Institutional Barriers and Enablers for Green Infrastructure Implementation: A Case-Study of the City of Brampton, Ontario, using the Institutional Analysis and Development framework.

by

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AUTHOR'S DECLARATION

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

I understand that my thesis may be made electronically available to the public.

ABSTRACT

Green infrastructure (GI) has increasingly being deliberated in the planning discourse for its multifunctionality and applicability to address a number of urban issues. However, despite the benefits, the mainstream use of GI principles and concepts in urban planning is limited. For some time now, city planners have found it challenging to institutionalizing GI approaches in policy and practise. Research has indicated a number of systemic barriers to operationalizing the concept including political will, funding opportunities, and existing city planning practises. However, despite these challenges, there are examples emerging in cities where municipal governments are foraying into implementing GI and the concept is finding a place in Official plans and policy documents. Using the City of Brampton as a case study, this thesis attempts to learn from the early experiences of policy and planning practises to identify enablers and challenges in GI implementation.

Using a qualitative case study research approach, the thesis investigates GI implementation through Ostrom's Institutional Analysis and Development (IAD) framework. Semi-structured interviews with 16 experts and document analysis of plans, and policy documents are used to focus on the operational level action arena. The case study shows a polycentric model supported through nested rules from all levels of governments. Though the various levels of government outline different outcomes from GI implementation, in this case study of Brampton, GI implementation centres around naturalisation policies and use of new GI technologies in water resource management. The case study observed a watershed scale of planning for GI and emphasises the changing role of conservation authorities as a technical unit that provides expertise and support for GI implementation

The study evaluates the observed polycentric model facilitated by a collaborative comanagement approach for required time, transaction costs and effectiveness. The observed collaborative approach is reliant on prescriptive policies, negotiations, experimental projects, and creation of awareness and capacities around new GI technologies. The study recommends a master planning approach to facilitate decentralised community-led approaches and supporting them through financial incentives and technical assistance to upscale new GI technologies.

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TABLE OF CONTENTS

AUTHOR'S DECLARATION	iii
ABSTRACT	v
ACKNOWLEDGEMENTS	vi
LIST OF FIGURES	ix
LIST OF TABLES	Х
LIST OF ABBREVIATIONS	xi
SECTION 1: INTRODUCTION	
1.1 Background	
1,2 Main Results and Recommendations	
1.3 Structure of the Thesis	5
SECTION 2: LITERATURE REVIEW	
2.1 Urbanisation and Environment	6
2.2 Environment Planning and Green Infrastructure	8
2.3 Definitions	
2.4 Application and Benefits of Green Infrastructure	13
2.5 Scale of Green Infrastructure Applications	
2.6 Implementation of Green Infrastructure	21
2.7 Need for the Study	30
SECTION 3: METHODOLOGY	33
3.1 Research Philosophy and Paradigm	33
3.2 Scope of the Study	34
3.3 Research Approach	37
3.4 Theoretical Framework	39
3.5 Research Methods	48
SECTION 4: SITUATING GREEN INFRASTRUCTURE – FINDINGS	57
4.1 Introduction	57
4.2 Exogenous Variables	59
4.2.1 Biophysical Attributes	60
4.2.2 Community Attributes	62
4.2.3 Rules-in-Use	65
4.3 Action Arena	85
4.3.1 Identifying Actors	87
4.3.2 Action Situation	89
4.4 Interactions	104
4.5 Outcomes	112
4.6 Evaluation Criteria	115
4.6.1 Time	116
4.6.2 Transaction Cost	118
4.6.3 Effectiveness	
	120
SECTION 5: DISCUSSION AND RECOMMENDATIONS	128
SECTION 5: DISCUSSION AND RECOMMENDATIONS	
5.1 Discussion	129
5.1 Discussion	 129 129
5.1 Discussion	129 129 132
5.1 Discussion	129 132 132
5.1 Discussion	129 132 132 133
5.1 Discussion	129 132 132 133 135
5.1 Discussion	129 132 132 133 135

5.3 Contributions of the Study		
5.4 Limitations and Further Research Opportunities	144	
5.5 Conclusions	145	
REFERENCES		
APPENDICES	159	
Appendix A. Interview Guide	159	
Appendix B. Material used for Document Analysis	163	
Appendix C. Recruitment Cover Letter/Email	164	
Appendix C1. Script for Recruitment of Participants over Phone	165	
Appendix D. Letter of Information	166	
Appendix E. Consent Form	168	
Appendix F. Feedback Letter	169	
Appendix G. Action Arena Analysis	170	

LIST OF FIGURES

Figure 1: Map showing Cities in Ontario having Policies for GI included in their Official Plan	36
Figure 2: Diagram showing the Research Questions mapped on the Components of the IAD Framew	vork.
	42
Figure 3: Diagram showing the Links between Rules-in-Use and Level of Analysis.	45
Figure 4: Diagram showing the Position Rules of the Action Situation.	46
Figure 5: Flow chart showing the Sequence followed to Design the Interview Questions	51
Figure 6: Exogenous Variables for the City of Brampton.	59
Figure 7: Map showing the Geographical Location of City of Brampton	60
Figure 8: Chart indicating the Flow of Funds for GI from the Federal to Provincial level	73
Figure 9: Chart showing the Rules-in-Use at the Provincial Level.	79
Figure 10: Chart showing the various Implementation Programs at the Municipal Level and the	
Stakeholders involved	86
Figure 11: Diagram mapping the Actors, and their Roles and Responsibilities in the Action Arena	88
Figure 12: Chart showing the Existing and Newly forming Horizontal Linkages (Interaction) between	1
various Stakeholders involved in Implementation.	111
Figure 13: Schematic Diagram - IAD Components	127

LIST OF TABLES

Table 1: Green Infrastructure Types and their Ecological Services as identified in Literature	18
Table 2: Different Scales of Green Infrastructure	20
Table 3: Purpose and Techniques used for the Research Study.	50
Table 4: Interview Guide.	50
Table 5: List of Study Participants Contacted and their Roles for the Research	52
Table 6: Various Initiatives and Tools used for GI Implementation at the different Government	Levels.84
Table 7: Categorising GI Types and Actions Tools by Action Situation	89
Table 8: Approaches for GI Implementation on Public Lands.	92
Table 9: Approaches for GI Implementation on Private Lands	97
Table 10: Funding Priorities at the Federal Level.	112
Table 11: Enablers and Challenges for GI Implementation in the City of Brampton.	131

LIST OF ABBREVIATIONS

	Consequentian Authority
CA	Conservation Authority
CEF	Clean Energy Fund
CVC	Credit Valley Conservation Authority
CWWF	Clean Water and Wastewater Fund
EIA	Environment Impact Assessment
EMP	Environmental Master Plan
EPA	Environmental Protection Agency
FCM	Federation of Canadian Municipalities
FSDS	Federal Sustainable Development Strategy
GGH	Greater Golden Horseshoe
GHG	Greenhouse gases
GI	Green Infrastructure
GIF	Green Infrastructure Fund
GIOC	Green Infrastructure Ontario Coalition
GTA	Greater Toronto Area
GTHA	Greater Toronto Hamilton Area
MAH	Ministry of Municipal Affairs and Housing
HERCULES	High Ecological Resolution Classification for Urban Landscapes and Environmental Systems
IAD	Institutional Analysis and Development
LCZ	Local Climate Zones
IEA	International Energy Agency
INFC	Infrastructure Canada
LID	Low Impact Development
LULC	Landuse and Land Cover
MEA	Millennium Ecosystem Assessment
MECP	Ministry of Environment Conservation and Parks
MNRF	Ministry of Natural Resources and Forestry
MOECC	Ministry of Environment and Climate Change
MTTP	MillionTreesNYC Training Program
NEA	Niagara Escarpment Area
NEP	Niagara Escarpment Plan
NHEMS	Natural Heritage and Environmental Management Strategy
NHRP	Natural Heritage System Restoration Program
NHS	Natural Heritage system
OPPI	Ontario Professional Planners Institute
ORMA	Oak Ridges Moraine Area
ORMCP	Oak Ridges Moraine Conservation Plan
PCF-CC	Pan Canadian Framework on Clean Growth and Climate Change
	Ü

LIST OF ABBREVIATIONS Continued

PPS	Provincial Policy Statement				
SCDG	Sustainable Community Development Guidelines				
SNAP	Sustainable Neighbourhood Retrofit Action Plan				
SPF	Sustainable Planning Framework				
STEP	Sustainable Technologies Evaluation Program				
TEEB	The Economics of Ecosystems and Biodiversity				
TPI	Tree Plantation Initiatives				
TRCA	Toronto Region Conservation Authority				

Section 1: Introduction

1.1 Background

For more than a decade, green infrastructure (GI) has been emerging as a subject of scholarly research and professional practice (Ahern, 2007, 2014; Benedict & McMahon, 2006; di Marino & Lapintie, 2017; Dupras et al., 2015; Mell, 2007, 2016; Williamson, 2003). Academics, professional experts and city planners advocate the use of ecosystem services to address modern day environmental challenges in urban areas (Ahern, 2007; Gómez-Baggethun & Barton, 2013; Mell, 2007; Millennium Ecosystem Assessment, 2003). Research and demonstrated projects have shown how GI practices enable important ecosystem services such as improving urban air and water quality, addressing urban flooding, mitigating climate change, mitigating heat island effect, and supporting urban biodiversity (Ahern, 2007; Gómez-Baggethun & Barton, 2013; Mell, 2007; Millennium Ecosystem Assessment, 2003). Documented examples of GI implementation have shown opportunities in green job creation and positively affecting mental and physical well-being of urban dwellers (Falxa-Raymond et al., 2013). Despite the increasing evidence on the benefits of GI, many studies point out that the actual use of the concept has been sporadic, largely experimental and small scale (Lennon, 2014; Young 2011). For some time now, studies are also suggesting that city planners find it equally challenging to upscale these approaches into mainstream city planning principles (Dupras et al., 2015; Schiappacasse & Muller, 2015). Policy progress on GI implementation and approaches of institutionalising GI are still in its early stages in Canada and around the world (di Marino & Lapintie, 2017).

