure experiments for sustainability

This section reviews literature exploring sustainability experiments and connections to green infrastructure. Experiments are approached to learn, trial, and understand opportunities with the intent of scaling up or scaling out interventions for system change. Conversely, and less explored, is understanding how experiments themselves provide material artifacts supportive of shaping the routine, practices or operations to enhance delivery. The second part of the review focuses on how green infrastructure experiments are understood to explore alternatives to performance-based outcomes alone. Green infrastructure experiments may uncover social, political, and operational arrangements all collectively important in providing opportunities for improved design and delivery of green infrastructure that better bring out and expose multiple social and environmental benefits (Chaffin *et al.*, 2016; Tillie and van der Heijden, 2016).

5.2.1 Sustainability experiments

Sustainability experiments are proposed as one mechanism to address and shift patterns of unsustainability in urban areas. Sustainability experiments are defined here as purposive interventions, conducted or co-designed with multiple actors, aiming to deliver evidence (Luederitz *et al.*, 2017; Torrens *et al.*, 2019), and opportunity for embedding technical and non-technical innovation into urban sustainability development processes (Marvin *et al.*, 2018). The emerging literature for sustainability experiments has received discussion from sustainability transitions scholars aiming to construct an understanding of development (Marvin *et al.*, 2018), scaling (Peng, Wei and Bai, 2019), and learning (Antikainen, Alhola and Jääskeläinen, 2017) of experiments broadly and specifically. Experiments, then, are used to understand the outcomes that have resulted from a particular action or set of actions to better direct sustainability-oriented activities. Moreover, as a purposive exercise, experiments can be identified retroactively (Sharp and Salter, 2017). Building on this, an opportunity may exist to advance this literature by exploring how experiments themselves are strategies to embed sustainability-oriented innovation, as opposed to simply trialling or tinkering with innovation.

According to Caniglia *et al.* (2017), experiments are performed to offer solutions to sustainability problems. As a solutions-oriented measure sustainability experiments align with normative aspects of

sustainability, searching less for objectivity and seeking to understand opportunities to navigate complex, dynamic, and diverse problems. The process and outcomes of experimentation broadly provide three key features that serve to offer an understanding of how experiments may be shaped and directed to leverage further sustainability-oriented action.

First, experiments yield products and tangible artifacts (Peng, Wei and Bai, 2019) important in opening up spaces for interaction and experiential opportunities. This is critical because it allows key stakeholders to understand what solutions are possible and how it connects to aspects of an organization or urban region. For example, in studies exploring e-bikes programs (Edge, Goodfield and Dean, 2020), walkable streets (Bertolini, 2020), and building redevelopment (Håkansson, 2018) it was shown that experiments shape direction or further clarity about possible outcomes, connections to existing programs, gaps to fill in future experiments, and areas for scaling interventions. The development of experiments and physical embedding of interventions serves to directly advance particular sustainable outcomes by providing tangible artifacts and visual aids supporting or advancing the integration of new communities of experts in highly-connected or seemingly un-connected fields (Radywyl and Bigg, 2013; Hawkins *et al.*, 2015; Longhurst, 2015; Trott, Even and Frame, 2020). Experiments then are important in shaping the cognitive understanding of how or what specific interventions can do and the connections to communities and users.

Second, developing sustainability-oriented innovation demands a search and application of alternative organizations and processes to support the delivery of new or unfamiliar interventions. This search and application are directly connected to governance arrangements aiming to improve existing relationships or seeking new arrangements (Jordan, Wurzel and Zito, 2005). For example, urban planning has shifted from centralized and expert-driven solutions towards some integration of participatory methods to include community actors when planning localized projects and policy (Healey, 1998; Nielsen and Farrelly, 2019). Experiments, similarly, require examination of procedures to better encourage multiple actors to share and learn about particular interventions, this helps support the identification of key actors to collaborate with, opportunities to navigate barriers to action (Antikainen, Alhola and Jääskeläinen, 2017), and potentially establish long-term buy-in to facilitate the adoption of programs (Carmichael and McDonough, 2019). This shift is well aligned with the broader shift in sustainability transitions literature, from expert-driven spaces of innovation with partial support from end-users to more participatory, bottom-up, and co-collaborative innovation spaces (Pesch, Spekkink and Quist, 2019).

Finally, experiments are themselves strategic policy tools used to build sustainability interventions and networks of infrastructure and innovation (Grin, 2020). This means that experiments are not simply tests of what is possible, instead, they are the embodiment of sustainability action and solutions currently, offering a clear purpose for future actions and approaches (see table 5.1). In this regard, experiments are operational tests, framed to protect and safe-guard cities from scrutiny if a catastrophic failure occurs. Experiments are leveraged as "tests", but do not radically diverge from the routines of conducting projects (Ansell and Bartenberger, 2016). Instead, carrying out experiments requires stability and familiarity of key governing actors, guiding policy and regulations, and well-structured physical spaces to ensure they are conducted in context and serve to advance urban sustainability outcomes, broadly or narrowly (Dignum *et al.*, 2020).

Table 5.1 Features of sustainability experiments to support and advance sustainability

Features	Description	Examples	References
Products (Experiments produce artifacts)	Sustainability experiments provide artifacts allowing for evidence and further opportunity to learn, shape, and spread specific elements, infrastructure, or innovation.	Walkable streets pilot programs and e-bike programs embed interventions in localized spaces allowing for interaction and learning between users, organizations, and decision-makers.	Bertolini, (2020); Edge, Goodfiled and Dean, (2020)
Processes (Experiments require organizing procedures)	Sustainability experiments require governance arrangements to confront new opportunities, integrate more actors, and improve existing practices of intervention development.	Public transit and active transit pilots, for example, require multiple organizations of specialist and non-specialists to direct and deliver interventions and reveal purpose or uses.	Sengers and Raven, (2015); Hodson, Geels and McMeekin, (2017); Bulkeley *et al.* (2019); Arancibia *et al.* (2019)
Purpose (Experiments must conform to existing goals)	Sustainability experiments conform, fit or align with the current conditions, providing valuable content related to outcomes or actions that may further contribute to existing programs' and sustainability objectives.	Experiments are proposed and applied to conform to existing social and economic structures, ensuring integration of innovation into incumbent socio-technical regimes, for example, low-carbon energy transitions and water management schemes in cities.	Hodson and Marvin, (2012); Dupras *et al.* (2015); Isaksson and Heikkinen, (2018); Liu and Jensen,(2018); Liu, Fryd and Zhang, (2019); Grin, (2020)

5.2.2 Green infrastructure experiments

Green infrastructure is one sustainability strategy deployed in cities to support water management, climate change adaptation goals, and health and well-being outcomes. The diversity of benefits while certainly positive often brings to light the challenging governing conditions to effectively deploy features and further attract increased use and development (Chaffin *et al.*, 2016; Fitzgerald and Laufer, 2017). Challenges ranging from inclusion in decision-making, access, and usage as well as often identified challenges associated with responsibility and resources such as finances, knowledge, and time make it difficult to maintain or build momentum amongst local communities or encourage local government to pursue schemes beyond routine practices (Bissonnette *et al.*, 2018; Carmichael and McDonough, 2019; Matsler, 2019; Miller and Montalto, 2019). Experiments may partially alleviate some of the challenges allowing for varying entry points for actors to pursue novel schemes or enhance multiple benefits in routine practices and processes.

Green infrastructure experiments are used to primarily understand performance and costs, both important pieces of evidence to justify or present as reasons to perform experiments and devise concrete evidence-based outcomes (Shields *et al.*, 2003; Oberndorfer *et al.*, 2007; Yang, Endreny and Nowak, 2015). Experiments conducted for performance and the like validate outcomes, for example, quantifying the filtration or retention capacity of street trees and related material (Armson, Stringer and Ennos, 2013), the ability to grow food (Nagle, Echols and Tamminga, 2017), or the costs of installing a particular green feature (Oberndorfer *et al.*, 2007). This is important and valuable to shift perceptions and clarify what green infrastructure does.

Another form of experimenting contributes to advancing governing arrangements, knowledge advancement and learning, or policy development (Tornaghi and Van Dyck, 2015; Chaffin *et al.*, 2016; Kabisch *et al.*, 2017; Spijker and Parra, 2018; Buijs *et al.*, 2019; van der Jagt *et al.*, 2019). This second form serves as a critical avenue to explore the sustainability solutions available in green infrastructure interventions by clarifying how experiments are conducted or navigated. This "how" issue becomes extremely important in the context of urban development when housing, human health, infrastructure, and transit agendas compete for resources. Green infrastructure development will not only be built by clarifying performance and cost-outcomes but further requires additional support mechanisms that articulate narrow sustainability benefits to multiple stakeholders and broader connections and relationships to urban sustainability goals.

Framing greening infrastructure as a tool to improve urban areas and connect to community needs may allow for alternative uses and solutions to emerge such as supporting community redevelopment (Barthel and Isendahl, 2013). Experiments by extension open-up possibilities to extend these propositions and ideally create opportunities for improved access to land, funding, and human resources, often barriers to developing projects (Deely *et al.*, 2020). Further, experiments serve to better expose critical outcomes such as evidence of physical improvements, improved community participation, capacity building, and agency by community partners to carry out new projects or preserve existing interventions. Specific green infrastructure experiments that have been deployed include community gardens, vegetation planting programs, and water retention structures, to name a few (Young *et al.*, 2014; Tornaghi and Van Dyck, 2015; Chaffin *et al.*, 2016),.

Research on green infrastructure experiments provides little understanding of how experiments themselves are conducted or navigated. Understanding this may offer direct opportunities to connect outcomes to the support functions and processes necessary to develop experiments. Clear understanding has connected why and with what intention experiments should be developed (e.g. performance, community development, flood attenuation, etc.). This may be a reflection of the attitude of experiments in cities as Aylett (2014) finds little support for "innovation and risk-taking" to confront climate change adaptation and mitigation. A similar outcome was observed by Fitzgerald and Laufer (2017) with green infrastructure experiments viewed by city staff as taking risks with the potential public perception of little care or attention to the spending of tax dollars. Though language around terms such as pilot projects, testing or demonstration sites can help ease perceptions of experiments (Fitzgerald and Laufer, 2017). Alternatively, then when studies are explored to clarify the outcomes of green infrastructure experiments, the findings and pathways forward rely on a need to improve novel governing arrangements (Antikainen, Alhola and Jääskeläinen, 2017), identify supportive and experimental partners (Chini *et al.*, 2017), and improve policy design (Liu and Jensen, 2018) to support improved delivery of projects.

The gap that arises, then, is examining the opportunities available to green infrastructure stakeholders to mobilize experiments, demonstrating the multifaceted processes and outcomes connected to knowledge and capacity building, organizing procedures to build relationships, and strategies to navigate urban development (Raymond *et al.*, 2017; Frantzeskaki *et al.*, 2020). The intent of supporting and improving the delivery of green infrastructure and exposing alternative perspectives complement functions and performance-based framings. Shifting discussions from

performance gains to exploring how experiments are being steered through design, governance, and policy moves forward tactics to build, organize, and justify the embedding of green infrastructure interventions in urban areas.

5.3 Methods

Using two urban regions and the experiences of green infrastructure stakeholders, this study aims to demonstrate how experiments are used to develop green infrastructure. An instrumental case study approach was used, where the object of study was not the cities but the underlying experiences and expertise of those performing green infrastructure development and experiments specifically (Stake, 1995). Using key informants and semi-structured interviews supported the objective of understanding how key actors mobilize green infrastructure development to strategically advance experiments. The sections below provide further details of the cases, data collection processes, and offer limitations of the research.

5.3.1 Case study overview

The Greater Toronto Area, (GTA) Canada (Toronto) and Greater London, UK (London) were selected for this study because they are two large urban regions that have demonstrated experimental leadership in areas such as smart city development (Bauman *et al.*, 2016; Cowley, Joss and Dayot, 2018; Tierney, 2019) sustainability-oriented action related to public and active transit schemes (Goldman and Gorham, 2006; Arancibia *et al.*, 2019; City of Toronto, 2020), and climate change adaptation and mitigation (Mees and Driessen, 2011) to name a few. Related to green infrastructure, both regions are pursuing strategies to further build an understanding of performance and cost (Credit Valley Conservation, 2018; Fairbrass *et al.*, 2018), better evaluate form and function (ARUP, 2014; Trenouth and Vander Linden, 2018), and assign asset value to green infrastructure (Cross River Partnership, 2016; The Regional Municipality of York, 2018). The purpose of experiments is to improve the efficiency of service delivery, develop knowledge and information, and explore the potential to complement grey infrastructure.

In Toronto, green infrastructure experiments have been leveraged in numerous areas to confront issues of stormwater management (Federation of Canadian Municipalities, 2020), tree loss (Greene, Millward and Ceh, 2011), and biodiversity restoration (De Sousa, 2003). Collectively, experts in local and regional government, the businesses and business-related networks, and civil society organizations (CSOs), each partially lead experiments to advance and strengthen policy development

or improve performance and design for key features such as green roofs and the application of regulatory instruments such as stormwater charges on private and residential properties (Dagenais, Thomas and Paquette, 2017; Lee, 2017). This approach to the delivery of green infrastructure reflects objectives aimed at improving the efficiency of urban environmental processes, confronting climate change through adaptation measures, and using green infrastructure to complement grey and hard infrastructure.

