

The Integration of Green Infrastructure and Equity within Urban Planning:
An Academic and Applicative Exploration

by

Anu Garcha

A thesis
presented to the University of Waterloo
in fulfilment of the
thesis requirement for the degree of
Master of Environmental Studies
in
Planning

Waterloo, Ontario, Canada, 2021
© Anu Garcha 2021

Author's Declaration

This thesis consists of material all of which I authored or co-authored: see Statement of Contributions included in the thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners. I understand that my thesis may be made electronically available to the public.

Statement of Contributions

This thesis follows the manuscript option for Master's students in the School of Planning at the University of Waterloo. This thesis consists of two manuscripts.

For all chapters of this thesis, I (Anu Garcha) am the principal author. I designed analytical criteria and research methods for both manuscripts based on literature review and supervisory guidance from Dr. Carrie Mitchell, conducted all data collection and analysis, and wrote 90% of content for both manuscripts. The remaining 10% reflects the written edits and additions contributed by Dr. Carrie Mitchell and Dr. Mark Seasons.

As primary supervisor, Dr. Carrie Mitchell contributed supervision and conceptual guidance, and supported the development of the research question, approach, and analytical framework for both manuscripts. Dr. Mark Seasons also provided written feedback and edits for both manuscripts and provided recommendations and comments as needed.

Abstract

This thesis examines the integration of green infrastructure and equity within academia and in practical applications such as comprehensive city plans. With climate change worsening and affecting urban areas with extreme weather events, many municipal governments are developing and implementing higher numbers of green infrastructure projects. However, cities need ensure that all residents are benefiting from green infrastructure otherwise those already at a risk of negative impacts from climate change may continue to be affected, or have those impacts exacerbated.

The goal of the first manuscript was to conduct a systematic literature review to explore 47 contemporary articles with the goal of identifying an overlap between equity and green infrastructure integration in urban planning. It is necessary to understand the integration, or lack thereof, of equity and green infrastructure in urban planning literature so that future research can fill in those missing considerations and build upon past work. Present research does indicate that green infrastructure and equity need to be considered in conjunction with one another so that the negative consequences of unconscious ignorance in planning is avoided. The second manuscript applies this research with the creation of a framework to evaluate Resilience Strategies – part of the “100 Resilient Cities” program by the Rockefeller Foundation, and comprehensive city plans, such as climate change adaptation plans. Eight plans were evaluated for four Canadian Cities: Toronto, Vancouver, Calgary, and Montréal.

My research concludes that research in green infrastructure and equity is growing as most papers were published within the last 5 years (2015 – 2021), but further acknowledgement of various types of equity and intersectionality need to be considered in green infrastructure research. In addition, resilience strategies and comprehensive city plans were lacking in equity considerations in green infrastructure implementation. The scores for the eight plans in four Canadian cities assessed vary from 5 out of 25 to 15.5 out of 25. A standardized framework to help apply an equity lens for green infrastructure implementation can help ensure that there will be consistent necessary considerations for green infrastructure and equity in city planning. Comprehensive city plans and resilience strategies need to have equity considerations to ensure that the benefits of green infrastructure can reach all populations as needed, and to prevent the exacerbation of socioeconomic inequality. Altogether, improving the integration of equity and green infrastructure in cities can support climate change mitigation and adaptation for all residents and help to build a more sustainable future.

Acknowledgments

This work was supported by the Social Sciences and Humanities Research Council of Canada (SSHRC) Insight Development Grants (#430-2017-00135). I would like to thank Dr. Carrie Mitchell, my thesis supervisor, for her support in my research and for invaluable guidance throughout my Master's. This wouldn't have been possible without you, and your unwavering commitment to resilience, equity, and climate research.

I would also like to thank Dr. Mark Seasons for his teachings and comments, they've also provided immense and invaluable help to make my research a reality. Thank you, Dr. Jeremy Pittman, for being my reader for this thesis and for your time and consideration. I am grateful for all the professors under whom I've had the privilege of learning or working during my time at the University of Waterloo.

So much has changed, in my life and in the world, in the short time since I became a Master's Student and began writing this thesis. Although such changes include the added stresses of adjusting to life amidst a pandemic on top of the sort of grad school breakdowns experienced by many before me, they also include wonderful additions and developments to my life which had existed previously only in my dreams. I am deeply thankful for all of the challenges and blessings and especially the people that have guided me through my Master's matriculation to my thesis defence.

I would like to thank my friend Liam for your constant support and belief in me. I don't know if would have made it this far without your friendship. I would also like to acknowledge all my other friends who have stuck by my side these past few years. Our chats and laughs have helped me in ways I cannot begin to adequately express. Thank you, Elizabeth, Lee, Kalong, Aruna, Telina, and to all my other friends. I want to thank my family as well, for their love and support all my life. I am made of all that I have met, and I am so grateful for all the people in my life who have helped me realize my potential.

Finally, I would also like to give a special shout-out to Cookie. Welcoming you into my family has been the greatest adventure. You have blessed my life and more; I am so grateful I got to help you raise five more biscuits of pure love and joy. You make me smile every day.

To all of you, I am so grateful.

Table of Contents

Author’s Declaration	ii
Statement of Contributions	iii
Abstract	iv
Acknowledgments	v
List of Tables	viii
List of Figures	ix
Chapter 1 – Introduction to Thesis	1
1.1 The Need for Equity	2
1.2 What is Green Infrastructure?	2
1.3 Climate Change and Resilience Applications of Green Infrastructure	3
1.4 Green Infrastructure and Equity Integration	4
Chapter 2 - The Implementation of Equity & Justice in the Greening of Urban Infrastructures: A Review	6
2.1 Overview	6
2.2 Introduction	7
2.2.1 The Necessity of Green Infrastructure and Equity Integration	8
2.3 Historical Context	9
2.3.1 Historical Zoning Impacts	10
2.4 Evolution of Equity in Urban Planning	11
2.5 Environmental and Green Equity	13
2.6 Limitations and Scope	15
2.7 Methods	16
2.8 Results	17
2.9 Green Infrastructure	17
2.9.1 Community-level Green Infrastructure	19
2.9.2 City-wide Green Infrastructure	19
2.10 Equity	20
2.11 Integration of Green Infrastructure and Equity in Academia	21
2.11.1 Accessibility	22
2.11.2 Gentrification and Displacement	23
2.12 Future Directions	24
2.13 Conclusion	26

Bridge	28
Chapter 3 - Assessing the Integration of Green Infrastructure and Equity of Comprehensive Municipal Plans and Resilience Strategies in Four Canadian Cities	30
3.1 Overview	30
3.2 Introduction	30
3.3 Literature Review	32
3.3.1 Climate Change, Green Infrastructure, and Equity	33
3.3.2 Resilience, Green Infrastructure, and Equity	35
3.4 Background	36
3.4.1 Flooding	37
3.4.2 Heat Island Effect	38
3.5 Methods	39
3.6 Limitations and Scope	42
3.7 Results	44
3.7.1 Framework Evaluation	44
3.8 Discussion	48
3.8.1 Equity Lenses	50
3.8.2 Green Infrastructure Considerations	51
3.8.3 Heat Island Considerations	53
3.8.4 Flooding Considerations	54
3.9 Future Directions	56
3.10 Conclusion	58
Chapter 4 - Thesis Conclusions	59
4.1 Contributions to Scholarship and Practice	61
Bibliography	63
Appendix A	78
Appendix B	79

List of Tables

Table 1. Table displaying the title and date of publication of all eight plans and strategies assessed and evaluated using the developed green infrastructure and equity framework.	43
---	-----------

List of Figures

Figure 1. The comparison of each plan or strategy’s total score out of 25 from the Green Infrastructure & Equity Framework Evaluation displayed on the graph.45

Figure 2. Map of areas in Montréal at varying risk to heat waves, obtained from the Montréal Climate Change Adaptation Plan.....54

Figure 3. Map displaying the varying risk of riverine flooding in Montréal, obtained from the Montréal Climate Change Adaptation Plan.....56

Chapter 1 – Introduction to Thesis

Urban planning is a profession that aims to guide community development to better the quality of life of its residents. The profession has evolved over the past century from simply zoning and transportation concerns to include environmental and equity considerations into the planning practice. Cities have grown increasingly complex and multifaceted. The Canadian Institute of Planners has developed a code of conduct to support planners and provide guidance on best practices.

Cities are improving their equity practices in urban planning. Transactive planning is a part of the planning practice in Canada (CIP, 2016). This allows the voice of the public to be heard in city planning decisions that may affect them. Many cities also have an Equity, Diversity, and Inclusion (EDI) department, such as the City of Vancouver. In Canada, several cities have are developing climate change strategies to aim to improve climate change mitigation and adaptation, and are applying equity lenses to ensure that all populations will benefit (Climate Atlas of Canada, 2019).

However, urban planning has a history of discriminatory practices in North America. In the United States of America, the government and private corporations practiced racial zoning and segregation, causing environmental racism, intergenerational inequality, and poverty (Metzger, 1996; Rothstein, 2017). Planning practices also resulted in the loss of livelihoods through forced displacement and internment (Rothstein, 2017; Anguelovski, 2020).

In Canada, planners and government officials conducted similar practices. For example, toxic waste disposal and heavily polluting industry is more commonly zoned in or adjacent to indigenous and minority communities than in predominantly white neighbourhoods (Keith et al., 2005; Dhillon & Young, 2010). Higher mercury concentrations in soil and water and lower air quality are disproportionately found in First Nation communities, such as Grassy Narrows, Ontario and Aamjiwnaang and Walpole Island First Nations near Sarnia, Ontario (Keith et al., 2005; Dhillon & Young, 2020). In Nova Scotia, the historically black community of Lincolnville has higher incidences of Cancer due to its proximity to first-generation landfills that leach toxic runoff (Campbell, 2020).

It is difficult to know the extent of influence that American planning has had on the Canadian system, nor is that the scope of this research. However, it is not impossible to say racist practices can be influential and experimental. The Canadian treatment of First Nations, such as the creation of the Indian

Act, was inspiration for South African Apartheid (Horwitz, 2016). Therefore, we cannot say with certainty that the discriminatory American planning practices did not influence Canadian planning practices.

Transparency is needed in the planning practice to build a relationship with equity-seeking groups, indigenous communities, and other minorities who were discriminated against systematically by government institutions (Dhillon & Young, 2010). In addition, the decision-making process needs to have transactive and participatory practices so that communities and individuals can voice their concerns, opinions, and needs (Fricker, 2003; Fainstein, 2005; Reece, 2018; Anguelovski et al., 2020). Thus, equity is needed so that those who are at most in need can receive the resources required to thrive (Lorinc & Pitter, 2016; Anguelovski, 2020).

1.1 The Need for Equity

Although cities are improving their equity practices, it is important that systematic change is applied. Planning practice needs to have equity integrated into all aspects of its planning process. Requiring the application of a social equity lens is essential to support the distribution of resources, to address the recognition of all individuals and communities (including intersectional identities), and to encourage participation in the decision-making process and other forums to share their lived experiences (Fricker, 2003; Fainstein, 2005; Reece, 2018; Anguelovski, 2020). It is also crucial for the city planning process to acknowledge and consider other types of equities and vulnerabilities that residents in a city may face, such as spatial equity that influences the accessibility to resources (Zhu et al., 2019; Anguelovski, 2020; Langemeyer & Connolly, 2020).

Conscious integration of equity in practical applications is essential; otherwise, vulnerable populations may not receive the benefits they need, and inequality may worsen in the community thanks to the implementation of inequitable projects (Lorinc & Pitter, 2016; Anguelovski, 2020). Applying equity considerations to comprehensive city plans would contribute to the Canadian Institute of Planners' Code of Professional Conduct, as the code states in section 1.1 that planners must, "practice in a manner that respects the diversity, needs, values and aspirations of the public and encourages discussion on these matters" (CIP, 2016).

1.2 What is Green Infrastructure?

When applying an equity lens, it is essential that equity is integrated into environmental and city planning, including green infrastructure development. Green infrastructure, also called natural infrastructure, is connected green spaces that deliver ecosystem services at a variety of spatial scales

(Williams et al., 2010; Meerow & Newell, 2016; Rigolon & Németh, 2018; Carmichael et al., 2019; Luz et al., 2019; Wang et al., 2019; Zuniga-Teran et al., 2020; Baró et al., 2021). Green infrastructure, such as a community garden that provides benefits to enrich the local soil and food system, can be neighbourhood-level (Cvejić et al., 2015). Green infrastructure can also be applied city-wide, for example, a network of riparian ecosystems along a river or street trees contributing to canopy cover in a community (Costanza et al., 1997; Bolund & Hunhammar 1999; Baró et al., 2021). Green infrastructure research states that it provides a critical ecological framework with economic, environmental, and social benefits to support sustainable development in cities (Costanza et al., 1997; Bolund & Hunhammar 1999; Newell et al., 2013). It is essential that all residents benefit from green infrastructure as green infrastructure can support sustainable and healthy lifestyles in communities and cities.

Historically, lower-income neighbourhoods and marginalized communities had less greenspace and less access to parks in other areas of the city (Anguelovski et al., 2018b; Rigolon & Németh, 2018). Contemporary city planning needs to have the integration of equity and green infrastructure to improve the quality of life for residents. Green infrastructure can help support mental, physical, and emotion well-being, so it is necessary that all residents can have equitable access to its benefits. Thus, equity and green infrastructure development need to be incorporated in comprehensive city plans.

1.3 Climate Change and Resilience Applications of Green Infrastructure

Climate change is another issue that cities across the globe are facing, and thus needs to be tackled with an equity framework. Climate change poses many challenges to urban environments including amplified uncertainty regarding weather patterns, rising temperatures and sea levels, and an increase in extreme weather events (Williams et al., 2010; Larson et al., 2013; William et al., 2017; Baró et al., 2019; Houston & Zuñiga, 2019; Mason et al., 2019; Zhu et al., 2019; Lanza & Durand, 2021). Green infrastructure can provide ecosystem services that can mitigate flooding from varied precipitation and rising sea levels (William et al., 2017; Mason et al., 2019; Majekodunmi et al., 2020). Other services include the reduction of the urban heat island effect from rising temperatures (Majekodunmi et al., 2020; Lanza & Durand, 2021), and can act as carbon sinks to sequester the carbon dioxide in the atmosphere (Faehnle et al., 2014).

It is necessary that ecosystems remain resilient to withstand climatic changes in their environments. Ecosystem resilience is one type of resiliency that cities are striving for in order to maintain ecosystem services to support sustainable development (Fang et al., 2021). Green infrastructure supports ecosystem resilience through strategic planning of the bionetworks of a variety of ecosystems in urban

areas that contribute to biodiversity and human health (Ferguson et al., 2018; Wang et al., 2019). Ecosystem resilience will help ensure that ecosystem functions provided by ecosystems will not be impacted by climate change and will rather mitigate or adapt to those effects.

Climate resiliency is also vital in cities to withstand the impacts of climate change. Through the implementation of beneficial green infrastructure in cities, ecosystem services can provide flood mitigation urban areas, thus increasing climate resilience to surface flooding from precipitation events (Meerow & Newell, 2016; Sanchez & Reames, 2019; De Lange, 2020; Majekodunmi et al., 2020; Venter et al., 2020; Lanza & Durand, 2021). By reducing the urban heat island effect through green infrastructure ecosystem services, cities can become more climate resilient to rising temperatures due to climate change too (Meerow & Newell, 2016; Sanchez & Reames, 2019). Green infrastructure can help support disaster resiliency and recovery by enhancing the geographical surroundings through its ecosystem services, such as community gardening to provide a local food system and forestry programs to mitigate shocks (McClintock et al., 2016; Meerow & Newell, 2016; Hall & Knuth, 2019).

1.4 Green Infrastructure and Equity Integration

Climate change disproportionately affects historically disenfranchised communities and marginalized neighbourhoods (Dobbs et al., 2018; Baró et al., 2019; Zuniga-Teran et al., 2020). Therefore, when planning for climate change mitigation and adaptation using green infrastructure, it is essential to apply an equity lens to ensure that those in most need receive the most benefits from green infrastructure development (Baró et al., 2019; Xiao et al., 2019; Scott, 2020; Zuniga-Teran et al., 2020). If not, the effects of climate change will continue to unfairly affect those at higher risk because the benefits will not reach those most in need (Williams et al., 2010; Scott, 2020; Zuniga-Teran et al., 2020).

Inequitable green infrastructure implementation can cause the consequences of climate change, such as flooding and extreme heat, to increase socioeconomic inequality in cities (Williams et al., 2010; Scott, 2020). For example, applying and utilizing the equity indexes can help vulnerable communities by decreasing disparities through green infrastructure implementation where needed (Heckert & Rosan 2016; McClintock et al., 2016; Heckert & Rosan 2018; Sanchez & Reames, 2019; Zuniga-Teran et al., 2020). In addition, applying and utilizing the equity indexes can help increase the adaptive capacity of disenfranchised neighbourhoods and thus the entire city (Baró et al., 2019; Zuniga-Teran et al., 2020).

The combination of climate and ecosystem resilience in urban areas contributes to overall urban resiliency through the development of green infrastructure (Meerow & Newell, 2016). However,

resiliency will only proliferate within the city if all residents benefit from green infrastructure; else, marginalized socioeconomic groups will remain vulnerable to climate change impacts (Anguelovski et al., 2018a; Dobbs et al., 2018; Zhu et al., 2019; Majekodunmi et al., 2020; Zuniga-Teran et al., 2020). Urban planners and government officials need to prioritize green infrastructure investment in vulnerable communities with recognition and application of social equity practices to increase resiliency in these neighbourhoods (Anguelovski et al., 2018a). Educational initiatives must be included to support residents to make choices and understand decision-making processes about green infrastructure that best improve their community resiliency (Anguelovski et al., 2018a; Baró et al., 2019; Hall & Knuth, 2019).

The aim of my first manuscript, chapter 2, is to understand contemporary literature published on the integration of green infrastructure and equity through a systematic literature review. I explore the research from these papers, and identify the need for future research on the integration of green infrastructure and equity. I also examine how these studies can be applied to urban planning. My second manuscript, in chapter 3, utilizes the systematic literature review from the first paper to develop a framework. This framework is then used to assess eight plans and strategies from four Canadian cities to determine if green infrastructure and equity integration is considered and embedded into these comprehensive plans. Between these chapters I provide a bridge to try to clarify the connection between my two areas of research. And in chapter 4, I provide an explanation of how my research is contributing to urban planning literature and recommendations based off of my research.

Chapter 2 - The Implementation of Equity & Justice in the Greening of Urban Infrastructures: A Review

2.1 Overview

Equity planning has gained renewed attention in both academic and professional circles catalyzed by recent social justice movements, such as Black Lives Matter (BLM) and #FridaysForFuture (also known as Youth Strike for Climate), in North American cities and increased attention to the injustices of both anthropogenic climate change and the attempts to mitigate and adapt to it. In this review, I explore how conceptualizations and applications of equity and justice have evolved in literature in the field of urban planning on green infrastructure over the last two decades.

Applying a systematic literature review process, I analyze 47 contemporary academic journal articles from 2000 to early 2021 with the aim of identifying an overlap between equity and green infrastructure. Several studies on green infrastructure examine case studies of cities that have implemented green infrastructure, by implementing street trees, for example, or by mitigating extreme events such as floods and heat waves. Other articles conduct research on applying a socio-spatial analysis to neighbourhoods to identify those in need of green infrastructure implementation to develop and utilize green infrastructure equity indices. Most of the articles have been published within the last five years, as they discuss a growing area of interest for urban planning academics. Several of the studies develop frameworks to include an equity lens or justice considerations in the application of green infrastructure.

The research from these papers can be applied to urban planning in order to develop equitable green infrastructure projects to plan for sustainable cities in response to population growth and the changing climate. This review also identifies the need for further research that specifically looks at the applicable intersection between equity and green infrastructure because many articles do not define equity or propose a framework for applying an equity lens to green infrastructure implementation. The aim of this study is to understand the integration, or lack thereof, of equity and green infrastructure in urban planning literature. I offer a systematic review of current literature to identify any gaps and discuss the applicability of current academia in urban planning projects. For a city to be resilient, benefits from green infrastructure need to reach all residents equitably otherwise socioeconomic inequality will increase.

2.2 Introduction

Prior to the advent of contemporary formal urban planning, cities around the world often showed some degree of coordination and structural layout (Smith, 2007). After the industrial revolution, modern cities have had increasingly complex development and greater technological progress, resulting in large-scale urbanization and environmental degradation (Moore et al., 2003; Banhalimi-Zakar et al., 2018). This has contributed to concentrated population growth and led to population demands that outpace city growth and services, leading to poverty and inequities (Moore et al., 2003). Nowadays, the anthropogenic climate crisis which is causing flooding, heat waves, and extreme weather events is another issue and one of the most pressing concerns in most cities worldwide, adding additional stress to degraded infrastructure and ecosystems within cities and disproportionately affecting those most at risk, such as marginalized populations (Jon, 2020; Zuniga-Teran, 2020). To mitigate climate change effects, increase sustainability and livability, and improve degraded environments, many cities globally are investing in green infrastructure (Anguelovski et al., 2020).

The concept of green infrastructure research existed prior to the 2000s, as historic civilizations around the world understood the benefits of the natural environment and the ecosystem services provided within their communities (Bolund & Hunhammar 1999; Costanza et al., 1997; Diamond, 2007). However, in academic literature, the concept of green infrastructure arose in the 1980s, and has been used in planning research since to identify conservation strategies (Weber & Wolf, 2000). Planning guides also have used green infrastructure (Davies et al., 2006). Later, Benedict and McMahon (2006) developed their definition that utilizes socioeconomic and ecological principles, along with the benefits that green infrastructure should deliver, as a large-scale planning framework that utilizes and focuses fundamentally on the environment, defining hubs, links and spots, and protecting lands of important ecological function (Benedict & McMahon, 2006; Canzonieri, 2007; Mell, 2017).

Green infrastructure is green space or infrastructure built to integrate or mimic natural ecosystem functions that benefit humans in an interconnected network (Benedict & McMahon, 2006; Coutts & Hahn, 2015; Bush & Doyon, 2019). Green infrastructure can refer to interconnected green spaces that enable ecosystems to deliver their services and can include nature-based solutions (Haase et al., 2017). Ecosystem services are functions from an ecosystem, such as carbon sequestration, that directly or indirectly benefit humans (Costanza et al., 1997; Bolund & Hunhammar, 1999). Examples of green infrastructure include trees canopies that intercept precipitation and reduce stormwater runoff; green roofs that enable rainfall interception and provide habitat for native species; green streets that store,

infiltrate, and evapotranspire stormwater; and rain gardens that harvest, absorb, and collect rainfall (Pickett et al., 2013; Davoudi, 2014; Hawken, 2018).

Green infrastructure can provide ecosystem services for residents within a city if it is implemented equitably (Bolund and Hunhammar, 1999; Haase et al., 2017; Anguelovski et al., 2020). Its implementation could encourage further application of nature-based solutions (Bush & Doyon, 2019). However, when integrating green infrastructure, it is essential to include equity-seeking groups in decision-making using an equitable framework to understand the potential effect on vulnerable population or to discuss what those populations believe are missing considerations for the neighbourhoods in a plan (Schlosberg, 2007; Haase et al., 2017; Anguelovski et al., 2018a; Baró et al., 2019; Meerow et al., 2019). Green infrastructure that only benefits higher-income populations or is applied for urban renewal is not equitable, and can thusly further increase socio-spatial inequalities and segregation by excluding disenfranchised communities (Haase et al., 2017; Anguelovski et al., 2018b; Rigolon & Németh, 2018).