Recent literature reviews list a number of barriers to mainstreaming GI at the planning and policy level. Political will, prevailing infrastructure planning practises, absence of planning and policy frameworks that recognise GI, need for localising GI knowledge and communication and awareness are some of the identified barriers in implementation (di Marino & Lapintie, 2017; Dupras et al., 2016). Current policy discourse, interdepartmental coordination, funding opportunities are also identified as areas that need further attention (di Marino & Lapintie, 2017;

Dupras et al., 2016). However, more recently research on understanding best practises in GI policy-making is emerging (Chinni et al., 2017; Cortinovis & Geneletti, 2018; Mekala & Hatton-Macdonalds, 2016; Young, 2011). Cities are also experimenting with different approaches in adopting GI concepts, developing policies, and an implementation environment at the municipal level (GIOC, 2018a; Young, 2011). However, the literature on how these cities perceive and are developing systems to internalise the opportunities provided by GI and the challenges and opportunities therein still is scarce.

This research aims to understand approaches to implementing GI concepts at the municipal scale. Using an institutional theory lens (Ostrom, 2005), and as case study the City of Brampton, the research explores the planning approaches adopted to use GI concepts at the city level and the tools that are shaping its implementation. Using a qualitative mixed methods research approach, the study explores the institutional enablers and barriers to implementing a GI policy framework by analysing policy documents (Mason, 1996; Patton, 2002), and undertaking interviews with stakeholders (Kvale, 2007) involved in the city planning discourse.

Understanding the institutional systems (Ostrom, 2005) is important because policy-making and city planning is influenced by the various socio-economic factors, and formal and informal rules, norms and strategies adopted by communities. Therefore, applying an institutional lens to the study is imperative to understand the barriers and enablers to arrive at an effective GI policy and implementation strategy.

1.1.1 Purpose statement

Adopting a case study approach, this research focuses on how planning practices are using GI concepts, and what institutional tools are shaping GI implementation. The study attempts to document the institutional structures emerging from these processes, to identify the intended process outcomes, and to evaluate qualitatively how these institutional tools are helping achieve the intended outcomes. Reviewing existing municipal planning practices and the use of GI within them will help understand the current status of implementation and management. This

knowledge will help bridge the gap between scholarly understanding of GI benefits and GI application in municipal city planning practises. Furthermore, it will help identify gaps in institutional systems that are acting as barriers to the use of GI benefits. Identifying these underlying issues will help future GI policy agendas of cities to effectively operationalise the concept which provides solutions to many urban issues. The case study can also become an example of how cities can benefit from GI and produce lessons learned that can be shared with other municipalities. For example, the study can help other municipalities to plan their investments on similar GI initiatives. Substantial investment and efforts go into creating capacities and mechanisms to operationalise such long-term plans. Therefore, it is useful to have knowledge on models that were effective and successful in implementing and producing the desired results, as well as of the reasons for the effectiveness and success of these models.

1.1.2 Case Study

The City of Brampton was selected as a case study from the twenty-two cities in Ontario which have adopted GI principles in their Official Plan. Brampton's opportune geographical location in the Greater Toronto and Hamilton Area (GTHA) allowing easy researcher access, and the initiatives taken by the City in GI implementation make it a suitable case study for this research. The City's environmental management plan describes several initiatives that use GI concepts for developing sustainable communities and climate resiliency (City of Brampton, 2014). The environmental management plan has resulted in a series of policy documents and implementation plans, which use GI multifunctionality¹ (City of Brampton, 2014, City of Brampton, 2013, City of Brampton, 2018). Along with the municipal government, other stakeholders, such as the conservation authorities and private residents, have also shown initiative for using GI in this city (Conservation Ontario, 2018; Denich & Zaghal, 2014). Hence it is considered a suitable case study for this research.

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¹ The diversity in typology, application, benefits, and scale together are termed the multifunctionality of GI (Naumann et al., 2011). The term multifunctionality is discussed later in the literature review section.

1.1.3 Theoretical Framework

The Institutional Analysis and Development (IAD) framework (Ostrom, 2005) was selected from various available frameworks and applied to further a systems' understanding of the current GI implementation efforts. The IAD framework provides an institutional theory lens to identify and understand the various tools, actions and institutional interactions instrumental to the above undertakings. The IAD framework provides a rational analytical unit to comprehend the complex collective actions taken by various stakeholders and to understand the action arena (McGinnis, 2011; Ostrom, 2005). Furthermore, the framework helps evaluate the observed interactions and outcomes to recommend solutions that improve policy and produce the desired results (Imperial, 1999; McGinnis, 2011). The current study uses required time, transaction cost and effectiveness as evaluative criteria (McGinnis, 2011; Ostrom, 2005) to analyse the action arena and identifies the enablers and challenges in this specific implementation model.

1.2 Main Results and Recommendations

The study results suggest that the action arena is polycentric which is enabled by nested policies and funding support for GI projects in the City. The study results also indicate that investment in developing research and implementation capacities, market transformation strategies, creating awareness and communication, and community involvement have helped in creating the necessary trust and support for GI. However, time, cost and clear policy mandates still remain challenges for upscaling and benefitting from more GI projects in multiple areas across the city. The study recommends that policy should focus on facilitating decentralised community-led approaches and creating a support system of financial incentives and technical assistance to upscale GI implementations. The recommendations are supported by the qualitative data gathered from interviews with stakeholders, who suggest that a community-led GI implementation policy, supported by market re-orientation would be helpful in providing long-term, cost-effective solutions for climate resiliency and sustainability.

1.3 Structure of the Thesis

This thesis comprises of five sections including this Introduction. Section 2 outlines the concepts, evolution, applicability and benefits of GI as studied through the academic literature on implementation. The section further reviews the academic literature on GI implementation in the Canadian context and sets the background for this study. Section 3 outlines the methodology adopted for this research along with explanation of the theoretical framework applied to the case study. Section 4 comprises of the research findings drawn from document analysis and interviews with key stakeholders. Section 5 discusses the findings of the study and concludes with recommendations.

Section 2: Literature Review

It has become important to consider green infrastructure (GI) as a planning paradigm for sustainable urbanisation because of the solutions it offers to mitigate the negative environmental effects of urbanization pressures (Ahern, 2007; Mell, 2010; Lennon 2014; Wright, 2011). However, policy makers and planners have encountered problems in integrating the GI concept in city planning practises (di Marino & Lapintie, 2017; Dupras et al., 2015; Schiappacasse & Muller, 2015). The literature indicates that some of the challenges for effective GI policy stem from the fact that the concept itself is complex and still evolving (Mell, 2010; Mell, 2016; Lennon, 2014). The current literature review briefly traces the evolution of the GI concept, its various types, functions and applications, all the while showing how these aspects create problems for integrating the GI concept in municipal planning practises. The review then outlines the currently available academic literature on implementing GI policy, and discusses the existing gaps in GI theory, policy and planning practice, particularly in the Canadian context. The findings of the literature review indicate that GI policy implementation research is moving towards a systems theory perspective in order to further understanding of how GI is addressed within existing planning systems. The literature review concludes with an argument that using a systems theory perspective will help bridging this knowledge gap in the context of Ontario cities, while learnings from these early experiences of implementing GI will help highlight the enablers and challenges in institutionalising GI.

2.1 Urbanisation and Environment

The accelerated rate of urbanisation globally and the resultant increase in the demand for urban land (Angel, Parent, Civco, Blei, & Potere, 2011; Angel, Parent, Civco, & Blei, 2011b; Seto et al., 2012; United Nations, 2015) has invariably put greater pressure on the physical urban environment, with a growing need for more resources and physical infrastructure (United Nations, 2015). Current estimates show that cities consume two-thirds of the world's energy and

account for 70 per cent of the global greenhouse gas emissions (Birol, 2010; UN-Habitat, 2011; United Nations, 2015). Along with the large-scale global impacts such as climate change attributed to anthropogenic causes, urban lifestyles also are said to negatively impact the local urban environment with increased levels of pollution, deteriorating health of city dwellers, endangering biodiversity, and increasing food insecurity.

Such environmental concerns in modern urban planning practises have historically been responded to through legislative and regulatory reforms, which can be traced back to 19th century sanitary reforms in public health legislation (Cherry, 1973; Miller, 1998; Williamson, 2003). However, while these health concerns were less conspicuous in the Town and Country Planning Acts, they continued to be present in early 20th century urban planning with concepts such as the Garden City concept promoted by Ebenezer Howard and the Park and Parkway design by Frederick Law Olmsted (Mell, 2010; Miller, 1998; Young, 2011; Williamson, 2003). Later, with inspectorates and public health departments regulating the sources of pollution such as dust, smoke and odour, this soon evolved into environmental regulation and monitoring systems to address increasing industrial pollution (Miller, 1998; Williamson, 2003). By the early 21st century, however, urban sprawl, globalisation and increased consumption of natural resources had given rise to the concept of sustainable development (Williamson, 2003).

The Sustainable development paradigm gained momentum following events such as the 1983 United Nations World Commission on Environmental Development or the President's Council on Sustainable Development, and the Rio+20 Conference on Sustainable Development, (Mell, 2008; United Nations, 2015; Williamson, 2003). Soon sustainability was defined with the help of the three pillars of economic development, social inclusion and environmental protection (Portney, 2003; United Nations, 2015). Portney (2003), argues that the term "sustainability" has its roots in environmental priorities particularly in the biophysical environment, ecological carrying capacity, sustainable agriculture practises and energy use (Brown et al., 1987; Kidd 1992; Portney, 2003, p.5., ch.1). However, the varied use of the term has resulted in shifting attention

from environmental concerns of development to sharing its prominence to equal parts with economic and social priorities (Portney, 2003; Williamson, 2003).