In London, green infrastructure experiments are deployed similarly, though, the presence of a regional governing authority aids in steering experimental green infrastructure providing policy and technical guidance and financial resources (Green Infrastructure Task Force, 2015; Greater London Authority, 2016). This is done in partnership with a variety of organizations, such as business improvement districts (BIDs), CSOs, and local authority government. Experiments are used as a strategy to address critical technical issues to confront problems emerging from climate change, such as flood management (Camden Council, 2019), at regional and borough levels. Non-government organizations, such as BIDs and CSOs operate at defined spatial scales or within program objectives, simultaneously performing actions that align with their statutory duties or mandates, but also contribute to the sustainability of local and regional government objectives (Rogers, Jaluzot and Neilan, 2011; ARUP, 2014).

5.3.2 Data collection and analysis

Green infrastructure stakeholders, including local government, regional government, green infrastructure-related businesses, and CSOs were identified using a web-based search. Local government, regional government, and arms-length government organizations were identified through online directories and policy documents (e.g. plans, strategies, programs, regulations) related to green infrastructure development or planning. Those involved with green infrastructure development were selected as these units could give details of specific experiments deployed, how experiments are approached, and the process of embedding experiments in the cases Similarly, private actors such as companies, BIDs, CSOs, and community-based groups involved with green infrastructure (e.g. urban forestry, storm-water management, public realm design, etc.) were identified through a general web-based search and by consulting local government green infrastructure documents, as these private actors play a critical role in directing, guiding, and creating policy, projects, and programs. Additionally, snowball sampling provided contacts of local and regional government and non-government actors from interview informants. A summary of interview groups based on each case is

presented in Appendix D, and Appendix C shows a detailed list of the interview informants. The University of Waterloo's Office of Research Ethics reviewed and approved this project. Interview informants' names and organizational affiliations are not included, this is intended to protect identities and satisfy confidentiality requirements.

In total 51 interviews (with 54 key informants) were conducted in person or by telephone, ranging from 30-90 minutes in duration, and occurring from January 2018-June 2018. Interview questions were designed to probe key informants of their organization's understanding, utilization, and management of green infrastructure experiments. Questions were designed to understand how experiments are utilized as a specific green infrastructure deployment strategy, how experiments support learning and improved governance, and the purpose(s) for approaching green infrastructure as an experimental activity. All interviews were audio-recorded, transcribed verbatim, and coded using NVivo 12 software.

Directed and summative content analysis (Hsieh and Shannon, 2005) was used to organize text content from interview transcripts based on theory derived codes as well as keywords (see Appendix G for coding structure). First, using the categories defined in table 5.1 exploratory coding (see Saldana, 2009) was used and captured the text passages and keywords related to experimental actions and applied them broadly to identify interventions (e.g. pilot projects, demonstrations, trials, test sites, etc.), the actors and organizations participating, and objectives the projects were designed to address. The codes were derived from the literature exploring sustainability experiments as discussed in section 2.1 (see Appendix G).

Following this, a second round of coding was applied to refine the text passages, drawing out content and connecting the experiments to more clearly establish what was produced and how it has been used to learn; the role of actors in the process of developing, delivering, or interacting with experiments; and how policy or organization objectives were used to justify support for the development of the experiment. The codes were derived from Caniglia *et al.* (2017), to guide inquiry, where codes offered refined criteria to evaluate text passages relative to framing interventions and experiments as contributing sustainability solutions, more clearly offering a way to understand the products or outcomes; the conduct and processes; and connection and contextual specificity. A final phase of concept building was undertaken, aimed to search for emerging themes (Saldana, 2009) that could more clearly articulate how experimental learning, governing partnership, and policy fit were achieved (see section 5.2.2 and Appendix G). Through this the search for

emergent themes was connected back to table 5.1 and guided by Caniglia *et al.* (2017). This suggests that the features of solutions-oriented experiments, specifically, provide artifacts and tangible products, understanding of organizing and procedural arrangements for actors, and reinforcement and fit to existing programs and policy.

5.3.3 Limitations

This research seeks to understand how experiments are framed and deployed for multiple purposes to support green infrastructure development. The object of inquiry is not the quantitative outcomes but the way stakeholders frame or leverage experiments as strategic tools for diverse benefits. This research has several shortcomings related to data collection and data analysis. The sources of data rely on key informants who have engaged with experiments and the conduct of acquiring this information was through semi-structured interviews. Semi-structured interviews may be critiqued for not rigidly adhering to an interview script (Longhurst, 2010). However a key set of questions or themes were established for the interviewer to ensure that key research objectives would be reached, yet still allow enough space and time for emergent themes and discussion points to naturally flow (Longhurst, 2010). The second shortcoming relates to the analytical approach used to understand the data. Interview transcripts offer rich detail of particular experiments and similarly foster mundane and meandering discussion, potentially obscuring the objectives of the research. However, qualitative data can follow rigid or well-structured coding schemes to ensure and maintain the object of focus (Hsieh and Shannon, 2005; Elo and Kyngäs, 2008).

5.4 Results: Showcasing, governing, and programming green infrastructure experiments for sustainability

The analysis revealed three themes associated with the development of green infrastructure experiments. Most critically these themes broadly capture how green infrastructure experiments are mobilized by a combination of the public sector, private sector, and CSOs to implement green infrastructure features (see figure 5.1). The first theme, showcasing interventions, is related to actions that rely on the notion of experimentation to motivate further engagement with green infrastructure projects in new or familiar spaces. The rationale underlying showcasing is that green infrastructure experiments are used to show a range of urban stakeholders what and how it works in a more localized space. Moreover, this theme encompassed how green infrastructure experiments are utilized by key advocates to build capacity and reshape understanding and knowledge of community-

oriented functions and opportunities to other aspects of urban development. The second theme, networking and organizing, captures how actors mobilize green infrastructure experiments to create confidence among practitioners to continue replicating and innovating with green infrastructure in new physical spaces. This confidence is gained through experiments that require extensive relationships and trust-building and negotiation to be successful in complex multi-actor arrangements. The final theme, programing and delivery, capture actions that employ and frame experiments in approaches that appeal to well-established procedures and routines within and between organizations necessary to support the existing and new installation of green infrastructure projects in urban areas. This means that green infrastructure practitioners leverage the institutional policy and procedures to present experiments as interventions that help strengthen the existing portfolio of the organization, for example, green infrastructure experiments are framed as a necessary action to achieve municipal objectives to increase urban tree canopy cover. Below these themes are further presented.

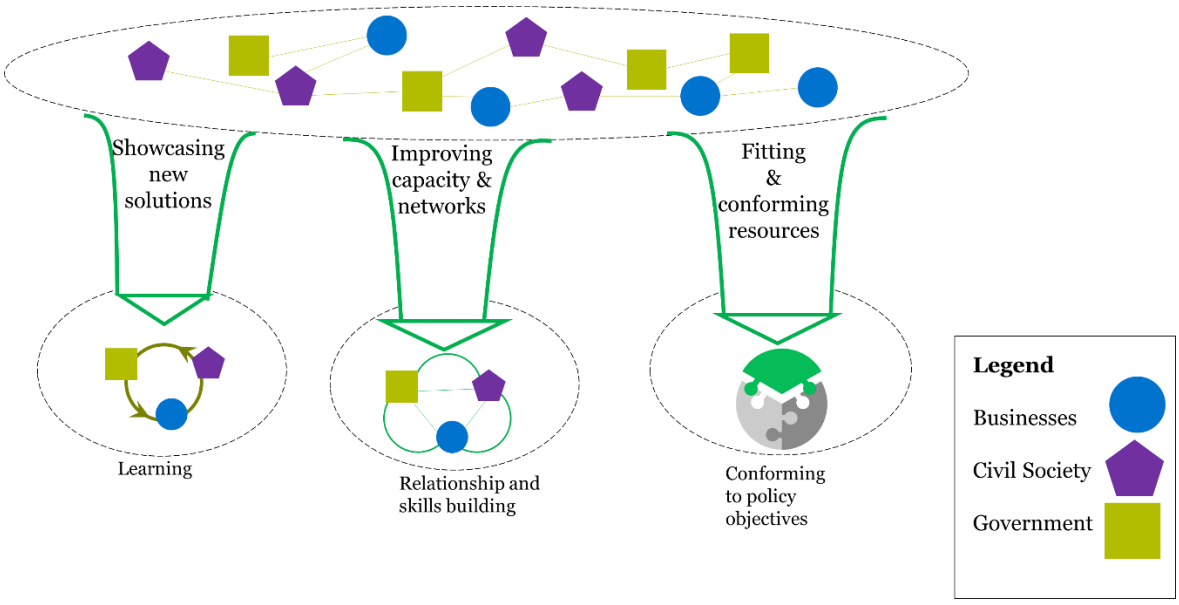

Figure 5.1 Illustration of the purpose of green infrastructure experiments
This figure depicts the purpose and outcomes associated with green infrastructure experiments. The oval represents a generic experimental space for different actors. The green arrows indicate how green infrastructure experiments may be framed. And the subsequent outcomes are placed in the circles at the bottom of the figure.

5.4.1 Showcasing green infrastructure experiments: Supporting knowledge building

Across the analyzed cases, informants identified that green infrastructure experiments were used to contribute to improving the knowledge, understanding, and interaction with interventions. Informants

identified physical green infrastructure interventions as important to actively shape attitudes and perceptions of colleagues and create future opportunities because visual and physical interventions provide clarity on how particular features look in practice (5.TO; 16.LO). Importantly, green infrastructure experiments offer interactive opportunities for various actors to see the different benefits of green infrastructure and urban development schemes.

Across both cases, green infrastructure experiments are used by practitioners and experts - local government, regional government, businesses and business-related organizations, and CSOs - as showpieces for a range of stakeholders, including the above mentioned along with local government councillors and colleagues, and local communities and citizens (12.TO; 13.TO; 1.LO; 11.LO; 19.LO). Successful experiments, in particular, serve as critical signposts or guides for organizations to advertise, coordinate site visits to, and build momentum all in the context of a real-world setting (9.TO; 8.LO; 11.LO) as noted by a London based CSO and Toronto based business owner of an urban forestry company respectively:

> "So they [experiments] definitely help to make the case for developing a proposal to build support on a project" (4.LO).

> "You try all new concepts by doing pilot projects…If it works, it proves the concept. Then we'll develop it further" (28.TO).

This is important as clear connections from abstract concepts to well-connected infrastructure helps show and build support for development. Using street trees, green walls, or green roof programs, to name a few, shows how green infrastructure is applied in a wider urban context and the connections to other departmental or organizational mandates (9.TO; 8.LO; 10.LO). Showpieces are critical outcomes and on-going interventions partially shaping perceptions and experiences with green infrastructure.

In Toronto, experiments related to stormwater management (5.TO; 9.TO; 21.TO) and urban forestry expansion (19.TO; 28.TO) were identified as important as visual and experiential opportunities to understand both success and failure of technical performance (16.TOA) as noted by one city planner:

> "We have a monitoring program that's just been finished. It's demonstrating how well it's working and removing contaminants from an otherwise untreated road. It's right in the center of the community. So it's high profile since everyone has to drive by it everyday. And we learned a lot from it. It is part of a larger neighbourhood action plan.

> So it's not just one off, it's part of a whole series of actions we're trying to do within this, in this neighbourhood (5.TO).

Key projects highlighted by interview informants extend beyond performance and are noted for a noticeable improvement in land-use and community development (5.TO, 9.TO, 25.TO) including beautification, improved access, and useable green spaces (e.g. parkettes). These projects are now routinely used as examples to show funders and decision-makers success related to both technical and non-technical outcomes of green infrastructure (9.TO; 14.TO). Further, learning about the outcomes of projects occurred in parallel with organizations learning about each other's strengths, as noted by one city planner:

> "You're learning and build with each other. Each have different skill sets, different disciplines, and professional disciplines. You come together to come to the best solution and you also work within divisions. Certain divisions are in better position to advocate than others" (9.TO).

The groups implementing green infrastructure were diverse in skills and expertise to design, plan, and deliver. CSOs were able to mobilize trained volunteers quickly or design programs meaningfully connected to community users (23.TO; 29.TO), while firms involved in stormwater management or water basin organizations were well-versed in policy and planning regulations. The value of experiments organized by these expert groups is in the ability to speak to each other with authority and show each other alternative practices and purposes, as noted by one science and policy manager at a water basin organization:

> "I think that's been really beneficial to show not only the development community but also the municipalities, that there's different ways of doing things that can have at least as good, if not better results" (20.TO).