2.2.1 The Necessity of Green Infrastructure and Equity Integration

In contrast to the historic literature on green infrastructure, integration with equity is a contemporary concept. Equity is the redistribution of resources, political power, and participation to those who systematically have been disenfranchised and disadvantaged (Krumholz & Hexter, 2018). Social equity is comprised of three factors: distributional equity, recognitional equity, and procedural equity. This means that for equity to exist, citizens must have equitable distribution of goods, services, and opportunities; citizens must have mutual acknowledgment and respect of different people and communities; and citizens must be able to participate equitably in decision-making processes (Schlosberg, 2007; Meerow et al., 2019).

Equity is an essential consideration during city planning because systemic inequity and inequality can increase and populations can be further segregated if planning is carelessly practiced (Fainstein, 2015; Lorinc & Pitter, 2016; Meerow & Newell, 2016). Green infrastructure integration also requires an equity lens for implementation because equitable green infrastructure must benefit all populations for it to support resiliency. There needs to be socially inclusive green infrastructure implementation, otherwise, creating greenspaces could displace populations. Green infrastructure can gentrify cities through urban renewal or causing a rise in property values. In addition, adding greenspace in areas that are inaccessible by public transportation can further encourage socioeconomic inequities (Haase et al., 2017). However,

applying an equity lens to green infrastructure implementation is still a new development and requires further research and application.

This systematic review researches how contemporary urban planning literature has integrated equity and green infrastructure in academic research in the past two decades. Historically, urban planning has excluded the voices of marginalized communities in North America in favour of automobile-centric development and urban renewal for the wealthier classes (Avila & Rose, 2009; Dory, 2017). Other reasons for excluding the voices of minorities, people of colour, and disenfranchised communities include racial segregation and class segregation (Rothstein, 2017). The integration of equity and green infrastructure is necessary for cities to have sustainable development and to improve quality of life for all citizens (Meerow & Woodruff, 2019; Anguelovski et al., 2020). Social equity and justice have also risen to the forefront of urban issues with the recent Black Lives Matter Movement in North America and Youth Strike for Climate worldwide, so it is necessary that the future of urban planning include all residents in the decision-making process in order to improve cities holistically (Anguelovski et al., 2018a).

Therefore, the aim of this study is to understand and analyze the integration of equity and green infrastructure within urban planning literature. I examine thematic similarities and common discourses of current urban planning literature. I intend to offer a systematic review of current literature to identify any gaps and discuss the applicability of current academia in urban planning projects. I first introduce the papers yielded in the review and the authors who are well-known academics in the field. Next, I will provide a historical overview of equity in urban planning. I then highlight the benefits and applications of green infrastructure, as well as the examining discourse about green infrastructure found in the literature. Afterwards, I review equity and analyze the different types of equity utilized in green infrastructure academia. I identify and discuss the overlap of green infrastructure and equity found in contemporary literature. I argue through this review how and why current literature needs to evolve to include more integration of green infrastructure and equity to build a larger foundation for social justice movements in urban settings. At the end, I offer recommendations for applications to current and future urban planning practices.

2.3 Historical Context

To understand the need for equity in urban planning, it is essential to understand the historical context. Zoning was introduced in North American cities in the 1900s to control density and land use, as well as to protect residential areas from industrial hazards (Silver, 1997). Zoning emerged to improve the

quality of life in cities as many wealthier citizens fled from the nuisances and chaos of North American cities to suburbs (Frey, 1979, Silver, 1997).

However, planners from that period generally were of elitist origins or had special interests, such as lobbying from developers; hence they used their zoning ordinances and power to keep working class citizens and minorities out of these suburbs (Silver, 1997). In some cases, planning without equity considerations or public engagement resulted in the destruction of communities and neighbourhoods of marginalized groups to make highways from the suburbs into the cities (Larson, 2009).

This was the case with Robert Moses in New York as he destroyed several inner-city communities in favour of highways (Caro, 1974, Larson, 2009). Elitist groups and individuals may have special interests in the automobile or oil industries, so they lobbied for automobile-oriented development rather public transportation, further causing socioeconomic segregation within cities (Jacobs, 1961; Caro, 1974; Skocpol & Hertel-Fernandez, 2016; Tabuchi, 2018). This helped keep the poorer working-class citizens in a poverty loop, as public funding was kept away from their neighbourhoods and developers and landowners can exploit their communities (Jacobs, 1961; Silver, 1997).

2.3.1 Historical Zoning Impacts

The desire to keep the working class and minorities out suburbs resulted in redlining and racial segregation within neighbourhoods, as was the case in Baltimore (Silver, 1997; Rothstein, 2017). Redlining occurs when parts of cities where minorities generally live are identified on a map, and this is done to reject loans or mortgages to people living in these areas (Rothstein, 2017). This practice is now illegal but, in some cases, banks and lenders nowadays will engage in offering predatory loans to people living in these neighbourhoods. This can destroy communities in cities, such as Detroit and other cities wrecked by the 2008 housing market crash, by causing bankruptcy and the loss of homes (Rothstein, 2017).

Furthermore, indigenous communities in Canada have suffered under Canadian governments and their planning approaches through territorial acquisition (Lane, 2006). Canadian planning was predominantly state imposed with colonial processes that disregarded indigenous voices, resulting in sustained systematic abuse, degradation and loss of unceded and traditional lands, and displacement and impoverishment of communities (Lane, 2006; Prusak et al., 2016). Now, community planning in Canada requires a transactive and participatory approach; however, there is still a lack of engagement due to cultural barriers, cynicism about authenticity, and lack of trust (Lane, 2006; Gerwing & Cox, 2017).

Rather, many First Nations communities are advocating for their own planning practices for their communities for their right of self-determination (Lane, 2006; Prusak et al., 2016).

In Canada, there is ongoing research and examination of historical environmental inequities because their effects continue to the present day. First Nations communities are often victim to horrendous environmental degradation due to systematic injustices. The Canadian government deliberately zoned hazardous waste sites, landfills, incinerators, and polluting industries near First Nations communities (Dhillon & Young, 2010). For example, the drinking water source for the Aamjiwnaang and Walpole Island First Nations is extremely polluted because of its proximity to several large petrochemical, polymer, and chemical industry plants (Keith et al., 2005; Dhillon & Young, 2010).

Another example is Grassy Narrows, Ontario, which has high levels of mercury content because of its proximity to a Dryden paper mill (Dhillon & Young, 2010). In addition, black communities have faced environmental discrimination and racism by having their communities zoned to be adjacent to polluting landfills that leach toxic waste, such as Lincolnville, Nova Scotia (Campbell, 2020). These communities disproportionately face air and water pollution that causes adverse health impacts, such as increased cancer rates and reproductive issues, as well as an overall lower quality of life (Keith et al., 2005; Dhillon & Young, 2020; Campbell, 2020).

It is understandable why certain communities may distrust the planning process. Historical injustices need to be addressed with genuine compassion and understanding, as well as a deliberate framework to prevent continuing inequity. Transparency and education are essential for planning practices to include all citizens. In addition, social equity that requires distributional, procedural, and recognition equity within the planning process can help to increase communication and understanding in communities. Simply having diversity and inclusion is not enough. Historically disenfranchised people may not want to participate in institutions that previously hurt or continuously harm their communities. As well, inviting members of disenfranchised communities to speak about their lived experiences is beneficial, but the institutions themselves also need to change internally to address social equity and historic injustices in order to evolve (Reece, 2018).

2.4 Evolution of Equity in Urban Planning

Equity has evolved to be prevalent in urban planning. Historically, equity planning has been studied in theory and practice. Metzger (1996) created an annotated bibliography compiling academic journal articles about equity planning objectives. In Metzger (1996)'s annotated bibliography, there are no

mentions of green infrastructure. Historically, planning was criticized for primarily serving the whims of special interest groups, such as real estate developers or landowners (Goodman 1971; Weiss 1987). This paper illustrates the evolution of equity planning from the 1970s, when advocacy planning gained popularity within municipal governments after black voters elected mayors to represent their interests (Metzger, 1996). Afterwards, equity-oriented planners gained voices in academia and practice, and frameworks for equity planning spread to more cities across the U.S. and into Canada (Metzger, 1996).

However, racial tensions remained in U.S. cities because the institutions themselves did not change. For example, housing shortages accelerated racial tensions leading to discrimination, riots, and violence, like in Detroit (Capeci & Wilkerson, 1990). Urban revitalization reflects the power imbalance of public-private partnerships and the resulting displacement of marginalized residents (Metzger, 1996). Metzger (1996)'s paper concludes by illustrating the importance of equity in city planning when addressing the aftermath of the race riots in Los Angeles caused by police brutality in the early 1990s. Metzger (1996) states the importance of community participation and the need to listen to lived experiences to mobilize underrepresented voices. Eventually, this evolves into advocacy planning, which is a people-oriented planning practice that focuses on economic and social empowerment of marginalized communities (Fainstein, 2005). The importance of advocacy planning remains prevalent today as racial discrimination continues to result in economic inequality and police brutality (Fainstein, 2005; Reece, 2018).

Reece (2018) conducts a literature review about equity in urban planning to address changes in social justice and planning since Metzger (1996)'s publication. Within the twentieth and early twenty first century, there have been continuous conflicts with social and racial equity and the planning profession remains complicit in discriminatory practices across cities in the U.S. (von Hoffman, 2009; Rothstein, 2017; Reece, 2018; Swanstrom, 2018). The demographic within U.S. cities has grown more diverse due to an influx of immigrants and globalization, which has caused racial tensions, as well as economic inequalities (Rothstein, 2017; Reece, 2018; Swanstrom, 2018).

Within planning practice, there have been advancements in equity considerations. "Place making" initiatives increased to address community challenges and for community empowerment by increasing engagement with residents (Fainstein, 2005; Reece, 2018). As well, planners can support various types of equity in neighbourhoods through different policies. For example, advancing public transportation can support mobility equity in neighbourhoods where many residents may not have cars. This can support ease of access to employment in other parts of the city and help reduce economic inequity (Grenge, 2018; Reece, 2018). Another example is supporting mixed-use development and a variety of

land use, to support a diversity of housing types in neighbourhoods and to introduce businesses into suburbs to reduce spatial inequity (Reece, 2018). Mixed-used can support aging equity too, as older citizens in neighbourhoods may not be able to drive and can access activities or have mobility due to public transportation or walkable communities (Howe, 2018).

The demographic of aging citizens in cities is diversifying as well, as a lot more seniors are minorities in larger cities, so it is important to consider their needs when planning neighbourhoods and developing policies (Howe, 2018). There are numerous types of equity and their respective considerations that are required to ensure that all citizens have their needs addressed. Professional planners have the roles of communicators, consensus builders, and educators for all residents (Reece, 2018). Thus, it is essential to have public engagement sessions and a variety of perspectives to understand the needs and lived experiences of the community (Fainstein, 2005; Reece, 2018).

Planners must address the complex dynamics of changing demographics and diversification in cities by incorporating intersectionality to the needs and concerns of individuals, which can compound marginalization due to traits such as age, class, gender, sexual orientation, and race (Reece, 2018). Equity issues are interrelated with urban environmental challenges. Therefore, considerations of distributional, recognitional, and procedural equity are essential to address issues with, but not limited to, age, economic, environmental, green, mobility, racial, and spatial inequities (Langemeyer & Connolly, 2020). Planning remains an important profession and equity considerations are necessary to enhance social justice in policies and practices (Reece, 2018). It is important to look beyond the trifecta of social equity, which just consists of distributional, procedural, and recognitional equity, and expand to incorporate other social movements related to urban greening interventions (Anguelovski et al., 2020). Therefore, it is important to analyze the information obtained from a systematic literature search for equity and green infrastructure to determine whether it adequately integrates the two.

2.5 Environmental and Green Equity

Environmental justice and equity aim to guarantee that residents will not suffer from disproportionate impacts of environmental hazards (Dhillon & Young, 2010). However, environmental justice remains an issue as climate impacts disproportionately affect lower-income and marginalized individuals as these communities are most vulnerable to flooding, heatwaves, and other natural hazards (Anguelovski et al, 2016). Historically in the United States of America, black, indigenous, and other minority communities were zoned or relocated to be near polluted areas that negatively affected their health, and are also now at greater risk to climate impacts (Earickson & Billick, 1988; Dhillon & Young, 2010).

Environmental inequity remains an issue today and climate change adaptation plans and other climate action goals within cities must address the social inequities of climate change impacts (Anguelovski et al., 2016). There are multiple drivers of social equity in relation to ecosystem service equity and there needs to be a robust linkage to ensure there is adequate progress in urban environmental justice advancement (Langemeyer & Connolly, 2020).

Equity continues to evolve. Terms like “green equity” are becoming more common in green infrastructure literature and in discussions about environmental justice (Nesbitt et al., 2019). Green equity, also called urban ecosystem service equity, refers to the access, benefits, and distribution of urban vegetation to all residents in a city (Nesbitt et al., 2019; Langemeyer & Connolly, 2020). These benefits from ecosystem services and green infrastructure can support climate adaptation and mitigation, and improve quality of life (Anguelovski et al., 2020). However, studies have also shown that ecosystem services are inequitably low in marginalized and minority communities (Nesbitt et al., 2019). This inequity is associated with intra-generational inequity, as vulnerable individuals are without adequate environmental amenities and are at higher risk of climate impacts without the necessary natural resources or ecosystem services than their wealthier counterparts (Anguelovski et al., 2016; Langemeyer & Connolly, 2020). Often, unfortunately, those at most risk have contributed the least to climate change and to greenhouse gas emissions. Poorer populations and populations in less developed nations, on average, emit less greenhouse gas emissions (Anguelovski et al., 2016). In addition, green inequity is linked to intergenerational inequity because of the irreparable damage done by past generations to the natural environment, which has added undue stress to younger citizens about the health and quality of life of their futures (Anguelovski et al., 2020; Langemeyer & Connolly, 2020).

Anguelovski’s et al. (2020) article describes the complex interrelated nature of justice with urban ecosystem services. The article explains the limitations to examining inequities within urban environments when solely using distributional, procedural, and recognition equity lenses. Rather, frameworks for urban greening need to explore other intersectional equity considerations as well, such as anti-subordination, and emancipatory, intersectional, and relational equity (Anguelovski et al., 2020). Anti-subordination is necessary in equity as members of disenfranchised communities will receive more resources as need to promote equality or equal opportunity (Anguelovski et al., 2020). Intersectionality will ensure all identities of an individual are considered and acknowledged (Fricker, 2003; Anguelovski et al., 2020). Relational equity is ensuring that the distribution of resources between people in a relationship is equal, or greater as needed to ensure there is equality between the two groups

(Anguelovski et al., 2020). These are all important considerations when examining the diversity of people living in a city and researching how governance affects their daily lives.

Often, politicians or planners that imagine what urban green interventions will accomplish may ignore vulnerable residents and intensify injustices (Anguelovski et al., 2020; Langemeyer & Connolly, 2020). This can cause displacement, gentrification, or simply the exclusion of their neighbourhoods from equitable urban greening interventions or green infrastructure investments (Anguelovski et al., 2020; Langemeyer & Connolly, 2020). Therefore, it is important to consider epistemic justice, which is the acknowledgement of the community's lived experiences, and advocacy justice, which is community participation when planning green infrastructure in neighbourhoods (Fricker, 2003; Anguelovski et al., 2020). It is necessary that a variety of perspectives and experiences can be included in equity considerations to avoid prejudices (Fricker, 2003; Anguelovski et al., 2020).

2.6 Limitations and Scope

This review is concerned with systematically investigating the integration of equity and green infrastructure in planning literature within three databases. The data is limited to searches in three English-language databases with three different searches from 2000 onwards to consider contemporary journal articles. The history and evolution of equity and green infrastructure is discussed briefly in the "Historical Context" section of this paper. I do not claim a total encapsulation of all English-language planning literature on the integration of equity and green infrastructure.

This review is limited in scope because of the keywords utilized. Green infrastructure is linked to other fields of research, such as sustainability or sustainable development, which may use other keywords to refer to similar practices, such as ecosystem services, natural infrastructure, or the use of "green" and "infrastructure" in the same article but not used together. Other articles, such as Anguelovski et al. (2020)'s article use "urban greening" to reference green infrastructure.

Equity, as well, can be used in place of "justice" in certain studies, or could be linked to similar research in "human rights" or "equality". Some journal articles also utilize key words such as "green equity". Due to time constraints, and to put a scope on my research, I chose to use "green infrastructure" and "equity" in the field of planning and urban studies to specifically search for inarguable terms that have concise definitions. As well, these words are used within city plans and resilience strategies, and thus, it is important to search for the same keywords in academic papers to relate to planning practice applications. Therefore, the scope of this systematic review is limited to focus solely on the literature

that uses the exact terms “green infrastructure” AND “equity” within the last twenty years in planning and urban studies.

2.7 Methods

I performed a keyword search within JSTOR, SCOPUS, and Taylor and Francis Online (TANDFONLINE) in their electronic databases. In JSTOR, I searched using << (“green infrastructure” AND equity*) >> for planning related journal articles. As well, I limited results to three subjects: Environmental Sciences, Environmental Studies, and Urban Studies. The search yielded 47 unique results, but journals that are not peer-reviewed, such as *American Water Works Association* and *Inside EPA’s Water Policy Report*, were excluded. I did not use a filter for the date as the oldest article yielded was published in 2010.

In SCOPUS I searched using , << ("GREEN INFRASTRUCTURE" AND equity*) AND (LIMIT-TO (SUBJAREA , "ENVI") OR LIMIT-TO (SUBJAREA , "SOC")) AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (LANGUAGE , "English")) >> and 50 unique results for journal articles were returned. All the articles were from 2013 and onwards therefore, the date did not need to be limited.

In TANDFONLINE, I searched using << [All: "green infrastructure"] AND [All: equity*] AND [All Subjects: Cities & Infrastructure (Urban Studies)]>> which resulted in six unique results for journal articles. The oldest article yielded was published in 2018, so I did not need to add a filter for the date.

In total, searches across the three databases yielded 71 unique English-language journal articles in peer-reviewed journals. To narrow the literature by relevance, I conducted a manifest analysis by searching the keywords “green infrastructure” and then “equity*” to see how many times and where in the article the keywords are mentioned. Furthermore, I created a questionnaire to identify in what context the articles mention these keywords. I used questions to review the literature to help analyze the content of the articles through a latent analysis. The questions used are as follows: (1) What examples of green infrastructure are given and their benefits? (2) What type of equity is mentioned and is it defined? (3) Does the article discuss the integration of green infrastructure with equity? After conducting my questionnaire, I identified 49 articles of the 71 that contained an overlap between equity and green infrastructure, but two of those 49 articles were not peer-reviewed and thus excluded. In total, I used 47 articles for my systematic review, and a ROSES (Reporting Standards for Systematic Evidence Syntheses) flowchart depicting my methods can be found in Appendix A.

2.8 Results

The oldest article yielded is from 2010, so all the research from this review has been published within the eleven years. Equity considerations within the greening of urban infrastructures are a growing field of contemporary research because of a higher awareness of social justice issues within cities. Certain authors consistently address the complex relationship between equity and green infrastructure in their relationship.

Anguelovski (2018a, 2018b, 2020) is one of the leading authorities on research about the integration of equity and green infrastructure. Anguelovski (2018a, 2018b, 2020) writes about how green infrastructure is one of the methods to contain urban expansion, reintroduce nature, and act as support to mitigate or adapt to climate change. However, in Anguelovski's research, the author demonstrates that irresponsible implementation can result in displacement of marginalized communities, so intersectional equity is a necessary consideration in community planning. These articles advocate the need for an environmental justice lens when planning green cities.

Heckert and Rosen (2016 & 2018) are both the co-authors of two articles in which they suggest the development of a green infrastructure equity index to assist in determining which communities are at most in need of urban greenery investments. Their research would support the development of equity lenses for future research.

Baró (2019 & 2021) is another author that researches the intersection of equity with green infrastructure, focusing on distributional equity integration within cities. Baró (2019 & 2021) has researched street trees and their distribution across a city so that residents can access nature and associated socioeconomic and health benefits. One of the issues Baró (2019 & 2021) addresses is spatial inequities linked with green infrastructure implementation.

Newell (2013 & 2016) is another author that addresses social and spatial equity, researching projects within Los Angeles in which the focus is green infrastructure. Newell (2013 & 2016) argues that marginalized communities need to be involved in the decision-making process for there to be procedural and distributional equity when implementing green infrastructure projects.

2.9 Green Infrastructure

Green infrastructure is described as a planned network of green and blue spaces that deliver ecosystem services locally, regionally, or at a larger spatial scale (Williams et al., 2010; Meerow & Newell, 2016; Rigolon & Németh, 2018; Carmichael et al., 2019; Luz et al., 2019; Wang et al., 2019; Zuniga-Teran et al.,

2020; Baró et al., 2021). Green infrastructure is considered an essential ecological framework to support environmentally, socially, and economically sustainable development (Newell et al., 2013). Some examples of ecosystem services provided by green infrastructure include contributing to biodiversity conservation, controlling floods, improving air quality, mitigating the urban heat island effect, protecting water resources, and providing recreational areas (Larson et al., 2013; Newell et al., 2013; Lin et al., 2015; McClintock et al., 2016; Meerow & Newell, 2016; Bahrini et al., 2017; Benton-Short et al., 2017; William et al., 2017; Anguelovski et al., 2018a; Dobbs et al., 2018; Ferguson et al., 2018; Porse, 2018; Baró et al., 2019; Carmichael et al., 2019; Luz et al., 2019; Mason et al., 2019; Sanchez & Reames, 2019; Wang et al., 2019; Xiao et al., 2019; Zhu et al., 2019; De Lange, 2020; Jayakaran et al., 2020; Majekodunmi et al., 2020; Uchiyama & Kohsaka, 2020; Venter et al., 2020; Zuniga-Teran et al., 2020; Baró et al., 2021). Planning authorities and city governments implement green infrastructure to advance sustainable development, educate children about the natural environment, improve quality of life, and mitigate climate change and disaster risks (William et al., 2010; Newell et al., 2013; Cvejić et al., 2015; Meerow & Newell, 2016; Benton-Short et al., 2017; Walsh et al., 2017; Williams et al., 2017; Ferguson et al., 2018; Baró et al., 2019; Hall & Knuth, 2019; Houston & Zuñiga, 2019; Mason et al., 2019; Wang et al., 2019; Xiao et al., 2019; Zhu et al., 2019; Jayakaran et al., 2020; Majekodunmi et al., 2020; Scott, 2020; Uchiyama & Kohsaka, 2020; Wolff et al., 2020; Baró et al., 2021).