Meanwhile, the impacts of human activities on the natural environment have become a subject of concern with recurring occurrences of extreme climate events such as flooding, heat waves and droughts (Ahern, 2007; Mell, 2007; Schiappacasse & Muller, 2015) as international organisations are generating substantial evidence linking these extreme climate events to anthropogenic causes. It has been observed that urban areas have reduced their capacity to absorb the shocks of natural hazards or mitigate climate vulnerabilities and recover from disaster events (Jha et al., 2013; Schiappacasse & Muller, 2015; UNISDR, 2011; Upto & Ibrahim, 2012). This reduced resilience has been attributed to prevalent urban planning practices, which centre on engineering prowess that increasingly has supplied the services previously provided by natural ecosystem (Ausubel, 1996; de Groots et al., 2002; Gómez-Baggethun & Barton, 2013; Millennium Ecosystem Assessment, 2003). It has been observed that these engineering-oriented practices have been designed for thresholds and have failed to respond to the pressures posed by the changing climate thus increasing losses due to damages caused by extreme events (Ahern, 2007; Schiappacasse & Muller, 2015). While these recent insights again reoriented the focus of spatial planning practises to resilience planning with debates such as "resilience of what, to what and for whom" (Schiappacasse & Muller, 2015, p. S14.), it also brought attention to GI approaches as a way of using natural ecosystem services within mainstream land use and environmental planning practice (Ahern, 2013; Schiappacasse & Muller, 2015).

2.2 Environment Planning and Green Infrastructure

The need for a sustainable development approach and for increasing the resiliency of urban areas led to solutions emerging from landscape ecologists who, with their 'transdisciplinary understanding of spatial dynamism' (Ahern, 2013), pointed to the reduction of natural spaces that had stripped urban areas of their vital ecosystem services. They proposed the use of

ecological processes as a cost-effective solution (Ahern, 2013; Beatley, 2000; de Groot et al., 2002; Gómez Baggethun & Barton, 2013; Millennium Ecosystem Assessment, 2003) that supported sustainability principles and served a wide range of urban services needs such as water management, pollution control, stormwater management, biodiversity and habitat creation, and food production (Ahern, 2007; Gómez-Baggethun & Barton, 2013). Increasingly ecosystem services started being represented as green infrastructure (GI) in public policy discussions (EEA, 2011; Environment D.G., 2012; Gómez-Baggethun & Barton, 2013) because of the positive undertone that the word infrastructure carried for decision-makers and policy-makers (Lennon, 2015).

However, what constitutes GI, how to define it, what methods to use for characterising and classifying it, is still an evolving field producing an inconclusive and continuously developing body of research (Ahern, 2007; Wright, 2011). Moreover, most of this emerging research is contextually bound to the research setting and differs based on the interpretations of researchers and practitioners (Byrne & Sipe, 2010; di Marino & Lapintie, 2017; EEA, 2011; Hansen & Pauleit, 2014; Kambites & Owen, 2006; Naumann et al., 2011). Lennon (2014) argues that trying to synthesise the definition of GI actually makes it more ambiguous because of complexity stemming from the various applications of the concept and the multidisciplinary research fields.

To understand the complexity the term poses to policy making, the next section reviews major developments in defining GI from the planning and landscape urbanism context. Though it is not an exhaustive review of GI definitions, it contextualises the concept for this study and attempts to list important milestones that contributed to the evolution of the GI definition in theory and policy.

2.3 Definitions

One of the earliest and widely referenced definitions of GI stems from the seminal work of Benedict & McMahon (2006, p.1), which defines green infrastructure as, "an interconnected network of natural and semi-natural areas that conserve and provide ecosystem

values and functions, that are beneficial to humans and other species and encompassing a broader ecological framework for environmental, social and economic health".

Subsequent literature suggests that this definition prompted the idea of identifying and spatially keeping environmentally significant lands intact and connected to maintain the integrity of the ecological services provided by these lands (Mell, 2008). Williamson (2003) conceptualised planning for GI as hubs (reserves, native landscapes, working lands, parks and open space areas, recycled lands) and links (conservation corridors, greenbelts, landscape linkages). Mell (2008) considered this "linkage theory as the foundational principle of the landscape ecology" (Farina, 1998; Jongman et al., 2004; Jongman & Pungetti, 2004) and suggested that it includes scale, multifunctionality and social, ecological and economic linkages of developing GI (Mell, 2007; Mell, 2008; Peet & Watts, 1996; Sibley, 1995; Valentine, 2001).

Tzoules et al.'s (2007) work on the other hand, provided a more definitive relation between GI and human health which concentrated on the conceptual links between GI, ecological health and human health. Tzoules et al. (2007) defined green infrastructure as "all natural, semi-natural and artificial networks of multifunctional ecological systems within, around and between urban areas, at all spatial scales" (Tzoules et al., 2007).

Not only did this latter definition (Tzoules et al., 2007) add the dimension of quantifying GI as per functional processes which support improvement in human health, but it also included artificially constructed and semi-natural systems which mimicked ecological processes. It included an array of technologies such as green roofs, permeable surfaces, infiltration beds and others into the ambit of GI. The study emphasised integrating the understanding of ecological and social systems for interdisciplinary research and highlighted the multifunctional nature of GI research (Dupras et al., 2016; McWilliam et al., 2014; Mell, 2007).

Ahern's (2007) converging cross-disciplinary work focussed on the environmental aspects of sustainability in the urban realm. Ahern also pointed out that ecological processes going on in the spatial landscape were "enabled through a green infrastructure" and promoted

that GI is inclusive of the hydrological links, the biotic and abiotic systems, the ecological functions and their relations to urban climatology that occurred over time and space in the urban environment.

The body of literature on GI definitions is still evolving, and the focus of this section is to look at how it is shaping policy and urban planning practices. Below are three examples where the Environmental Protection Agency, US, the European Union and the Federal and Provincial governments (Ontario) in Canada have defined GI.

The Environmental Protection Agency (EPA, U.S.) defines GI as an "adaptable term used for a range of products, technologies and practices that use natural and or engineering systems that mimic natural process to augment the environmental quality and provide utility services" (EPA, 2017).

The EU considers GI as "a strategically planned network of ecosystems of natural and semi-natural areas and other environmental features that provide a cost-effective alternative to traditional grey infrastructure and offers multiple benefits to citizens and biodiversity" (EU, 2017).

In Canada, the federal government defines green infrastructure as the infrastructure required to protect and support Canadian communities in transitioning to a clean economy (MOECC, 2016, p.87, in FSDS).

In Ontario, the Provincial Policy Statement, 2014, defines green infrastructure as "natural and human-made elements that provide ecological and hydrological functions and processes. It can include components such as natural heritage features and systems, parklands, stormwater management systems, street trees, urban forests, natural channels, permeable surfaces, and green roofs" (MAH, 2014).

One can observe that most GI definitions integrated into the planning process include:

(i) natural and technological systems that provide ecosystem services, and (ii) spatially interconnected landscapes and ecological process that provide services for human well-being.

Mell (2008) suggests that the definitions of GI need to be flexible and broad to tie together elements of "landscape ecology, human geography and planning disciplines" such that they accommodate a diverse range of ideas and interdisciplinary use. Many scholars synthesising GI concepts identified water as an important but separate component of green infrastructure (Mell 2008). Ahern's (2007) work on the patch-corridor-matrix-model of classifying landscape elements into GI categories identified urban parks, wetlands, cemeteries, vacant plots, campuses, sport fields and community gardens as urban patches, and rivers, canals, drainageways, roads and power lines as urban corridors. Mell (2008) suggests that the relevance to water in the work of scholars had the potential of a separate sub-category as blue-green infrastructure and turquoise infrastructure (Ahern, 2007; Mell, 2008). Blue-green infrastructure was identified for the ecological and cultural functions provided by interconnected network of riverine corridors and urban green areas as observed in the case studies of Taizhou City in China and Staten Island borough in New York (Ahern, 2007). Wetlands were identified for their distinctly separate ecological functions (Ahern, 2007) as turquoise infrastructure (Ahern, 2007; Mell, 2008). Further Ahern (2007) observed the role of GI particularly for climate mitigation when he included the hydrological connectivity, and biotic and abiotic systems into the green infrastructure umbrella (Ahern, 2007; Mell, 2008).

Some scholars are also of the opinion that the lack of an unanimous definition creates confusion amongst planning professionals and academics (Baró et al., 2014; di Marino & Lapintie, 2017). Others suggested that the vast variation in approaches and scopes of research allow new and encompassing definitions to add new understanding on GI (Bartesaghi Koc et al., 2017; Chinni et al., 2017). However, to benefit and use GI, along with defining it, scholars postulated that identifying, characterising and classifying GI is also becoming an equally important area of research.

For this thesis, we use the above provided broad definition of GI given by the Provincial Policy Statement, 2014, mainly because we are investigating policy implications in reference to Ontario cities. The Provincial Policy Statement, 2014, defines green infrastructure as a combination of "natural and human-made elements that provide ecological and hydrological functions and processes" (MAH, 2014).

2.4 Application and Benefits of Green Infrastructure

Academics, professionals and governments suggest that a common language and system for categorising GI will help in benchmarking, condition assessments, policy creation and planning projects (Bartesaghi Koc et al., 2017; Jacobs et al., 2014; Naumann et al., 2011; Young et al., 2014). To better understand this, the next section reviews two separate approaches for classifying and categorising GI.

One method used to classify GI is based on evaluating ecosystem services, which is useful for understanding ecosystems and estimating their values especially for municipal accounting of GI project's value. (Gomez-Baggethun & Barton, 2013; The Economics of Ecosystems and Biodiversity, 2010). Bartesaghi Koc et al. (2017) on the other hand categorised GI based on spatial and visual typologies, which is helpful for quantifying the amount of various natural green resources (for example as number of trees or area of tree canopy) as well as for spatial planning purposes (Bartesaghi Koc et al., 2017). Literature indicates that the method used for classification is dependent on the purpose and the discipline of research but has several implications during policy creation and practise. While a value-based method is useful in determining economic value of GI, a typology-based method is useful in identifying, mapping and delineating GI.