Collectively, the Toronto case shows how green infrastructure experiments are used to further shape the internal organizational understanding of outcomes with interventions as well as the expertise to consult, shape, and direct development.

Similarly, in London, sustainable urban drainage systems (SUDS), urban greening and open spaces development and management have emerged as issues requiring experiments to improve performance as well as understanding the on the ground experiences (1.LO; 17.LO). The role of community-

oriented experiments is important in supporting interactive place-based community engagement and learning aiming to address direct problems as well as embedding long-term knowledge development and learning (3.LO; 20.LO), as noted by one CSO manger

> "It's not necessarily really been the master plan tackling those environmental challenges… how can we make all of our parks better for the environment? We want to make this park work for local people. We want local people to really shape how it works" (20.LO).

Multiple organizations view these as critical elements that improve understanding and engagement with green infrastructure, for improved knowledge of biodiversity conservation (1.LO; 3.LO), water management (13.LO), and access and safe use of space (14.LO). Further, showing local community members and nurturing their desire to further install green infrastructure to pursue other sustainability projects as identified by one CSO informant:

> "One of the estates came together to do de-pave gardens. They met the neighbours, built a sense of community and it made the residents in the estate feel like they could push for more. The residents formed this group based around the gardens and they then pushed for the windows to be replaced in their buildings. And that group is still going" (13.LO).

In London, then, the importance of showpieces is in the ability to shape external, societal learning about the benefits and opportunities afforded by green infrastructure to support creative input or access to spaces.

Overall, showcasing experiments serve to embed opportunity for practitioners, decision-makers, and community actors to see interventions in context, potentially spurring opportunity to build green infrastructure. Green infrastructure experiments are providing products that offer visual, experiential, or other interactions serving to embed the knowledge for others or expert organizations to further develop green infrastructure.

5.4.2 Governing through green infrastructure experiments: Improving capacity building and networks

The second way experiments are utilized is to create an understanding of support and organizing functions of partners and other stakeholders, important for developing green infrastructure (Frantzeskaki, 2019). Based on the analyzed cases, experiments allow for multiple actors, specifically, local and regional government, CSOs, and businesses and business-related organizations

to participate in the development of green infrastructure by sharing resources and expertise (7.LO). The relationship between organizations implementing interventions and those providing supportive functions such as funding (4.LO), volunteering (23.TO; 7.LO), land use (29.TO; 20.LO) and data collection and monitoring (21.TO; 20.LO) can be explored through experimental projects. This inherently connects to improving governing relationships and building the confidence necessary to further pursue green infrastructure development.

Across the analyzed cases, experiments allow multiple actors to connect to fill gaps related to human and financial resources and green infrastructure-related resources (e.g. equipment, plants, trees, supplies). The types and aim of experiments serve to improve delivery (16.TO; 10.LO), land sharing (21.TO; 14.LO), and urban development (5.TO; 19.LO). Distinct roles emerge between private actors (e.g. firms, BIDs, and CSO) and public actors (e.g. local, regional, and arms-length government organizations and departments). Green infrastructure firms, businesses, and BIDs use experiments as strategies to attract clients (21.TO; 20.LO) or fulfill statutory duty (17.TO; 10.LO) leveraging expertise and using contractual duties to improve the delivery of green infrastructure offering a clearer understanding of the coordination and organizations needed to further support undertakings. CSOs certainly deliver green infrastructure (7.TO; 29.TO; 3.LO; 4.LO), however, experiments are better served as strategic practices to leverage relationships for resources and expertise sharing (7.TO; 14.LO), as noted by one CSO manager in London and one CSO green infrastructure planner in Toronto:

> "I think it always works better if you can set up a project with a local authority in partnership because other things come out of that, if they've got too many plants they give it to us" (14.LO).

> "In my opinion, it's [pilots] a good way to test the function and viability; and from a non-profit perspective, get some funding behind it. Working with non-profits can help secure third party buy-in for publicly funded projects" (7.TO).

Experiments are deployed using well-understood technology or identifying supportive conditions and contexts to assist local government in addressing climate change and sustainability-related problems using experiments as tools to improve and define new relationships and visions (7.TO; 6.LO) - including, understanding how different actors (e.g. consultants, firms, or community actors) understand and view the potential of green infrastructure and the alignment with those visions in real-world settings.

In London, experiments expose the diverse functions and capacities of various organizations tied to traditional relationships (e.g. government providing publicly available funds). The opportunity for resource sharing and partnering among local government, CSOs, and BIDs, for example, work well within the institutional rules of land-use policy and planning and are contractually directed. The rules are well-defined, green infrastructure however demands creative application and navigation of rules, such as the application of SUDS (10.LO), street vegetation (11.LO; 19.LO), and land-sharing agreements (11.LO; 14.LO). Whereas, the limited authority of local and regional government, pushes forward highly creative and well-designed projects, with direct goals important to fulfill organizational mandates, as wells as emergent outcomes between diverse actors such as BIDs. Experiments are pursued rather directly to confront immediate problems, for example, improving community-development by focusing on designing community gardens, allowing for food sovereignty, biodiversity education, and community cohesion; or directed street planting and vegetation implementation programs to engage people about green infrastructure. As noted by one BID manager:

> "We have the physical infrastructure and now we're fostering the social engagement with our businesses… offering businesses the opportunity to formally adopt a site where they can be given a kit of gardening gloves and high vis-vests and hand trials to help with basic training. Help them take over some of the maintenance. Businesses are really keen to be more actively involved, getting their hands dirty in some of these spaces" (10.LO).

In Toronto, experiments are used to better embed, leverage, and build relationships for the management of green spaces. For example, CSOs are increasingly identifying local community residents as critical actors to support the long-term maintenance of green spaces and features (5.TO; 8.TO; 23.TO), ranging from the direct implementation (e.g. private and public tree planting) to more supportive functions (e.g. invasive species monitoring). Also, experiments serve to improve the delivery of green infrastructure and relationships between diverse stakeholders involved in green infrastructure development. Local government, water basin organizations, and private actors (e.g. firms and CSOs) work together to develop projects to confront immediate problems and share resources, including expertise. As noted by one city planner, experiments create an opportunity for the integration of local community residents to shape green infrastructure outcomes:

> "We showed them [community group] the concepts of the bioswale…we got them involved in planting the bioswale… we found opportunities for that resident's group to start taking ownership,

> helping with the design, some of the planting, monitoring and long-term maintenance...So we started that way…Green infrastructure is going to need residents to take an active role" (5.TO).

Overall, green infrastructure experiments allow for coordination and exploration of actor duties, responsibilities, and capabilities extending the application of demonstrating the role of ecological features in supporting land-use and infrastructure delivery schemes. Experiments are critical in supporting various actors in understanding each other's roles and facilitating new governing arrangements and building relationships. The utilization of experiments clarifies roles and opportunities to work within rules and contracts, or upgrade and update how they are applied, better constructing and forming networks of actors with diverse ideas and expertise.

5.4.3 Programing green infrastructure experiments: Negotiating for experiments into existing procedures

Finally, green infrastructure experiments are framed as strategic interventions that conform to the existing policies and programs in urban regions. In this sense, experiments are used to justify green infrastructure development based on objectives and priorities of government and other organizations, as well as larger urban sustainability outcomes.

Across the analyzed cases strategic leveraging is used by organizations or local government to establish how green infrastructure experiments fit well within the existing urban context (5.TO; 16.TO; 4.LO; 17.LO). Green infrastructure practitioners navigated political and local contexts, creatively framed and connect outcomes to existing problems, and capitalized on triggering events. Challenges remain, however, due to a hesitancy to pursue "radically new" ideas, risk aversion, and uncertainty of performance are still deeply embedded in decision-making related to green infrastructure, particularly when multiple government units are intimately connected to it. The solution, then, requires a clear demonstration of how green infrastructure fits within broad or narrow mandates, such as existing programs or objectives, as described by one regional water manager in London and one basin authority manager in Toronto:

> "There's been enough pilots across London, most of it was a success. I think the issue - it's slightly outside of the norm, there's a slight hesitation because, suddenly you're starting to introduce new green infrastructure and [they] are not set up to maintain this and this is going to cost more… we need to make sure that the way in which we're quantifying them aligns with how they would" (17.LO).

> "I'd like to see us have a little bit more latitude to bring about a more experimental and less risk averse approach to try things out… trying to appease municipal councils and assure them that we're not just doing research we're doing real on the ground change management" (17.TO).

Differences emerge, related to the way programs are leveraged and negotiated. In London SUDS and green space access are important matters to CSOs (1.LO; 4.LO) and local government and regional government (16.LO; 19.LO). Experiments are framed as extensions of existing efforts to improve water management and open and green space programs. Moreover, past experiments are leveraged to further pursue action, the simplicity of which is summarized by a sustainability manager and biodiversity conservation manager:

> "someone will do the experiment. Then you just need to tell everyone how great it was and they will all want one" (6.LO).

> "they [pilots] all lead to building this narrative, which fundamentally revolves around social validation. If other people are doing it, I should do it" (1.LO).

More significantly, the role of localized and highly contextual experiments is increasingly pursued and justified as serving to better confront issues of regeneration and community well-being and development (10.LO; 17.LO) as noted by a London-based green infrastructure manager:

> "And decision-makers, the thing that motivates them, it's about health. It's about transport. It's not conserving wildlife… by demonstrating that having a more ecological approach to the management of the city, benefits your health, that's the thing that taps into the majority" (16.LO).

In this sense, there is increasingly creative leveraging of a more holistic approach to the pursuit of experiments, better exploring the improvements to non-technical issues, yet purposefully constructing a green infrastructure network, and simultaneously contributing to functional and operational improvements related to urban challenges.

In Toronto, experiments are were actively negotiated to confront issues such as flooding, urban heat island effects, stream restoration, or invasive species management to name a few, and increasingly demand innovation to confront these problems. Green infrastructure experiments are a difficult proposition for local government to pursue or administer due to limited resources, expertise, and risks (14.TO; 15.TO; 21.TO; 28.TO). City planners and managers were required to confront this by demonstrating clearly to managers and decision-makers how projects fit within existing essential

programs or to work within the organizational structures to partner and piggy-back on projects, and frame experiments as viable projects, as noted by a water basin planner, a city planner, and a forestry manager:

> "I had to show that it was low risk. I would say in the meetings, 'I'm doing it anyway. So, either we do it for storm water capture or not. This road is coming out'…I had to fight for the pilots. I have to work with people who I know want the pilots, but we have to work hard to get the permission to do the pilots" (19.TO).

> "We've done a few pilot projects with the aim of trying to integrate that practice into all of our new road resurfacing programs… integrating low-impact development and bio swells within our capital projects" (5.TO).

> "I think sometimes they're a little bit easier for people to accept this as a pilot project. That's the test versus this is the way we're going to do it from now on. I understand that it's for trying something" (16A.TO).

This shows that to get green infrastructure implemented in local government, green infrastructure units and practitioners, in particular, must negotiate, direct, and shape the purpose(s) of the experiments to fit firmly within the boundaries and objectives of improved efficiency and management of the city (9.TO; 21.TO; 25.TO; 28.TO).

Firms and CSOs are typically integrated into projects to offer innovative ideas for municipalities, while fulling municipal objectives (5.TO; 12.TO; 16.TO). These actors recognize the incremental nature of experiments from a local government perspective, as noted by one CSO green infrastructure planner:

> "Building trust and support for these projects, through education and piloting new ideas provides the systematic change needed to redesign our cities…Pilots allow many municipalities to test and experiment in response to long-term goals and strategies and then determine if they could be scaled in other areas" (7.TO).

CSO's and firms slowly pull municipalities along and increasingly push for more innovative ideas, building trust in both the performance of technology and relationships (14.TO; 21.TO; 28.TO). The presence of multiple non-municipal government actors provide the necessary technical expertise (9.TO; 21.TO) to pursue more innovative experiments, as noted by one firm owner:

> "We've always hit a barrier with the operations staff, the people that will ultimately be the ones to pick up the pieces when one of these things fails or clogs or will be responsible for them… we would say,

> ‘here's how you do it and here's what it costs’, you give them the facts so that they don't go in with the sky is falling kind of attitude” (21.TO).

Examples, however, are uncovered where local government lead highly innovative projects (9.TO; 25.TO; 27.TO), again, the presence of diverse actor constellations appears to be a critically important factor in supporting local government visions (21.TO; 28.TO). Nevertheless, the willingness of local government to attempt these projects is recognized as a positive move by government and non-government practitioners (9.TO; 21.TO) to pursue green infrastructure development.

Overall, experiments are leveraged as framing devices and policy tools to pursue the installation of green infrastructure. Practitioners target existing operations and management strategies to fit experimentation into the existing mandates or objectives of a city or organization.

5.5 Discussion

The analyzed cases shed light on a variety of roles performed through experimentation. This study demonstrates how practitioners use green infrastructure experiments to support actors to build capacities through experiential learning and practice, create opportunities for alternative governing arrangements, and strengthen policy orientation and fit within existing urban development objectives. The results illustrate how diverse actors such as city civil servants, CSOs, and business owners all use green infrastructure experiments as purposive exercises to navigate and steer development beyond that which adheres to performance criteria alone. This means that green infrastructure experiments are strategically designed as opportunities to not only validate performance but potentially and intentionally strengthen and diversify the green infrastructure network.