This review shows that cities worldwide implement green infrastructure through the creation of community gardens, green alleyways, green roofs, green spaces, and/or tree canopies, among other innovative applications (Williams et al., 2010; Cvejić et al., 2015; Newell et al., 2013; Brooks et al., 2016; Heckert & Rosan 2016; Meerow & Newell, 2016; Bahrini et al., 2017; William et al., 2017; Ferguson et al., 2018; Baró et al., 2019; Carmichael et al., 2019; De Lange, 2020; Luz et al., 2019; Xiao et al., 2019; Zhu et al., 2019; Majekodunmi et al., 2020; Tuvikene et al., 2020; Uchiyama & Kohsaka, 2020; Zuniga-Teran et al., 2020; Baró et al., 2021; Fang et al., 2021; Lanza & Durand, 2021). Different applications of green infrastructure can be executed at various spatial scales throughout a city. For example, green infrastructure can be executed at a local neighbourhood level by planting trees at bus stops (Faehnle et al., 2014) or as an initiative that spans throughout a city by applying green infrastructure policies into stormwater management (Heckert & Rosan 2016; Heckert & Rosan 2018; Homsy & Hart, 2019). However, this review also states that cities must have coherent integration and investment into well-researched green infrastructure projects otherwise urban greening programs will simply create a green concealment, merely an aesthetic, without any benefits (Larson et al., 2013; Bahrini et al., 2017; Benton-Short et al., 2017; Homsy & Hart, 2019; De Lange, 2020; Dimitriou & Field, 2020). As well, green

infrastructure integration without a consideration for equity can further exacerbate socioeconomic inequities.

2.9.1 Community-level Green Infrastructure

Green infrastructure, in the form of green spaces throughout the city, also provides access to nature in the form of recreational areas (Meerow & Newell, 2016; Bahrini et al., 2017; Hall & Knuth, 2019; Luz et al., 2019; Xiao et al., 2019; Tuvikene et al., 2020; Uchiyama & Kohsaka, 2020; Baró et al., 2021). This exposure to nature can benefit residents' physical health, improve their mental well-being, and reduce stress (Ferguson et al., 2018; Luz et al., 2019; Xiao et al., 2019; Zhu et al., 2019; Wolff et al., 2020). Recreational areas can strengthen social bonds in communities by acting as a beneficial socio-ecological gathering area in cities (Meerow & Newell, 2016; Hall & Knuth, 2019; Luz et al., 2019). Green spaces can improve quality of life by providing trails to walk, places to relax, and spaces to play sports (Newell et al., 2013; Meerow & Newell, 2016; Tuvikene et al., 2020; Uchiyama & Kohsaka, 2020). As well, integrating green infrastructure throughout a city by planting street trees can increase contact with nature, which can help foster an appreciation for the natural environment (Brooks et al., 2016; Baró et al., 2019; Uchiyama & Kohsaka, 2020; Baró et al., 2021;).

Community gardens are a form of green infrastructure that strengthen the local food system and reduce dependence on imported fruits and vegetables (Cvejić et al., 2015; McClintock et al., 2016; Hall & Knuth, 2019; Luz et al., 2019; Majekodunmi et al., 2020). Community gardens, as well as backyard and rooftop gardens are a type of urban agriculture, which is the practice of growing food crops within the city (Cvejić et al., 2015, McClintock et al., 2016). Urban planning policymakers are interested in urban agriculture because of its community-oriented initiatives and its transformation of vacant land to enhance the local environment (Cvejić et al., 2015).

2.9.2 City-wide Green Infrastructure

More cities are having flood-related issues due to variable precipitation events related to climate change and/or urbanization increasing the stress on water resources (Lin et al., 2015; Heckert & Rosan 2016; Porse, 2018; Baró et al., 2019; Carmichael et al., 2019; Mason et al., 2019; Wang et al., 2019; Zuniga-Teran et al., 2020). Green infrastructure can be applied as complementary infrastructure when integrated with traditional grey infrastructure to support stormwater services, such as by implementing rain barrels, permeable pavements, infiltration planters, bioretention cells, and vegetated buffer strips to reduce and delay peak flows, as well as to improve recharge to local groundwater resources (Heckert & Rosan 2016; Heberle et al., 2017; William et al., 2017; Heckert & Rosan 2018; Carmichael et al., 2019;

Homsy & Hart, 2019; Mason et al., 2019; Wang et al., 2019; Zuniga-Teran et al., 2020). Philadelphia is one North American city that has integrated green infrastructure with its grey infrastructure system successfully to mitigate flooding events by reducing stormwater runoff (Heckert & Rosan 2018; Heckert & Rosan 2016; Homsy & Hart, 2019).

Green infrastructure is also referred to in this review as a method to mitigate the urban heat island effect, which is caused by warming temperatures due to climate change as well as lower albedo in the built environment (William et al., 2017; Baró et al., 2019; Carmichael et al., 2019; Luz et al., 2019; Zhu et al., 2019; Majekodunmi et al., 2020; Venter et al., 2020; Lanza & Durand, 2021). Tree canopies increase shade, resulting in less direct and thermal radiation, so they can reduce street-level temperatures (Lin et al., 2015; Lanza & Durand, 2021). As well, green roofs on buildings can reflect sunlight because of their low albedo vegetation, rather than concrete or asphalt which can retain heat (Lin et al., 2015; Carmichael et al., 2019; Majekodunmi et al., 2020). These benefits can provide a cooling effect and relief from heat stress for residents within a city.

Green infrastructure initiatives include conserving, regenerating, or restoring ecosystems, such as wetlands and forests, that local development or anthropogenic activities previously disturbed or harmed so that they can provide beneficial ecosystem services (Larson et al., 2013; Newell et al., 2013; Faehnle et al., 2014; Carmichael et al., 2019; Luz et al., 2019; Dobbs et al., 2018; Ferguson et al., 2018; Uchiyama & Kohsaka, 2020). As well, connecting urban greenery such as green parks and spaces, green roofs, street trees, and urban forests can improve biodiversity and increases local ecosystems' ability to support natural and urban sustainability (Larson et al., 2013; Newell et al., 2013; Venter et al., 2020). Creating a bionetwork of green infrastructure with a variety of native flora and fauna can mitigate disaster risks and facilitate recovery (Hall & Knuth, 2019; Uchiyama & Kohsaka, 2020).

2.10 Equity

Many papers in this review mention equity as a goal or an important aspect of urban planning but few define the term, and fewer have integrated it into their discussion or research of green infrastructure. Environmental equity and justice are focuses in green infrastructure literature as they relate to the distribution of environmental benefits but also environmental threats and hazards (Ortiz-Moya, 2018; Zhu et al., 2019). Environmental justice is a type of social equity, meaning that resources need to be distributed in greater quantities to disadvantaged groups to ensure that they benefit those who are most in need, like vulnerable populations (Ortiz-Moya, 2018; Zhu et al., 2019).

The trifecta of social justice is defined partially in several papers and wholly in two. Distributional equity is related to social equity and refers to how resources, such as environmental benefits, are distributed to disadvantaged groups (Benton-Short et al., 2017; Anguelovski et al., 2018a; Rigolon & Németh, 2018; Baró et al., 2021). Another aspect of social equity is procedural equity. Procedural equity refers to having an inclusive decision-making process that invites all citizens to voice their concerns and opinions (Newell et al., 2013; Benton-Short et al., 2017; Anguelovski et al., 2018a; Mason et al., 2019). Recognitional equity is another branch of social equity that refers to acknowledging the multiple identities that make up a community and their varying beliefs, desires, needs, and opinions (Benton-Short et al., 2017; Anguelovski et al., 2018a; Ortiz-Moya, 2018; Zhu et al., 2019).

Intergenerational equity is currently a pressing topic in social justice discussions and has resulted in discussions concerning the equitable access of a sufficient quantity and quality of resources, such as water, for current and future residents (Larson et al., 2013). Intergenerational equity in an urban planning context requires diverse representation for future generations in decision-making (Larson et al., 2013). In addition, intragenerational equity ensures members of the same generation have safe and unbiased access to necessary resources which often may be obstructed by racism or politics (Larson et al., 2013).

2.11 Integration of Green Infrastructure and Equity in Academia

Several papers have conducted research to integrate green infrastructure and equity through applicable projects (Newell et al., 2013; Heckert & Rosan 2016). In Guangzhou, China, there has been research to develop a Green Infrastructure Equity Index and related map, which shows which neighbourhoods have higher numbers of green spaces and parks (Zhu et al., 2019). This research shows green infrastructure provisions across several neighbourhoods and can help identify which areas are lacking in green spaces and which areas may have inequitable accessibility to these green spaces (Zhu et al., 2019). Other papers also propose including a Green Infrastructure Equity Index in urban planning to incorporate community perspectives on how to distribute green infrastructure across a city to meet community needs, as well to determine which communities might have the greatest benefits from green infrastructure investment (Heckert & Rosan 2016; Heckert & Rosan 2018). Other projects also use socio-spatial analysis to determine which areas are most in need of green infrastructure based on equity disparities in access to resources for certain demographic neighbourhoods to mitigate the urban heat island effect (McClintock et al., 2016; Sanchez & Reames, 2019).

In addition, fellowships like the Rose Fellowship that promotes sustainable buildings, such as LEED certified developments, can promote green infrastructure initiatives with goals that provide measures of socioeconomic equity and can help with sustainable communities (Swenson et al., 2014). Sustainable development goals also provide frameworks and goals to support the integration of green infrastructure and equity to meet future projections (Dimitriou & Field, 2020; Scott, 2020). International organizations, such as C40 Cities and the Global Covenant of Mayors promote sustainable development through integrating the concepts of social equity, environmental sustainability, and liveability (De Lange, 2020).

2.11.1 Accessibility

Green space accessibility is an intersection of equity and green infrastructure (Benton-Short et al., 2017; Luz et al., 2019; Zhu et al., 2019; Wolff et al., 2020). Green space accessibility refers to the association between inequitable and unequal distributions of environmental stressors, access to resources, and socioeconomic circumstances of community members, resulting in reduced accessibility for lower income neighbourhoods and marginalized citizens (Benton-Short et al., 2017; Ferguson et al., 2018; Baró et al., 2019; Luz et al., 2019; Wolff et al., 2020). As well, parks may not be equitably accessible to vulnerable groups because of mobility patterns as young, elderly, or lower-income groups may not have access to vehicles or adequate public transit services (Bahrini et al., 2017; Benton-Short et al., 2017; Xiao et al., 2019). Lisbon is one city where citizens have inequitable access to green infrastructure due to historically uneven distributions within the city, hence isolating certain individuals from green spaces (Luz et al., 2019). As a result, inequitable access to green spaces and parks can minimize the benefits of green infrastructure to disadvantaged groups (Meerow & Newell, 2016). There needs to be an equity lens when planning for green spaces to acknowledge the importance of distribution when developing park spaces so that they are accessible for all citizens (Meerow & Newell, 2016; Zhu et al., 2019). Applying procedural equity is necessary too, so that the planning process is democratic and informs a variety of citizens about the positives and negatives of implementation (Newell et al., 2013; Benton-Short et al., 2017; Anguelovski et al., 2018a). This allows all citizens to voice their wants and needs for green spaces in their neighbourhoods, which can include providing their ideas for solutions in regards to accessibility issues (Newell et al., 2013; Benton-Short et al., 2017; Anguelovski et al., 2018a).

Accessibility of green infrastructure includes having access to street trees and greenery on sidewalks within neighbourhoods (Brooks et al., 2016; Baró et al., 2021; Lanza & Durand, 2021). Lower socioeconomic neighbourhoods generally have fewer walkable streets with trees, whereas higher socioeconomic neighbourhoods generally have more, resulting in an inequitable distribution of green

infrastructure across a city (Brooks et al., 2016; Baró et al., 2019; Lanza & Durand, 2021). Trees can provide shade at bus shelters to reduce heat stress (Lanza & Durand, 2021) and can help make commuting more enjoyable, improving mental health and providing exposure to nature to residents at a young age (Brooks et al., 2016; Baró et al., 2021). An equity lens needs to be applied when planning for green infrastructure so that marginalized groups that are at greater risk of stormwater runoff and urban heat island effect can benefit from valuable green infrastructure implementation, as well as have a voice in the decision-making process (Meerow & Newell, 2016; Benton-Short et al., 2017; Anguelovski et al., 2018a; Sanchez & Reames, 2019; Zhu et al., 2019).

2.11.2 Gentrification and Displacement

One concern researched in this review is ‘green’ or ‘environmental’ gentrification (Anguelovski et al., 2018a; Rigolon & Németh, 2018; Baró et al., 2019; Carmichael et al., 2019; Hall & Knuth, 2019; Houston & Zuñiga, 2019). These terms refer to the displacement of marginalized communities or lower-income individuals because of the addition of green infrastructure in historically disenfranchised neighbourhoods that causes an influx of wealthier residents (Anguelovski et al., 2018a; Rigolon & Németh, 2018; Carmichael et al., 2019; Hall & Knuth, 2019). Adding greenery to urban areas can increase property values, unintentionally pushing out the residents that the green infrastructure was designed to benefit (Carmichael et al., 2019; Hall & Knuth, 2019; Houston & Zuñiga, 2019; Xiao et al., 2019). Cities can implement green infrastructure and become more sustainable but, without equity considerations, they can exclude lower-income, minority, and working-class residents (Anguelovski et al., 2018a; Rigolon & Németh, 2018). Therefore, it is essential for green infrastructure projects to consider social and environmental equity, otherwise green infrastructure benefits may not reach communities most in need and therefore not support the city holistically (Anguelovski et al., 2018a; Rigolon & Németh, 2018).

Gentrification is an important environmental justice and equity issue as large green infrastructure investments can cause harm to the neighbourhoods most in need of the benefits of green infrastructure (Anguelovski et al., 2018a; Rigolon & Németh, 2018). Integrating an equity lens into planning initiatives is essential for holistic green infrastructure; otherwise, green infrastructure may not reduce the vulnerability of the whole city (Anguelovski et al., 2018a). Thus, it is important to ensure that all community members can participate in the discourse and that educational resources about green infrastructure are provided through public engagement sessions or outreach initiatives (Newell et al., 2013; Benton-Short et al., 2017; Walsh et al., 2017; Rigolon & Németh, 2018; Mason et al., 2019;

Jayakaran et al., 2020). Procedural and recognitional equity are required to ensure all residents, especially those in historically disenfranchised communities, voice their concerns about green infrastructure projects in their cities (Newell et al., 2013; Anguelovski et al., 2018a; Ortiz-Moya, 2018; Rigolon & Németh, 2018; Scott, 2020). Distributional equity is required so that green infrastructure will benefit all communities as required for their well-being rather than only the wealthier classes (Benton-Short et al., 2017; Anguelovski et al., 2018a; Rigolon & Németh, 2018; Scott, 2020; Baró et al., 2021). Overall, planned and contemporary green infrastructure implementation with considerations for all communities in a city is a growing worldwide trend.

2.12 Future Directions

The purpose of this systematic review is to determine how literature on equity and green infrastructure integrates the two fields of research. Conscious integration of social equity and green infrastructure in urban planning is vital to improve sustainability and to ensure all citizens benefit as needed from ecosystem services from green infrastructure implementation (Anguelovski et al., 2020). As well, it is essential for research regarding green infrastructure to include all aspects of social equity and their definitions so there is no miscommunication about terms and there is a framework for implementation. Municipal, regional, and larger-scale governmental authorities need to communicate with each other because of the complexity of cities. Governments must also include the public in planning and developmental discussions for equitable and sustainable growth (Fricker, 2003; Fainstein, 2005; Larson, 2009; Reece, 2018; Anguelovski et al., 2020). Therefore, it is important that literature and research lay a foundation for cities to reference when creating official plans. The proper adoption of social equity and green infrastructure into city planning will support urban and environmental justice within communities in order to develop sustainable futures.

The systematic literature review has demonstrated that the articles yielded about green infrastructure including the word equity are lacking necessary equity considerations as few articles considered the historical context of equity in urban planning or elaborated on the type of equity their article addressed. The authors may just use the term 'equity' as a buzzword without deeper understanding the historical context or meaning behind the word. Many articles briefly mention the term equity without further explanation. Most articles did not elaborate on the definition of equity, nor did they mention what type of equity was of consideration. With the amount of historical academic articles and research on equity in city planning, it is unjustifiable not to consider how planning green infrastructure could influence communities at risk.

Environmental equity is acknowledged as it refers to the distribution of environmental benefits but also environmental threats and hazards (Ortiz-Moya, 2018; Zhu et al., 2019). Yet, there are no considerations of historic environmental inequities, such as racial segregation and zoning for indigenous or minority communities so they purposely suffered from environmental hazards or lacked ecosystem service benefits. The articles do not create the essential linkage between ecosystem service justice and spatial equity, as location certain populations may live in areas of the cities that are already at higher risk of vulnerability. As well, these articles do not address any of the intersectionality that is crucial to understand the complexities of individual lives and lived experiences. These acknowledgements are necessary for inclusive city planning so that all residents receive the benefits they need from green infrastructure investments, and without these inclusions, decision-makers can inadvertently ignore their needs or the potential impacts of planned developments.

Certain articles do integrate both equity and green infrastructure within their research and planning. This demonstrates that other articles have the capacity to reflect on equity planning matters. Much of the literature demonstrates that green infrastructure implementation is inequitable, as certain neighbourhoods benefit from thoughtful investment, whereas marginalized communities are lacking access to parks, street trees, green spaces, and their subsequent benefits that are needed greatly (Meerow & Newell, 2016; Baró et al., 2019; Zhu et al., 2019; Baró et al., 2021). This puts communities at greater risk of natural hazards, such as heatwaves, floods, and other climate impacts, reducing the overall sustainability of a city, and further exacerbating socioeconomic inequality (Meerow & Newell, 2016).

Green gentrification is studied and acknowledged in several articles, displaying that green infrastructure implementation could cause further harm to vulnerable communities without respect to epistemic justice and community participation (Fricker, 2003). Recent literature states that those most at risk will continue to remain at risk of displacement or gentrification without the application of necessary equity lenses (Anguelovski et al., 2018b; Rigolon & Németh, 2018). However, there are not any mentions of spatial equity when discussing green gentrification, nor the historical context of environmental racism when planning. History needs an analysis to address present-day injustices.

However, the articles that do describe and define equity only consider social justice, such as considerations of distribution, procedure, and recognition equities (Newell et al., 2013; Benton-Short et al., 2017; Anguelovski et al., 2018b; Ortiz-Moya, 2018; Rigolon & Németh, 2018; Mason et al., 2019; Zhu et al., 2019; Baró et al., 2021). Only one article discusses equity that is more intricate, such as

considerations of intergenerational and intra-generational equity, which is an important issue causing social movements, such as Black Lives Matter and Youth Strike for Climate. More considerations for intra-generational equity are required in planning literature, as green infrastructure needs to benefit current residents equitably (Larson et al., 2013). Considerations for intergenerational equity are also essential so that plans for cities are sustainable for future generations, such as by caring for resources and ensuring that there are quality resources for children and subsequent generations (Larson et al., 2013).

Future research about green infrastructure implementation in cities must address these social justice issues so that the urban greenery is neither exclusionary nor exploitative. Green infrastructure must not benefit only the wealthier class or exclude certain residents from green space access because that will not create a holistically sustainable city. All residents, regardless of mobility, disability, age, sex, gender, ethnicity, or class deserve the social and health benefits from green infrastructure in their cities. Otherwise, injustices and inequities will continue to grow within urban systems, especially during extreme crises like extreme climate events or pandemics, such as the current Covid-19 emergency, where those who are most at risk will suffer more from any impacts. Future research on city planning needs to improve by learning from the past and evolving understanding and integration of green infrastructure and equity to build a better future. Thus, city plans must utilize contemporary and future literature to develop plans and policies that will adequately integrate intersectional social equity with green infrastructure implementation so that it benefits those most in need.

2.13 Conclusion

For adequate adoption into city planning frameworks, academics must ensure that their research adheres to procedural, distributional, and recognitional equity for urban greening studies. It is essential that green infrastructure research does not continue to exacerbate socioeconomic inequity in cities or ignore the needs of historically marginalized communities. However, green infrastructure implementation requires more than just the trifecta of social equity, but rather an understanding of the complexity and intersectionality of the lived experiences of all residents within a community (Anguelovski et al., 2020). Green infrastructure implementation must have a community participation so that residents can speak about their concerns, their experiences, and their issues with any planned development. Planners and other government officials need to listen to understand the different power dynamics that affect various communities. Decision-makers and planners need to have engagement sessions to address their needs and concerns of vulnerable populations and listen to their suggestions

because they may unconsciously ignore a group of people that planning decisions ultimately will affect. This understanding and recognition will help with developing green infrastructure with considerations for accessibility, feminism, and other marginalized identities to improve quality of life across all neighbourhoods in a city.

It is important to understand the historical context of equity within urban planning because it outlines why certain communities may distrust municipal governments and planning officials. There is a mistrust due to environmental racism, social injustices, and systemic racism in cities. For social cohesion and public involvement, governments and officials must demonstrate their understanding of their histories and provide frameworks for social advancement and support. It is important not to be dismissive of the lived experiences of communities and to welcome stories so that implementation of green infrastructure will not repeat historic injustices or contribute to current inequities within cities, such as environmental racism. In addition, there needs to be an indigenous lens applied to green infrastructure development as well. Most of these articles do not consider indigenous perspectives or acknowledge the longstanding systematic injustice of colonization and oppression on minority communities. If the article contains both equity and green infrastructure in its keywords, then it must do the due diligence and understand the meaning behind the word equity, rather than using it as a buzzword. I recommend that city plans explain and demonstrate their understanding of historical injustices within in their community. By showing their willingness to learn and support healing through epistemic justice, then planner and other officials can develop green infrastructure with all communities in mind. There will then be more inclusive advocacy planning and community participation.

Bridge

Equity and its connection with green infrastructure is a contemporary topic in urban planning literature, as shown by Chapter 2, which is Manuscript 1. The integration of equity and green infrastructure are essential to ensuring planning policies are inclusive, diverse, and socially responsible. As cities grow, demographics change and all populations and their intersectionality need to be considered by decision-makers when developing and implementing green infrastructure (Anguelovski et al., 2020). For cities to be holistic and welcoming, no communities should be excluded or ignored by government officials and planners. Multiple types of equity need to be considered when using an equity lens in the planning practice (Anguelovski et al., 2020).

As well, cities are undergoing rapid change due to climate change as well. Climate change impacts disproportionately affect underprivileged groups as they are most vulnerable to extreme weather events because of a lack of support and resources (Langemeyer & Connolly, 2020). Equity then needs to be considered so vulnerable communities can receive the resources as needed to improve their resilience and quality of life. The city needs to support and understand all communities in order for there to be transformative change that addresses systematic issues (Anguelovski et al., 2020).

As a result, it is crucial to analyze whether equity and green infrastructure research conducted by academics has been applied to present planning practice. In Manuscript 2, I will take the research conducted from Manuscript 1, and use those results to develop a framework to assess the integration of equity and green infrastructure in comprehensive city plans and resilience strategies of Calgary, Montréal, Toronto, and Vancouver. The comprehensive city plans were developed by municipal planners, and the resilience strategies were developed thanks to grants awarded by the Rockefeller Foundation.

The framework developed in Manuscript 2 is emulating the framework created by Fitzgibbons & Mitchell, 2019. Their framework also assessed strategies of cities that participated in the 100RC program. Fitzgibbons & Mitchell's framework assessed equity and social justice in their resilience strategies, whereas mine will assess equity and green infrastructure.

My framework consists of 25 questions based on the systematic literature review conducted in Paper 1. By assessing the plans in Manuscript 2 and giving them a total score out of 25, I can then determine

whether the integration of equity and green infrastructure was woven into the cities' planning practice. I will then be able to provide recommendations of how to better incorporate equity considerations into green infrastructure planning for those cities assessed. As well, I provide examples of other utilizations for my framework so that equity is not just an afterthought in urban planning practice.