Through a literature review, Gomez-Baggethun & Barton (2013) built upon the existing studies on classifying and categorising methods that had grouped twenty-two types of ecosystems into four main categories of provisioning, regulating, supporting and cultural services

(Daily, 1997; de Groot et al., 2002; Gomez-Baggethun & Barton, 2013; Millennium Ecosystem Assessment, 2003; The Economics of Ecosystems and Biodiversity, 2010). This study pointed out the association between vital functions performed by ecosystems and their components (trees, open spaces, wetlands, etc.) and then categorised ecosystems into eleven major ecosystem services. These include: (i) food supply, (ii) water flow regulation and runoff mitigation, (iii) urban temperature regulation, (iv) noise reduction, (v)air purification, (vi) moderation of environmental extremes, (vii) water treatment, (viii) climate regulation, (ix) pollination and seed dispersal, (x) recreation and cognitive development and (xi) animal sightings. Secondly, the study also synthesised the disservices provided by ecosystems under specific circumstances in particular urban settings (Bixler & Floyd, 1997; Chapparro & Terradas, 2009; D'Amato, 2000; de Stefano & Deblinger, 2005; Geron et al., 1994; Gómez-Baggethun & Barton, 2013; Jorgensen & Anthopoulou, 2007; Koskela & Pain, 2000; Lyytimaki & Sipila, 2009) and argued that for municipal auditing and project evaluations, both services as well as disservices should be considered. This makes GI implementation a highly case-specific, scientific area of expertise, which is dependent on geographical and socio-economic settings of the city (Bolund & Hunhammar, 1999; Gomez-Baggethun & Barton, 2013; MEA, 2003).

On the other hand, Bartesaghi Koc et al. (2017) approached the lack of a comprehensive classification system for GI through a systematic literature review of 85 studies across 15 countries. The study synthesised and evaluated the prevailing global trends, approaches and parameters being used to categorise and characterise GI. Bartesaghi Koc et al. (2017) proposed grouping the various GI terminologies into four typologies as (i) tree canopy, which included everything from individual and street trees to urban forest cover, (ii) green open spaces (iii) green roofs, which included rooftop gardens to eco or brown roofs and (iv) vertical greenery systems. With regards to categorising the prevailing approaches used for classification, Bartesaghi Koc et al. (2017) focused on the principles used for these typological categorisations and observed three main approaches:

- (i) Functional classification approach that looked for 'multi-functional networks and connectivity' for identifying significant ecosystems based on the purpose, use and the frequency of occurrence and distribution of GI (Dobbs et al., 2011; Gill et al., 2007; Mell, 2008; Mell, 2010; Pauleit et al., 2003; Tzoulas et al., 2007; Young, 2011). The 'hierarchy and significance' is a subcategory of this system where ecosystems were categorised based on their scales which varied from local, regional to national (Byrne & Sipe, 2010; CBC 2008; CCC, 2010; Dunnett et al., 2002; TSG, 2008; VEAC, 2011; Wong, 2011).
- (ii) Structural classification that approach looked at the morphological characteristics of land cover, vegetation heterogeneity and physical characteristics to categorise and classify GI systems. Some of the methods used for such classifications are the Land Use Land Cover (LULC) classification method (Anderson, Hardy, Roach, & Witmer, 1976; Brady et al., 1979; Liu & Yang, 2013), the High Ecological Resolution Classification for Urban Landscapes and Environmental Systems (HERCULES) (Cadenasso et al., 2007; 2013; Zhou et al., 2014; Zhou & Troy, 2009), the local climate zones (LCZ) method proposed by Stewart and Oke (2012), and the use of Urban Biotope theory used in Germany (Arlt et al., 2005; Mathey et al., 2010; 2011; Lehmann et al., 2014).
- (ii) Configurational classification approach that mainly grouped the research work of Ahern (1995), Mell (2010), and Young et al. (2014), which looked at GI as matrices of form, scale, function and attributes such as socio-economic and political considerations to propose improved understanding of GI (Bartesaghi Koc et al., 2017).

These studies demonstrate that deriving a single system of GI classification is difficult because of the variations in site-specific considerations, research objectives, geopolitical situations and regulatory frameworks (Bartesaghi Koc et al., 2017). Though many studies suggest that a comprehensive classification system would be useful for auditing, mapping, valuing and assessing GI, currently not many studies enumerate the implications caused by the absence of such a singular method. However, to understand how these technical methods of classifying,

quantifying and valuing shape policy, researchers are increasing looking at municipal plans (Chinni et al., 2017, di Marino & Lapintie, 2017; Dupras, 2015; Dupras et.al, 2017; McWilliam et al., 2012; 2014; 2015; Cortinovis & Geneletti, 2018; Mekala & Hatton-MacDonald, 2016; Young, 2011). For example, Chinni et al. (2017) studied how GI is perceived and applied in stormwater management plans across 27 U.S. cities. The study observed that not only did the GI categories vary across plans, the motivations behind using GI were also wide-ranging from tapping ecosystem services to minimising local flooding, improving water quality to climate change mitigation, regulatory needs of reducing combined sewer overflows, and receiving GI grants provided through EPA's consent decrees. Chinni et al. (2017) categorised these motivations into four broad categories – (i) water quality improvement (ii) environmental (iii) economic and (iv) social motivation. The comparative analysis also showed that various GI typologies could be combined in a variety of combinations to achieve the same kind of services or different end goals making GI application highly context specific. Chinni et al. (2017) classified these into six categories based on the goals and motivation of use, as (i) infiltration, (ii) transportation, (iii) natural systems, (iv) stormwater re-use, (v) buildings, and (vi) other (these included elements such as solar panels).

The above three studies (Bartesaghi Koc et al., 2017; Chinni et al., 2017; Gomez-Baggethun & Barton, 2013), indicate that though components of GI are based within natural systems, classifying and categorising GI methods are dependent on the perceived benefits and the purpose of GI. Table 1 tabulates the GI classifications as observed from the three studies. However, like Gomez-Baggethun & Barton (2013) contended that using GI as an alternative or in place of conventional infrastructure is further complicated because of the currently practised methods of cost-benefit analysis in municipal budgeting. Therefore, scholars advocate using a "pluralistic perspective in valuing" (Gomez-Baggethun & Barton, 2013) ecosystems which include economic, socio-cultural and the insurance value of GI – specific to the local conditions

and contexts of municipal budgets (Chan et al., 2012; Douai, 2009; Gomez-Baggethun & Barton, 2013; Martinez-Alier et al., 1998; Spash, 2012).

But despite these technical complications to planning and adopting GI practises, the usefulness of GI for providing a multitude of cost-effective benefits has created interest among urban stakeholder groups to consider the creation of a policy framework for its implementation (Gordon et al., 2011; Falxa-Raymond et al., 2013; Jones, 2008; Muro et al., 2011). Moreover, studies have also established the mental and social benefits that volunteering and participation in urban greening activities have on individuals and communities (Barton & Pretty, 2010; D'Amato & Krasny, 2011; Falxa-Raymond et al., 2013; Hull, 1992; Schusler et al., 2009; Schusler & Krasny, 2010; Wolf, 2003). Falxa-Raymonds et al. (2013) studied the contributions of GI programs such as New York City's MillionTreesNYC Training Program (MTTP) to creating employment opportunities for a specific socio-economic segment of the community. The MTTP program was created through a public-private partnership for planting and maintaining a million new trees in New York City and had allocated budgets to train professionals for planting and maintaining these trees over the long term. The study concluded that the program created a motivated and job-specific workforce, fostered positive social networks along with good health and livelihood opportunities. The research reported job satisfaction, learning of technical skills, enhanced awareness about the local environment, and an active lifestyle as positive impacts of the program with ripple effects to urban residents' quality of life (Falxa-Raymond et al., 2013). But more importantly the study outputs have piqued the interest of policy makers to consider GI for its socio-cultural and workforce development aspects (Falxa-Raymond et al., 2013). However, studies reflecting on the appropriate levels of government to create such policies and the implications of integrating these policies within existing municipal planning systems are still scarce.

Table 1: Green Infrastructure Types and their Ecological Services as identified in Literature.

Ecological services	Provisioning Regulating Supporting		Supporting		Cultura		ıl				
Green Infrastructure Types	Food Production	Water Storage	Providing timber, fibre, Fuel	Climate regulation (mitigating Urban Heat Island, flood protection, erosion control)	Life Cycle Maintenance, Biological regulation,	Waste treatment Utilisation and Management	Storm water regulation/ treatment/ water quality improvement)	Land and biodiversity Conservation and Habitat creation	Educational and Recreational	Aesthetic Socio- psychological well- being and health	Appreciating property value
Tree canopy i		*	*	*	*			*	*	*	*
Shrubs, hedges and other vegetation ii	*	*	*	*	*	*	*	*	*	*	*
Yards, open spaces, parks, gardens i	*	*	*	*			*	*	*	*	*
Woodlots, urban forests ii	*	*	*	*	*	*	*	*	*	*	
Green belts, ecological buffers, greenways ii	*	*	*	*	*	*	*	*	*	*	
Waterbodies, ponds ii	*	*		*	*	*	*		*	*	
Wetlands, mudflats, marshlands ii	*	*		*	*	*	*	*	*		
Bioswales, bio strips ⁱⁱ		*		*	*	*	*	*			
Rivers, streams ii	*	*		*	*	*	*	*	*	*	
Estuaries ii	*	*		*	*	*	*	*			
Cycle paths, trails, mud paths ii								*	*	*	
Permeable pavements ii		*			*		*			*	*
Green roofs, green walls, blue roofs i	*	*		*	*		*	*	*		
Rain barrels, cisterns ii		*		*			*		*		*
Rain gardens ⁱⁱ		*		*	*		*	*	*	*	*
Infiltration gardens, planters, boxes ii		*			*	*	*	*		*	*
Bioretention areas ii	*	*		*	*	*	*	*	*		
Vegetated detention strips ii	*	*		*	*	*	*	*	*		*

Source: Adapted from Gomez-Baggethun & Barton (2013); Chinni et al. (2017); Bartesaghi-Koc et al. (2017). Note: The information for ecological services was synthesized from Gomez-Baggethun & Barton (2013). The GI typologies (i) are as those classified by Bartesaghi-Koc et.al (2017). The GI typologies (ii) were identified by Chinni et.al. (2017) through their review of City plans of 27 cities.