Building on these insights, further analysis demonstrates how the strategic orientation of green infrastructure development is undertaken through an experimental framing. First, green infrastructure experiments support social-technical reconfigurations towards more sustainable forms of urban sustainable development. Second, practitioners do not view and conceive of experiments as radical undertakings to test innovative technology. Rather they serve specific needs by building confidence and navigating the complex inertia of political and social arrangements capturing a more diverse understanding of green infrastructure beyond supporting grey infrastructure alone. These observations are discussed further below, highlighting the emerging points.

5.5.1 Strategic development using experiments

Green infrastructure experiments are critical socio-material artifacts contributing to current sustainability efforts. Practitioners use the diverse opportunities afforded by green infrastructure experiments as a strategy to connect with other urban development units and specialists, leveraging specific and broad funding sources, and complement on-going critical infrastructure projects. In this sense then, experiments are an important strategy to increase and diversify green infrastructure networks and build the requisite knowledge, skills, and communities to further embed and enhance green networks in urban areas. Figure 4.1 in chapter 4 broadly captures this dynamic by offering a simple conceptualization of the recursive nature of system change driven by practices and the feedbacks shaped by agendas and visions.

The benefits of green infrastructure experimentation then lie in the entrenching of an alternative set of purposes beyond performance and cost, for practitioners and stakeholders alike. This speaks to Etzion *et al.* (2017) who suggest that sustainability practitioners must embrace short-term wins and a wider set of outcomes. As identified by a green infrastructure specialist in the London transportation sector "*We can't necessarily wait for 10, 20, 30 years to see the outcome before we recommend doing it more widely*" (8.LO). This inherently requires diverse perspectives establishing purpose, needs, and desired outcomes of green infrastructure in the short-term to potentially achieve long-term ecological benefits.

Green infrastructure experiments promote interactive, visual, and experiential opportunities situated deeply in place and context. As was demonstrated across both cases, participatory and multi-actor green infrastructure experiments integrated diverse voices promoting the potential for green infrastructure or sustainability-oriented gains. The intent and outcomes of green infrastructure experiments allowed for the embedding of green spaces, expansion of green infrastructure networks, and the simultaneous opportunity of learning and policy-oriented goal achievement.

The simultaneous achievement of multiple processes to achieve green infrastructure implementation, allows experiments to serve as a strategic development tool that, extends beyond the construction of physical artifacts and expert voices fulfilling routine projects. Here, Etzion *et al.* (2017), establish the value of "multivocality," which is the ability to recognize the diversity in perspectives for sustainability solutions and even the utilization of artifacts. Moreover, by exploring or exposing the multi-stream solutions available in experiments, practitioners may be able to better connect opportunities directly to on-going policies and programs. As well, Caniglia *et al*. (2017)

reaffirm the importance of experiments to provide multiple outcomes, including tangible products to facilitate learning and knowledge development, the need for alternative organizing strategies, and entrenching solutions into current contexts and conditions. In the cases presented, green infrastructure was utilized as a diverse proposition to firmly established the value, connectivity, and opportunity for practitioners and stakeholders to leverage different aspects of an experiment. The significance of this is green infrastructure shifting from an abstract concept or inconsistently defined (di Marino and Lapintie, 2018; Conway, Khan and Esak, 2020) to practices and infrastructure more clearly understood, applied in context, and directed and shaped by experts and users.

5.5.2 Recognizing experiments as ongoing actions

Second, green infrastructure experiments are ongoing sequences of action. This means that experiments are imbued with emergent properties; new goals emerge out of actions and are not prescribed before the experiment. This highlights, the importance of green infrastructure leaders embracing ambiguity and recognizing the importance of short-term gains to build future actions (see Etzion *et al.*, 2017). This is a challenging proposition in the context of urban and city-led planning and development that have emphasized the need for clarity and definitive outcomes, as the resources invested must yield tangible and "politically" meaningful outcomes (Aylett, 2014). However, as revealed by the cases, experimentation serves to satisfy multiple streams of sustainability-oriented development simultaneously. Articulating or presenting green infrastructure experimentation as both conforming to, and revealing new opportunities serves to expose the unique and multi-beneficial properties of green infrastructure.

Across the analyzed cases, green infrastructure experiments aimed to connect and challenge the way people engage with nature and learn from it (though within well-defined problems and goals). Through this, experiments were practical mechanisms to enhance green infrastructure networks, framed as logical extensions of sustainability action. This speaks to the concept of generative experiments presented by Ansell and Bartenberger (2016), where experiments are intentionally developed or are well understood to produce known outcomes, as noted by a regional green infrastructure manager in London "*we fund projects which we know are going to get good outcomes and we take people there to show them what it does*" (16.LO). Experimentation is designed as "safe-to-fail" providing a clear understanding of intended outcomes and opportunities for innovative and adaptive projects (Ahern, 2013) as reaffirmed by one Toronto green infrastructure manager, "*we call it fail forward. We want to try things in small increments, test it, and learn from it*" (13.TO).

Experimentation is a strategy aimed at problem-solving and solutions development while managing uncertainty (Ansell and Bartenberger, 2016; Caniglia *et al.*, 2017). Sustainability experiments are diverse in the degree of control, the physical application (e.g. outside of lab), and the participatory opportunities afforded.

As an ongoing process, green infrastructure experiments offer a way for practitioners and other stakeholders to capture outcomes to better synthesize and refine processes to further deliver or construct the basis for green infrastructure development. Confronting how green infrastructure supports more development is addressed in the potential of experimental practitioners to push for or recognize the importance of developing knowledge, building new actor relationships, and improving the skills and policy fit (Raymond *et al.*, 2017; Frantzeskaki *et al.*, 2020). Moreover, as experiments provide diverse innovation related to processes, outcomes, and artifacts, Smith and Raven (2012) offer a degree of understanding of how experiments may be viewed to support pathways of system change. Innovation may follow adaptive (fit and conform) and transformative (stretch and transform) pathways. As seen in the cases, experiments may simply follow along with the existing policy objectives to incrementally advance green infrastructure development such as small or local planting initiatives. However, experiments may also transform and demonstrate weaknesses in exiting policy to improve the way green infrastructure is used and alteration in the conduct of city operations (e.g. installing a man-hole cover for stormwater on private property TO.21). These propositions may help shift views of experiments from only one-time investments and instead as ongoing programs facilitating continued learning for future projects potentially changing perspectives limited to high-risk vs-low risk as noted by one engineering consultant *"people still say 'it's unproven technology'… we're past that and people are still using that as a defense.. we'll show them 50 research papers that say it's not unproven"* (21.TO).

Instead, projects may be better viewed from more practical and evidence-based lenses more supportive of recognizing the existing opportunities and potentially re-designing (stretch and transform) and supporting (fit and conform) city-level contexts. Simultaneously, practitioners eager to pursue projects must be cognisant of their responsibility to those allocating funds, committing land, and the long-term maintenance. This then reinforces the argument that experiments must be viewed more holistically to support multiple opportunities connected to learning, governing, and policymaking. The boundaries of the purpose and types of experiments may be partially limited by what has worked successfully and what urgent needs and goals are required currently. Further, the

opportunities for more collaborative partnerships for experiments serve to lessen the perceived or real burdens of responsibility, funding, and land. The aim of partnering and aligning projects to the existing policy goals shows how practitioners tacitly produce experiments suited to the existing context and objectives of clients or partners.

5.5.3 Summary and recommendations

The above discussion attempted to demonstrate the nature of experiments serving as a tool to frame and deploy green infrastructure supportive of navigating uncertainty and governing contexts. Moving forward this must be translated into policy, therefore one policy recommendation is offered to better ensure the recognition of the power of experiments to support sustainability and expansion of green infrastructure development. First, green infrastructure experiments as ongoing process of change must be followed with formalized evaluation programs, as noted by one informant in Toronto, *"I don't know if there's a formal process to do that [project evaluation]…we kind of just do it as a matter of course with a lot of projects*" (16A.TO). Ensuring that formalized evaluation processes are undertaken serves to enhance the evidence of performance, often argued as the primary purpose of conducting these projects. However, the formalized evaluation will also serve to bring to light the governing processes, forms of learning, and alignment of projects to sustainability goals. In addition, table 5.2 below provides a list of recommendations or steps forward to support the deployment of experiments.

Table 5.2 Suggested recommendations to advance experiments

Purpose of experimenting	Recommendations	Implications
Showcasing and realizing the power of experiments	• Actively pursue organizational retreats to sites and pilots for colleagues. • Demonstrate the value of showpieces as serving to reinforce or introduce ideas and purpose of green infrastructure.	• Green infrastructure experiments as multi-beneficial tools to learn about processes and outcomes. • Sustained efforts to maintain experiments will be needed to extract learning connections.
Relationship building	• Connect with regional partners to leverage resources and expertise. • Demonstrate how experiments serve relationship-building strategies. • Show the regionally integrative opportunities to deploy green infrastructure.	• Active and sustained network building and targeting approaches for experimentation local communities may be required to sustain the momentum of actions and reinforcement of purpose.
Aligning experiments	• Connect experiments to urban sustainability priorities, serving to attract more partners and ensuring alignment with current programs.	• Policy targets and urban sustainability goals will provide a clear articulation of experiments purpose and connections to urban areas.

5.6 Conclusion

This paper has demonstrated how green infrastructure experiments are leveraged as a development strategy to achieve multiple outcomes connected to learning and knowledge development, facilitating governing arrangements, and supporting existing sustainability outcomes. These findings highlight the importance of recognizing the strategic nature of experiments as a tool for embedding interventions in urban areas. This means that experiments contribute to urban sustainability development by proving the infrastructure and socio-material artifacts necessary to understand of how future actions may unfold, while also providing immediate and tangible sustainability outcomes. Second, experiments are ongoing, allowing practitioners to design interventions that may sit firmly within the sustainability objectives of a region or organization. This further allows experiments to partially conform to diverse interests and actors important in supporting and facilitating an understanding of the potential array of sustainability outcomes or solutions available.

Chapter 6
Conclusion and synthesis

6.1 Summary

This research has demonstrated how green infrastructure development is shaped by diverse governing arrangements supportive of mobilizing alternative actors, practice-oriented solutions, and strategic experiments. The research question that led to this finding was: how can green infrastructure development by heterogeneous urban actors expose governing arrangements supportive of sustainability transitions? To address the research question, the three empirical chapters (chapters 3-5) explored various governing frameworks revealing the supportive roles of private actors in leading or directing the purpose and opportunities for green infrastructure development; the role of interventions and actions in building the confidence for green infrastructure development; and the importance of experiments in building capacity and experiential opportunities for multiple actors to participate in or better understand green infrastructure.

The purpose of this research was to understand how governance arrangements support the mobilization of green infrastructure development for sustainability transitions. An instrumental case study approach was undertaken to understand how green infrastructure is developed through different governing arrangements in two urban region cases, Toronto, Canada and London, UK. Governing arrangements explored, broadly, the intersection between heterogeneous actors, the intentions of their actions or approaches for green infrastructure development, and the outcomes that facilitate or guide green infrastructure development. These governing arrangements are mediated through the orientation of practices and the refinement of processes to support intervention embedding in urban areas, specifically, through the direction and guidance of private actors, the recursive process of interventions informing development trajectories, and the strategic delivery of experiments.

This research builds on multiple bodies of literature to help frame the conditions and processes guiding societal change supported by practices (see Loorbach, 2010; Grin, 2020) and arrangements (see Bulkeley and Castán Broto, 2011) utilized by green infrastructure actors, primarily local and regional government, and the private and civil society sectors. To understand how governing actors are mobilizing to embed green infrastructure in urban areas, a constructivist research approach was used to underscore the actions, practices, and routines of green infrastructure actors. Chapters 1 and 2 established the conceptual and methodological foundations for this research. The problem of focus

emerges from the challenges confronted by unsustainable trajectories of development and the associated difficulties with searching for narrow solutions to address them. Moreover, narrow views built on the premise of technical and regulatory solutions alone will underplay the deeper challenges associated with sustainability. Sustainability certainly requires technical and regulatory instruments to facilitate change, however, it is also deeply connected to personal and contextual cultures, behaviours, and routines. This means that the role of people and their actions (or unwillingness to act) strongly dictates the actions and the multiple problems and solutions available.