Chapter 3 - Assessing the Integration of Green Infrastructure and Equity of Comprehensive Municipal Plans and Resilience Strategies in Four Canadian Cities

3.1 Overview

Green infrastructure is recognized as a beneficial solution to help support the mitigation and adaptation of climate change and its consequences. Equity considerations in comprehensive community plans are necessary when implementing green infrastructure projects to ensure that green infrastructure benefits a city at large, including its disenfranchised communities. Four cities in Canada received grants from the Rockefeller Institute to write Resilience Strategies as part of the “100 Resilient Cities” program (100RC) to support sustainable development for the future. These strategies have common themes such as climate change, flooding, and the urban heat island effect. I developed a framework to evaluate green infrastructure and equity integration in municipal plans and the aforementioned resilience strategies. I assessed literature regarding green infrastructure and equity to create this framework. Green infrastructure that benefits higher-income populations or is used solely for urban renewal can result in socio-spatial inequalities and segregation.

Multiple types of equities and intersectionality need to be considered as cities are growing more diverse, and city planners need to be conscious of the lived experiences of a variety of individuals. If equity is not analyzed explicitly, the plans may unconsciously ignore disenfranchised communities. An equity lens must be applied to create healthy and sustainable cities with green infrastructure. For example, an equitable framework evaluation helps to ensure that all residents benefit from green infrastructure. Without equity considerations, marginalized socioeconomic groups may remain vulnerable to climate change impacts and other vulnerabilities.

3.2 Introduction

Approximately 54% of the world’s population currently lives in cities; by 2050, that percentage will grow to nearly 66% (Leeson et al., 2018). The global human population is increasing, surpassing 7 billion in 2010 and estimated to rise to approximately 10 billion by 2050 (Lutz & KC, 2010). Demographics in Canada will shift so that the number of senior citizens will increase as the baby-boomer demographic advances in age. In contrast, the number of younger Canadians will remain lower due to decreasing

fertility rates (Barbieri & Ouellette, 2012). There is also more immigration and growing diversity in Canadian cities (Barbieri & Ouellette, 2012). Cities are changing at an unprecedented rate, and city officials need to be mindful of demographic changes and population growth. These are considerations for planners and politicians when developing city plans and proposing future actions.

In addition to demographic changes, there will likely be an increase of at least 1.5°C in worldwide temperatures given the planet's current greenhouse gas emissions (IPCC, 2018). These greenhouse gas emissions will result in urban heat islands, heatwaves, varied precipitation, extreme flooding events, and consequent social inequality and displacement due to climatic hazards and disasters (IPCC, 2018). In conjunction with current social issues afflicting cities, it is essential to plan for climate change to mitigate climatic events and prevent compounding societal issues. Numerous municipal governments worldwide have created climate change adaptation strategies or have incorporated climate change action strategies in existing policies to mitigate adverse effects or adapt to shifting conditions (Henestra, 2012; Lipper & Nelson, 2019).

The Rockefeller Foundation gave cities grants to publish resilience strategies to support resilience and adaptation to future conditions. The 100 Resilient Cities (100RC) program aimed to support resilience, which in their view included shocks and chronic stresses of a city, such as high unemployment and endemic violence. The 100RC program aimed to help cities respond to adverse events and better deliver essential services to all populations (Climate Initiatives Platform, 2020).

The Rockefeller Foundation described urban resilience as “The capacity of individuals, communities, institutions, businesses, and systems within a city to survive, adapt, and grow no matter what kinds of chronic stresses and acute shocks they experience” (Climate Initiatives Platform, 2020). However, *Resilience* can also be defined as the ability of an urban system “to maintain or rapidly return to desired functions in the face of a disturbance, to adapt to change, and to quickly transform systems that limit future adaptive capacity” (Meerow et al., 2016). Four Canadian Cities, Calgary, Montréal, Toronto, and Vancouver, participated in the Resilience Cities program until the program was cancelled in 2019 (Lipper & Nelson, 2019). In that time, the cities received grants, published their resilience strategies, and provided an opportunity to study lessons learned and plans developed in an international setting (Lipper & Nelson, 2019).

The four cities' resilience and climate change strategies address the impacts of climate change with mitigation and adaptation initiatives to benefit the cities. Cities want to prevent and protect residents

against climatic disasters such as flooding, urban heat island, and other extreme weather events. Green infrastructure supports urban resilience by providing ecological functions and services to cities and residents. However, equitable implementation of green infrastructure is necessary so that all populations in a city benefit from green infrastructure benefits. All four Canadian cities have populations of over one million, and their populations continue to grow and diversify. Therefore, future development must be sustainable and resilient to climate change.

The resilience strategies must consider green infrastructure and equity in their plans. In addition, I have also evaluated municipal climate change adaptation plans as those plans also have climate action goals and incorporate green infrastructure implementation. The framework used in this paper was developed for this assessment through an intensive literature review of contemporary academic journal articles on the topics of green infrastructure and equity, and their overlap. My goal is to assess these plans and have this framework as a tool to assess other comprehensive community plans (e.g., Official Plans) and future iterations of these plans to ensure adequate consideration for the integration of equity within green infrastructure development and implementation. Because green infrastructure is a known solution to several environmental issues, green infrastructure integration also requires an equity lens for implementation because equitable green infrastructure must benefit all populations for it to be resilient and to avoid further segregation and inequality of populations (Fainstein, 2015; Lorinc & Pitter, 2016). I will end this paper with recommendations for the urban planning practice so that future iterations of plans and strategies can utilize a more in-depth equity lens for their green infrastructure development and implementation policies.

3.3 Literature Review

Climate change is the third-largest concern among member cities of the 100RC program (Climate Initiatives Platform, 2020). Anthropogenic activities cause climate change by emitting an excess of greenhouse gases into the atmosphere (Carmichael et al., 2019; De Lange, 2020; Dimitriou & Field, 2020). In addition, climate change poses many challenges to urban environments, including amplified uncertainty regarding weather patterns, rising temperatures and sea levels, and an increase in extreme weather events (Williams et al., 2010; Larson et al., 2013; William et al., 2017; Baró et al., 2019; Houston & Zuñiga, 2019; Mason et al., 2019; Zhu et al., 2019; Lanza & Durand, 2021). Thus, it is essential for climate change actions to have green infrastructure and equity considerations; otherwise, specific populations, unconsciously or consciously, will be excluded from municipal climate adaptation and mitigation benefits.

3.3.1 Climate Change, Green Infrastructure, and Equity

Green infrastructure is referred to in the four Canadian cities' resilience strategies and the climate change adaptation strategies. Green infrastructure includes greenspace such as parks or tree canopies or built infrastructure such as green roofs to incorporate natural ecosystem functions that benefits residents and those residents may value in urban spaces (Coutts & Hahn, 2015; Bush & Doyon, 2019). Ecosystems can provide services, such as carbon sequestration or water filtration from forests and tree canopies in an urban environment, which benefit humans and support a healthy quality of life (Costanza et al., 1997; Bolund & Hunhammar, 1999). Green infrastructure can be applied at various levels in a city, such as neighbourhood-level or city-wide.

There are numerous benefits to implementing green infrastructure projects in a city, and green infrastructure can be used to develop a sustainable future. Green infrastructure in urban environments increases their resilience against climate change, and its implementation could inspire additional nature-based solutions (Bush & Doyon, 2019). For example, utilizing urban forests and wetland ecosystems as green infrastructure can provide flood protection and mitigation (Bolund and Hunhammar, 1999). Green infrastructure applications can be used in conjunction with traditional grey infrastructure to manage stormwater runoff, and can help mitigate or prevent flooding due to varied precipitation and extreme weather events (Meerow & Newell, 2016; Ramirez-Rubio et al., 2019; de Lange, 2020; Majekodunmi et al., 2020). Local communities can implement green infrastructure strategies themselves. Community gardens are a green infrastructure application used to increase the resilience of a local food system and the social resilience of a community by supplementing resources because climate change can stress global food production (Kameshwari & Molnar, 2016; Sañudo-Fontaneda & Robina-Ramírez, 2019).

Green infrastructure must be equitable for all city residents. Green infrastructure that only benefits higher-income populations, or is used solely for urban renewal, does not benefit the entire city and is not equitable (Haase et al., 2017). Instead, inequitable green infrastructure implementation further increases socio-spatial inequalities and segregation (Haase et al., 2017). Less affluent and homeless populations could be at risk of displacement during infill processes or green infrastructure integration. The addition of urban green spaces could also raise housing prices (Haase et al., 2017; Rigolon & Németh, 2018; Baró et al., 2019; Carmichael et al., 2019; Hall & Knuth, 2019; Houston & Zuñiga, 2019). The effects of careless green infrastructure implementation could result in green gentrification and disproportionately harm vulnerable groups by inadvertently forcing lower-income residents out of their communities (Anguelovski et al., 2018b; Rigolon & Németh, 2018; Baró et al., 2019; Carmichael et al.,

2019; Hall & Knuth, 2019; Houston & Zuñiga, 2019). Therefore, it is necessary to integrate green infrastructure and equity when developing city plans so that green infrastructure projects do not worsen inequity and inequality.

When implementing or developing green infrastructure projects, it is essential to consider social equity, which consists of distributional, procedural, and recognitional equity. Distributional equity refers to how resources, such as ecosystem services, are distributed to disadvantaged populations versus wealthier groups (Benton-Short et al., 2017; Anguelovski et al., 2018; Rigolon & Németh, 2018). Procedural equity means ensuring that there are inclusive decision-making processes and other proceedings so that all citizens have an invitation to voice their concerns and ideas towards city-building (Newell et al., 2013; Benton-Short et al., 2017; Anguelovski et al., 2018; Mason et al., 2019; Baró et al., 2021). Recognitional equity refers to acknowledging the numerous identities that contribute to a community and respecting their different beliefs, needs, thoughts, and wants (Benton- Short et al., 2017; Anguelovski et al., 2018; Ortiz-Moya, 2018; Zhu et al., 2019).

There is more than just social equity needed to ensure that a city is just. When applying an equity lens to a city plan, there are other concerns and considerations, such as intergenerational and intragenerational equity (Langemeyer & Connolly, 2020). Intergenerational equity raises the concern of equitable access to a sufficient quantity and quality of resources for future generations despite current and past generations' excessive consumption (Larson et al., 2013; Langemeyer & Connolly, 2020). Thus, intergenerational equity requires diverse representation in decision-making for future generations so that cities can be sustainable and provide a healthy quality of life with essential resources such as clean water and healthy forests (Larson et al., 2013). Intragenerational equity ensures that people living in the same generation have safe and unprejudiced access to necessary resources (Larson et al., 2013). Currently, intragenerational inequity is abundant worldwide due to greed, politics, and racism, which prevents people from accessing basic human needs such as food, shelter, and water.

Another equity consideration is the intersectionality of populations within a city (Anguelovski et al., 2020). Communities are complex, and people have various lived experiences, so decision-makers such as planners and politicians need to create a safe environment for community members to speak about their concerns, experiences, and ideas for the city. Having city planners recognize, respect, and understand multiple identities will improve accessibility for spatial equity, quality of life, gender equity, and create a welcoming home for all individuals (Benton-Short et al., 2017; Luz et al., 2019; Zhu et al., 2019; Anguelovski et al., 2020; Wolff et al., 2020). In urban planning, the cognizant assimilation of all

types of equity and green infrastructure is necessary to develop sustainable cities and guarantee that all populations benefit from ecosystem services provided by implementing green infrastructure projects (Anguelovski et al., 2020).

Climate change can affect historically disenfranchised communities in greater magnitudes than higher-income communities due to systematic issues caused by decreased investment in lower-income neighbourhoods (Dobbs et al., 2018; Baró et al., 2019; Zuniga-Teran et al., 2020). When implementing green infrastructure for climate change mitigation and adaptation, applying an equity lens is critical so that neighbourhoods most in need of green infrastructure benefits receive them equitably (Baró et al., 2019; Xiao et al., 2019; Scott, 2020; Zuniga-Teran et al., 2020). Otherwise, climate change and extreme weather events will continue to negatively impact disenfranchised and marginalized communities (Williams et al., 2010; Scott, 2020; Zuniga-Teran et al., 2020). Without conscious integration of green infrastructure and equity, inequitable green infrastructure implementation may result in extreme weather events, such as flooding and extreme heat, increasing socioeconomic inequality in cities because of exacerbated climate change affects (Williams et al., 2010; Scott, 2020).

3.3.2 Resilience, Green Infrastructure, and Equity

Altogether, the integration of green infrastructure will support resilience. Ecosystem resilience is one type of resiliency that cities strive for to maintain ecosystem services and support sustainable development (Fang et al., 2021). Green infrastructure supports ecosystem resilience through strategic planning of the bionetworks of various ecosystems in urban areas that contribute to biodiversity and human health (Ferguson et al., 2018; Wang et al., 2019). In addition, climate resiliency is vital in cities to withstand the impacts of climate change.

Through the implementation of beneficial green infrastructure in cities, ecosystem services can provide flood mitigation in urban areas, thus increasing climate resilience to surface flooding from precipitation events (Meerow & Newell, 2016; Sanchez & Reames, 2019; De Lange, 2020; Majekodunmi et al., 2020; Venter et al., 2020; Lanza & Durand, 2021). In addition, green infrastructure can help support disaster resiliency and recovery by enhancing the geographical surroundings through its ecosystem services, such as community gardening to provide a local food system and forestry programs to mitigate shocks (McClintock et al., 2016; Meerow & Newell, 2016; Hall & Knuth, 2019).

Climate resiliency and ecosystem resilience need to be included in urban planning to promote urban resiliency throughout the city. Urban resiliency can proliferate with the implementation and

development of green infrastructure (Meerow & Newell, 2016). However, for resilience to reach all members of a city, green infrastructure implementation and development needs to include an equity lens. Otherwise, disenfranchised socioeconomic groups will remain vulnerable to negative climate change influences and extreme weather events (Anguelovski et al., 2018; Dobbs et al., 2018; Zhu et al., 2019; Majekodunmi et al., 2020; Zuniga-Teran et al., 2020). An equitable approach would include ensuring that urban planners and government officials highlight green infrastructure investment in vulnerable communities with a social equity lens application (Anguelovski et al., 2018). Another approach would include providing and disseminating educational materials and outreach so residents can make informed choices that improve community resiliency and help voice their concerns and ideas in public town hall meetings about green infrastructure projects (Anguelovski et al., 2018; Baró et al., 2019; Hall & Knuth, 2019).

3.4 Background

The plans evaluated in this paper are the four Resilience Strategies written as part of the 100RC, “100 Resilient Cities” program. The program was developed with the support of the City Resilience Framework that was used to provide a resilience lens to identify areas in a city that needed additional actions and programs to improve their urban resilience with the support of a Chief Resilience Officer (Resilient Cities Network, 2020). The program built networks and partnerships and received funding from global stakeholders to support collaborative action on urban shocks and stresses (Rockefeller Foundation, 2020). The 100RC program aims to support global research and provide a forum for coordinated learning to foster the integration of multiple projects and reduced governmental silos (Rockefeller Foundation, 2020). The 100RC program concluded that resilience strategies could support creating a resilience lens that helps implement higher-impact projects (Resilient Cities Network, 2020).

Cities were chosen because of problems associated with rapid urbanization and globalization. These problems can include essential health and well-being or environmental needs, such as climate adaptation and mitigation. Each city is unique and developed their own resilience strategy based on its needs and desires for improvement (Rockefeller Foundation, 2020). The program is international, and cities around the world participated in the program. Each city published their unique resilience strategy based on the challenges that the city faces. However, the program aims to create a global collaborative social change by sharing findings and research with international funding partners to support initiatives (Rockefeller Foundation, 2020).

The Rockefeller Foundation announced its dissolution in late 2019. However, the Resilient Cities Network continues its legacy by maintaining and expanding the stakeholders and partnerships it created so that cities continue to have a network of support and funding for their resilience strategies (Resilient Cities Network, 2020). The Resilient Cities Network aims to support cities to develop resilient futures and provide benefits to vulnerable communities (Resilient Cities Network, 2020). The 100RC, although has discontinued, can continue to provide valuable insight through my green infrastructure and equity framework by analyzing its successes, failures, strengths, and weaknesses. This opportunity for learning can be used to better develop future plans and strategies.

The only four Canadian cities that participated in the program and received grants from the Rockefeller Foundation are Calgary, Montréal, Toronto, and Vancouver. The Resilience Strategy for Montréal was published and approved by the city council in 2018. Calgary, Toronto, and Vancouver had their plans published and approved by their respective councils in 2019. The other four plans assessed with the same framework are the municipal climate change strategies for the respective cities. These plans are created using governmental funds and are created with the support and work of public servants. These plans also have common themes to mitigate and adapt to the consequences of climate change, such as extreme weather events like flooding and heatwaves.

These four Canadian also have written their respective municipal climate change adaptation strategies, or comprehensive community plans with climate goals. Toronto published *TransformTO* in July 2017, with its next iteration set to be published as the *TransformTO* Implementation Plan 2021-2023 (City of Toronto, 2021). The *Vancouver Climate Change Adaptation Plan* was published in 2018 and has goals that extend to 2050 (City of Vancouver, 2020). The Montréal Climate Adaptation Strategy was published in 2015 and had an updated 2017 report assessed for this paper. The City of Montréal has recently published a newer iteration that will extend from 2020-2030 (Ville de Montréal, 2020). Finally, Calgary has adopted its resilience strategy as its climate adaptation strategy (City of Calgary, 2021). *ImagineCalgary* is the City's long-range urban sustainability plan that was published in 2006, and has been used in place for the framework evaluation to assess because it contains long-range climate actions and goals. All the plans and strategies names and date of publication can be found in Table 1 under the Limitations and Scopes section.

3.4.1 Flooding

All four Canadian cities have stated within their plans and strategies that flooding is an increasing threat to infrastructure and residents in the City. Recently, there are more flood events due to decaying or

outdated infrastructure and changing precipitation and weather patterns caused by climate change (Poff et al., 1997; Milly et al., 2002; Nirupama et al., 2014). Climate change can cause earlier spring thaws to alter river peak flows and intensity or to coincide with warmer winters and snowmelt (Naess, 2004). It is essential to emphasize that flooding can exacerbate inequity in a city. Populations who live in basements, people without shelters, or those dependent on public transportation can be affected greatly by flood events (O'Hare & White, 2018).

In addition, certain populations are more exposed to risk due to place inequity or social equity because of their lack of resources (Burningham et al., 2007; O'Hare & White, 2018). Exposure and vulnerability to flooding risks in an urban environment can be dependent on an individual's and a community's wealth and education, disability status, health status, age, gender, class, and other social or cultural characteristics (Owrangi et al., 2014; Anguelovski et al., 2016).

Calgary, Montréal, and Toronto are all prone to riverine flooding because of the cities' proximity to large rivers. In Vancouver, sea-level rise from melting ice caps can put coastal environments at increased risk of coastal flooding and storm surges. Coastal flooding can also further exacerbate pre-existing damage from erosion and the effects of saltwater (Vitousek et al., 2017; Hallett et al., 2018). Urbanization can reduce the permeable surfaces of cities, such as forested areas that can store water through interception in the foliage and percolation in the soil, as well as in floodplains and, consequently, can reduce their ability to naturally mitigate flood events (Wheater & Evans, 2009).

Green infrastructure can provide ecosystem services for all residents, including flood protection and mitigation (Bolund and Hunhammar, 1999). However, when integrating green infrastructure, it is essential to include equity-seeking groups to understand the effect on vulnerable populations (Haase et al., 2017). Green infrastructure that benefits higher-income populations or solely is used for urban renewal does not benefit the entire City and is not equitable, and thus can further increase socio-spatial inequalities and segregation (Haase et al., 2017). Less affluent and homeless populations could be at risk of displacement during the infill process or green infrastructure integration. The addition of urban green spaces could potentially raise housing prices (Haase et al., 2017).

3.4.2 Heat Island Effect

Increasing temperatures due to climate change are a threat in Calgary, Montréal, Toronto, and Vancouver as well. Urban areas also are prone to heat island effect because of decreasing albedo due to darker coloured manufactured infrastructure such as asphalt and concrete (Yang et al., 2016).

The transpiration of vegetation and the lower heat index of soil can reduce temperatures in rural areas compared to urban cities. Increasing tree canopies, greenspaces, and integrating additional green infrastructure can reduce the urban heat island effect (Gallo et al., 1993; Hawken, 2018). Green infrastructure such as green roofs can also reduce the urban heat island effect by creating a higher albedo. Plants also absorb heat and give off moisture (Oberndorfer et al., 2007; Hawken, 2018).

Lowering temperatures in the city can benefit citizens and ecosystems that are not adapted to extreme heat or prolonged extreme heat. Heatwaves can cause death in populations that do not have air conditioning or other methods to escape the heat. Minimum nightly temperatures are also an essential factor in heatwave severity. If the temperatures do not decrease, then no relief is given to residents or animals in the City at night (Smoyer-Tomic et al., 2003). Heatwaves and extreme heat can also cause death in vulnerable populations, such as the elderly or ill. Heatwaves in Canada are likely increase further in severity, frequency, and longevity due to climate change (Smoyer-Tomic et al., 2003; IPCC, 2018).

3.5 Methods

In my first paper, *The Implementation of Equity & Justice in the Greening of Urban Infrastructures: A Review*, I completed a systematic literature review of contemporary academic journal articles from 2000-2021 using the key terms “green infrastructure” and “equit*” in JSTOR, SCOPUS, and TANDFONLINE. I then conducted a qualitative literature review focusing on the historical context of equity and modern literature on green infrastructure. I used this literature review from my first paper to develop a framework of 25 questions to assess municipal climate change action plans and resilience strategies as found in Appendix B. I will go through each of the eight plans and strategies to answer the questions in the framework, giving a score of 0, 0.5, or 1. A score of 0 means that the plan or strategy did not meet the criteria of the question and lacked the equity and green infrastructure asked. A score of 0.5 means that the plan did not fully integrate green infrastructure and equity in the context of the question asked but has completed some steps to show consideration for both. A score of 1 means that the plan meets the criteria of the question asked. The questions are all weighted the same, resulting in a total score out of 25.

This framework is emulating Fitzgibbons & Mitchell (2019), as those researchers have previously created a framework to evaluate equity and social justice in resilience strategies. Fitzgibbons & Mitchell (2019) also developed questions and gave a score out of 1 to assess the cities’ focus on social equity in the narratives of the resilience strategies.

The questions for my framework were developed through an extensive review of the literature found through the systematic review. The literature outlined the importance of integrating equity with green infrastructure implementation so that equity-seeking groups can participate in decision-making so that planners and other officials will understand the effect of proposed developments on vulnerable populations (Haase et al., 2017; Anguelovski et al., 2018; Baró et al., 2019; Meerow et al., 2019). Including equity-seeking groups in the decision-making process will expose missing considerations in a plan for their neighbourhoods. In order to include all populations, barriers such as language and accessibility need to be addressed as well (Newell et al., 2013; Benton-Short et al., 2017; Walsh et al., 2017; Anguelovski et al., 2018; Rigolon & Németh, 2018; Mason et al., 2019; Jayakaran et al., 2020). Some of the questions in the framework fall under multiple categories, such as questions that refer to both recognitional equity and intersectionality.