2.5 Scale of Green Infrastructure Applications

While the issue of determining the scale and spatial influence areas of GI is a niche expertise and a separate line of research (Gomez-Baggethun & Barton, 2013; Kroll & Cray, 2010), Kroll & Cray (2010) observed that most studies on valuing GI, were at a neighbourhood scale with less research for valuation at the street level or regional scales. Moreover, Young (2011), has observed that most GI initiatives were not planned as community-level programmes but rather single projects at the neighbourhood level executed by individual developers (Novotny & Brown, 2007; Young, 2011).

Young (2011) researched the role of urban planning in scaling up GI objectives into integrated metropolitan scale initiatives, by studying urban forestry initiatives in 8 major U.S. cities. The study showed that cities were using a range of approaches to scale up urban tree planting initiatives (TPI) to citywide projects. These approaches ranged from highly institutionalised, data-driven project planning to grassroots participatory methods. The study highlighted the lack of sustained funding and stewardship plans as challenges to such initiatives. The study concluded that institutionalised agency level implementation and robust funding models were instrumental for successful implementation (Young, 2011). The study recommended: (i) a conscious long-term strategy, (ii) data-driven, detailed planning, (iii) diversified and institutional commitment for funds from capital budgets, (iv) having long-term contracts for fieldwork and education programs with non-governmental organisations, and (v) controlled supply chains for tree saplings made these TPI programs less susceptible to failure in economically challenging times. The study suggested that having a federal policy to initiate and sustain TPI at a metropolitan scale would provide the necessary impetus for other cities to plan similar GI strategies. The study also recommended further research on large-scale initiatives implemented through a bottom-up approach which combined metropolitan, municipal, private and grassroots efforts.

While research on scaling up GI projects is observed as a gap, examples of GI initiatives beyond single typologies (such as TPI schemes or green stormwater management) across multiple spatial scales is even more scarce (Chinni et al., 2017). In analysing GI from an ecosystem services perspective, Bartesaghi-Koc et al. (2017) proposed using a micro, meso and macro scale lens to evaluate each ecosystem. At present, the European Environment Agency, (2011), categorizes GI into two scales namely, the urban scale which includes city-regions, city, neighbourhood and local levels, and the landscape scale which includes inter-regional and international levels (di Marino & Lapintie, 2017; EEA, 2011). Table 2 shows the different scales and the type of applications for GI projects in urban planning practice. This diversity in application, its benefits, scales and typologies together are termed the multifunctionality of GI (Naumann et al., 2011). But more importantly, this diversity highlights the need to further understand at what level of governance GI policy would be appropriate and how such a policy would look like.

Table 2: Different Scales of Green Infrastructure.

Scale	Application						
0	Greening of pedestrian walkways, greenways, bicycle tracks						
Level	Green roofs and living walls						
	Revitalisation of open spaces for recreation, biodiversity, green cover, urban farming						
City level	Urban forests						
	Lake revitalisation and river edge treatments						
	Storm water systems for urban flooding						
	Wetland protection, artificial wetland creation						
	Waste recycling						
Level	Preservation and restoration of natural landscapes, revitalisation of natural hydrological cycle, restructuring of the connections between wetlands, riparian buffers and natural habitats						
Metropolitan/	Integrating regional green spaces, forest and creating connectors, green belts						
Regional level	River and floodplain conservation						
	National Parks network for biodiversity propagation, wildlife movements.						

Source: Adapted from Benedict & McMahon (2006); EEA (2011); Schiappacasse & Muller (2015).

2.6 Implementation of Green Infrastructure

The literature suggests that adopting the multifunctionality of GI provides several opportunities but also poses practical challenges in policy-making and project development (Hansen & Pauleit, 2014; Naumann et al., 2011; Norton et al., 2015). In the USA, GI is used as a tool for resource management through the land zoning system as well as for several stormwater management projects (Benedict & McMahon, 2006; di Marino & Lapintie, 2017; EPA, 2015; Wright, 2011). In the UK, GI is used as a mechanism to control urban development with greenbelt policies and community forestry initiatives (di Marino & Lapintie, 2017; Wright, 2011). In Germany, GI objectives are observed for providing recreational areas, urban development control tools and climate adaptation practices (Schiappacasse & Muller, 2015).

Scholars advocate developing appropriate policy tools and strategies for mainstreaming and institutionalising GI in planning practice (Mell, 2007). Some of the literature on proposed planning and implementation strategies for GI is discussed below. Williamson (2003) proposes a six steps comprehensive approach to implement interconnected landscapes concepts which include: "1 – Develop an Approach; 2 – Inventory Community Resources; 3 – Envision the Future; 4 – Find the Hubs and Links; 5 – Create the Plan; 6 – Build the System". He suggests protecting ecologically significant lands through tools such as zoning ordinances, land acquisition tools, transfer of development rights and partnering with land trusts. Protecting these lands can be achieved through a long-term management plan which aims at safeguarding and ensuring the continuity of the sensitive ecosystem processes within these lands with continued monitoring and assessment systems. Lastly, Williamson (2003) encourages public participation in conservation efforts to ensure residents' perspectives are included and to help making wellinformed land use decisions, especially if difficult choices have to be made. Benedict & McMahon (2009) suggest that "foresight, political will and continuous effort by the state, region and community" are precursors for successful implementation of a GI plan (Benedict & McMahon, 2009. p 251).

Biggs, Schluter & Schoon (2015) (as cited in Schiappacasse & Muller, (2015)) promoted the use of GI in planning practices for resilience thinking. The {ir} seven principles include: (i) promoting diverse applications, (ii) managing connectivity, (iii) managing control variables, (vi) fostering urban complex systems thinking, (v) encouraging learning and knowledge building practices, (vi) encouraging participation and partnerships, and (vii) facilitating and encouraging multi-level governance. Schiappacasse & Muller (2015) advocate the use of Biggs, Schluter & Schoon's (2015) principles for "theoretically activating and operationalising" GI implementation (p S14).

However, recently the debate has shifted towards questioning how urban planning practices are implementing scientific knowledge on GI to develop planning policies. Researchers observe a gap between the scientific body of knowledge and how the concept is being adopted in planning practices (di Marino & Lapintie, 2017 pp. 2, 3, para 1; Dupras et al., 2015; Mell, 2016; Lofortezza et al., 2013). Therefore, the current literature review focuses on understanding this gap and seeks answers to how cities are using GI in city planning practices. Considering the geographic scope of the current research, this literature review focuses on the available research on the subject in the context of Canada and more specifically Ontario. Two search strings were used to identify journal articles from databases such as Scopus and Web of Science. The first search string, "Green Infrastructure" AND "*Planning" AND ("Implement*" OR "Evaluat*"), resulted into 249 articles of which 39 articles were from the North American context in the most recent 10-year period. Of these 39 articles, 7 were from the Canadian context. A separate search string, "green infrastructure" OR "ecological services" OR "ecosystem services" OR "green structure" OR "green space" AND Ontario AND "implement*" OR "realiz*" OR "achiev*" OR "accomplish*" OR "execut*", was used to identify the literature on implementation in the context of Ontario and resulted in a total of 37 articles. After comparing the results from the first and second search and removing duplicates, seventeen articles were selected for a detailed review.

2.6.1 Canadian and International Context- Implementation of Green Infrastructure.

Di Marino and Lapintie (2017), investigated the gap between academic theory on GI and its use in planning practises by reviewing literature and conducting a comparative document analysis of three metropolitan level areas of Milan (Italy), Montreal (Canada) and Helsinki (Finland). The literature review first identified the gaps and similarities between academic research and planning practises to make the following observations:

- The knowledge on ecosystem services within practioners was limited. Knowledge on evaluating and operationalising the multifunctionality of GI was even less within the planning agenda (Digiovinazzo et al., 2011; Niemela et al., 2010). Rigid planning frameworks further limited the scope of introducing innovative strategies in planning systems (Ahern, Cilliers, & Niemela, 2014).
- Scientific studies involving practioners and stakeholders such as urban planners, foresters, farmers, and property-owners were few (Hasse, Frantzeskaki et al., 2014). Scientific research at city and regional scale mostly focussed on single ecosystem typologies, while there were fewer studies at the neighbourhood scale (Hasse, Frantzeskaki et al., 2014).
- Many North American and European municipalities introduced GI in plans but their knowledge of what services ecosystems could provide was weak (Hansen et al., 2015).
 Scholars were advocating for interdisciplinary and interdepartmental knowledge sharing practice-based learning, and involvement of subject experts from outside of conventional organisational frameworks (Ahern et al., 2014; Dupras et.al., 2015; Haase, Frantzeskaki et al., 2014; Kopperoinen et al., 2014; Ugolini et al., 2015).

Through analysis of select planning documents from the three case study areas, di Marino & Lapintie (2017) arrived at the following observations:

• GI was used for a range of benefits including: reducing agricultural impacts on land and water, harnessing the multifunctionality of urban forests, controlling invasive species,

promoting biodiversity, and addressing challenges of climate change and growing urbanisation.

- GI understanding was divided and variable between maintenance of spatial green linkages
 and harnessing ecosystem services, as well as between administrative departments.
- Both in Europe and Canada, GI was mostly addressed as a strategic approach in master plans, leading to local development plans inserting policies for recreational areas and provision of certain ecological services.
- Though qualitative and quantitative methods to evaluate ecosystem services were made available by academic studies (di Marino & Lapintie, 2017; Haase, Frantzeskaki et al., 2014; Haase, Larondelle et al., 2014;) practitioners still did not have hands-on knowledge on the subject.