One set of solutions used in urban areas is green infrastructure – a suite of ecological tools utilized to design a network of natural, semi-natural, and human-made features managed to provided sustainability benefits. Green infrastructure research has better recognized the importance of governance in shaping outcomes associated with development. However, it was argued in this paper that a better understanding of how a heterogeneous set of actors can mobilize to develop and embed green infrastructure in urban areas, contributing to a processes-based perspective. In this regard, understanding how private actors exercise various expertise, skills, and characteristics to steer development or partner with local government complements the literature on local government-led green infrastructure development. Further, it is important to note the tensions arising from unaccountable and unelected private actors dictating the actions and projects deployed in urban areas. Second, governing arrangements were argued to be directed by the alteration and reproduction of practices, critical in mediating the processes and conditions for green infrastructure agendas and long-term visions. This contribution aimed to demonstrate how the engagement of actors with green infrastructure actions is important to create confidence and knowledge of the possibilities for future actions. Finally, green infrastructure experiments were framed as important in strategically embedding interventions and facilitating knowledge development, partnership building, and fulfilling local and regional sustainability goals. Collectively, these points are further discussed below.

Private actors support green infrastructure development through governing arrangements important in facilitating leadership, collaboration, and government partnerships (chapter 3). Specifically, private actors actively shape the purpose and context for green infrastructure and associated development and interventions. This is important because it creates a more fulsome picture of the diverse governing arrangements available and in practice currently in the cases. Much literature has been devoted to reaffirming the competencies and contributions of local and regional governments in directing green infrastructure development (Young and McPherson, 2013; Harrington and Hsu, 2018;

Johns, 2019). Private actors, as revealed through the cases, are extending their expertise and competencies, advancing technology, identifying supportive programs to integrate and partner with other private and public actors, and ensuring synergy between private and public projects and sustainability-related objectives. Using a modes of governing frame to aid in understanding the role of private actors (Bulkeley and Castán Broto, 2011), it is clear that private actors may be able to act across jurisdictional boundaries, important for accessing resources and land, work at multiple spatial scales, designing and implementing programs and projects at neighbourhoods and private property, and finally, complementing and strengthening the delivery of public programs. This work is significant because it reveals the opportunities available to better guide the development of green infrastructure with private actors as leading or supporting. Private actors are deeply embedded in the development processes and by recognizing the multiplicity of roles and competencies, diverse governing arrangements can support the guidance and implementation of green infrastructure interventions and support programs.

Green infrastructure is further embedded in urban areas by practices supportive of mediating recursive dynamics to guide sustainability transitions (see chapter 4). This means that the actions and interventions associated with green infrastructure development shape transition dynamics, provides the necessary understanding and experience for the formulation of agendas, and the confidence and scope of possibility to inform visions. At the heart of practices are the green infrastructure actors "doing" or more concretely engaging with the various actions, processes, and interventions to better understand the contributions, societal dynamics, and performance outcomes. This enables a better understanding and the building of attributes important to demonstrate competencies, confidence in actions, and capacity-building for other actors. The practice dimension or the direct actions supportive of implementing interventions are driving the formulation of green infrastructure agendas to create the broad structural and contextual conditions to scale development and organizational routines to embed green infrastructure interventions in urban areas. As well, practices drive long-term visions critical in framing problems, constructing multi-actor working groups, and shaping the contents of long-term green infrastructure network objectives. This is significant because it establishes the role of agency in directing the intention of green infrastructure development and firmly places people at the centre of change. Recognizing actors as steering green infrastructure development through actions that allow for interactive and place-based implementation highlights the importance of creating spaces and offering resources for interventions to influence established routines, challenge existing development pathways, and potentially allow for a reconceptualization of

the possibilities of broad and specific actions all collectively important in supporting and further embedding of green infrastructure in cities.

Finally, green infrastructure experiments strategically support the embedding of sustainability interventions across a city by exposing actions, building networks, and aligning urban sustainability objectives (see chapter 5). Green infrastructure experiments may be developed to allow multiple actors to better understand and develop knowledge, build capacity and potentially participate, and support the embedding of actions in urban areas. Green infrastructure experiments were utilized in both cases to install features, new technologies, spread routine actions or connect with new actors to support green infrastructure development. Experiments served to navigate difficult political, planning and development structures, whereby the presentation of a pilot or trial site offered less risk or opportunity to better understand the action. Further, piloting was also connected to governing arrangements supportive of accessing land, uncovering actor's resources, and drawing on different expertise to better connect the diverse users and draw on novel opportunities to improve arrangements and sustainability action. This provides an understanding that sustainability experiments may be supportive of navigating process-based issues as opposed to outcomes alone. This is important, while experiments certainly support outcomes to improve sustainability from an efficiency or performance view, the governing processes and ability to better connect actions directly to people may serve to more concretely establish how interventions are disconnected from users and consumers of resources.

6.2 Research contributions

This research offers a clear articulation of the multiple ways governing arrangements may be deployed by a heterogeneous set of actors to mobilize the development of green infrastructure. This work has strengthened theoretical and practical understanding of how private actors lead, guide, and support development, the mediating role of green infrastructure actions and interventions in embedding green infrastructure development into urban development routines, and the strategic development of experiments to increase knowledge, build capacity, and strength sustainability objectives. Building on this, it is suggested that this research contributes to further conceptualizations of green infrastructure as connected to sustainability governance, sustainability transitions, sense of place, and the geography of sustainability transitions.

This research contributes to the *theory* of sustainability governance, which is a framing to help understand the multi-actor processes directed at confronting broad sustainability-related issues.

Critical to this is the role of diverse governing actors, who bring different needs, perspectives, and solutions to support improved sustainability in social, ecological, and economic domains. This, however, has still resulted in much literature exploring the role of government across levels leading or providing the necessary policy direction and policy instruments to push non-government actors to participate on sustainability action (Bauer and Steurer, 2014; Lupova-Henry and Dotti, 2019). In cities the focus has been on local governments and their strategies to facilitate, motivate, and implement sustainability actions (Toly, 2008; Gore, 2010; Khan, 2013; Homsy and Warner, 2015). The dissertation has added to this work by examining the role of private actors, that is businesses, business networks, and civil society organizations (CSOs) in leading and supporting local government efforts on green infrastructure development. Moreover, this research examined how the constellation of actors driving green infrastructure development leverage diverse resources and partnerships supportive of collaborative arrangements to guide actions.

Green infrastructure development requires diverse actor arrangements due to the multiple benefits, uses, and connections of ecological features to broad and specific problems and solutions. Indeed, the *empirical* research findings support this and provide deeper insight into the way green infrastructure development exposes opportunities for the actions of actors to inform the processes of development and implementation beyond performance and efficiency gains alone. First, chapter 3 demonstrated how green infrastructure governing is diffused with private actors playing a vital role in supporting government but also leading development through on the ground actions and through policy development. Second, chapter 4 showed how embedding green infrastructure into multiple domains for system change is mediated by formal and informal practices and actions. A constellation of actors are involved in designing and navigating rules and procedures, implementing green infrastructure, and reformulating and redirecting long-term visions and potential of green infrastructure objectives and goals in urban areas. Finally, chapter 5 presented the strategic deployment and utilization of green infrastructure experiments revealing how different actors deploy and use experiments to support learning and relationship building. Collectively, green infrastructure governance arrangements are diverse because of the opportunities afforded by development pathways and the potentially different uses and connections to various actors.

This research also contributes to *theories* of sustainability transitions, understood and framed as the alignment of multiple system processes altering socio-technical, socio-ecological and socio-institutional arrangements to better support more sustainable outcomes in the modes of production

and consumption (Loorbach, Frantzeskaki and Avelino, 2017). Recent lines of research in the sustainability transitions community have attempted to better support an understanding of agency (Pesch, 2015), politics (Avelino *et al.*, 2016; Avelino, 2017) and governance (Frantzeskaki, Loorbach and Meadowcroft, 2012; Leal Filho *et al.*, 2016), while also being less confined to the theoretical models of change defined through innovation selection and retention environments. Building on this, the dissertation research advances understanding of how transition practices and sustainability experiments may be supportive of navigating sustainability action, though, purposefully designed to support diverse governing arrangements for the implementation of interventions.

In particular, chapter 4 focused on the socio-institutional arrangements (Loorbach, Frantzeskaki and Avelino, 2017), which is a more analytical understanding of the actors and the governing arrangements and the processes aimed at reinforcing green infrastructure actions in urban areas. Using the transition management framework to support analysis in this chapter, it is argued that practices revealed through interventions, actions, and experiments are important in mediating the development and reinforcement of green infrastructure agendas and visions in urban areas. This does not suggest that agendas and visions are less important or irrelevant, simply, the ability to develop and design the rules and processes for implementing green infrastructure widely require clear evidence of possibility, appropriate governing systems, as well as suitable performance outcomes.

Moreover, the dissertation research contributes to the *empirical* literature of transition management, by offering examples of how transition practices for sustainability-oriented development deliver the prerequisite opportunities for application, learning, and relationship development all-important to designing, implementing, and using novel and routine green infrastructure interventions. Where other research has focused on transition arenas and distributional power issues (Avelino, 2009; Hölscher *et al.*, 2019) or explored transitions agendas to better support multi-actor policy-shaping, market design, and embedding policy into government (Kemp and Rotmans, 2009; Killip, 2013; Kenis, Bono and Mathijs, 2016), it is argued in this dissertation that transition practices - understood broadly - are direct and tangible actions which create the diversity of interventions, demonstrate multiple opportunities for sustainability action, and expose the actors and user opportunities for green infrastructure. This supports and may help explain how transitions are mediated, providing breadth in the actors who shape transition practices, supporting an understanding of how transition practices open-up alternative arrangements and action, while also offering stability to existing agendas and processes.

Second, chapter 5 presented a deeper understanding of green infrastructure experiments as important strategic actions providing an opportunity for diverse actors to understand, interact, and shape the purpose or need of green infrastructure interventions. The *empirical* contribution of this chapter was demonstrating how experiments are used as interventions to install and embed physical green infrastructure in cities. The ability to navigate institutional processes associated with urban planning and development demands searching for diverse resources and expertise and the application of experiments. Chapter 5 offered a process-based approach for practitioners to frame experimental contributions as more than technical and efficiency-related to potentially support the ability to install green infrastructure by connecting approaches to urban objectives, attracting partners, and diversifying opportunities. By highlighting the improved governing processes and learning opportunities it is shown how experiments can be presented as a valuable tool to more holistically connect with users and community needs to support sustainability goals.

Finally, this research contributes to highlighting the importance of context in directing sustainability development. First, sense of place is a concept in human geography used to describe and explain how people connect to their surrounding physical spaces as more than utilitarian and better attribute meaning and uniqueness to these spaces (Tuan, 1977, 1979; Agnew, 2011). In connecting the concept of sense of place in social-ecological systems, Masterson *et al.* (2016) direct researchers to consider the importance of time lags, shifting baselines, and local identity in shaping larger system change. In describing the role of sustainability experiments Frantzeskaki *et al.* (2018) demonstrates the multifaceted dimensions of sense of place in facilitating participation and relationships, spurring and guiding visions for innovation, and the opportunity to learn and shift the meaning of and purpose of actions. Building on these insights chapter 5 *empirically* demonstrated the strategic and deliberate nature of experiments to be used as interventions to redirect knowledge, relationships, and objectives. More concretely and connected to developing a sense of place through experiments, practitioners reached out to community members to solicit an understanding of user needs related to green infrastructure. Certainly, the primary purpose of designing green infrastructure feeds into technical outcomes (e.g. flood control), however, the processes and extension of schemes to identify additional outcomes for community members served to motivate early participation in design and potential for management of the spaces. This shows that experimental design and approaches must search for deeper connections to people, places, and outcomes to offer a clear understanding of the potential for users to contribute to projects and learn about the benefits of green infrastructure in context.

Another collective contribution of this dissertation is in advancing *theories* on the geography of sustainability transitions, generally understood as a lens to capture spatial and scale dimensions related to shifting technical innovation systems and the disruption of incumbent technical spaces (Coenen, Benneworth and Truffer, 2012; Hansen and Coenen, 2015). More recent advances have further narrowed in on the urban scale encapsulating the importance of governance processes in supporting sustainability transitions (Murphy, 2015; Binz *et al.*, 2020). Certainly, the importance of context and the specific socio-technical system(s) have been acknowledged in earlier work on the geography of sustainability transitions (Truffer and Coenen, 2012). However, the recent work aims to better incorporate voices less connected to the innovation systems and more clearly shows how the fringe actors and users are important in diversifying problems and solutions for sustainability transitions. As well, the work of Loorbach *et al.* (2020) further aims to demonstrate the importance of diverse actions and networks at the localized scale in shaping urban sustainability transitions. This dissertation follows along these *theoretical* research lines and aims to show that transitions may unfold differently across areas as opposed to unevenly, as suggested by transition geographers (Coenen, Benneworth and Truffer, 2012; Binz, Truffer and Coenen, 2014). This distinction is important to note because it firmly establishes the localized context such as actors, problems, solutions, actions, and visions as guiding or shaping the sustainability development trajectories. Past research deeply rooted in economic and evolutionary geography was well suited to integrating the history of industrial development and space into an analysis of a narrowly defined innovation system (Coenen, Benneworth and Truffer, 2012; Truffer and Coenen, 2012). Thus, the trajectory of development was well suited to the ebbs and flows of innovation forerunners, destabilizing events, and suitability of innovation retention environments. The dissertation instead shifts attention to the plurality and multiplicity of governing actors, actions, and contexts shaping the multiple opportunities for diverse green infrastructure processes to unfold. Rather than a singular innovation trajectory, multiple green infrastructure development trajectories (e.g. stormwater capture, community gardening, natural heritage management, urban forestry development) are needed to unfold to reinforce the development of a green infrastructure network.