The framework also asks questions based on the terms “acts of commission” and “acts of omission” which were terms devised by Anguelovski et al. (2016). These terms refer to inequitable acts enacted by cities through their climate change adaptation actions or strategies. An act of commission is one that commits an action that directly negatively affects or displaces a disempowered community. An example would be one that tears down homes of marginalized people to create a park. Whereas, an act of omission, on the other hand, is an action which enriches the quality of life for higher-income or privileged members of a community at the expense of a disempowered community. An example of an act of omission would be to plant street trees in an already affluent neighbourhood, but not in a lower-income neighbourhood.

Furthermore, it is essential to address the root causes of vulnerability and understand why specific populations are marginalized in their cities (Anguelovski et al., 2016; Reece, 2018; Langemeyer & Connolly, 2020). It is necessary to recognize the history of vulnerabilities and inequities certain communities face to address and change them. The literature explored helped create questions related to distributional and recognitional equity about green infrastructure implementation. To ensure equity is integrated into discussions and actions regarding green infrastructure, it is essential to ask questions such as, “Are benefits of green infrastructure goals/actions intentionally directed at populations of interests?” Questions about the integration of distributional and recognitional equity are questions 1, 3, 4, 8, 9, 12, 15, 16, 18, and 25.

Questions about epistemic justice are also essential to include in the framework, as literature states politicians or planners may unconsciously ignore the needs of vulnerable residents and thus strengthen

injustices because they assume their best interests without consultation (Fricker, 2003; Anguelovski et al., 2020; Langemeyer & Connolly, 2020). Such a framework supports the need for having equity-seeking groups and other disenfranchised populations included in the decision-making process to include and acknowledge their lived experiences for community planning as a form of procedural equity. Including epistemic justice considerations and encouraging ongoing participation from all community members can also help make the plan better by addressing any negative impacts from any planned or implemented actions or goals (Fricker, 2003; Anguelovski et al., 2020). Thus, it is crucial that frameworks addressing equity ask questions like, “Is the root cause vulnerability of certain populations explored or treated?” Questions about lived experiences and procedural equity are questions 2, 5, 10, 11, 13, and 17.

Other equity considerations are needed in urban planning, as cities are increasingly diversifying (Barbieri & Ouellette, 2012; Anguelovski et al., 2020). Intergenerational equity is vital as planning for the future needs to include the voices of younger generations who will be impacted by the results and actions of these plans (Langemeyer & Connolly, 2020). Intergenerational equity is significant to climate change actions, as the future will likely have unprecedented weather events due to climate change. Thus, it will greatly affect the younger generation’s access to resources and quality of life as they age. Accessibility is a factor as well, as specific populations may not have access to vehicles or may not be able to commute to parks and greenspaces (Zhu et al., 2019). It is also important to note that residents in a city can belong to multiple groups and have numerous identities that intersect with one another (Anguelovski et al., 2020; Langemeyer & Connolly, 2020). More than one of these identities can also be a part of an equity-seeking group, so this as well needs to be recognized (Anguelovski et al., 2020), so it is critical to ask questions like “Are multiple types of equity and potential intersection between them addressed in the strategy?” Questions about the intersectionality and different equity types are 6, 24, and 25.

The plans cannot assume that all readers know what green infrastructure and it must be defined. Green infrastructure needs to have a definition so that all readers, including other officials and the public, know what is meant by the term in reference to the plan. The public also may not be aware of benefits and services that green infrastructure provides for cities, so that needs to be explained within the plan (Benton-Short et al., 2017; Anguelovski et al., 2018; Ferguson et al., 2018; Baró et al., 2019; Hall & Knuth, 2019; Luz et al., 2019; Wolff et al., 2020). The plans need to provide these definitions and information to readers for transparency and so that the public can voice their concerns and opinions about any proposed actions or developments across the city or even in smaller-scale projects, such as

neighbourhoods (Anguelovski et al., 2018; Anguelovski et al., 2020). Equity itself needs to be defined so that the plans have a working definition and can have conscious integration of equity when they refer to it and other potential equitable outcomes (Anguelovski et al., 2020). For example, question 7 simply asks, “Is equity defined in the strategy?” Questions regarding the background knowledge and transparency of green infrastructure developments and the definition of equity are 7, 17, 18, 19, 20, 21, 22, and 23.

Indigenous knowledge must also be considered in city plans because the Canadian cities are built on the ancestral and traditional territories of respective indigenous groups. Respectful dialogue and relationship building is required so that government officials, planners, and First Nations groups can work together to develop actions and goals upon which both parties can agree. Plans need to acknowledge the claims and knowledge of the indigenous populations on their traditional land to support Canada’s truth and reconciliation actions. Historically, planning in Canada was a colonial process that resulted in systematic discrimination and disregarded indigenous needs and voices (Lane 2006; Prusak et al., 2016). Canada needs to have a transactive and participatory planning practice to build trust and, respect First Nations communities that advocate for their own planning practices and self-determination on their own lands (Lane, 2006; Prusak et al., 2016). Thus, question 24, “Is indigenous knowledge addressed and considered for green infrastructure implementation within the strategy?” refers to indigenous knowledge and asks whether First Nations considerations and traditional knowledge are included in the plans.

3.6 Limitations and Scope

There are several limitations to this paper. I am only assessing climate change adaptation plans and resilience strategies in this paper. The Resilience Strategies were chosen to be assessed for green infrastructure and equity for this framework to evaluate if green infrastructure projects considered equity. That is one way to ensure the city will be resilient as a whole, including against climate change. These four Canadian cities were chosen because they are the only four Canadian cities with resilience strategies. Assessing the plans and strategies of only Calgary, Montréal, Toronto, and Vancouver does not provide an adequately representative sample of all climate change adaptation plans within Canada or of the country’s green infrastructure and equity policies.

Climate Change Adaptation plans for municipalities were chosen as they attempt to mitigate and adapt to climate change. Thus, they would be an excellent companion to use to evaluate with the framework created. As climate change strategies have common themes found in the resilience strategies, they help

assess green infrastructure implementation and equity. Their strategies also need to support all populations and the city as a whole. Thus, they provide a comprehensive municipal plan to demonstrate the usefulness of the framework developed and how the framework could be used for other municipal plans.

<u>City</u>	<u>Title</u>	<u>Date of Publication</u>
Toronto	TransformTO	2017
	Toronto Resilience Strategy	2019
Vancouver	Vancouver Climate Change Adaptation Plan	2018
	Vancouver Resilience Strategy	2019
Calgary	imagineCalgary	2006
	Calgary Resilience Strategy	2019
Montréal	Montréal Climate Change Adaptation Plan	2015
	Montréal Resilience Strategy	2018

Table 1. Table displaying the title and date of publication of all eight plans and strategies assessed and evaluated using the developed green infrastructure and equity framework.

There may exist other plans and strategies written by municipalities that include equity, diversity, and inclusion in their policies, or other plans that include green infrastructure strategies, but due to time constraints and because climate change is the focus for green infrastructure and equity integration within implementation in this paper, only two types of official plans will be assessed. My goal is to create a framework that can be used to assess other comprehensive community plans that use green infrastructure development and implementation. Future amendments to these plans will be not be assessed, as I am focusing on the comprehensive city plan as published.

Additionally, the City of Calgary has adopted the resilience strategy as part of its climate change action strategy. As a result, there is no specific climate change adaptation plan to assess. In lieu, I will assess ‘*imagineCalgary*’, their 100-year action plan for long-range urban sustainability with climate and equity considerations. Montréal has also since published a new climate change adaptation plan in late 2020 as their 2020-2030 iteration, but this paper assessed their previous climate change adaptation plan, their 2015-2020 iteration. This paper focuses on the 2015-2020 iteration because the new plan was published after the research for this paper started.

3.7 Results

I conducted a plan assessment and evaluation of the eight plans and strategies of the four Canadian cities using the framework I developed. For Calgary, I assessed *imagineCalgary*, their 100-year action plan. For Montréal and Vancouver, I judged their Climate Change Adaptation Strategies. For Toronto, I evaluated *TransformTO*, the City's climate action strategy.

3.7.1 Framework Evaluation

The framework used to evaluate the municipal plans and resilience strategies is found in Appendix B. By using the framework, which consists of 25 questions, the plans and resilience strategies are given a score of either 0, 0.5, or 1. 0 indicates that the plan or strategy does not meet the criteria asked of the question. 0.5 means the plan or strategy does indicate it is making progress towards the criteria but has not reached it yet, or has plans to address the criteria soon. A score of 1 shows that the plan or strategy does meet the criteria asked by the framework question. Appendix B shows the score earned by each plan and strategy per question in the framework. Figure 1 displays the final scores accumulated by each plan and strategy. The *Calgary Resilience Strategy* earned the highest total and *imagineCalgary* and the *Vancouver Resilience Strategy* tied for having the second lowest scores. These scores are not an indicator of the plan's quality but solely an indicator of the degree to which equity and green infrastructure considerations were prioritized and integrated within the plan. The lowest score, the *Montréal Resilience Strategy*, demonstrate that equity or green infrastructure was not considered.

The questions for the plan were developed through a systematic literature review of contemporary journal articles that analyze the integration of green infrastructure and equity in urban planning. Common themes regarding equity and common issues from lack of equity were pulled from the articles and used to form questions. I include questions regarding equity which researchers emphasize are important to include, otherwise it could harm vulnerable populations. In the Methods section, I dive deeper into which questions refer to what types of equity. The framework in Appendix B also contains a column to indicate the equity lens applied for each question.

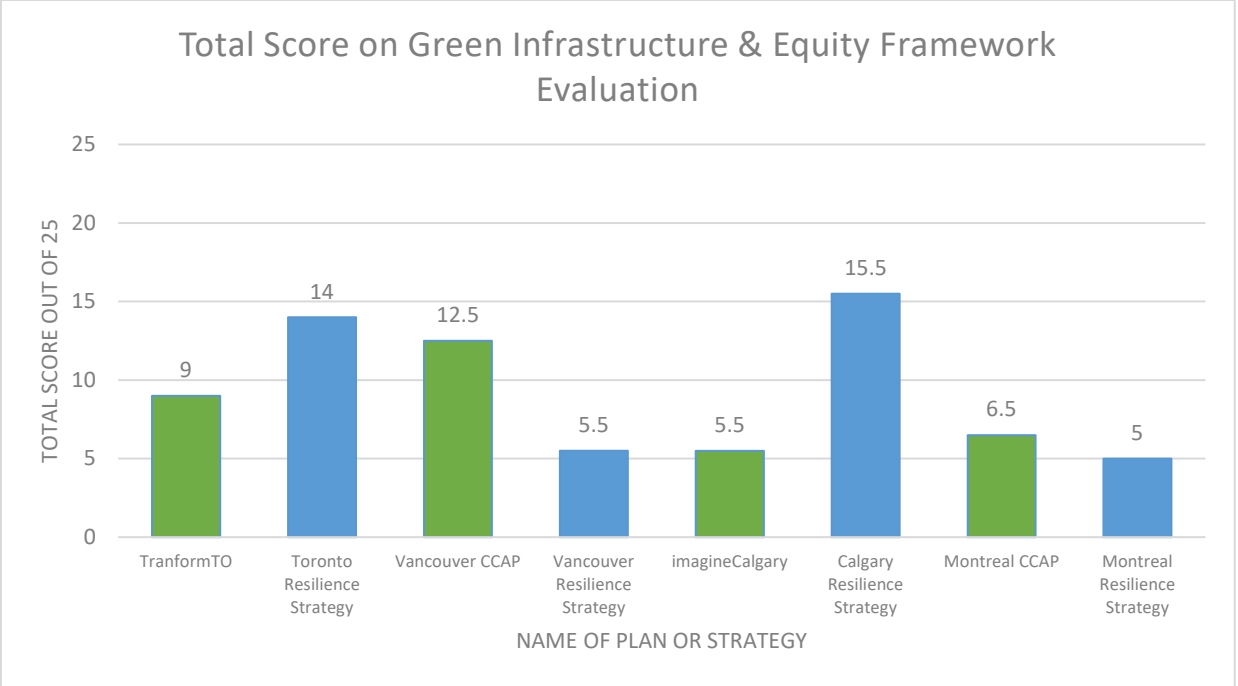


Figure 1. The comparison of each plan or strategy's total score out of 25 from the Green Infrastructure & Equity Framework Evaluation displayed on the graph.

The majority of the plans address that specific vulnerable groups are more prone to natural disasters and other insecurities in cities. However, only the *Toronto Resilience Strategy* and the *Calgary Resilience Strategy* address that these equity-seeking groups face systematic and historical injustices contributing to these insecurities. All the plans, at least, discuss the benefits of green infrastructure that will implicitly or explicitly support these vulnerable populations. However, the *Montréal Resilience Strategy* and *imagineCalgary* do not make attempts to improve access to these benefits.

None of the plans address the negative impacts that certain actions or goals, such as gentrification or displacement, may have on vulnerable populations (Fricker, 2003; Rigolon & Németh, 2018; Anguelovski et al., 2020; Langemeyer & Connolly, 2020). Historically and internationally, green infrastructure projects can increase property values and result in an influx of higher-income residents. This can displace members in a community and price out lower-income residents. Therefore, it is essential to consider the consequences of green infrastructure implementation and create actions to mitigate the adverse effects on present residents not to reduce their quality of life.

Not all of the plans provide definitions for equity and green infrastructure, such as *TranformTO*, the *Toronto Resilience Strategy*, *imagineCalgary*, and both *Montréal* plans. Both of these definitions need to be provided, as they are important considerations for municipal plans. In addition, not all of the plans

provide educational outreach or materials to inform the public about green infrastructure initiatives. The governments and their plans must be transparent. It is also crucial that information is accessible and available to everyone. Thus, having materials in multiple languages is necessary. For example, none of the plans provide translation materials for minority groups in the community. Only *TransformTO* provides volunteers to inform residents about climate change initiatives in the community in numerous languages.

Since all of the cities are located on the traditional territories and lands of respective First Nations communities, all the plans must have respectful and consensual consultations with those First Nation communities. The First Nation communities are keepers of the land and must be involved in the decision-making process. The plans and strategies must remain mindful of the indigenous communities and include actions and goals to strengthen their relationship while also contributing towards truth and reconciliation. Equity lenses should also ensure that indigenous knowledge is integrated into the plans to embed the cultural traditions of regional, indigenous, or local communities respectfully. For example, the Calgary, Toronto, and Vancouver Resilience Strategies include goals to empower the indigenous community and to include them in decision-making processes and stakeholder consultations in city plans; however, the *Montréal Resilience Strategy* does not mention indigenous knowledge or First Nation communities at all. For the municipal plans, the *Montréal Climate Change Adaptation Plan* does not mention indigenous knowledge or First Nations communities.

3.7.1.1 Plan Content

Each plan has different visions, resulting in different goals and subsequent actions to achieve those goals. Regardless, each plan does have actions towards climate change adaptation and mitigation, as well as aspects of integrating equity within their plans.

In Toronto, *TransformTO* has sections focusing on “buildings”, “energy”, “transportation”, “waste”, “outreach and engagement”, and “finance and governance”. In the sections on buildings and energy, there are actions focusing on retrofits and green energy for residential housing, and providing funding for those unable to afford retrofits on the homes they own. There are other goals within *TransformTO* to lower greenhouse gas emissions throughout the City. It is also stated that the Environment and Equity Division is “applying equity lens analysis early in program and policy design and specific instances are highlighted throughout this report.” (pg 11, *TransformTO*, 2019).

The *Toronto Resilience Strategy* has equity as a core component of their strategy and a resilience priority. Actions in the *Toronto Resilience Strategy* that have an equity component are highlighted with

an equity symbol. A lot of the climate and environment actions will include an equity component as well, such as action A2.1, which aims to improve neighbourhood resilience, and action B1.5 which aims to develop, integrate, and advance green infrastructure throughout the City.

The Vancouver Climate Change Adaptation Plan has numerous goals for integrating green infrastructure in the City, and also applies equity considerations to try to ensure all citizens benefits. One of the objectives of the plan is to focus on equity in climate change preparedness actions, which is shown Section 4, “Connected and Prepared Communities” (pg. 42, Vancouver Climate Change Adaptation Plan, 2019). These include actions such as improving health and safety during heat waves by prioritizing housing for green infrastructure retrofits. Other actions like the Urban Forest Strategy also integrate equity with green infrastructure development.

For the *Vancouver Resilience Strategy*, equity and intersectionality is a guiding principle. This plan does include various types of inequity that are present within a city, such as gender inequity and racial inequity, and considers the intersectionality an individual may have in a society. This strategy values lived experience for all these groups of people and aims to use this equity framework to guide its actions, such as in objective 2.1, which aims to elevate underrepresented voices, and objective 2.4, which aims to advance to disaster risk reduction with holistic recovery planning.

Imagine Calgary is a guiding document for the City of Calgary and includes a section on equity and on the environment. These sections are divided into silos, so the equity does not consciously integrate with other sections. Although the climate section does say that it aims to guarantee equitable access to land and water, it does not define how it will do that in an equitable manner, and it does not define what types of equity are considered.

The *Calgary Resilience Strategy* consciously integrates equity into its Pillar 2, Inclusive Futures, and subsequently its Pillar 3, Natural Infrastructure. The strategy defines equity-seeking communities and aims to listen and speak to them in meaningful ways so that they can be included in city building decisions. This will continue to its section on Natural Infrastructure, which aims to support the natural environment and its assets throughout the City. However, the integration of equity and green infrastructure is not explicitly stated.

The *Montreal Climate Change Adaptation Plan* has green infrastructure related strategies to mitigate flooding, heat waves, and to improve the overall climate resilience of the City. The plan even has maps showing areas at higher risk of flooding and heat island effect. Elderly populations and children were

also described to be more vulnerable to these extreme climate events. However, there is no mention of equity considerations throughout the plan.

In the Montreal Resilience Strategy, there are also actions that aim to mitigate risk of flooding and extreme heat. This includes action 10, which aims to develop green infrastructure to improve resilience for flooding and for heat waves. But, equity considerations are not applied in this plan. There are no mentions of equity-seeking communities, or certain populations that may be more vulnerable to climate change risks. Despite that, action 9 will aim to develop a list of vulnerable populations under certain situations so that certain groups can be targeted for support.

3.8 Discussion

As equity-seeking groups are often most at risk of heat stress, flooding, and air pollution, integrating green infrastructure will increase equity and overall better quality of life. For example, tree canopies intercept precipitation, improve air quality, and support biodiversity and soil health. Likewise, ravines can help protect the city from flooding, reduce urban heat island effects, and support biodiversity. Green infrastructure is one of the solutions that can support mitigation and adaptation for current and future residents, but it needs to be applied with an equity lens.

Overall, the resilience strategies have scored higher than the municipal climate change adaptation plans, except for the *Vancouver Climate Change Adaptation Plan*. The Resilience strategies as a whole combine multiple sectors and projects to avoid silos, allowing for interdisciplinary projects that are impactful. For example, in the *Toronto Resilience Strategy*, the Basement Flooding Protection Program is part of one of its actions: Action B1.3, “Review and update existing flood mitigation programs to account for resilience” (pg. 98, 2019). Flooding in Toronto impacts lower-lying areas and causes severe water damage. In addition, since generally equity-seeking groups may live in basements, they will need more support during a flood event. Since equity-seeking groups are more likely to use public transportation, the public transportation system will need to be more resilient and redundant in the event of a flood. Action B1.3 touches upon the climate change considerations, the financial considerations, the transportation considerations, and the equity considerations of basement flooding.

The Resilience Strategies focus on more than just climate change due to their holistic nature; however, the *Vancouver Climate Adaptation Plan* demonstrates that even plans focusing on climate change can support green infrastructure and equity integration through their actions. The Urban Forest Strategy, mentioned in the *Vancouver Climate Change Adaptation Plan* (pg 30, 2019), is an example of equitable

climate action as those most in need of these resources can receive them. Lower-income neighbourhoods at risk of higher urban heat islands and flooding receive priority tree planting initiatives to help mitigate and prevent extreme weather events from damaging their communities. Thus, both resilience strategies and municipal climate change adaptation plans must consciously decide to utilize an equity lens when implementing green infrastructure projects in their planning process.

Imagine Calgary, on the other hand, has few policies that integrate equity and green infrastructure policies. The equity actions in the plan tend to focus on political representation than support community members, however, it could be argued the diverse representation will result in greater social equity. However, through this representation, *Imagine Calgary* aims to further indigenous self-governance, as stated in action 56, “By 2020, all public institutions and systems create and implement an urban Aboriginal policy that recognizes the detrimental colonial history experienced by First Nations, Metis and Inuit people; reduces barriers to public participation and governance; and supports economic, social and political advancement.”

Comprehensive city plans need to ensure that equity is applied to their actions, goals, and strategies. Cities are complex urban systems and decision-makers need to consider all of the intricacies of a growing city, especially with impending climate change impacts such as extreme heat and variable precipitation events. Green infrastructure implementation and development can provide benefits to all community if integrated with an equity lens. So, it is essential that green infrastructure is integrated with equity in urban planning practice so that policies do not contain acts of commission and acts of omission (Anguelovski et al., 2016). Acts of commission and omission in regard to flood and extreme heat events could be potentially fatal and also exclude those most vulnerable to these events in the first place. Green infrastructure development needs to be equitable to mitigate and adapt to climate change holistically, so that those most in need of benefits and resources to protect and enhance their lives receive them as needed.

For example, question 5 of the framework, “Are potential negative impacts from actions acknowledged in the strategy?” has a 0 across all city strategies and plans. There are no discussions relating to possible displacement from green infrastructure implementation or development, or any discussions about possible green gentrification (Anguelovski et al., 2018b; Rigolon & Németh, 2018; Baró et al., 2019; Carmichael et al., 2019; Hall & Knuth, 2019; Houston & Zuñiga, 2019). My framework displays an equity consideration missed by these comprehensive city plans and strategies. This is harmful and thus an equity lens that considers the possible ramifications of acts of omission needs to be applied. Vulnerable

populations must be part of the decision-making process so that they can raise their concerns about how to avoid negative impacts and government officials must plan to mitigate potential negative impacts from their actions (Anguelovski et al., 2016).

Another example is question 22, “Does the strategy explain how green infrastructure can support disaster recovery”, which the framework shows does not have a score of 1 by any of the plans or strategies assessed. This is another equity consideration overlooked by the plans. Green infrastructure can support disaster recovery through providing a source of local food, providing ecosystem rehabilitation and restoration to mitigate future shocks (McClintock et al., 2016; Meerow & Newell, 2016; Hall & Knuth, 2019). In the event of a disaster, generally the vulnerable populations have the least amount of resources to recuperate their losses, and thus green infrastructure needs to be able to provide support to these communities. Extreme weather events and climate impacts are becoming increasingly common (IPCC, 2018), and therefore equitable green infrastructure implementation for disaster recovery will support these communities and should not be discounted by decision-makers (Hawken, 2018).

3.8.1 Equity Lenses

If equity is not explicitly considered, plans have the potential to ignore equity-seeking communities unconsciously. Recognition equity is necessary to ensure all community members are heard and seen (Schlosberg, 2007; Krumholz & Hexter, 2018). This is especially true in cities where large portions of the population may speak and read another language as their first language. Accordingly, translation services or copies of the plans and educational materials in several languages must be available for transparency’s sake (Fricker, 2003; Anguelovski et al., 2020; Langemeyer & Connolly, 2020).