The authors concluded that a gap between an evolving body of scientific research and practitioners' field knowledge on GI, was limiting the use of GI concepts in landuse planning (di Marino & Lapintie, 2017). The authors suggested developing collaborative and interdisciplinary links between academics and practitioners, professionalism, and sharing of tasks to help generate a more practice-oriented research that will enable developing techniques, methods, and policies to support the inclusion of GI in the planning context (di Marino & Lapintie, 2017).

Using semi-structured interviews, Dupras et al., (2015) inquired into the perspectives of practitioners to understand the opportunities and limitations in implementing GI in the Montreal metropolitan area. The research concluded that practitioners characterised GI as landscape connectivity that ensured the ecological and biodiversity potential of the region. Maintaining a quality of life was perceived as the main advantage of implementing GI. While the respondents did not foresee any apparent disadvantages in using a GI agenda, they argued that communication, public awareness, and legal recognition were priority actions for successful implementation (Dupras et al., 2015). The research highlighted that with an increase of public interest in environmental issues, there was a political opportunity that could allow the

government to acquire natural areas for protection (Dupras et al., 2015). The study identified lack of political will and vision as well as disinformation, as the main challenges in implementing GI concepts (Dupras et al., 2015). Dupras et al. (2015) reported a need for greater interdisciplinary collaboration and inclusion of sectors such as forestry and agriculture, as essential to mobilise the multifunctionality of GI. They further reasoned that the commoditization of land and the existing dependence on municipal taxes generated through urban growth and private tenure were disincentives to land conservation and environmental law enforcement (Bohman, 1996; Chaloupka, 1999; Dupras, 2015).

Dupras et al. (2015) observed that a decentralised multi-level governance structure made it difficult for creating a shared conservation-centric regional vision. Consequently, Dupras et al. (2015) recommended fostering a commitment from all stakeholders to mobilise a shared vision that supported GI, and suggested that planning approaches need to shift from rigid greenbelt protection to multidisciplinary approaches of designing ecological networks (Amati & Taylor, 2010; Ignatieva et al., 2008; Meurk & Hall, 2006) at city (Taylor et al., 1995; Evans & Freestone, 2010) and sub-national level (Thomas & Littlewood, 2010) through enabling legislation. To support GI, the authors also emphasised identifying best practices in all allied urban development sectors, creating a flexible institutional structure with multiple programs, as well enabling legislation and financing mechanisms that ensured participation from multiple actors (Dupras et al., 2015). According to Dupras et al. (2015, p. 356) "implementing green infrastructure in urban areas required a broader understanding of complex issues related to integrating social, political, economic and environmental issues".

Benson's (2002) work highlighted the decades of proactive conservation and waterfront restoration effort observed in Ontario. The Lake Ontario Waterfront Trust spearheaded the Lake Ontario Waterfront Trail and Greenway initiatives and worked for more than a decade to collaboratively develop several projects that re-establish the connection between the surrounding natural areas and the waterfront (Benson, 2002). The initiatives in turn gave rise to several

community-based projects that generated backing for having a larger vision for the Lake Ontario Greenway initiative, with goals to improve the water quality of the Toronto harbour and protect the Oak Ridges Moraine (Benson, 2002). Benson (2002) attributed the development of clear and transparent policies, streamlined approval processes, introduction of flexible financial mechanisms, and municipal direction to the success of the project. Benson (2002) finally suggested that supportive and committed leadership, community involvement, and initial public-sector investment attracted confidence in the private sector to take up stewardship roles in the project.

Using three Ontario case studies of (i) a bioretention facility, (ii) a pilot street retrofitting project, and (iii) a water quality improvement project using rain gardens, Denich & Zaghal (2014) demonstrated how low impact development (LID) technologies (based on GI concepts) can be used to address urban environmental issues. The study suggested that using these technologies required specific localised knowledge about location in the watershed, the proximity to water bodies, and local soil and slope conditions (Denich & Zaghal, 2014). Along with a proactive legislation, which provided ample scope for innovation and improvisation, Denich & Zaghal (2014) stated the need for changing the operation and maintenance procedures, cost calculations, life cycle analysis methods, and creating social acceptance for these technologies. Denich & Zaghal (2014) further pointed out that unlike conventional grey infrastructure, a different set of skills involving sociologists, biologists, ecologists, geotechnologists, geomorphologists, and landscape architects was required for LID designs. The paper pointed to the manuals released by conservation authorities, which provided direction and guidelines for using LID technologies in stormwater management (Denich & Zaghal, 2014).

The research by McWilliam et al. (2012, 2014, 2015) came closest to understanding the policy approaches, barriers and enablers for effective management of GI at the municipal level.

Using six cities in Ontario as case studies, they evaluated municipal planning approaches

(McWilliam et al., 2012), considered barriers for effective management of GI (McWilliam et al.,

2014), and investigated policies for managing lands at the interface of built developments and urban forests (McWilliam et al., 2015).

McWilliam et al. (2012) synthesised the approaches and tools available to municipal staff to manage encroachments on forest edges and found that: (i) education and communicative tools such as print and digital advertisements, (ii) management practises such as boundary treatment, and (iii) zoning tools such as buffer zones, were used in varying degrees to control and manage encroachments. Municipal governments used monitoring and enforcement measures as well as ensured new developments provided disclaimers informing its occupants about their property limits, and the penalties of encroachment. However, interview participants believed that these above tools and approaches present in the Official Plans were inadequate and resource intensive (McWilliam et al., 2009; 2012). Planners preferred well-designed buffers for reducing the impacts of development on urban woodlots, and also found that education and penalty regulations had a limited impact on resident attitude towards encroachment. The study concluded that municipalities were ill-equipped to address encroachment on sensitive forest areas or to implement effective control measures.

McWilliam et al. (2014) then identified seven barriers for implementing effective management practises: (i) municipalities tended not to define the term encroachment in their policies and by-laws, making it difficult to ascertain what could be termed as encroachment in urban forests (ii) regularly monitoring was not formally mandated and therefore the intensity and frequency of encroachments was not documented, (iii) less importance was attributed to the impacts of encroachment, (iv) clear goals and objectives within planning frameworks that address encroachment were absent, (v) necessary municipal governments resources were unavailable for addressing encroachments and preventive measures, (vi) some municipalities lacked bylaws and policies that could address existing encroachment, and (vii) some municipalities lacked policies to prevent future encroachments (McWilliam et al., 2014). Further, because of poor awareness on how built developments negatively impact the health of urban

forests, the policy framework itself lacked clear protection goals and commitment from the municipal governments (McWilliam et al., 2014).

McWilliam et al. (2015) evaluated policy frameworks of the six cities and identified policies that protected GI. The analysis concluded that the Provincial Policy Statement published in 2005 (PPS, 2005) contained long-term goals for protecting at least some GI typologies such as wetlands and urban forests, whereas only some municipal plans included policies to protect natural landforms, remnant forest fragments, and ecosystem health at specific watershed scales. McWilliam el al. (2015) concluded that these municipal goals were basic, with short-term aims limited to identifying and protecting GI, whereas provincial policies asked for enhanced goals of protecting biodiversity and hydrological systems in those landforms. McWilliam et al. (2015) further argued that (i) since objectives are measurable, the existing policies did not contain any real objectives, as they did not include the indicators to measure their success, and (ii) local plans did not mandate minimum requirements and were not connected to municipal budgets since the provincial policies themselves were only suggestive. Nevertheless, most municipal governments had formulated progressive policy tools to encourage management, education and stewardship actions to protect GI. Overall, McWilliam et al. (2015) concluded that provincial policies were insufficient to protect GI from the impacts of urban encroachment, were suggestive instead of directive, targeted developers instead of municipalities, and concentrated only on the construction phase instead of long-term protection. Ultimately, to protect GI McWilliam et al. (2015) proposed: (i) co-management techniques², (ii) education of residents, (ii) research on the efficacy of existing policy, and (iv) increased buffers areas between residential developments and urban forests.

The literature reviewed thus far indicates that while there are multiple techniques and policy instruments available in Ontario for use of GI concepts, there is still a gap in

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² Co-management is an institutional arrangement to share power and responsibility of managing a resource between the government and local community stakeholders (Berkes et al. 2007).

understanding of how ecosystem services are integrated into city planning practices as well as dealing with the multifunctionality of GI. Another issue raised concerns the expertise and local innovation required for GI implementation and how municipal governments are addressing it. The literature indicates a need for development of a systemic understanding of GI implementation at the institutional level and the challenges and enablers therein.

Some more recent studies were focussing on this gap in understanding of institutional factors in GI implementation and reviewed the extent and scope of GI in official plans. Chinni et al. (2017) utilized a socio-technical systems approach to understand how stormwater management plans in US cities applied a policy feedback loop through which field learning from projects was used to refine implementation policies. Cortinovis & Geneletti (2018) developed a methodology to review the content of official plans of twenty-two Italian cities and identified how ecosystem services were addressed in these plans irrespective of their terminology.

Mekala & Hatton-Macdonalds (2016) used the Institutional Analysis and Design (Crawford & Ostrom, 1995; Imperial, 1999; Ostrom et al., 2017) framework to study the governance impediments in delivering GI in the City of Brimbank, Victoria Australia. Mekala & Hatton-Macdonalds (2016) highlighted that the City Council was responsible for implementing GI. However, other departments such as Victoria Water, VicRoads and VicRail, Parks Victoria and Department of Environment and Primary Industries, administering the water, transit, and parks along with voluntary community associations, shared responsibility for planting, maintenance, awareness creation and advocacy for GI. The research found that even though the overall per capita open space within most parts of the city was sufficient, the ecological value of these spaces to serve as GI was low. The loss in ecological value was attributed to the landscaping practices, which centred around mowing, de-weeding and beautifying (Mekala & Hatton-Macdonalds, 2016). Interview participants expressed the need to shift the skill-sets of professionals working in the parks departments of municipal governments and private contractors from a landscape management approach to that of ecological conservation. They

also expressed the need for creating new legislation for managing trees on private land, especially old trees with significant ecological value (Mekala & Hatton-Macdonalds, 2016). The study concluded that collaborations between resource managers and users were key to successful GI implementation and advocated for the development of new communication tools between local governments and stakeholders (Mekala & Hatton-Macdonalds, 2016).