Finally, this research contributes to the *practice* of green infrastructure development offering clear lines of support for policy development and multi-actor project development. Green infrastructure is experiencing increased attention from urban and city level actors as an approach to improve processes and outcomes of sustainability-oriented action. This will allow a diverse group of actors to shape understanding of the need and use of green infrastructure in various urban contexts, such as

stormwater management or community-based recreation. Applying the lessons from this dissertation will allow decision-makers and non-state actors the opportunity to initiate conversations or implement projects.

First, policy development processes - the practice of designing, selecting, implementing, and evaluating initiatives programs, plans, and projects (Kingdon, 1995; Pal, 2007) - may be enhanced through this research because a set of practices are offered supportive of uptake and design of green infrastructure features. Past work has offered clear lines of thinking of how policy action may spur green infrastructure development if clearer targets of programs are offered to more flexible approach design related to shifting land-use patterns or use (La Rosa and Privitera, 2013; Derkzen *et al.*, 2017) and detailed accounting of the life cycle costs and financial commitments (Brack, 2002; Merk *et al.*, 2012; Guerry *et al.*, 2015; Feldman, Foti and Montalto, 2019; Matsler, 2019). Certainly important for municipal decision makers and the like when selecting projects and allocating limited resources, this research adds to the practical considerations by offering a considerations of how actor and actor networks may facilitate green infrastructure development.

Chapter 3 demonstrated how diverse actor constellations may be supportive of leveraging various resources and expertise to design, encourage, or complement green infrastructure development. Chapter 5 explained how experiments specifically offer clear lines of evidence of how green infrastructure may be presented and deployed to support knowledge, learning, and relationship building. By recognizing this, green infrastructure policy may be better designed to offer schemes that better connect land-use access, spaces for experimental design, and funding programs, resources, and organizations collectively limiting the challenges associated with conducting green infrastructure projects. This does not suggest that policy design alone will resolve all problems or connect all producers and users of green infrastructure. Simply, policies oriented towards green infrastructure may benefit from identifying objectives and outcomes aimed at designing and implementing green infrastructure requires supportive mechanisms for land, resources, and people to find come together. Certainly, a degree of organic relationship development and user needs must accompany policy direction. Several examples of estate redevelopment, community-based green space development, and tree planting show how the ability to have resources (e.g. money, plants, space, expertise, etc.) along with keen and committed green space users is important as well.

Second, and connected to the above, the delivery of projects benefits from collaborative partnerships between public and private actors. Much literature has emerged to discuss grassroots

and social innovation by local community members in diversifying or utilizing underused spaces and developing urban ecological stewardship programs (Connolly *et al.*, 2013; Conway and Bang, 2014; Kati and Jari, 2016; Spijker and Parra, 2018); increasingly coordinated attempts by both local government and green infrastructure organizations in partnering to deliver vegetation planting programs (Conway and Urbani, 2007; Young, 2011; Young and McPherson, 2013). The dissertation builds on this and has shown how businesses, business-related organizations, and CSOs direct the purpose and intent of programs or are important in supporting local government in partnering to deliver projects. In this regard, chapter 4 showed how multiple actors are critical in facilitating engagement with green infrastructure actions. Further, chapter 3 showed how private actors may act as mobilizing agents offering physical spaces or the expertise to demonstrate how green infrastructure is used, established, or sustained by expert and non-expert audiences. Chapter 4 demonstrated the importance of practices supporting diverse actors in engaging with green infrastructure features to learn about and build a better understanding of the possibilities or potential opportunities to use green infrastructure. Building on from this it may be valuable for green infrastructure practitioners to spend time cultivating new relationships and nurturing existing relationships, as many already do in the case study regions. Further, with the emergence of green infrastructure as a priority issue in urban areas, intermediary organizations for green infrastructure may be valuable in promoting to act as partially centralized repositories of information, policy guidance, and network building (e.g. Green Infrastructure Ontario Coalition, 2020; Town and Country Planning Association, 2020).

6.3 Research limitations

Reflecting on the research and dissertation, several limitations are identified that are broadly related to the research approach and generalizability of the findings and contributions. Nevertheless, the limitations do not detract from the research program instead acknowledging these limitations should persuade the reader to carefully apply any lesson to different cases. Below these points are further discussed.

The first limitation identified is related to the number of cases selected and the corresponding generalizability of information and findings. Two distinct cases were selected because of the diverse engagement with the concept of green infrastructure and recognized leadership in developing green infrastructure engagement and actions. This means that a large sample size of cases was not sought but instead the quality of experiences with green infrastructure and key informants to provide a depth of information and unique experiences developing and implementing projects or interventions.

Certainly, the two different governing contexts make the generalizability and replicability of findings difficult. Nevertheless, the examples and lessons offered in this research provide an opportunity for researchers to selectively translate and recognize that localized context will be important in directing the specific action. The outcomes from this research can be used as examples of potential direction action may take as opposed to definitive outcomes and pathways. Further, as Yin (2014) notes, generalizability does not necessarily relate to practical generalizability, but may also support theoretical generalizability. This means that the findings and implications discussed in this paper can offer some broad lessons to support theoretical findings related to green infrastructure transitions and governance.

Second, the theoretical framework utilized in this research was an interdisciplinary approach. This may be argued as problematic as the boundaries often applied with a disciplinary approach structures the research methods, problems, and applicability of the findings. Further, interdisciplinarity may promote a shallow excavation of the literature, leaving the researcher with an excellent breadth of the literature available but a shallow ability to engage and meaningfully critique the literature and arguments presented. This may be true, however, the nature of complex and dynamic problems afflicting cities requires multiple lines of thinking that better support the identification of solutions, diverse actors groups and opportunities to direct solutions. An interdisciplinary approach allows researchers to bring together multiple research frames and identify a set of features that best support research inquiry suited to the problems and solutions identification.

6.4 Connections to human geography

Reflecting on this research project the connection between this dissertation and the field of geography is identified below, drawing on the relationships between green infrastructure development and the connections to place and urban sustainability.

Human geography as a discipline explores a range of issues and topics, from issues related to population movement, human settlement, and industrial growth; to more recent issues associated with economic change, political tensions, and supporting questions of why and how people are agents of change (Douglas, 1987). This is significant, as the field has expanded to include important lines of thought in areas of power and resource distribution (Watts, 2000); local government and societal class issues (Fincher, 1987; Carmichael and McDonough, 2019), and the application of geographical concepts to shape structure and agency (Lake, 1992). The 21st century has been described as the

urban century (Brenner and Schmid, 2014) because people are increasingly moving to cities and urban regions. This then demands greater attention to understanding how people conduct themselves in urban areas combining the confluence of old and new human geographical concepts to be studied in these spaces.

Urban areas are critical sites to study climate change impacts, urban sustainability, and associated decision-making processes to confront complex problems. Certainly, geographers have paid attention to issues such as acid rain and ecosystem degradation from a global and national scale (Whittow, 1987). However, as multiple scholars have suggested a more transformative approach to studying and confronting urban problems and to devise more durable solutions (Seto, Sánchez-Rodríguez and Fragkias, 2010; O'Brien, 2011; Koch, Kabisch and Krellenberg, 2018). Suggested differently, human geographers are placed in an ideal position to pull together interdisciplinary research strategies to better connect the relationships between human-nature interactions, human decisions making for nature, and offering improvements to the places and spaces where people live.

Karen O'Brien (2011), for example, suggests that geography is sensitive to appreciating scale dynamics and human-nature relationships, critical themes to support transformative change research. Authors such as Seto, Sanchez-Rodriguez and Fragkias (2010) and Harvey (1989) have presented urban areas as moving away from centralized decision-making models, offering more decentred, devolved, and pluralistic decision-making arenas. Seto, Sanchez-Rodriguez and Fragkias (2010) are certainly more optimistic in outlook, demonstrating how this has ushered in a sustainability turn in urbanization guided by governing processes more inclusive of diverse interests. Though perhaps the work of Harvey (1989) tempers this optimism as predominantly market and profit-oriented because non-state actors are given a significant role in providing public services as well as given greater decision-making authority in shaping private land-use decisions (e.g. real estate industry). However, as sustainability-oriented research has demonstrated, the approaches and solutions at the disposal of cities will require and extend beyond market-based approaches alone. Instead, diverse solutions connecting people to places will complement technical innovation or efficiency supporting planning aimed at maximizing form and function of a city along with more bottom-up and socially-oriented sustainability actions (Simon, 2014; Muñoz-Erickson *et al.*, 2016; Scott *et al.*, 2016)

The research presented in this dissertation follows the shifting understanding of urban areas as critical sites to redirect sustainability trajectories beyond simple technical and efficiency-related fixes alone (Bulkeley and Castán Broto, 2013). As urban areas increasingly change in form and function

(Seto, Sánchez-Rodríguez and Fragkias, 2010), the drivers of complex and dynamic biophysical and human change processes are enacted rapidly in these places. Transformative change for sustainability will require deep innovation of technical and social domains offering both durable outcomes and flexibility in processes to respond to deep uncertainty (Bulkeley, 2005; O'Brien, 2012). Critical to this process is the role of urban actors exercising agency and expertise in the places they live and work in. Action-oriented practices and collaborative governance are collectively important towards improving how people are connected to places and spaces, integrated into important decision-making processes, and provided opportunities to advance knowledge to confront dynamic issues.

6.5 Opportunities for future research

Finally reflecting on the research program this dissertation offers three key areas for future research to advance and build a better understanding of the governing processes utilized to shape green infrastructure development in urban areas.

First, green infrastructure proponents must uncover the governing arrangements utilized by diverse actors to better apply development processes and outcomes to contextual opportunities. Certainly, sustainability, climate change, and urban planning research have provided a diverse and wide-ranging set of governing arrangements to borrow from. However, green infrastructure (and related concepts) require clarity of how these governing arrangements are different and similar to other research domains. Building on the modes of governing framework future research may be able to focus on specific actors, for example, understanding of formal and informal community-based groups such as residents' associations. This is important because each actor possesses resources and skills vital in directing development as well as supporting other actors in performing or realizing the benefits and opportunities of green infrastructure. Moreover, it is still unclear how reliable and productive certain actors are in supporting green infrastructure goals and outcomes. Additionally, research should also aim to show the connections between actors and how actors leverage each other's expertise, knowledge, and relationships to push forward green infrastructure development. Overall, pursuing these research lines will improve understanding of how the wider constellation of green infrastructure actors conduct, coordinate, or partner to direct the purpose of green infrastructure development in cities.

Another area of future research is offering a clear articulation of the way actions and interventions shape and direct the substance of policies and objectives which are intended to offer clear guidance,

rules, and prescriptions of how organizations should engage with green infrastructure. Green infrastructure is unique as it is can be used differently by multiple actors. It is not necessary to generate a singular definition but recognition of what green infrastructure and the plethora of options, uses, and solutions available must be identified and recognized as valuable in addressing urban sustainability challenges. One future line of research may be to better encapsulate, catalogue, and categorize the action and interventions available and establish the diverse benefits available. This partially speaks to the framework developed by de Haan and Rotmans (2018) in supporting system transformation requiring a better understanding of the diverse actors and their specific functions in mediating change. Also, a deeper understanding must be made of the interventions and the diverse solutions, because drawing distinctions between interventions and the way interventions may have supported changes in transition agendas and transition visions may create a more fulsome picture of how green infrastructure practices support sustainability transitions.

Finally, future research may be advanced or benefit by further exploring the role of green infrastructure experiments and specific intentions of the experiments in reshaping perspectives, understanding, and objectives for urban sustainability. This moves the understanding of green infrastructure experiments from technical or localized projects to more broadly understand the multi-scale nature of change that sustainability-oriented experiments can support. Further, while "risk-taking" continues to be a challenge to implement green infrastructure, experiments are strategic maneuvers to demonstrate and present green infrastructure as well-suited to the urban sustainability objectives of cities. Here then, another line of research must seek to understand how specific green infrastructure actions facilitate changes to support the mainstreaming of those actions. This means that research may benefit from narrowly studying experiments examining very specific actions and how those actions have become embedded and normalized as the routines or set of practices followed by green infrastructure practitioners. The aim of this should be to show how green infrastructure experiments are not haphazard but very well defined - yet still open to emergence - and while narrowly defined to address a small problem can become establish a new set of operational practices.