Procedural equity ensures that all community members can engage in the decision-making process and in public engagement sessions (Schlosberg, 2007; Krumholz & Hexter, 2018). Procedural equity also ensures that groups that may have been historically disenfranchised or distrustful of the government have a safe space to voice their concerns (Lane, 2006; Schlosberg, 2007; Meerow et al., 2019). However, simple diversity and inclusion may not be enough for systemic change; there needs to be internal change to create opportunities for marginalized groups.

Distributional equity helps make sure benefits are accessible to all residents (Schlosberg, 2007; Krumholz & Hexter, 2018). In response to growing diversity in cities, green infrastructure implementation must be mindful of multiple identities and intersectionality when planning for projects

(Anguelovski et al., 2020). Other equities, such as food equity, gender equity, and racial equity and vulnerabilities, such as age, disabilities, and lower-income level need to be considered. Specific populations may have compounding vulnerabilities because they belong to several equity-seeking groups and may not have easy access to some benefits. Aside from the *Toronto Resilience Strategy*, all of the plans need to better address multiple equities and intersectionality in their plans to include the lived experiences and challenges faced by various individuals (Fricker, 2003; Anguelovski et al., 2020).

These plans and strategies look to make a positive impact so that the future is sustainable and healthy. These plans are often part of more extensive regional plans that make goals and actions to make sure the community is healthy and vibrant in the future. Therefore, it should be necessary for all the plans to have intergenerational considerations when planning for the future (Larson et al., 2013). The youth are increasingly aware of the realities of climate change and have protested to make their voices heard, such as through the Youth Strike for Climate. Equity lenses in each plan should look to how actions and goals will affect generations into the future and if there will be enough resources to sustain them (Larson et al., 2013; Langemeyer & Connolly, 2020). It is unfair to give future generations the burden of an unhealthy community and lesser quality of life due to current unsustainable consumption and environmental demands.

3.8.2 Green Infrastructure Considerations

The literature describes the necessity of integrating equity and green infrastructure. However, certain community members could face negative impacts without active consideration of vulnerable populations and the possible unintended effects that development and projects could have on a neighbourhood (Anguelovski et al., 2020; Langemeyer & Connolly, 2020). For example, construction in a neighbourhood may displace certain residents. Alternatively, adding greenspace or a community park in a neighbourhood may contribute to gentrification resulting in higher property taxes and pushing lower-income residents out of their communities (Rigolon & Németh, 2018; Carmichael et al., 2019; Hall & Knuth, 2019; Houston & Zuñiga, 2019; Xiao et al., 2019).

Also, implementation without public engagement sessions and consultations with community members could leave certain benefits inaccessible by creating a greenspace that is not accessible by public transportation, for example (Meerow & Newell, 2016; Rigolon & Németh, 2018; Zhu et al., 2019). None of the plans address the potential negative impacts that happen due to park development. Notable examples of such unfavourable impacts can be seen near New York City's High Line greenway park and Lene-Voigt-Park in Leipzig, where creating greenspace led to gentrification (Haase et al., 2017; Rigolon &

Németh, 2018). Plans must consider the possibility of the actions and goals of the strategies to harm to certain residents and have steps to mitigate or prevent such externalities.

Certain neighbourhoods may also be at higher risk of climate effects, such as the urban heat island effect and flooding (Nesbitt et al., 2019). This may be due to spatial inequities, caused perhaps by being located near or in a floodplain for flooding, or in an urbanized area without tree canopies for urban heat island (Brooks et al., 2016; Baró et al., 2019; Lanza & Durand, 2021).

It can be helpful to prioritize certain neighbourhoods for green infrastructure initiatives, such as the Urban Forestry Strategy, as addressed in the *Vancouver Climate Change Adaptation Plan*. The *Vancouver Climate Change Adaptation Plan* and *Vancouver Resilience Strategy* provide maps showing areas of higher risk of floods and seismic activity. The *Montréal Climate Change Adaptation Plan* has maps to show areas prone to heavy rainfalls, riverine floods, heatwaves, and droughts. Knowledge and analysis of these areas can help provide support for disaster prevention or recovery measures. Additionally, *TransformTO* provides a map of areas with higher air pollution due to vehicle emissions, which can be used to prioritize green infrastructure projects, such as tree planting to help reduce carbon emissions in those neighbourhoods.

Green infrastructure has multi-functional, adaptable, and sustainable forms. In all forms, green infrastructure provides ecosystem services that provide environmental, economic, and social benefits in both its natural forms, such as forests and riparian areas, and its human-built forms, such as green roofs and bioswales. Investing in green infrastructure provides cost-saving benefits over time as well. Green infrastructure may incur a cost to implement, but the improved quality of life, human health benefits, recreation, and food production result in savings over time in a community. As well, many green infrastructure additions save money in stormwater management and energy expenditures.

It is important that these cost savings benefit those most in need. Green infrastructure savings need to be equitable. For example, green roof subsidies and grants can ensure that lower-income residents can afford to retrofit their homes. In addition, city policies and programs can ensure that rental units also are able to attain retrofits and the energy savings can go renters. If green roofs are not accessible to disempowered communities, then green roof retrofits would be act of omission (Anguelovski et al., 2016).

Furthermore, connectivity and proximity is also important in green infrastructure in order to create a network. Coordinated planning for green infrastructure can provide greater benefits by ensuring that natural areas are connected along a corridor. Disenfranchised communities need to be included in the network so the benefits will also reach their neighbourhoods, such as through a continuation of a network of street trees, or green trails that connect urban forests. This will increase the benefits throughout the city and ensure that vulnerable populations are in proximity to greenspaces. Integrating their communities with regional green infrastructure projects can further improve connectivity and provides an opportunity to hear the needs of those communities.

3.8.3 Heat Island Considerations

During an extreme heat event, vulnerable communities are less likely to have air conditioning or a car to access cooling centres if located far away, an equity lens needs to be applied to ensure that all communities can access essential, potentially life-saving services provided by their city. As stated, extreme heat events and overall summer heat temperatures are expected rise in cities. It is crucial that green infrastructure benefits, such as cooling from shade from tree canopies, be available and equitably implemented throughout the city to mitigate heat island effect.

Equitable green infrastructure would include using an equity index to determine which areas of the community are most in need of natural infrastructure to provide cooling benefits, such as the urban forest strategy in the *Vancouver Climate Change Adaptation Plan*. As well, retrofits on older buildings to make them energy efficient can also provide cooling effects, as stated in *TransformTO*. *TransformTO* has several retrofit policies. For example, action 1.4, which is “Improving energy efficiency of social housing” and action 1.5, “Continued support for residential property owners” intends to improve residential homes for both rents and homeowners with energy efficient retrofits. Action 1.1, which is “Enhancing the better buildings partnerships” aims to support energy efficient retrofits of commercial and institutional buildings around the City.

The *Montréal Climate Change Adaptation Plan* has a section on heat wave related actions, such as, “Design spaces allowing people to refresh themselves and avoid exposure to extreme heat” and to “Develop emergency response measure for heat waves” (pg 30, 2015). Although it does not focus on a particular vulnerable group of residents for these heat waves, aside from young children and the elderly, the plan does show it has considerations for those at risk of extreme heat. The plan also provides a map

displaying areas of the City most at risk to heat waves, as seen in Figure 2 and these could be used as focus areas for priority actions.

AGGLOMERATION OF MONTRÉAL VULNERABILITY TO HEAT WAVES

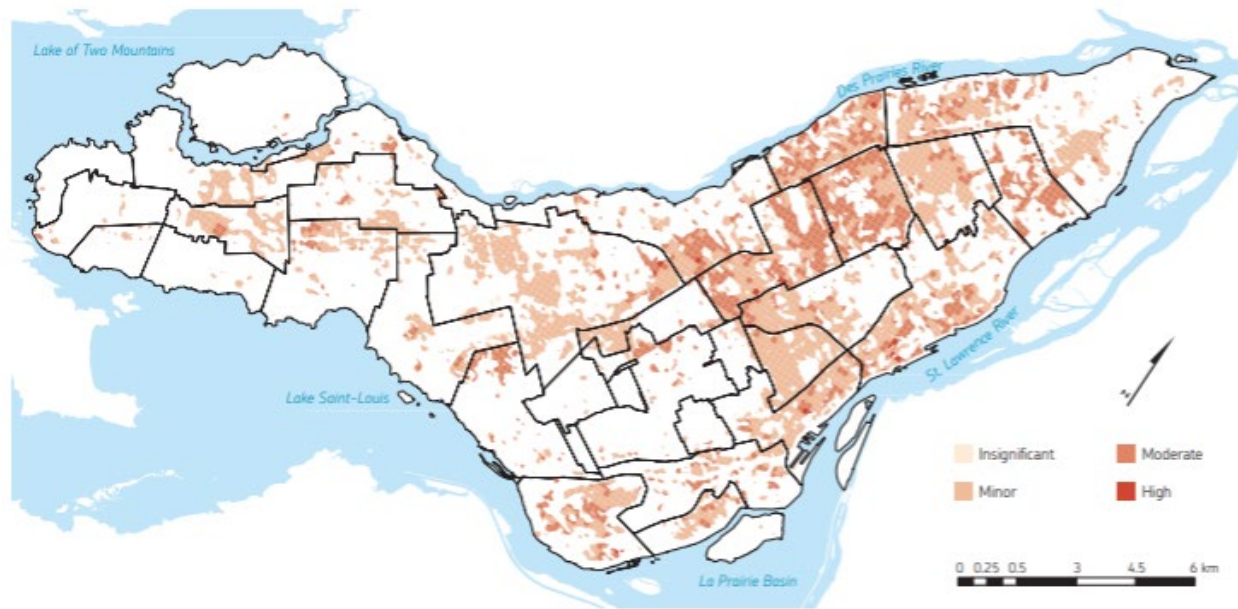


Figure 2. Map of areas in Montréal at varying risk to heat waves, obtained from the Montréal Climate Change Adaptation Plan (pg 18, 2015).

My framework shows that heat island is considered in every plan and strategy, but certain plans do not provide equitable actions to support vulnerable communities in the event of a heat island event. My framework shows that improvements could be made through having more city plans address the root causes of these vulnerabilities, as well as include vulnerable population in the decision-making process for green infrastructure so that they can address how they would like to be approached going forward on issues related to heat island effect. My framework also shows that the comprehensive city plans for all four cities did not include direct strategies to improve access to cooling centres or greenspaces in relation to heat island effect, except for the Toronto Resilience Strategy. An equity lens needs to be applied so that vulnerable populations do not continue to suffer disproportionately from extreme heat.

3.8.4 Flooding Considerations

Flooding is an extreme weather event that is occurring more often in all four Canadian cities assessed. Vulnerable communities are more at risk of the impacts of flooding as they may be renters or live in basement apartments. These communities may also rely heavily on public transportation, which may

not be able to service certain areas in the event of a flood. As well, vulnerable groups may not be able to afford insurance or have monetary recuperation in the event of a flood, thus putting them more at risk and increasing their vulnerability. In addition, certain populations in these communities may have no place to go or find shelter if their residence is flooded, putting them at risk of homelessness.

Flooding disproportionately affects disenfranchised communities, and thus an equity lens is essential when developing green infrastructure policies that mitigate or help adapt to flooding so that these communities are not excluded. They need to express their concerns, needs, and desires in the case of a flooding event, and they need to have their voices heard when developing green infrastructure so that those benefits reach their communities. For example, a restoration project at the mouth of the Don River, called the Port Lands Flood Protection (Toronto Resilience Strategy, 2019, pg 95), will mitigate flooding by rehabilitating and restoring riparian ecosystems along the river. This is part of the policy action B1.2, “Flood Resilience”. It is essential that vulnerable communities are reached out for their input so their concerns are addressed, and their input can be added to better supporting them in the case of a flood.

As well, the *Vancouver Climate Change Adaptation Plan* does clearly intend to use green infrastructure to mitigate flooding. As stated in the plan, Vancouver will mitigate flood events with their policy Action 1.3, “Utilize the piped system, green infrastructure and other rainfall storage strategies to attenuate water from catchments that drain into floodplain areas prone to coastal flooding.” This indicates that flooding is a known issue that certain cities are using scientific research to try to address problems through policy.

The *Montréal Climate Change Adaptation Plan* also has actions for flooding and provides a map, as seen in Figure 3, for those at higher risk of fluvial flooding during spring events or destructive storms. Actions relating to flooding in this plan include “Increase the stability of riverbanks against erosion” and “Increase the resilience of infrastructures and buildings to flooding of river banks”. However, green infrastructure is not referred to in the narrative as a method to mitigate the flood events.

AGGLOMERATION OF MONTRÉAL VULNERABILITY TO RIVER FLOODS



Figure 3. Map displaying the varying risk of riverine flooding in Montréal, obtained from the Montréal Climate Change Adaptation Plan (pg 28, 2015).

My framework demonstrates that flooding is a risk in all four Canadian cities, but certain cities do not have equitable actions to mitigate floods or educate residents on flooding. Improvements could be made by address spatial equity so that all residents do have a way to access shelter during a flood event. As well, another recommendation would be to increase barrier-free participation so that residents can make their concerns about flooding heard and to propose their ideas on how to best support them.

3.9 Future Directions

Equity needs to be defined in all plans so that all stakeholders, officials, and community members understand their premise and purpose, especially if an equity lens is applied to actions and goals towards green infrastructure implementation. Multiple equities and considerations of vulnerabilities should be included, and definitions of those equities should be provided to provide clarity to all readers too. All plans with green infrastructure projects should have a definition of green infrastructure so any stakeholders, officials, or members of the community who are unaware of the term or require additional information can access it. This will prevent confusion and help outline the requirements when integrating equity and green infrastructure considerations in community plans.

The Covid-19 pandemic has exacerbated inequities found in contemporary cities. Many residents who live in cities and are lower-income residents or apartment dwellers do not have their own backyards.

These residents need access to green spaces for their mental, physical, and emotional health. As a result, a lack of access to greenspace and walkable space is a significant concern. In the United States of America, in 100 major cities, white neighbourhoods, on average, have access to more park acreage than minority neighbourhoods (Chapman et al., 2021). As well, lower-income and disenfranchised communities are less likely to have the ability to drive to parks further away and are more dependent on parks accessible by walking or public transportation (Bahrini et al., 2017; Benton-Short et al., 2017; Xiao et al., 2019).

Spatial equity is essential because certain neighbourhoods are further away from certain parks and their associated benefits. Generally, lower-income and marginalized neighbourhoods do not have access to the same high-quality parks and natural features as higher-income neighbourhoods, or may not have access to vehicles to drive to parks at a distance (Brooks et al., 2016; Baró et al., 2019; Anguelovski et al., 2020; Lanza & Durand, 2021). Therefore, it is vital to keep this in consideration when developing green infrastructure so that the benefits purposefully reach disenfranchised communities, as they are at higher risk of climate impacts and consequently need the socioeconomic and ecological benefits of green infrastructure (Meerow & Newell, 2016; Baró et al., 2019; Zhu et al., 2019; Baró et al., 2021).

Using the developed framework to evaluate the integration of green infrastructure and equity in city plans can be beneficial. It can outline where considerations towards either aspect are missing in a comprehensive community plan. The framework can help determine if multiple equity considerations are met, as well as intersectionality. This framework can help plan for cities that are equitable and sustainable through the development of green infrastructure. The framework also considers climate change and the two common themes found in all four cities plans: flooding and the urban heat island effect. Climate change disproportionately affects historically disenfranchised communities and marginalized neighbourhoods (Dobbs et al., 2018; Baró et al., 2019; Zuniga-Teran et al., 2020).

As resources were limited, I was not able to hire another reader to assess the same eight plans and strategies using my framework to determine if the results would be duplicated. Future researchers studying the topic of green infrastructure and equity integration in Canadian Cities could try to use my framework to duplicate the results. This will help validate the reliability of my developed framework. As well, researchers could take this framework to new cities and determine which issues residents in respective cities care most about to weigh certain questions in the framework more greatly. This will also change the results and help assess where equity integration is most needed in green infrastructure implementation in certain cities.

Resiliency will only proliferate if all residents benefit from green infrastructure; else, marginalized socioeconomic groups will remain vulnerable to climate change impacts (Anguelovski et al., 2018; Dobbs et al., 2018; Zhu et al., 2019; Majekodunmi et al., 2020; Zuniga-Teran et al., 2020). Urban planners and government officials need to prioritize green infrastructure investment in vulnerable communities with recognition and application of social equity (Anguelovski et al., 2018). Educational initiatives need to be inclusive, as well as included, to help residents make choices that improve their local resiliency and, give them a voice in community and city-level discussions about green infrastructure projects (Anguelovski et al., 2018; Baró et al., 2019; Hall & Knuth, 2019). Finally, implementation of green infrastructure needs to be systematic and with an equity lens for the city to become more resilient, and thus more sustainable, as a whole (Anguelovski et al., 2018; Dobbs et al., 2018; Zhu et al., 2019).

3.10 Conclusion

Therefore, when planning for climate change mitigation and adaptation using green infrastructure, it is essential to apply an equity lens to ensure that those most in need receive the most benefits from green infrastructure development (Baró et al., 2019; Xiao et al., 2019; Scott, 2020; Zuniga-Teran et al., 2020). Inequitable green infrastructure implementation can amplify the consequences of climate change, such as flooding and extreme heat, to increase socioeconomic inequality in cities (Williams et al., 2010; Scott, 2020). Using a framework, such as the one developed for this paper, can help ensure that equity considerations are included when implementing green infrastructure in urban planning.

Resilience strategies, on average, demonstrate more cohesion and integration of multiple sectors, including the combination of green infrastructure and equity considerations. Official plans from municipal governments can use this framework to ensure their strategies include vulnerable communities and equity considerations in their green infrastructure developments. However, vulnerable populations can be excluded even with the best intentions, and inequities can worsen without considering and integrating multiple types of equity in the urban planning process. Lessons dictate that equity in conjunction with other actions and goals needs to be part of the planning process to support holistic urban resilience in the face of climate change.

Chapter 4 - Thesis Conclusions

My thesis has explored the integration of green infrastructure and equity within city and community planning. I have examined equity implications of green infrastructure development without conscious considerations of residents' lived experiences, and how marginalized communities may be prone to an increased risk of harmful climate change effects without an adequate equity lens. I also examine how green infrastructure and equity can help increase resiliency within a city so that it may improve sustainability.

The goal of my research was to examine if there was contemporary literature on the topic of green infrastructure and equity integration in urban planning and then to use that literature to develop a framework to assess green infrastructure and equity considerations in comprehensive city plans in Canadian Cities. My thesis explores numerous types of equity and intersectionality considerations in conjunction with various green infrastructure implementations. In order to prevent the exacerbation of socioeconomic inequality in cities and improve the overall well-being of residents, the consideration of green infrastructure and equity is necessary. The following conclusions have been

1. *Ignoring or unconsciously dismissing equity considerations when developing or implementing green infrastructure can exacerbate inequality.* Scholars have argued that it is necessary to be conscious of equity integration with green infrastructure; otherwise, planners and policymakers will involuntarily exclude certain groups of people from receiving the benefits of green infrastructure (Anguelovski, 2018a; Rigolon & Németh, 2018; Anguelovski, 2020). In some situations, not applying an equity lens on green infrastructure projects or implementation can cause extremely adverse effects, such as displacement, gentrification, or further inequality within a community (Meerow & Newell, 2016; Anguelovski et al., 2020; Langemeyer & Connolly, 2020).
2. *Future research on equity and green infrastructure needs to consider more than just social equity.* As Anguelovski (2020) stated in their article, various types of equity and intersectionality must be considered for equity to permeate throughout the city, including anti-subordination. It is also necessary to listen to and consider the lived experiences of citizens because planners and policymakers may not understand or relate to their daily struggles (Fricker, 2003). Lived experiences are important for decision-makers to understand and respect (Fricker, 2003; Lorinc & Pitter, 2016; Langemeyer & Connolly, 2020). Each individual may be facing several difficulties

and challenges in their daily lives due to their intersectional identities that other people may not recognize due to their privileges, such as gender, sexual orientation, disability, or race (Owring et al., 2014; Anguelovski et al., 2016; Anguelovski et al., 2020). Future scholarship needs to research a variety of equity considerations when applying green infrastructure to include the wide spectrum of individuals that live within a city. Then that research can be applied to policymaking and decision-making.

3. *Green infrastructure can support climate change mitigation and adaptation, so it is necessary to ensure equitable implementation.* Green infrastructure supports ecosystem resilience, protects biodiversity, and provides ecosystem benefits (Costanza et al., 1997; Bolund & Hunhammar 1999; Newell et al., 2013). It is crucial for city planners and decision-makers to implement green infrastructure to mitigate and adapt to extreme weather events since they are becoming increasingly common and severe due to climate change (IPCC, 2018). It also is essential that the green infrastructure projects benefit all members of a community so that the city and community are protected holistically and that inequality does not grow because certain individuals are at high risk of climate vulnerabilities (Fainstein, 2015; Lorinc & Pitter, 2016; Anguelovski et al., 2018a; Anguelovski et al., 2020; Langemeyer & Connolly, 2020).

4. *Understanding the historical context of disenfranchised communities during the planning process is necessary so to improve relations and to acknowledge better why certain communities may distrust municipal governments and planning officials.* City officials must apply an equity lens to their decision-making process and public engagement sessions to include disenfranchised communities. However, it is also essential for policymakers, planners, and other government officials to understand why these inequities exist in the city and why certain groups may be hesitant to trust the process or hesitant to join in (Metzger, 1996; Rothstein, 2017; Reece, 2018). City planners can address and apologize for past historical injustices by understanding and recognizing the city's history and then start a dialogue or conversation with affected groups to rebuild and strengthen relationships. Transparency and mutual respect are important in city building and transactive planning (Fricker, 2003; Fainstein, Dhillon & Young, 2010; 2005; Reece, 2018; Anguelovski et al., 2020).

5. *Future iterations of city plans and resilience strategies need to include an equity lens framework to ensure that the benefits of green infrastructure can reach all populations as needed.* Planning is a continual process to create a better and sustainable future (Meerow & Woodruff, 2019; Anguelovski et al., 2020). Feedback is essential from citizens who are affected by actions and projects implemented through city planning. Future iterations of comprehensive city plans must address the issues that the city is facing and may face in the future, and that includes ensuring all citizens profit from green infrastructure development and its benefits (Fainstein, 2005; Newell et al., 2013; Benton-Short et al., 2017; Reece, 2018; Rigolon & Németh, 2018). An equity lens framework, such as the one produced for Manuscript 2, can support such initiatives for a city to ensure that equity needs and considerations are met in conjunction with green infrastructure implementation.

6. *Equity capacity building for planners is necessary.* Planners work with the public and develop plans that will directly influence residents. It is essential for planners to take empathy training and build equity capacity in their work to understand how their actions could affect others, directly or indirectly. All accredited planning institutions should offer courses on equity and planning. My analysis demonstrates that many plans may not consciously integrate equity into the planning process, and research proves the integration of an equity lens is needed in planning (Anguelovski, 2020).

4.1 Contributions to Scholarship and Practice

The climate is changing and causing unprecedented and adverse effects around the world (IPCC, 2018). The world population continues to grow and more people live in cities that may be vulnerable to extreme climate impacts (IPCC, 2018; Leeson et al., 2018). News headlines are increasingly grim with a barrage of apocalyptic information about climate impacts now and in the upcoming years, which can cause feelings of hopelessness and despair (Hulme, 2007; Moser, 2016).