2.7 Need for the Study

Overall, the reviewed literature suggests that GI implementation needs new legislative and management tools (Denich & Zaghal, 2014; di Marino & Lapintie, 2017; Dupras et al., 2015) along with collaborative and interdisciplinary methods of implementation (Mekala & Hatton-Macdonalds, 2016; Pond 2009a, McWilliam el al., 2015). Most importantly, municipal GI planning practices globally and in Ontario are just starting to create the systems required to cope with the renewed understanding of natural landscapes, the ecosystem services they provide, and the dependence of human well-being on urban ecosystems (GIOC, 2018a). To understand what new planning interventions are shaping GI implementation in Ontario, the research needs to focus on synthesising these planning approaches, as well as how collaborations and interdisciplinary methods are shaping implementation. Therefore, the study needs to investigate the interactions between various governmental and non-governmental actors involved in devising GI strategies through a systems perspective. Such a systems perspective will enable increased understanding of the myriad interactions among social, economic and institutional factors affecting GI implementation. A systems perspective will also help to systematically organise the various approaches at the various stages of implementation and to synthesise from them common opportunities and challenges in their implementation. Finally, a systems perspective will help identify policy gaps and create institutional capacities for implementation.

To address the knowledge needs identified by this literature review, the current research is pursuing the below following goal, objectives, and research questions.

2.7.1 Goal

The goal of this thesis is to understand GI implementation at the city-level using an institutional theory lens in the context of Ontario cities. Two research objectives are pursued while aiming for this goal. The research objectives are framed in the context of the case study area, which is the City of Brampton.

2.7.2 Objectives

- 1. Determine how municipal institutional structures are evolving as a response to the adoption of green infrastructure concepts in the case of Brampton.
- 2. Determine the municipal institutional enablers and challenges in implementing green infrastructure in the case study area.

The above research objectives are pursued by answering a series of research questions. The research questions are framed using Ostrom's IAD Framework (Ostrom, 2005) to apply an institutional theory lens to the study. The IAD framework provides a systematic method of analysing policy with its hierarchical interactions among institutions and social establishment. Each research question connects with a component of the IAD framework. Content analysis of documents (Babbie, 1990) and semi-structured interviews (Kvale, 2007) with stakeholders provide the data inputs, which are analysed within the IAD framework.

2.7.3 Research Questions

The two research objectives are pursued by answering the following research questions: RQ1. What are the legislation, norms and regulations that are guiding green infrastructure implementation in Brampton? (Objective 1)

RQ2. What are the intended outcomes of the existing green infrastructure policy observed through the case study? (Objective 1)

RQ3. What model is emerging for implementing green infrastructure in the case study area? (Objective 1)

RQ4. Are the resultant institutional structures sufficient to integrate green infrastructure concepts into city planning practices? (Objective 2)

RQ5. What are the enablers and challenges for green infrastructure implementation in this particular institutional structure? (Objective 2)

Section 3: Methodology

This section outlines the process used for the current research and details the philosophical assumptions, theoretical framework, approaches and methods used to frame, synthesise and validate the research (Blaikie, 2007). Using an inductive qualitative research approach, the study explores the institutional structures that are enabling green infrastructure (GI) implementation at the City of Brampton. Ostrom's (2005) Institutional Analysis and Development (IAD) framework, discussed in section 3.4, is used as the theoretical framework for the study. The study adopts a mixed methods research design involving qualitative content analysis and semi-structured interviews. The processes used for data collection, synthesis, drafting interview questionnaires, recruiting interview participants and the ethical considerations are discussed in section 3.5. The last section 3.6 discusses the expected contributions and limitations of the thesis.

3.1 Research Philosophy and Paradigm

The research philosophy outlines the philosophical assumptions that guide the research and forms the basis of inquiry procedures, research methods, analysis and interpretation of the data (Creswell, 2014). Creswell (2014) uses the term "worldviews" to define the four dominant philosophical paradigms: post-positivism, constructivism, transformativism and pragmatism which guide the actions and interpretations of the researcher (Creswell, 2014; Lincoln, Lynham & Guba, 2011; Mertens, 2010). While all research is guided in varying degrees by all four paradigms, most studies mainly adhere to one paradigm over others based on the research questions and findings of the literature review (Creswell, 2014). This research mainly adopts a constructivist approach with elements of a pragmatic approach.

The constructivist paradigm claims that knowledge is created through "multiple social constructs of meaning and knowledge" (Creswell, 2014, p. 18; Mertens, 2010) and relies on open-ended searches of diverse realities (Creswell, 2014). It builds theory by converging experiences and multiple perspectives arising from a variety of contexts (Charmez, 2003;

Creswell, 2014; Mertens, 2010, pp.18-19). On the other hand, the pragmatist philosophy is focused on actions and their consequences. Following a pragmatic approach, it is primarily the research problem that leads to the choice of methods that could be used to answer the given question (Creswell, 2014; Rossman & Wilson, 1985). Both approaches can accommodate application of mixed methods designs to analyse the same subject and triangulate the findings by taking different routes (Creswell, 2014). This current research constructs theory based on the "lived" experiences (Creswell, 2014; Mertens, 2010) of the participants involved in implementing GI using open-ended, semi-structured interviews. Participants' perspectives and experiences are validated through evidence found in the planning framework and through document analysis. The IAD framework makes it possible to view the qualitative data through an institutional theory lens. This positioning of the research within a theoretical framework leans toward a pragmatic approach. It allows the researcher to observe and give meaning to the factors that led to certain actions and their consequences.

The current research uses a qualitative approach within a mixed methods research design (Morse, 2010) and depends on multiple data sources to qualitatively analyse and triangulate the findings. The practice of continuously validating data by a back-and-forth analysis between data collection and analysis to produce a theory draws on the grounded theory approach and provided the flexibility to observe themes emerging from the data and generate meaning while continuously analysing data (Bowen, 2006).

3.2 Scope of the Study

The current research aims to investigate 'how cities are implementing GI concepts at the municipal level using an institutional theory lens' (see 2.7.2.). This goal is pursued with two research objectives, which are addressed through five research questions. The five research questions are framed within the conceptual theory of the IAD framework and answered using qualitative research methods (Morse, 2010).

Given the decentralised municipal planning and policy framework in Ontario, focusing on a particular city and exhaustively studying this specific implementation scenario was felt appropriate for the current research. Case studies help in placing a research question in a particular context, which helps in a detailed and exhaustive understanding of the subject (Creswell, 2014; Yin, 2009). Using case studies to accommodate a specific policy context is a proven technique for synthesising the structure of complex institutional situations (Ostrom, 2009). Therefore, a case study approach was adopted in this research to help in systematic analysis of GI policies and planning systems specific to the selected city. The case study approach allows to focus on the city-level implementation and to understand top-down and bottom-up planning systems and socio-economic dynamics influencing implementation.

A single case study design was selected over a multi-case study design. Given the logistic constraints, use of the single-case study design allowed greater depth in the identification of various actors, their positions in the action arena, and interactions between these actors. Alternatively, a multi-city case study approach would have enabled recruiting more interview participants, but it would have come at the expense of analytical depth. Furthermore, the same federal and provincial rules are applicable to all municipalities in Ontario and therefore a multi-case study design would not have led to greater understanding of rules at that level.

3.2.1 Case Study Selection Criteria

The literature review found Ontario's Greenbelt legislation as exemplary in creating and enabling landuse legislation for protecting and enhancing a regional greenbelt (Dupras, 2015; Pond, 2009a). This legislation has ensured protection for regional GI and aligns with the landscape connectivity concept explored widely in the literature (Benedict & McMahon, 2006; Dupras, 2015; Greenbelt Ontario, 2018; MAH, 2017a; MAH, 2014; Williamson, 2003). In addition, it is evident from the literature that there are several other connotations to GI in Ontario's policy discourse which operationalise the multifunctionality of GI in relation to

stormwater management, infiltration, flood mitigation and reducing soil erosion (Denish & Zaghal, 2014; Saini & Singh, 2016). Thus, studying a city within the Greater Toronto Area (GTA), which is affected by Greenbelt legislation and has GI concepts embedded in its planning policy and projects, would provide a useful case for this research. The Green Infrastructure Ontario Coalition, (GIOC), an advocacy association of industry partners working towards promoting GI objectives (GIOC, 2018), has identified twenty-two cities in Ontario who have introduced GI concepts in various capacities in their Official Plans (Figure 1). These twenty-two cities were used as the population from where to identify the case study area (GIOC, 2018a).

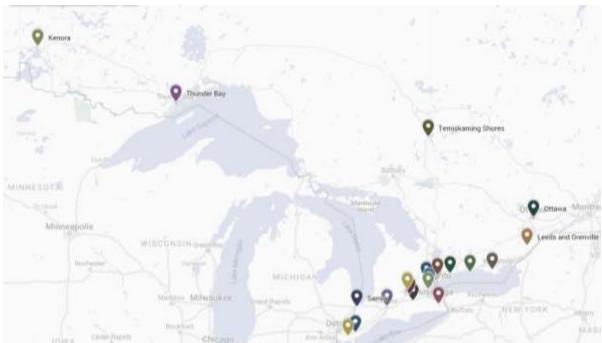


Figure 1: Map showing Cities in Ontario having Policies for GI included in their Official Plan. Source: Created on Google maps. and information regarding cities from GIOC, 2018a.