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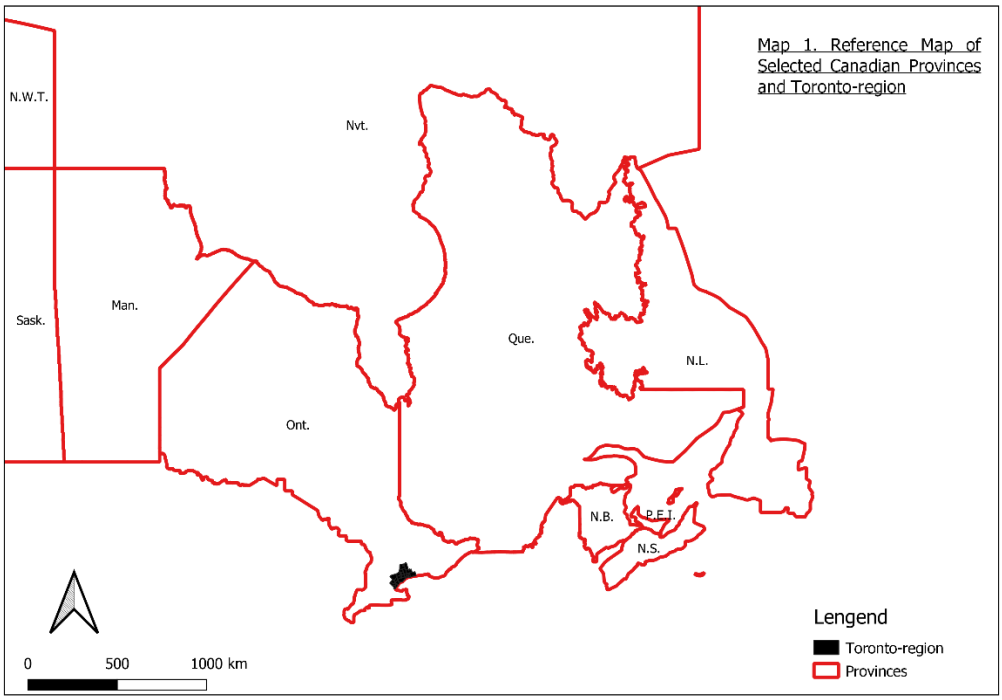
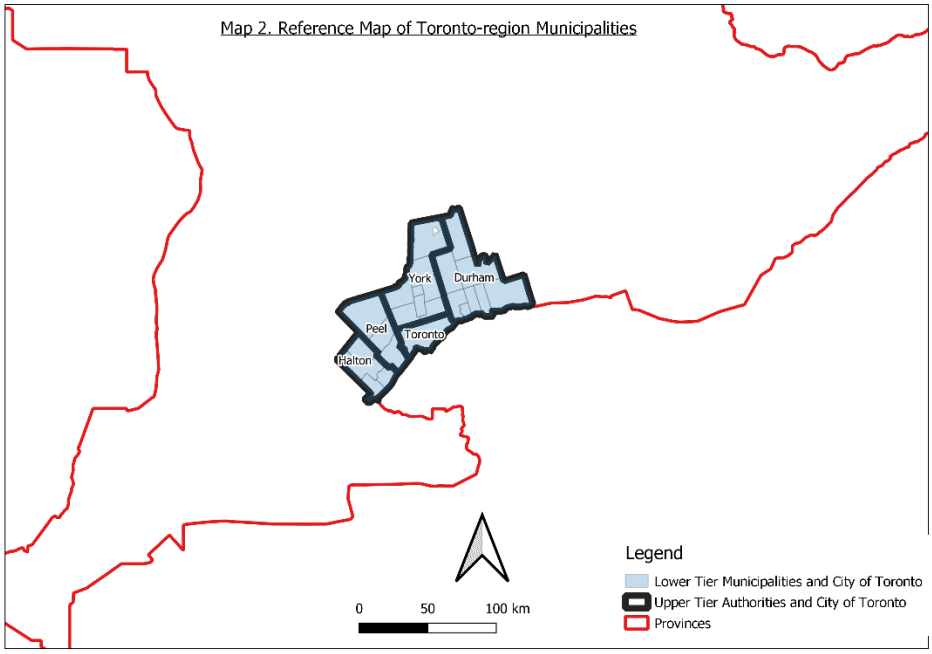
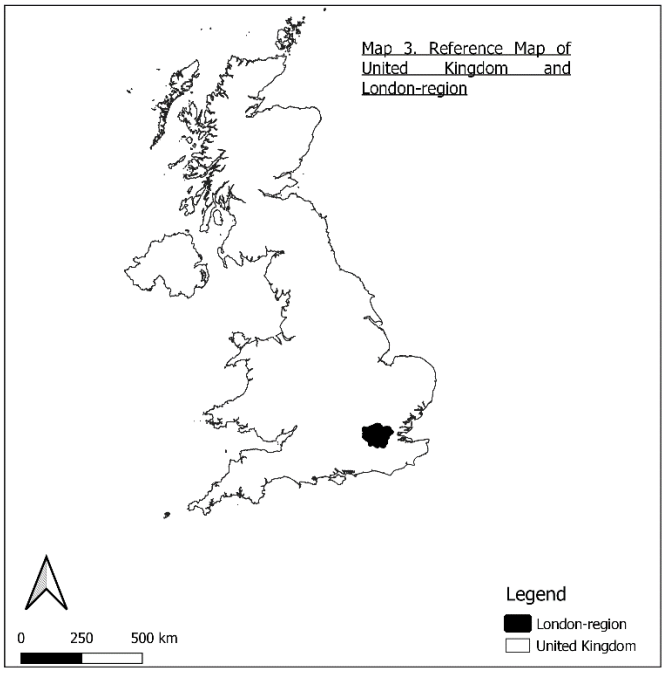
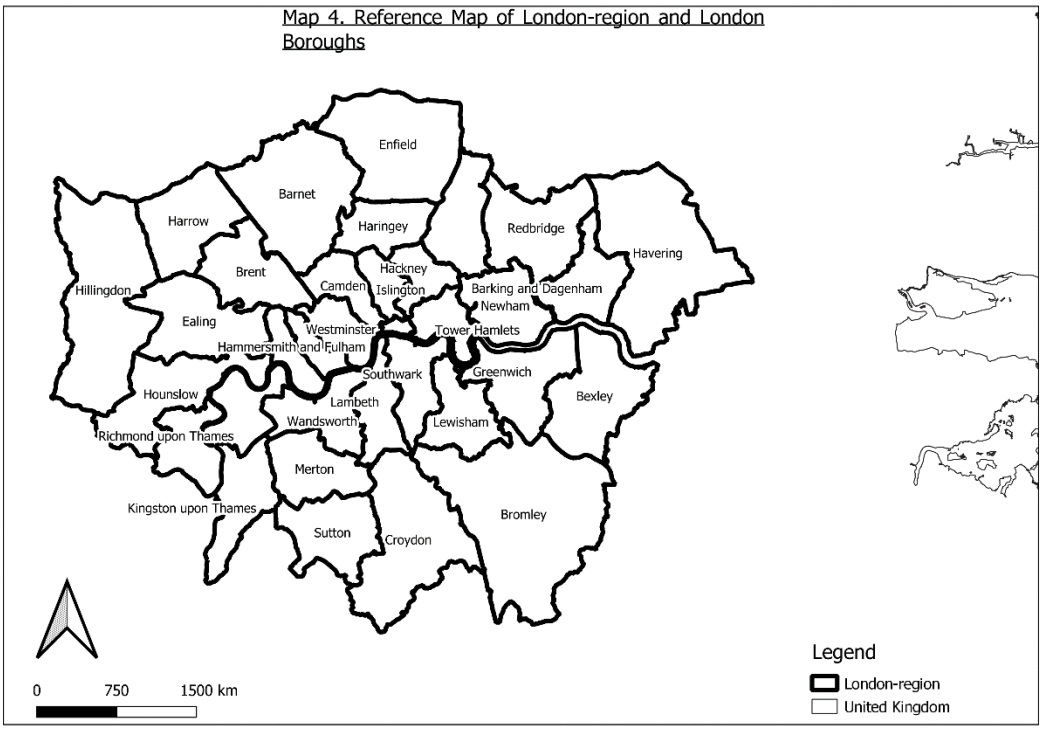
Appendix A. List of maps






Map 3. Reference Map of United Kingdom and London-region
0 250 500 km
Legend
London-region
United Kingdom


Map 4. Reference Map of London-region and London Boroughs
Enfield
Barnet
Harrow
Haringey
Redbridge
Havering
Hillingdon
Brent
Camden
Hackney
Islington
Barking and Dagenham
Newham
Ealing
Westminster
Tower Hamlets
Hammersmith and Fulham
Southwark
Greenwich
Hounslow
Lambeth
Bexley
Wandsworth
Lewisham
Richmond upon Thames
Merton
Kingston upon Thames
Bromley
Sutton
Croydon
0 750 1500 km
Legend
London-region
United Kingdom

Appendix B. Email invitation and consent form

[Date]

Dear [Key informant]

I am a PhD candidate at the University of Waterloo in Waterloo, Ontario Canada in the department of geography and environmental management (GEM). My current research focuses on the opportunity and ability for cities to implement green infrastructure as a strategy to climate proof and improve urban sustainability. I intend to collect interview data in Toronto and London, UK. The title of the research project is: Green Infrastructure Governance for Urban Transformation: A multi-case study of sustainability governance in Toronto, Canada and London, UK.

This letter is an invitation to consider participating in the research project I am conducting as part of my PhD degree under the supervision of Professor Sarah Burch. I would like to provide you with more information about this research project and what your involvement would entail if you decide to take part. Your contact information was obtained through your organization's publicly available online directory. Further, you are sought out due to your expertise in the areas of green infrastructure and sustainability.

Green infrastructure has received increased attention as a valuable strategy for cities to utilize to prepare for the impacts of climate change. However, barriers to implementation such as lack of knowledge, and recognition of multiscale and multi-functional benefits continue to impede progress. Critical to overcoming barriers to implementation is improving governing techniques, that is, integrating multiple societal actors to participate in the planning, designing, managing, and implementing of relevant policies, plans, and programs. The purpose of this study is to understand, assess, and recommend an approach to green infrastructure governing to improve urban sustainability.

This study will focus on organizational experiences and practices with green infrastructure governance in cities. In particular, I am concerned with creating a comprehensive map of the best and most often used procedures to implement green infrastructure actions in cities. Moreover, critical to sustainability governance is the role of actor networks, co-creation, and stakeholder participation. I will be particularly interested in identifying which green infrastructure actions create opportunity for network formation. Therefore, I would like to include you as one of several participants to be involved in my study. I believe that your experience in developing and shaping sustainability policy and practice will contribute to answering questions related to, organizational approaches, processes of network formation, and visions of green infrastructure development.

Participation in this study is **voluntary**. It will involve an in-person or telephone interview of approximately **one hour** in length to take place in a mutually agreed upon location. You will be asked to provide in-depth answers to the best of your ability on green infrastructure and sustainability topics related to your organization. You may decline to answer any of the interview questions if you so wish. Further, you may decide to withdraw from this study within one month after the interview has been completed without any negative consequences by advising the researcher. With your permission, the interview will be audio recorded to facilitate collection of information, and later transcribed for analysis. Shortly after the interview has been completed, I will send you a copy of the

transcript to give you an opportunity to confirm the accuracy of our conversation and to add or clarify any points that you wish. Your identity will be confidential. Using the collected data, I will analyze your responses, and create publishable results that will be presented in seminars, conferences, journal articles, and my thesis. Your name will not appear in any reports, documents, or presentations resulting from this study, however, with your permission anonymous quotations may be used, you and your organization will not be identified or named. Data collected during this study will be retained for a minimum two years in on a password protected files, saved on my personal password protected laptop. Only I will have access to the files. There are no known or anticipated risks to you as a participant in this study.

This study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Committee (ORE#22632 -). If you have questions contact the Chief Ethics Officer, Office of Research Ethics, at 1-519-888-4567 ext. 36005 or ore-ceo@uwaterloo.ca.

For all other questions or if you would like additional information to assist you in reaching a decision about participation, please contact me at ***647-454-1504*** or by email at ***avkundur@uwaterloo.ca***. You can also contact my supervisor, Professor ***Sarah Burch*** at 519-888-4567 ext. 31932 or email sarah.burch@uwaterloo.ca.

I hope that the results of my study will be of benefit to those organizations directly involved in the study, other organizations not directly involved in the study, as well as to the broader research community.

I very much look forward to speaking with you and thank you in advance for your assistance in this project.

Yours Sincerely,

Aravind Kundurpi
PhD Candidate
Department of Geography and Environmental Management
University of Waterloo

Written consent form

I have read the information presented in the information letter about a study being conducted by Aravind Kundurpi of the Department of Geography and Environmental Management at the University of Waterloo, in Waterloo, Ontario, Canada. I have had the opportunity to ask any questions related to this study, to receive satisfactory answers to my questions, and any additional details I wanted.

I am aware that I have the option of allowing my interview to be audio recorded to ensure an accurate recording of my responses.

I am also aware that excerpts from the interview may be included in the thesis and/or publications to come from this research, with the understanding that the quotations will be anonymous. Furthermore, excerpts from the interview will be used only when permission is granted by participant.