Planners, policymakers, and scholars can find value in the findings of my thesis. First, it is essential to remember that people can still make a difference themselves and in government, so municipalities must incorporate green infrastructure into city planning which can help with climate change mitigation and adaptation (Meerow & Newell, 2016; Sanchez & Reames, 2019; De Lange, 2020; Majekodunmi et al., 2020; Venter et al., 2020; Lanza & Durand, 2021). It is also critical that the green infrastructure support all populations within a city (Baró et al., 2019; Xiao et al., 2019; Scott, 2020; Zuniga-Teran et al., 2020).

In practice, planners and policymakers can use these findings to consider the importance of equitable participation and engagement with all community members and listen to their lived experiences when creating green infrastructure policies or plans. The officials can use the findings to develop their own framework for their city to assess the integration of green infrastructure and equity within their cities. This framework could be used as a tool to be adapted and used by public servants to evaluate their current comprehensive city plans and to support future amendments or updates.

In addition, my thesis contributes to research on the 100 Resilient Cities program and evaluates its strategies by analyzing its equity and green infrastructure considerations in Canadian cities. The 100RC program was a relatively new initiative. Therefore, it is necessary to analyze its Resilience Strategies to be improved for potential future amendments or iterations, or to change aspects discovered to be inadequate for city planning. Manuscript 2 evaluates the four Canadian resilience strategies through a green infrastructure and equity framework developed through the research from Manuscript 1.

For planning scholarship, this thesis provides value in defining and condensing multiple contemporary articles on the integration of equity and green infrastructure. Future studies will find value in the multiple types of equity my research examines and their relationship to green infrastructure implementation in city planning. Manuscript 1 demonstrates through the systematic literature review that the contemporary literature about green infrastructure in urban planning lack crucial equity considerations. My thesis contributes to scholarship by supporting equity considerations in green infrastructure research and its applications.

Equity is both a process and a goal. It will be important to ensure there is monitoring and evaluation of equity integrations in comprehensive city plans. Monitoring the plans could include qualitative research, such as asking residents if they feel their quality of life has improved. Examples could include: improvements in spatial equity (e.g. residents now have easier access to amenities), or improvements of recognitional equity (i.e. resources are now available in multiple languages). The evaluation of plans can determine if equity was met as a goal. This can be done through quantitative research by looking at metrics such as income wealth disparity or a happiness index. Monitoring and evaluation is important for plans that integrate equity to ensure that the plans are improving the wellbeing of the communities in the city, and, if equity is not improving, to determine where and what interventions are needed to address the gaps in the planning process.

Bibliography

Anguelovski, I., Brand, A. L., Connolly, J. J., Corbera, E., Kotsila, P., Steil, J., ... & Argüelles Ramos, L. (2020). Expanding the Boundaries of Justice in Urban Greening Scholarship: Toward an Emancipatory, Antisubordination, Intersectional, and Relational Approach. *Annals of the American Association of Geographers*, 1-27.

Anguelovski, I., Irazábal-Zurita, C., & Connolly, J. J. (2018a) Grabbed urban Landscapes: Socio-spatial tensions in green infrastructure planning in Medellín. *International Journal of Urban and Regional Research*, 43(1), 133-156. doi:10.1111/1468-2427.12725

Anguelovski, I., Connolly, J., & Brand, A. L. (2018b). From landscapes of utopia to the margins of the green urban life. *City*, 22(3), 417-436. doi:10.1080/13604813.2018.1473126

Anguelovski, I., Shi, L., Chu, E., Gallagher, D., Goh, K., Lamb, Z., Reeve, K., & Teicher, H. (2016). Equity Impacts of Urban Land Use Planning for Climate Adaptation: Critical Perspectives from the Global North and South. *Journal of Planning Education and Research*, 36(3), 333–348. <https://doi.org/10.1177/0739456X16645166>

Avila, E., & Rose, M. H. (2009). Race, culture, politics, and urban renewal. *Journal of Urban History*, 35(3), 335-347. doi:10.1177/0096144208330393

Bahrini, F., Bell, S., & Mokhtarzadeh, S. (2017) The relationship between the distribution and use patterns of Parks and their spatial accessibility at the city level: A case study from Tehran, Iran. *Urban Forestry & Urban Greening*, 27, 332-342. doi:10.1016/j.ufug.2017.05.018

Banhalmi-Zakar, Z., Gronow, C., Wilkinson, L., Jenkins, B., Pope, J., Squires, G., . . . Womersley, J. (2018). Evolution or revolution: Where next for impact assessment? *Impact Assessment and Project Appraisal*, 36(6), 506-515. doi:10.1080/14615517.2018.1516846

Barbieri, M., & Ouellette, N. (2012). The Demography of Canada and the United States from the 1980s to the 2000s A Summary of Changes and a Statistical Assessment. *Population*, 67(2), 177–280. <https://doi.org/10.3917/pope.1202.0177>

Baró, F., Camacho, D. A., Pérez Del Pulgar, C., Triguero-Mas, M., & Anguelovski, I. (2021) School greening: Right or privilege? Examining urban nature within and around primary schools through an equity lens. *Landscape and Urban Planning*, 208, 104019. doi:10.1016/j.landurbplan.2020.104019

- Baró, F., Calderón-Argelich, A., Langemeyer, J., & Connolly, J. J. (2019) Under one canopy? Assessing the DISTRIBUTIONAL environmental JUSTICE implications of street TREE benefits in Barcelona. *Environmental Science & Policy*, 102, 54-64. doi:10.1016/j.envsci.2019.08.016
- Benedict, M. A., & McMahon, E. T. (2006). *Green infrastructure: Linking landscapes and communities*. Urban Land (Vol. June). Washington, DC: Island Press
- Benton-Short, L., Keeley, M., & Rowland, J. (2017) Green infrastructure, green space, and sustainable urbanism: Geography's important role. *Urban Geography*, 40(3), 330-351. doi:10.1080/02723638.2017.1360105
- Bolund, P., & Hunhammar, S. (1999). Ecosystem services in urban areas. *Ecological Economics*, 29(2), 293-301. doi:10.1016/s0921-8009(99)00013-0
- Brooks, K. R., Kelley, W., & Amiri, S. (2016) Social equity of street trees in the PEDESTRIAN REALM. *Papers in Applied Geography*, 2(2), 216-235. doi:10.1080/23754931.2015.1121163
- Burningham, K., Fielding, J., & Thrush, D. (2007). 'It'll never happen to me': understanding public awareness of local flood risk. *Disasters*, 32(2), 216–238. <https://doi.org/10.1111/j.1467-7717.2007.01036.x>
- Bush, J., & Doyon, A. (2019). Building urban resilience with nature-based solutions: How can urban planning contribute? *Cities*, 95, 102483. doi: 10.1016/j.cities.2019.102483
- Calgary Resilience Strategy. (2019). Rockefeller Foundation. City Resilience Framework - 100 Resilient Cities.
- Canadian Institute of Planners (CIP). (2016). Codes of Professional Conduct. Retrieved September 19, 2021, from <https://cip-icu.ca/Careers-in-Planning/Codes-of-Professional-Conduct>.
- Canzonieri, C. (2007). M.E. Benedict and E.T. McMahon, *Green Infrastructure: Linking Landscapes and Communities*. *Landscape Ecology*, 22, 797–798. doi:10.1007/s10980-006-9045-7
- Capeci, D., & Wilkerson, M. (1990). The Detroit Rioters of 1943: A Reinterpretation. *Michigan Historical Review*, 16(1), 49-72. doi:10.2307/20173210
- Carmichael, C., Danks, C., & Vatovec, C. (2019) Green infrastructure solutions to health impacts of climate Change: Perspectives of affected residents in Detroit, Michigan, USA. *Sustainability*, 11(20). doi:10.3390/su11205688

Caro, R. (1975). *The power broker: Robert Moses and the fall of New York*. New York: Vintage Books.

Chapman, R., Foderaro, L., Hwang, L., Lee, B., Muqueeth, S., Sargent, J., & Shane, B. (2021, May). Parks and an equitable recovery. The Trust for Public Land. <https://www.tpl.org/parks-and-an-equitable-recovery-parkscore-report%20>.

Charlton, R. (2008) *Fundamentals of Fluvial Geomorphology*. London. p. 234

City of Calgary. (2021). Calgary's Climate Program. <https://www.calgary.ca/uep/esm/energy-savings/climate-change.html?redirect=/climateprogram>

City of Calgary. (2021a). Calgary River Flooding. <https://maps.calgary.ca/riverflooding/>.

City of Toronto. (2021, June 28). TransformTO, Net Zero Strategy, and GHG Inventories. City of Toronto. <https://www.toronto.ca/services-payments/water-environment/environmentally-friendly-city-initiatives/TransformTO/TransformTO-climate-action-strategy/>.

City of Vancouver. (2020). Climate Change Adaptation Strategy. City of Vancouver. <https://vancouver.ca/green-vancouver/climate-change-adaptation-strategy.aspx>.

Climate Atlas of Canada. (2019). Building a climate-Resilient City. Climate Atlas of Canada. Retrieved from <https://climateatlas.ca/building-climate-resilient-city>.

Climate Initiatives Platform. (2020, July). 100 Resilient Cities. 100 Resilient Cities - Climate Initiatives Platform. https://climateinitiativesplatform.org/index.php/100_Resilient_Cities.

Costanza, R., D'Arge, R., De Groot, R., Farber, S., Grasso, M., Hannon, B., . . . Van den Belt, M. (1997). The value of the world's ecosystem services and natural capital. *Nature*, 387(6630), 253-260. doi:10.1038/387253a0

Coutts, C., & Hahn, M. (2015). Green Infrastructure, Ecosystem Services, and Human Health. *International Journal of Environmental Research and Public Health*, 12(8), 9768–9798. doi: 10.3390/ijerph120809768

Cvejić, R., Železnikar, Š, Nastran, M., Rehberger, V., & Pintar, M. (2015) Urban agriculture as a tool for Facilitated Urban Greening of sites in Transition: A case study. *Urbani Izziv*, 26(Supplement). doi:10.5379/urbani-izziv-en-2015-26-supplement-006

Davies, C., Macfarlane, R., McGloin, C., & Roe, M. (2006). Green infrastructure planning guide. Anfield Plain: North East Community Forest

Davoudi, S. (2014). Climate Change, Securitisation of Nature, and Resilient Urbanism. *Environment and Planning C: Government and Policy*, 32(2), 360–375. doi: 10.1068/c12269

de Lange, D. E. (2020). International isomorphism, sustainable innovation and wealth for OECD CITIES. *Journal of Urban Affairs*, 1-25. doi:10.1080/07352166.2020.1730698

Dhillon, C. & Young, M. G. (2010). Environmental Racism and First Nations: A Call for Socially Just Public Policy Development, *Canadian Journal of Humanities and Social Sciences*, 1(1), 23-37

Diamond, J. M. (2007). *Collapse: How societies choose to fail or succeed*. Camberwell, Vic.: Penguin.

Dimitriou, H. T. & Field, B. G (2020) [47]. Mega infrastructure projects as agents of change: new perspectives on 'the global infrastructure gap'. *Journal of Mega Infrastructure & Sustainable Development*, (1)2.

Dobbs, C., Escobedo, F. J., Clerici, N., De la Barrera, F., Eleuterio, A. A., MacGregor-Fors, I., . . . Hernández, H. J. (2018) Urban ecosystem services in Latin America: Mismatch between GLOBAL concepts and REGIONAL realities? *Urban Ecosystems*, 22(1), 173-187. doi:10.1007/s11252-018-0805-3

Dory, J. (2017). Clash of urban philosophies. *Journal of Planning History*, 17(1), 20-41. doi:10.1177/1538513217691999

Erickson, R. J., & Billick, I. H. (1988). The areal Association of urban air pollutants and residential Characteristics: Louisville and Detroit. *Applied Geography*, 8(1), 5-23. doi:10.1016/0143-6228(88)90002-1

Faehnle, M., Söderman, T., Schulman, H., & Lehvävirta, S. (2014) Scale-sensitive integration of ecosystem services in urban planning. *GeoJournal*, 80(3), 411-425. doi:10.1007/s10708-014-9560-z

Fainstein, S. (2005). Planning Theory and the City. *Journal of Planning Education and Research*, 25, 121–30.

Fainstein S. (2015) Resilience and Justice, *International Journal of Urban and Regional Research*, 39(1) <https://doi.org/10.1111/1468-2427.12186>

- Fang, L., Zhang, D., Liu, T., Yao, S., Fan, Z., Xie, Y., . . . Li, X. (2021) A multi-level investigation of environmental justice on cultural ecosystem services at a national scale based on social media data: A case of accessibility to FIVE-A ecological attractions in China. *Journal of Cleaner Production*, 286, 124923. doi:10.1016/j.jclepro.2020.124923
- Ferguson, M., Roberts, H., McEachan, R., & Dallimer, M. (2018) Contrasting distributions of urban green infrastructure across social and ethno-racial groups. *Landscape and Urban Planning*, 175, 136-148. doi:10.1016/j.landurbplan.2018.03.020
- Fielding, J. & Burningham, K. (2005) Environmental inequality and flood hazard, *Local Environment*, 10:4, 379-395, DOI: 10.1080/13549830500160875
- Fitzgibbons, J. & Mitchell, C. (2019) Just urban futures? Exploring equity in “100 Resilient Cities”. *World Development*, 122, 648-659. Doi:10.1016/j.worlddev.2019.06.021
- Fricker, M. (2003). Epistemic justice and a role for virtue in the politics of knowing. *Metaphilosophy*, 34 (1–2), 154–73. doi: 10.1111/1467-9973.00266
- Gallo, K. P., McNab, A. L., Karl, T. R., Brown, J. F., Hood, J. J., & Tarpley, J. D. (1993). The use of a vegetation index for assessment of the urban heat island effect. *International Journal of Remote Sensing*, 14(11), 2223–2230. <https://doi.org/10.1080/01431169308954031>
- Gerwing, T. G., & Cox, K. (2017). Erosion of trust in government consultation will impede the creation of environmental policy. *Marine Policy*, 83, 126–127. <https://doi.org/10.1016/j.marpol.2017.06.005>
- Goodman, R. (1971). *After the Planners*. New York: Simon & Schuster.
- Grengs, J. (2018). ON THE WAY BUT NOT THERE YET: Making Accessibility the Core of Equity Planning in Transportation. In Krumholz N. & Hexter K. (Eds.), *Advancing Equity Planning Now* (pp. 127-148). ITHACA; LONDON: Cornell University Press. Retrieved March 20, 2021, from <http://www.jstor.org/stable/10.7591/j.ctv43vr3d.11>
- Haase, D., Kabisch, S., Haase, A., Andersson, E., Banzhaf, E., Baró, F., . . . Wolff, M. (2017). Greening cities – to be socially inclusive? About the alleged paradox of society and ecology in cities. *Habitat International*, 64, 41-48. doi:10.1016/j.habitatint.2017.04.005

Hall, C. R., & Knuth, M. J. (2019) An update of the literature supporting the well-being benefits of plants: Part 3 - social benefits. *Journal of Environmental Horticulture*, 37(4), 136-142. doi:10.24266/0738-2898-37.4.136

Hallett, R., Johnson, M. L., & Sonti, N. F. (2018). Assessing the tree health impacts of salt water flooding in coastal cities: A case study in New York City. *Landscape and Urban Planning*, 177, 171–177. <https://doi.org/10.1016/j.landurbplan.2018.05.004>

Hawken, P. (2018). *Drawdown: The most comprehensive plan ever proposed to roll back global warming*. London: Penguin Books.

Heberle, L., McReynolds, B., Sizemore, S., & Schilling, J. (2017) HUD's Sustainable Communities Initiative: An Emerging Model of Place-Based Federal Policy and Collaborative Capacity Building. *Cityscape* (19)3, 9-37.

Heckert, M., & Rosan, C. D. (2018) Creating gis-based planning tools to promote equity through green infrastructure. *Frontiers in Built Environment*, 4. doi:10.3389/fbuil.2018.00027

Heckert, M., & Rosan, C. D. (2016) Developing a green infrastructure equity index to promote equity planning. *Urban Forestry & Urban Greening*, 19, 263-270. doi:10.1016/j.ufug.2015.12.011

Henstra, D. (2012). Toward the Climate-Resilient City: Extreme Weather and Urban Climate Adaptation Policies in Two Canadian Provinces. *Journal of Comparative Policy Analysis: Research and Practice*, 14(2), 175–194. doi: 10.1080/13876988.2012.665215

Hogg W. D. & Hogg A. R. (2010) Historical trends in short duration rainfall in the Greater Toronto area. In: Report for the Toronto and region conservation authority. <http://trca.on.ca/dotAsset/105189.pdf>

Homsy, G. C., & Hart, S. (2019) [45]. Sustainability backfire: The unintended consequences of failing to engage neighborhood residents in policymaking. *Journal of Urban Affairs*, 1-22. doi:10.1080/07352166.2019.1607746

Horwitz, S. (2016). “Apartheid in a parka”? Roots and longevity of the Canada–South Africa comparison, *The Journal of South African and American Studies*, 17(4), 460-478. Doi:10.1080/17533171.2016.1223613

Houston, D., & Zuñiga, M. E. (2019) Put a park on it: How freeway caps are reconnecting and greening divided cities. *Cities*, 85, 98-109. doi:10.1016/j.cities.2018.08.007

Howe, D. (2018). PLANNING FOR AGING: Addressing Issues of Equity. In Krumholz N. & Hexter K. (Eds.), *Advancing Equity Planning Now* (pp. 203-224). ITHACA; LONDON: Cornell University Press. Retrieved March 20, 2021, from <http://www.jstor.org/stable/10.7591/j.ctv43vr3d.14>

Hulme, M. (2007). Newspaper scare headlines can be counter-productive. *Nature* 445, 818. <https://doi.org/10.1038/445818b>

ImagineCalgary (2006). Calgary's long-range urban sustainability plan. City of Calgary. <https://www.calgary.ca/pda/pd/office-of-sustainability/imaginecalgary.html>

[IPCC] Hoegh-Guldberg, O., D. Jacob, M. Taylor, et al. M. Bindi, S. Brown, I. ..., & G. Zhou (2018). Impacts of 1.5°C Global Warming on Natural and Human Systems, *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways...* In Press.

Jacobs, J. (1961). *The Death and Life of Great American Cities*. New York, New York: Random House.

Jandaghian, Z., & Akbari, H. (2021). Increasing urban albedo to reduce heat-related mortality in Toronto and Montréal, Canada. *Energy and Buildings*, 237, 110697. <https://doi.org/10.1016/j.enbuild.2020.110697>

Jon, I. (2020). Deciphering Posthumanism: Why and how it matters to urban planning in the Anthropocene. *Planning Theory*, 19(4), 392-420. doi:10.1177/1473095220912770

Kameshwari P. & Samuel M. A. (2015) Sustainable Food Systems at Urban Public Universities: A Survey of U-21 Universities, *Journal of Urban Affairs*, 37:3, 341-359, DOI: 10.1111/juaf.12149

Keith, M., Lockridge, A. & Mackenzie, C. (2005). Declining Sex Ratio in a First Nation Community. *Environmental Health Perspectives*, 113 (10) 1295-1298

Krumholz N. & Hexter K. W. (2018). *Advancing Equity Planning Now*, Cornell University Press. Retrieved from <https://www.jstor.org/stable/10.7591/j.ctv43vr3d>

Lane, M. B. (2006). The role of planning in achieving indigenous land justice and community goals. *Land Use Policy*, 23(4), 385-394. doi:10.1016/j.landusepol.2005.05.001

Langemeyer, J., & Connolly, J. J. (2020). Weaving notions of justice into urban ecosystem services research and practice. *Environmental Science & Policy*, 109, 1-14. doi:10.1016/j.envsci.2020.03.021

- Lanza, K., & Durand, C. P. (2021) Heat-moderating effects of bus stop shelters and tree shade on public transport ridership. *International Journal of Environmental Research and Public Health*, 18(2), 463. doi:10.3390/ijerph18020463
- Larson, S. (2011). Whose city is it Anyway? Jane Jacobs Vs. Robert Moses and contemporary redevelopment politics in New York City. *Berkeley Planning Journal*, 22(1). doi:10.5070/bp32215358
- Larson, K. L., Wiek, A., & Withycombe Keeler, L. (2013) A comprehensive Sustainability appraisal of WATER governance in Phoenix, AZ. *Journal of Environmental Management*, 116, 58-71. doi:10.1016/j.jenvman.2012.11.016
- Lin, B., Meyers, J., & Barnett, G. (2015) Understanding the potential loss and inequities of green space distribution with urban densification. *Urban Forestry & Urban Greening*, 14(4), 952-958. doi:10.1016/j.ufug.2015.09.003
- Lipper, B., & Nelson, P. (2019, July 31). 100 Resilient Cities. Retrieved from <https://www.100resilientcities.org/>
- Lorinc, J., & Pitter, J. (2016). *Subdivided: City-building in an age of hyper-diversity*. Toronto: Coach House Books
- Lutz, W., & K C, S. (2010). Dimensions of global population projections: what do we know about future population trends and structures?. *Philosophical transactions of the Royal Society of London. Series B, Biological sciences*, 365(1554), 2779–2791. <https://doi.org/10.1098/rstb.2010.0133>
- Luz, A. C., Buijs, M., Aleixo, C., Metelo, I., Grilo, F., Branquinho, C., . . . Pinho, P. (2019) Should I stay or should I go? Modelling the fluxes of urban residents to visit green spaces. *Urban Forestry & Urban Greening*, 40, 195-203. doi:10.1016/j.ufug.2019.01.009
- Lyle, T. S., & Mills, T. (2016). Assessing coastal flood risk in a changing climate for the City of Vancouver. *Canadian Water Resources Journal / Revue Canadienne Des Ressources Hydriques*, 41(1–2), 343–352. <https://doi.org/10.1080/07011784.2015.1126695>
- Mason, L. R., Ellis, K. N., & Hathaway, J. M. (2019) Urban flooding, social equity, and “backyard” green infrastructure: An area for multidisciplinary practice. *Journal of Community Practice*, 27(3-4), 334-350. doi:10.1080/10705422.2019.1655125