I was informed that I may withdraw my consent at any time without penalty by advising the researcher within one (1) month after the completion of the interview

This study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Committee (ORE#22632). If you have questions for the Committee contact the Chief Ethics Officer, Office of Research Ethics, at 1-519-888-4567 ext. 36005 or ore-ceo@uwaterloo.ca.

For all other questions contact Aravind Kundurpi, avkundur@uwaterloo.ca or 647-454-1504. As well you may contact Aravind's supervisor Dr. Sarah Burch at 519-888-4567 ext. 31932 or email sarah.burch@uwaterloo.ca.

With full knowledge of all foregoing, I agree, of my own free will, to participate in this study.

☐YES ☐NO

I agree to have my interview audio recorded.

☐YES☐NO

I agree to the use of anonymous quotations in any thesis or publication that comes of this research.

☐YES ☐NO

By signing this consent form, you are not waiving your legal rights or releasing the investigator(s) or involved institution(s) from their legal and professional responsibilities

Participant Name: _____ (Please print)

Participant Signature: _____

Witness Name: _____ (Please print)

Witness Signature: _____

Date: _____

Appendix C. List of key informants

Interview	Focus area	Organization	Case
1.TO^	Urban Climate Change	Civil Society	Toronto
2.TO^	Local Authority Planning Unit	Government	Toronto
3.TO^	Local Authority Planning Unit	Government	Toronto
4.TO^	Local Authority Sustainability Unit	Government	Toronto
5.TO^	Local Authority Planning Unit	Government	Toronto
6.TO	Local Authority Corporation	Government	Toronto
7.TO	Parks and Green Space Development	Civil Society	Toronto
8.TO^	Local Authority Sustainability Unit	Government	Toronto
9.TO	Local Authority Planning Unit	Government	Toronto
10.TO	Green Space Policy Development	Civil Society	Toronto
11.TO^	Local Authority Environment Unit	Government	Toronto
12.TO	Local Authority Forestry Unit	Government	Toronto
13.TO	Local Authority Forestry Unit	Government	Toronto
14.TO^	Water and Stormwater Management	Business	Toronto
15.TO^	Urban Climate Change (Mitigation)	Civil Society	Toronto
16.TO.A	Local Authority Forestry Unit	Government	Toronto
16.TO.B	Local Authority Forestry Unit	Government	Toronto
16.TO.C	Local Authority Forestry Unit	Government	Toronto
17.TO	Conservation Authority	Government	Toronto
18.TO	Conservation Authority	Government	Toronto
19.TO	Conservation Authority	Government	Toronto
20.TO	Conservation Authority	Government	Toronto
21.TO	Ecological Urban Design	Business	Toronto
22.TO	Local Authority Planning Unit	Government	Toronto
23.TO	Local Authority Parks and Forestry Unit	Government	Toronto
24.TO	Forestry Development	Civil Society	Toronto
25.TO	Local Authority Public Realm	Government	Toronto
26.TO^	Urban Gardening	Business	Toronto
27.TO	Environmental and Planning Consultant	Business	Toronto
28.TO^	Urban Forestry and Naturalization	Business	Toronto
29.TO	Ravine, Valley, and Trails Management	Civil Society	Toronto
1.LO	Biological Conservation and Wildlife Management	Civil Society	London
2.LO	Regional Government – Local Urban Development	Government	London

3.LO	Urban Forestry and Parks	Civil Society	London
4.LO	Urban Sustainability and Public Education	Civil Society	London
5.LO	Local Authority Ecology	Government	London
6.LO	Urban Sustainability	Civil Society	London
7.LO	Landscape and Gardening	Business	London
8.LO	Regional Government Transport	Government	London
9.LO	Urban Planning and Green Infrastructure	Civil Society	London
10.LO	Business Improvement District	Business Network	London
11.LO.A^	Business Improvement District	Business Network	London
11.LO.B^	Business Improvement District	Business Network	London
12.LO	Business Improvement District	Business Network	London
13.LO	Biological Conservation and Wildlife Management	Civil Society	London
14.LO	Urban Green Space Development	Civil Society	London
15.LO	Local Authority Planning	Government	London
16.LO	Regional Government Environment	Government	London
17.LO	Regional Government Drainage Management	Government	London
18.LO^	Regional Government Climate Change	Government	London
19.LO	Local Authority Parks	Government	London
20.LO	Urban Green Space Development	Civil Society	London
21.LO^	Landscape	Business	London
22.LO^	Landscape and Urban Nature	Business	London

^ Key informant is from GATE Project

Appendix D. Key informant categories

	Business and Business networks	Civil society organizations, including, community-based and voluntary organizations	Local and regional government and government-related	Total
Toronto	5	6	18	29
London	6	8	8	22
Total	11	14	26	51

Appendix E. Coding structure for Chapter 3

Purpose of coding	Purpose or focus of coding	Coding rule	Citation
Who are the actors involved in the development of GI?	What support has the central, provincial governments and arm's length agencies provided?	Any mention of top-down central government's conduct related to sustainability and GI. Any mention of the governing tools or policy tools used to facilitate the necessary support for actions.	Driessen *et al.* (2012); Lange *et al.* (2013); Lange, Bornemann and Burger (2019)
	What support has the regional, local and, borough governments provided?	Any mention of local government's conduct related to sustainability and GI.	
	How have public-private (sector) partnerships supported development?	Any mention of local government and private sector conduct related to sustainability and GI.	
	How has interactive and network forms of governing supported development?	Any mention of local government's and all private actor conduct related to sustainability and GI.	
	How has private actor-led governing supported development?	Any mention of private actor conduct related to sustainability and GI.	
How have private actors developed GI?	How have private actors led the development and with what intent are they acting?	Any mention of actions conducted by private actors aimed at leading, intermediating, and fulfilling contractual obligation including for routine delivery, contract fulfillment, and formal operations; innovation with techniques and practices requiring leveraging expertise with other organizations.	Bulkeley and Castán Broto (2011)
	How have private actors supported the coordination and active establishment of actions supportive of guiding, encouraging, and mediating development?	Any mentions of private actors collaborating to support education and learning, and capacity building, and partnering for development; empowering or guiding other actors to lead, initiate or maintain interventions.	
	How have private actors leveraged the objectives and resources of public sector organizations to shape and guide development?	Any mention of private actors and working with public sector actors in partnerships capacity, for formal and informal project or programs; coordinating the delivery of public sector programs.	
Concept building	Evidence of private actors leading and networking	Details of the specific action, including physical interventions; program, plan, and policy development.	
	Evidence of private actors mobilizing and capacitating	Details of the specific purpose, outcomes, or intended goals of working in a collaborative setting to facilitate and mobilize others to understand or develop green infrastructure.	

	Evidence of private-public partnering	Details of the actions pursued in partnership between private and public actors, including but not limited to client-vendor relationships, policy and program development over multiple time scales, devolution of responsibility and coordination, and shared access to land, resources, or volunteers.	

Appendix F. Coding structure for Chapter 4

Purpose of coding	Purpose or focus of coding	Coding rule	Citation
What role does green infrastructure play in shaping urban sustainability transitions?	What societal structures were mentioned?	Any mention, or words or phrases describing or detailing establishment of, rules, procedures, or conduct of GI.	Grin, Rotmans and Schot (2010); Loorbach (2010); Loorbach and Rotmans (2010); de Haan and Rotmans (2011); Loorbach, Frantzeskaki and Avelino (2017)
		Any mention of laws, acts, regulations, and by-laws.	
		Any mention of plans, policy, strategies, and programs.	
		Any mention of physical GI installation or presence of existing GI features.	
	What societal cultures were mentioned?	Any mention of long-term, future-oriented processes of GI-related development.	
		Any mention of futures concepts, including smart cities and different ways cities will be produced and consumed with a connection to GI development.	
		Any mention of visioning activities connected to GI development.	
	What societal practices were mentioned?	Any mention of experiments, pilots, proof of concept design, test site, demonstrations, and trials or trial sites.	
		Any mention of specific projects, names, dates, locations, participants.	
		Any mention of "doing" GI, implementation.	
		Any mention of routine maintenance, installation, operations, management.	
How can green infrastructure development become embedded in societal structures, practices, and cultures?	Evidence of agenda establishment	Any mention of the established or routine manner of conducting GI development or providing guidance to others with clear articulation of specific rules, guidance documents, and organizational procedures.	Loorbach (2010); Bush (2020); Grin (2020)
	Actors of structures	Any mention of actors involved in shaping agendas.	
	Evidence of visioning and future consideration	Any mention of long-term discussion, thinking, or visioning formalized in the case including discussions or acknowledgement of new purposes and opportunities for deeper changes, clarifying problems and the corresponding opportunity for green infrastructure strategies.	Loorbach (2010);Bettini *et al.* (2015); Grin (2020)
	Actors of visions	Any mention of actors in shaping visions and long-term processes.	
	Evidence of interventions, experiments, or actions	Any mention of interventions, experiments, or actions including utilization of practices to challenge existing configurations or reproducing routines.	Loorbach (2010); Farrelly and Brown (2011); Bettini *et al.* (2015)
	Actors of action	Any mention of the actors involved in interventions, experiments, or actions.	
Concept Building	What is the intent of agendas	Detailed accounts of how agendas were used to develop green infrastructure and associated programs, plans, and policy, including regulatory or voluntary tools.	Loorbach (2010); Bush (2020); Grin (2020)
	How do actors enforce or reproduce these agendas?	Detailed accounts of the actors involved and the role in shaping specific agendas and the role of actor arrangements to advance agendas.	
	What interventions and actions were utilized to	Detailed accounts of how practices, including experiments, routine implementation, or physical	

	reproduce existing development strategies or experiment with new technology or tools to implement actions?	installations, were pursued, developed, and implemented supporting governing, processes and arrangements, learning and knowledge, and multi-actor expressions of problems and solutions, and the search for novelty or innovation in existing routines and organizational procedures.	Loorbach (2010); Bettini (2015); Bush (2020); Grin (2020)
	How do actors intervene and embed action?	Detailed accounts of the actors involved in actively directing, doing, implementing GI, including through support and intermediary functions, direct leadership or participation in intervention development, experimentation, or actions.	
	How are visions manifested?	Detailed accounts of the guidance, activities, or organization to direct problem framing, and long-term thinking of green infrastructure for urban, regional, or local contexts including goals, objectives, and targeting setting for long term development of GI networks.	Loorbach (2010); Bettini (2015); Bush (2020); Grin (2020)
	Who shapes the objectives or aims of visions?	Detailed accounts of the actors involved in supporting and leading the spaces and discussion for visions connected to GI and the proposal or long-term thinking associated with GI network development.	

Appendix G. Coding structure for Chapter 5

Purpose of coding	**Coding or concept building**	**Coding Rule**	**Citation**
How are experiments used to design and develop green infrastructure?	What was developed?	Any mention of physical installation, intention, or on-going experiment, including names of projects, locations, and connections to other projects.	Luederitz *et al.* (2017)
	Who was involved in the experiment?	Any mention of actors including government, private sector, civil society, business networks, community-based organizations.	Hargreaves *et al.* (2013)*;* Kampelmann, Kaethler and Hill (2018); Mukhtar-Landgren *et al.* (2019)
	How are experiments supported or resourced?	Any mention of resources or support provided to undertake an experiment, including financial, human, materials, programming, knowledge, skills, machines, etc.	Geels and Raven (2006); Bulkeley and Castán Broto (2013) Mukhtar-Landgren *et al.* (2019)
	How are experiments evaluated?	Any mention of learning, measurement, evaluation related to understanding the outcomes of an experiment, include on-going experiments with data incomplete or in process.	Ansell and Bartenberger (2016); Luederitz *et al.* (2017)
How are experiments leveraged as an intervention to embed green infrastructure in urban areas?	What did the product provide?	Any mention of experiments, pilot projects, and related terms to pursue actions that are identified as attempting novel technologies and governing arrangements, as well as supporting routine activities.	Caniglia *et al.* (2017)*;* Luederitz *et al.* (2017)
	How did actors use this experiment?	Any mention of learning, educational tools, controlled site testing, opening spaces of interaction with other actors; and support mechanisms to advance development.	
	What is the purpose of the experiments?	Any mention of how experiments have served as tools or programs to better connect to other areas of local and community development.	
Concept building	Showcasing	Experiments are used for learning and knowledge development supporting a clear understanding or connection to other sectors, units, organizations, and solutions.	Hodson and Marvin (2010); Longhurst (2015); Dunn *et al.* (2017)
	Relationship building	Experiments are used to leverage relationships and promote alternative governing arrangements while also building the tools, skills, and opportunities for leading or guiding more interventions.	Farrelly and Brown (2011); Frantzeskaki *et al.* (2020)
	Conformity	Experiments are presented as objectives that align or achieve existing policy objectives; offering clear and tangible action connected to urban development contexts.	Farrelly and Brown (2011); Liu and Jensen (2018); Frantzeskaki *et al.* (2020)