- Maivel, M., Kurnitski, J., & Kalamees, T. (2014). Field survey of overheating problems in Estonian apartment buildings. *Architectural Science Review*, 58(1), 1–10. <https://doi.org/10.1080/00038628.2014.970610>
- Majekodunmi, M., Emmanuel, R., & Jafry, T. (2020) A spatial exploration of deprivation and green infrastructure ecosystem services Within Glasgow city. *Urban Forestry & Urban Greening*, 52. doi:10.1016/j.ufug.2020.126698
- Mason, L. R., Ellis, K. N., & Hathaway, J. M. (2019) Urban flooding, social equity, and “backyard” green infrastructure: An area for multidisciplinary practice. *Journal of Community Practice*, 27(3-4), 334-350. doi:10.1080/10705422.2019.1655125
- McClintock, N., Mahmoudi, D., Simpson, M., & Santos, J. P. (2016) Socio-spatial differentiation in the Sustainable city: A mixed-methods assessment of RESIDENTIAL gardens in METROPOLITAN Portland, Oregon, USA. *Landscape and Urban Planning*, 148, 1-16. doi:10.1016/j.landurbplan.2015.12.008
- Meerow, S., & Newell, J. P. (2016) Urban resilience for whom, what, when, where, and why? *Urban Geography*, 40(3), 309–329. doi: 10.1080/02723638.2016.1206395
- Meerow, S., Newell, J. P., & Stults, M. (2016). Defining urban resilience: A review. *Landscape and Urban Planning*, 147, 38–49. doi: 10.1016/j.landurbplan.2015.11.011
- Meerow, S., & Woodruff, S. C. (2019). Seven Principles of Strong Climate Change Planning. *Journal of the American Planning Association*, 86(1), 39–46. doi: 10.1080/01944363.2019.1652108
- Mell, I. C. (2017). Green infrastructure: Reflections on past, present and future praxis. *Landscape Research*, 42(2), 135-145. doi:10.1080/01426397.2016.1250875
- Metzger, J. T. (1996). The Theory and Practice of Equity Planning: An Annotated Bibliography. *Journal of Planning Literature*, 11(1), 112–126. <https://doi.org/10.1177/088541229601100106>
- Milly, P. C. D., Wetherald R. T., Dunne, K. A. , & Delworth, T. L. (2002). Increasing Risk of Great Floods in a Changing Climate, *Nature*. 415, 514-517
- Montréal Resilience Strategy. (2018). Rockefeller Foundation. City Resilience Framework - 100 Resilient Cities.
- Moore, M., Gould, P., & Keary, B. S. (2003). Global urbanization and impact on health. *International Journal of Hygiene and Environmental Health*, 206(4-5), 269-278. doi:10.1078/1438-4639-00223

- Moser, S. C. (2016). Reflections on climate change communication research and practice in the second decade of the 21st Century: What more is there to say? *WIREs Climate Change*, 7(3), 345–369. <https://doi.org/10.1002/wcc.403>
- Naess, L.O., Bang G., Eirksen S., & Veatne J. (2004). Institutional Adaption to Climate Change: Flood Responses at the Municipal Level in Norway, *Global Environmental Change*. 15(2), 125-138.
- Nirupama, N., & Simonovic, S. P. (2006). Increase of Flood Risk due to Urbanisation: A Canadian Example. *Natural Hazards*, 40(1), 25-41. doi:10.1007/s11069-006-0003-0
- Nirupama, N., Armenakis, C. & Montpetit, M. (2014). Is flooding in Toronto a concern?. *Nat Hazards* 72, 1259–1264. <https://doi.org/10.1007/s11069-014-1054-2>
- Nesbitt, L., Meitner, M. J., Girling, C., Sheppard, S. R., & Lu, Y. (2019). Who has access to URBAN vegetation? A spatial analysis of DISTRIBUTIONAL GREEN equity in 10 US cities. *Landscape and Urban Planning*, 181, 51-79. doi:10.1016/j.landurbplan.2018.08.007
- Newell, J. P., Seymour, M., Yee, T., Renteria, J., Longcore, T., Wolch, J. R., & Shishkovsky, A. (2013) Green alley programs: Planning for a sustainable urban infrastructure? *Cities*, 31, 144-155. doi:10.1016/j.cities.2012.07.004
- Nowell, L. S., Norris, J. M., White, D. E., & Moules, N. J. (2017). Thematic Analysis. *International Journal of Qualitative Methods*, 16(1), 160940691773384. doi:10.1177/1609406917733847
- Oberndorfer, E., Lundholm, J., Bass, B., Coffman, R. R., Doshi, H., Dunnett, N., Gaffin, S., Köhler, M., Liu, K. K., & Rowe, B. (2007). Green Roofs as Urban Ecosystems: Ecological Structures, Functions, and Services. *BioScience*, 57(10), 823–833. <https://doi.org/10.1641/b571005>
- O’Hare, P., White, I. Beyond ‘just’ flood risk management: the potential for—and limits to—alleviating flood disadvantage. *Reg Environ Change* 18, 385–396 (2018). <https://doi.org/10.1007/s10113-017-1216-3>
- Ortiz-Moya, F. (2018) Green growth strategies in a shrinking city: TACKLING urban revitalization through environmental justice in kitakyushu city, japan. *Journal of Urban Affairs*, 42(3), 312-332. doi:10.1080/07352166.2018.1448225

Owringi, A.M., Lannigan, R. & Simonovic, S.P. (2014). Interaction between land-use change, flooding and human health in Metro Vancouver, Canada. *Nat Hazards* 72, 1219–1230. <https://doi-org.proxy.lib.uwaterloo.ca/10.1007/s11069-014-1064-0>

Permansingh, J. (2017). Hydrological Analysis of the Historical May 2017 Flooding Event in Montréal and Surrounding Areas. BREE 631: IWRM Internship Project, McGill University

Pellow, D. N. (2016). TOWARD a CRITICAL environmental Justice studies. *Du Bois Review: Social Science Research on Race*, 13(2), 221-236. doi:10.1017/s1742058x1600014x

Pickett, S. T., Mcgrath, B., Cadenasso, M., & Felson, A. J. (2013). Ecological resilience and resilient cities. *Building Research & Information*, 42(2), 143–157

Poff, N., Allan, J., Bain, M., Karr, J., Prestegard, K., Richter, B., . . . Stromberg, J. (1997). The Natural Flow Regime. *BioScience*, 47(11), 769-784. doi:10.2307/1313099

Porse, E. (2018) Open data and stormwater systems in Los ANGELES: Applications for equitable green infrastructure. *Local Environment*, 23(5), 505-517. doi:10.1080/13549839.2018.1434492

Prusak, S. Y., Walker, R., & Innes, R. (2016). Toward indigenous Planning? First Nation community planning in Saskatchewan, Canada. *Journal of Planning Education and Research*, 36(4), 440-450. doi:10.1177/0739456x15621147

Ramirez-Rubio, O., Daher, C., Fanjul, G., Gascon, M., Mueller, N., Pajín, L., Plasencia, A., Rojas-Rueda, D., Thondoo, M., & Nieuwenhuijsen, M. J. (2019). Urban health: an example of a "health in all policies" approach in the context of SDGs implementation. *Globalization and health*, 15(1), 87. <https://doi.org/10.1186/s12992-019-0529-z>

Reece, J. W. (2018). In Pursuit of a Twenty-first Century Just City: The Evolution of Equity Planning Theory and Practice. *Journal of Planning Literature*, 33(3), 299–309. <https://doi.org/10.1177/0885412218754519>

Resilient Cities Network. (2021). <https://resilientcitiesnetwork.org/>

Rigolon, A., & Németh, J. (2018) “We’re not in the business of housing:” environmental gentrification and the nonprofitization of green infrastructure projects. *Cities*, 81, 71-80. doi:10.1016/j.cities.2018.03.016

Rockefeller Foundation. (2020, March 30). City Resilience Framework - 100 Resilient Cities. City Resilience Framework – 100 Resilient Cities. <https://www.rockefellerfoundation.org/report/city-resilience-framework-2/>.

Sanchez, L., & Reames, T. G. (2019) Cooling detroit: A socio-spatial analysis of equity in green roofs as an urban heat island mitigation strategy. *Urban Forestry & Urban Greening*, 44. doi:10.1016/j.ufug.2019.04.014

Sañudo-Fontaneda, L. A., & Robina-Ramírez, R. (2019). Bringing community perceptions into sustainable urban drainage systems: The experience of Extremadura, Spain. *Land Use Policy*, 89, 104251. <https://doi.org/10.1016/j.landusepol.2019.104251>

Schlosberg D. (2007) Defining Environmental Justice: Theories, Movements, and Nature. DOI:10.1093/acprof:oso/9780199286294.001.0001

Scott, K.A. (2020) Reconciliation and Energy Democracy. *Canadian Journal of Program Evaluation*, 34(3)

Silver, C. (1997). THE RACIAL ORIGINS OF ZONING IN AMERICAN CITIES From: Manning Thomas, June and Marsha Ritzdorf eds. *Urban Planning and the African American Community: In the Shadows*. Thousand Oaks, CA: Sage Publications, 1997.

Skocpol, T., & Hertel-Fernandez, A. (2016). The Koch network and Republican party extremism. *Perspectives on Politics*, 14(3), 681-699. doi:10.1017/s1537592716001122

Smith, M. E. (2007). Form and meaning in the earliest cities: A new approach to ancient urban planning. *Journal of Planning History*, 6(1), 3-47. doi:10.1177/1538513206293713

Smoyer-Tomic, K.E., Kuhn, R. & Hudson, A. (2003). Heat Wave Hazards: An Overview of Heat Wave Impacts in Canada. *Natural Hazards* 28, 465–486. <https://doi.org/10.1023/A:1022946528157>

Swanstrom, T. (2018). EQUITY PLANNING IN A FRAGMENTED SUBURBAN SETTING: The Case of St. Louis. In Krumholz N. & Hexter K. (Eds.), *Advancing Equity Planning Now* (pp. 101-124). ITHACA; LONDON: Cornell University Press. Retrieved March 20, 2021, from <http://www.jstor.org/stable/10.7591/j.ctv43vr3d.10>

Swenson, K. (2014) [6]. Designing Better Designers: Families First. *Cityscape*, (16)2, 103-116.

Tabuchi, H. (2018, June 19). How the Koch brothers are killing public transit projects around the country. Retrieved March 15, 2021, from <https://www.nytimes.com/2018/06/19/climate/koch-brothers-public-transit.html>

Toronto Resilience Strategy. (2019). Rockefeller Foundation. City Resilience Framework - 100 Resilient Cities.

TRCA (2006) Don mouth naturalization and port lands flood protection project: revised terms of reference. The Toronto and Region Conservation Authority, Toronto

TRCA. (2019). Don Mouth Naturalization and Port Lands Flood Protection Project, Toronto Region Conservation Authority. Retrieved November 13, 2020, from <https://trca.ca/conservation/green-infrastructure/don-mouth-naturalization-port-lands-flood-protection-project/>

TRCA. (2021). Flood Plain Map <https://trca.ca/conservation/flood-risk-management/flood-plain-map-viewer/#map>.

Tuvikene, T., Sgibnev, W., Zupan, D., Jovanović, D., & Neugebauer, C. S. (2020) Post-socialist infrastructuring. *Area*, 52(3), 575-582. doi:10.1111/area.12590

Uchiyama, Y., & Kohsaka, R. (2020) Access and use of green areas during the COVID-19 PANDEMIC: Green infrastructure management in the “New Normal”. *Sustainability*, 12(23), 9842. doi:10.3390/su12239842

Venter, Z. S., Shackleton, C. M., Van Staden, F., Selomane, O., & Masterson, V. A. (2020) Green apartheid: Urban green infrastructure Remains unequally distributed across income and Race geographies in South Africa. *Landscape and Urban Planning*, 203. doi:10.1016/j.landurbplan.2020.103889

Vancouver Resilience Strategy. (2019). Rockefeller Foundation. City Resilience Framework - 100 Resilient Cities.

Ville de Montréal. (2020, December). Montréal Climate Plan: Objective carbon-neutral by 2050. Montréal. <https://Montréal.ca/en/articles/Montréal-climate-plan-objective-carbon-neutral-2050-7613>

Vitousek, S., Barnard, P., Fletcher, C. et al. Doubling of coastal flooding frequency within decades due to sea-level rise. *Sci Rep* 7, 1399 (2017). <https://doi.org/10.1038/s41598-017-01362-7>

von Hoffman, A. (2009). Housing and Planning: A Century of Social Reform and Local Power. *Journal of the American Planning Association* 75 (2), 231–44

Walsh, E., Becker, W., Judelsohn, A., & Hall, E. (2017) Civic Infrastructure and Sustainable Regional Planning: Insights From the Sustainable Communities Initiative Regional Planning Grantees. *Cityscape* (19)3, 63-92.

Wang, J., Xu, C., Pauleit, S., Kindler, A., & Banzhaf, E. (2019) Spatial patterns of urban green infrastructure for equity: A novel exploration. *Journal of Cleaner Production*, 238. doi:10.1016/j.jclepro.2019.117858

Wang X., Huang G., Liu J. (2014b) Projected increases in intensity and frequency of rainfall extremes through a regional climate modeling approach. *J Geophys Res Atmos* 119(23):13271–13286. doi: 10.1002/2014JD022564

Weber, T., & Wolf, J. (2000). Maryland's Green Infrastructure—Using Landscape Assessment Tools to Identify a Regional Conservation Strategy. *Environmental Monitoring and Assessment*, 63(1), 265-277. doi:10.1023/a:1006416523955

Weiss, M. A. (1987). *The rise of the community builders: The American real estate industry and urban land planning*. New York: Columbia University Press.

Welsh, M. (2019, May 21). Toronto keeps flooding when it rains hard. Here's why. Retrieved November 15, 2020, from <https://projects.thestar.com/climate-change-canada/toronto-flooding/>

Wheater, H., & Evans, E. (2009). Land use, water management and future flood risk. *Land Use Policy*, 26. <https://doi.org/10.1016/j.landusepol.2009.08.019>

William, R., Garg, J., & Stillwell, A. S. (2017) A game theory analysis of green infrastructure stormwater management policies. *Water Resources Research*, 53(9), 8003-8019. doi:10.1002/2017wr021024

Williams, K., Joynt, J. L., & Hopkins, D. (2010) Adapting to climate change in the compact city: The suburban challenge. *Built Environment*, 36(1), 105-115. doi:10.2148/benv.36.1.105

Wolff, M., Scheuer, S., & Haase, D. (2020). Looking beyond boundaries: Revisiting the Rural-urban interface of green SPACE accessibility in Europe. *Ecological Indicators*, 113. doi:10.1016/j.ecolind.2020.106245

Xiao, Y., Wang, D., & Fang, J. (2019) Exploring the disparities in park access through mobile PHONE DATA: Evidence from Shanghai, China. *Landscape and Urban Planning*, 181, 80-91. doi:10.1016/j.landurbplan.2018.09.013

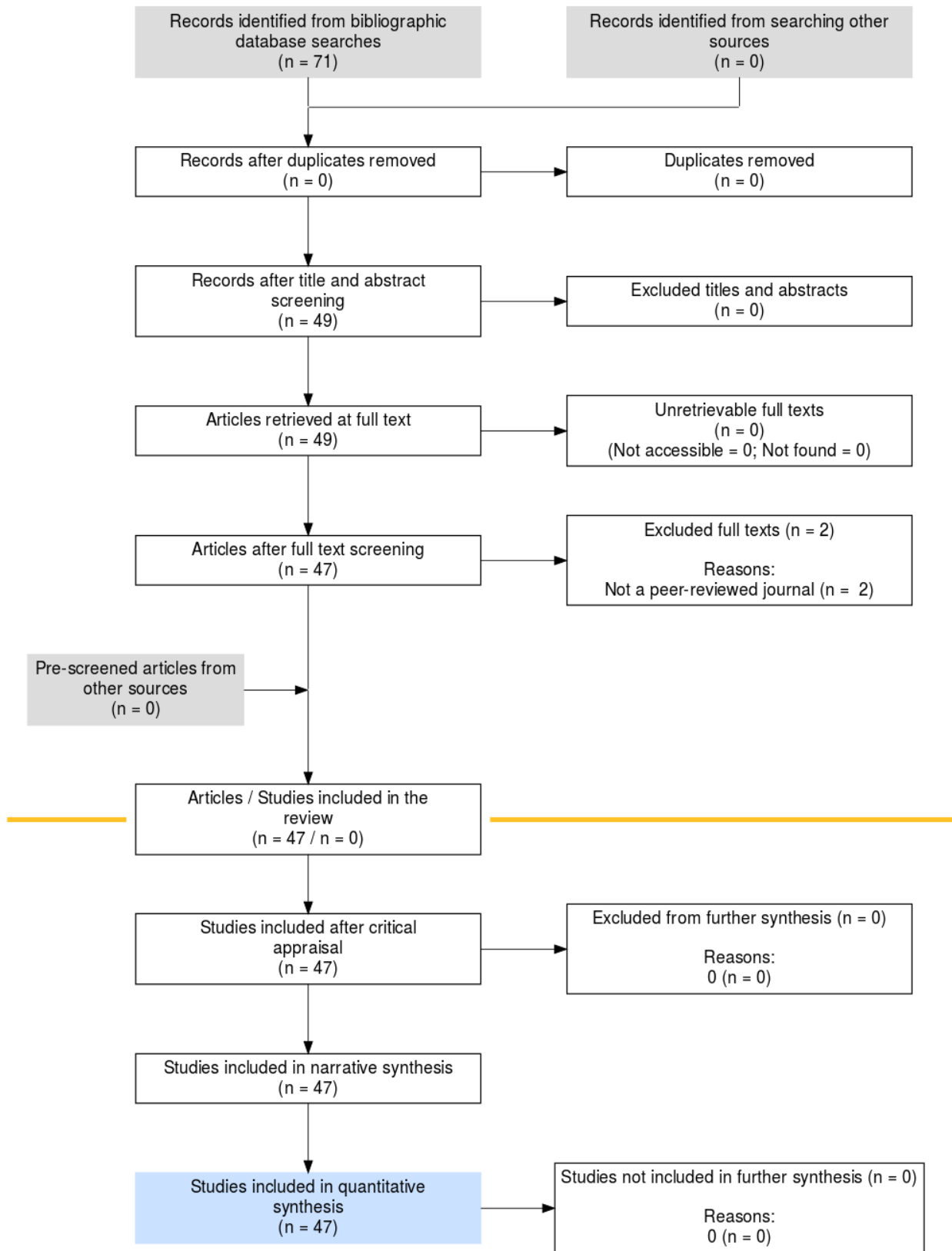
Yang, L., Qian, F., Song, D.-X., & Zheng, K.-J. (2016). Research on Urban Heat-Island Effect. *Procedia Engineering*, 169, 11–18. <https://doi.org/10.1016/j.proeng.2016.10.002>

Zhu, Z., Ren, J., & Liu, X. (2019) Green infrastructure provision for environmental Justice: Application of the equity index in Guangzhou, China. *Urban Forestry & Urban Greening*, 46. doi:10.1016/j.ufug.2019.126443

Zuniga-Teran, A. A., Staddon, C., De Vito, L., Gerlak, A. K., Ward, S., Schoeman, Y., . . . Booth, G. (2019). Challenges of mainstreaming green infrastructure in built environment professions. *Journal of Environmental Planning and Management*, 63(4), 710-732. doi:10.1080/09640568.2019.1605890

Zuniga-Teran, A. A., Mussetta, P. C., Lutz Ley, A. N., Díaz-Caravantes, R. E., & Gerlak, A. K. (2020) Analyzing water policy impacts on vulnerability: Cases across the Rural-urban continuum in the ARID AMERICAS. *Environmental Development*. doi:10.1016/j.envdev.2020.100552

Appendix A



Appendix B

Questions	<i>TransformTO</i>	<i>Toronto Resilience Strategy</i>	<i>Vancouver CCAP</i>	<i>Toronto Resilience Strategy</i>	<i>imagineCalgary</i>	<i>Calgary Resilience Strategy</i>	<i>Montréal CCAP</i>	<i>Montréal Resilience Strategy</i>	Type of Equity Assessed
1. Are specific populations of interest (e.g. vulnerable populations) identified in the strategy?	1	1	1	0.5	0.5	1	1	0.5	Recognitional Equity
2. Is the root cause vulnerability of certain populations explored or treated? (e.g. historic or structural reasons for their vulnerability)	0	0	0	0.5	0	1	0	0	Recognitional Equity; Epistemic Justice
3. Are benefits of green infrastructure goals/actions intentionally directed at populations of interests?	0.5	1	1	0.5	0.5	0.5	0.5	0.5	Distributional Equity
4. Is there evidence that the strategy attempts to improve access and spatial equity for residents so all populations can receive benefits of green infrastructure by actions in the strategy?	0.5	1	0.5	0.5	0	0.5	0	0	Distributional Equity; Spatial Equity
5. Are potential negative impacts from actions acknowledged in the strategy?	0	0	0	0	0	0	0	0	Recognitional Equity; Epistemic Justice
6. Are multiple types of equity and potential intersection between them addressed in the strategy?	0.5	1	0.5	1	0	1	0	0	Recognitional Equity; Intersectionality
7. Is equity defined in the strategy?	0.5	1	1	0	0	1	0	0	Procedural Equity; Transparency
8. Does the plan address equity considerations when applying green infrastructure?	0	1	0.5	0	0	0.5	0	0	Recognitional Equity
9. Does the strategy include vulnerable populations in the decision-making process for green infrastructure implementation?	0.5	0.5	0	0	0	1	0	0	Procedural Equity
10. Does the strategy describe what rationale was used to identify and recruit stakeholders?	1	1	0.5	0.5	0	1	0	0	Procedural Equity; Epistemic Justice

11. Does the strategy mention that vulnerable populations were encouraged to voice their concerns about green infrastructure?	0	0	0.5	0	0	0.5	0	0	Procedural Equity; Epistemic Justice
12. Does the strategy offer translation services or multi-language materials for minority or second-language communities?	0.5	0	0	0	0	0	0	0	Recognitional Equity; Intersectionality
13. Are there plans for ongoing participation in regard to voicing concerns with green infrastructure implementation, or is the strategy portrayed as "finished"?	1	0.5	1	0.5	0	1	0.5	0	Procedural Equity; Epistemic Justice
14. Is green infrastructure and its benefits defined and explained in this strategy?	0	1	1	0	0	1	0.5	0.5	Procedural Equity; Transparency
15. Does the strategy indicate that it offered educational materials or outreach initiatives to help residents learn about green infrastructure in their community?	0	0	0	0.5	0.5	0.5	0.5	0	Procedural Equity
16. Do any educational outreach initiatives include vulnerable neighbourhoods?	1	0	0	0	0	0	0	0.5	Procedural Equity; Spatial Equity
17. Does the strategy include a plan for monitoring the effectiveness of implemented green infrastructure?	0	0	0	0	0	1	1	0.5	Procedural Equity; Epistemic Justice
18. Does the strategy identify priority neighbourhoods for green infrastructure implementation?	0.5	0.5	1	0	0	0	0.5	0	Procedural Equity; Spatial Equity
19. Does the strategy identify and explain how green infrastructure can mitigate climate risks?	0	1	1	0	1	1	0.5	0.5	Procedural Equity
20. Does the strategy identify and propose actions to mitigate heat risks using green infrastructure?	0.5	1	1	0	0.5	0.5	1	1	Procedural Equity

21. Does the strategy identify and propose actions to mitigate flood risks using green infrastructure?	0	1	1	0	1	1	0.5	1	Procedural Equity
22. Does the strategy explain how green infrastructure can support disaster recovery?	0	0.5	0	0	0	0.5	0	0	Procedural Equity
23. Are different levels of the city addressed for green infrastructure implementation (e.g., microscale, neighbourhood, holistic?)	0	0	0.5	0	0	0	0	0	Distributional Equity; Spatial Equity
24. Is indigenous knowledge addressed and considered for green infrastructure implementation within the strategy?	1	0.5	0.5	1	0.5	0.5	0	0	Recognitional Equity; Intersectionality
25. Does green infrastructure implementation consider intergenerational equity?	0	0.5	0	0	1	0.5	0	0	Intergenerational Equity; Intersectionality
Total Score:	9	14	12.5	5.5	5.5	15.5	6.5	5	