3.2.2 Study Area

Considering its population size, progressive policies, institutional complexity and ease of access, the City of Brampton was ultimately selected for the case study: GI concepts are central to the City's first environmental management plan, the Brampton Grow Green Master Plan (City of Brampton, 2014), which was prepared in response to the provincial government's target of setting a municipal-level sustainable development framework. In addition to the GI policy interventions in the Grow Green Master Plan, Brampton also has drafted Natural

Heritage and Environmental Management Strategies and a Restoration Action Plan (NHEMS). Moreover, Brampton was reviewing its Official Plan 2006 during the literature review period of this study, providing enough scope to understand the city's priorities and contextualise stakeholders' opinions. Brampton's municipal jurisdiction overlaps with the watershed of two large rivers and two conservation authorities are functional in the city. Both conservation authorities also support several initiatives and programs to promote GI implementation and have pioneered LID technologies that use GI. Further, Brampton's physical setting within the Greater Toronto Hamilton Area (GTHA) with its strong development pressures and its proximity to natural assets such as Lake Ontario provided strong reasons to consider it as a case study. Demographically, Brampton is the third most populous city in the GTHA and ninth largest city in Canada. Given that the City of Brampton is identified as an economic growth centre in Ontario and is a manufacturing and logistics base, it is expected to continue experiencing considerable urbanisation pressures in the near future. For all the above reasons, it was expected that Brampton would be an informative case study area for understanding how cities negotiate between conflicting economic and environmental priorities.

3.3 Research Approach

Selecting an appropriate research approach is influenced by the purpose of the research, sources of data, the audience for the research outcomes, the timeline of the research and the use of the findings (Creswell, 2014). This research has adopted a constructivist paradigm to build a theory around institutionalising GI. It uses multiple data sources and research methods and relies on people's perceptions to document the challenges and barriers in implementation (Bryman, 2016; Farthing, 2016; Creswell, 2014). Use of the IAD framework leads to the application of a theoretical framework that allows triangulation of research outcomes with data gathered through qualitative document reviews and interviews (Farthing, 2016; Creswell, 2014). The components of the IAD framework form the reference themes that helped design the research questions. The IAD framework components also help to articulate the findings of the qualitative data analysis

and validate the findings based on the IAD framework's theory. Thus, this research can be classified as an inductive qualitative research, which applies an interpretivist style and builds theory using a constructivist paradigm.

Referencing the National Research Council's position on qualitative and quantitative methods, Shavelson & Towne (2002) point out that qualitative methods are used for discovery while quantitative methods are used to test relationships. This differentiation is challenged by introducing the concept of agential causation or a-causation (Mertens & Hesse-Biber, 2012). Acausation assumes that in qualitative research involving humans, the researcher depends on the respondent's interpretations of the world and their intentional and unintentional responses may be difficult for the researcher to capture and comprehend. The complexity of these interpretations and choices made by the researcher may affect the construction of new knowledge through the research. This is said to be the 'interpreter's bias and is considered an inherent risk' in this kind of research (Hesse-Biber, 2010). Interpretation bias in research may sometimes cause issues of validity of the research and scholars suggest a mixed methods research approach in such situations (Hesse-Biber, 2010; Mertens & Hesse-Biber, 2012). Scholars also suggest integrating triangulation techniques in qualitative research to eliminate the interpreter's bias (Creswell, 2014; Hesse-Biber, 2010; Mertens & Hesse-Biber, 2012). The current research employs (i) a qualitative document review (Mason, 1996; Patton, 2002) and (ii) qualitative analysis of interview data (Kvale, 2007) to synthesise the findings. The IAD framework provides the theoretical basis required to interpret and to contextualise the qualitative data observed in reference to GI implementation. Thus, the study is using a combination of qualitative-qualitative research methods to triangulate the results making it a qualitative mixed methods research (Hesse-Biber, 2010; Morse, 2010).

Mason (1996) reasons that data generation is different from data collection as "data is not lying around waiting to be collected by a neutral researcher but that the data is constructed by the decisions which are made about how to "frame a project". The current research depends

on archival research techniques and narrative inquiry strategies to generate data (Creswell, 2014; Yin, 2009).

Relevant documents from federal, provincial and municipal government as well as conservation authorities provide information regarding the formal rules and regulations that affect GI implementation. To reveal these rules, the above documents were reviewed with keyword searches using the terms, 'green infrastructure', 'ecosystem', 'ecosystem services', 'natural heritage system', 'green' 'greenbelt', 'greenways', in addition to reading the documents completely. Semi-structured interviews collected within the case study situation helped gather information and validate the evidence found in the documents (Yin, 2009). The revealed rules, regulations and norms shape the prevailing socio-political structures and existing regulatory mechanisms, which collectively affect the outcomes of the policy. The Institutional Analysis and Development (IAD) framework developed by Ostrom (Ostrom, 2005; McGinnis, 2011) allows interpretation of all these factors in the case study's context to provide a systemic understanding. Therefore, the IAD framework is useful as an institutional theory lens helping to understand the challenges and enablers in GI implementation.

3.4 Theoretical Framework

Using a framework to obtain a systems understanding allows 'a meta-theoretical schema to organise, analyse, diagnose systems and prescribe policy changes' (Ostrom, et al., 2017, p. 51). Several frameworks are available for developing a systems approach to the study of planning policy and natural resource management. For example, Chinni et al. (2017) used the sociotechnical systems approach to study technological innovation in GI implementation that created niches to allow policy changes. Pond (2009a) used a political economy lens to understand the socio-economic and political implications of greenbelt policy in Ontario. Socio-Ecological Systems (SES) approaches have been used to study natural resource planning and management (Hoffman, 2003; Ostrom 2009). Brink et al. (2016) used the SES framework for an extensive

review of literature of ecosystem-based adaptations in 112 cities. The study concluded that research on ecosystem-based adaptations is fragmented because of the differing concepts, types of GI and disciplinary approaches (Brink et al., 2016).

While all the above examples provide frameworks to contextualize data in a systems perspective, they are limited in their capabilities to synthesise institutional organisations and how they influence policy making (Mekala & Hatton-Macdonalds, 2016). The current research aims to increase understanding of how municipal institutional systems are integrating new knowledge on GI and which factors are supporting or detrimental to this cause. The IAD framework conceived in the 1980s by Ostrom and other scholars provides a systems' perspective that helps to compartmentalise the biophysical, economic, socio-cultural, and political aspects influencing policy as well as to review the interactions among these different components (Crawford and Ostrom, 1995). The IAD allows observing how stakeholders organise themselves, strategize within these influences, and operationalize policy outcomes (Allen, 2005; Ostrom, 2005). The IAD framework has been used for studying ecosystem-based management of resources (Imperial, 1999) such as fisheries (Imperial & Yandle, 2005) forestry (Andersson, 2006) as well as more recently GI implementation (Mekala & Hatton-Macdonalds, 2016). Considering the knowledge needs identified through the literature review (Chapter 2) and the requirement to obtain a systems' understanding of GI implementation, the IAD framework is considered suitable for this study.

3.4.1 Institutional Analysis and Development Framework

Institutions are enduring regularities of human action in situations structured by rules, norms, and shared strategies, as well as by the physical world. The rules, norms, and shared strategies are constituted and reconstituted by human interaction infrequently occurring or repetitive situations. (Crawford & Ostrom, 1995, p. 582)

Institutions are defined as formal and informal rules that are established to organise social, political and economic relations and interactions (Hodgson, 2006; North, 1990, p. 2).

These rules, or a lack of them, benefit or constraint individuals in choice situations. Both formal

and informal rules have consequences under given socio-cultural and political conditions. Thus, to understand the existing GI implementation scenario in the current planning and policy discourse, it is imperative to investigate rules and norms.

There is a wide variety of institutions differing in their purpose, form, scale and complexity, making it very difficult for scholars to arrive at generalizable conclusions about institutional structures and functioning. More recently, Vincent and Elinor Ostrom, along with other scholars through their work in political theory and policy analysis, developed a common language with the critical building blocks that help us understand the structure of institutions as well as how institutions function and change over time. This language is captured in the Institutional Analysis and Development (IAD) framework (Ostrom, 2005). Through the IAD framework, Ostrom provided the universal building blocks necessary for understanding the complex workings of institutions across scales and systems, and enabled comparison among different institutions (McGinnis, 2011; Ostrom, 2005).

In addition, the IAD framework has been used extensively to identify and study the relationships that affect governance systems, as well as to understand the implications of policy for institutions in a given situation and suggest policy modifications (Whaley & Weatherhead, 2014). Though the IAD framework is often used as a diagnostic tool for policy analysis (McGinnis, 2011; Whaley & Weatherhead, 2014), in the current research it is used for its value of understanding an institutional arrangement and its performance. More recently the IAD framework has been useful in analysing the political and economic factors affecting natural resource management (Clement, 2010; Whaley & Weatherhead, 2014), similar to its application in the current study. Imperial & Yandle (2005) highlight the main types of institutional arrangements as: (1) bureaucracy-based, (2) market-based, (3) community-based, and (4) comanagement based. This typology assists in observing institutional arrangements in the current case study.

3.4.2 Components of the IAD framework

The IAD framework is comprised of a set of components, whereby the 'action arena' is the central component of the framework. The 'action arena' is influenced by a set of variables collectively called the 'exogenous variables' and gives rise to a series of 'outcomes' (Imperial, 1999; McGinnies, 2011). The 'outcomes' are evaluated with the help of a set of 'evaluative criteria' (Figure 2).

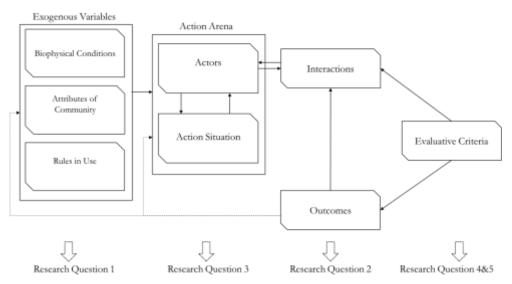


Figure 2: Diagram showing the Research Questions mapped on the Components of the IAD Framework.

Adapted from Ostrom, 2005.

For the current research, the IAD framework was used to help identify the action arena and the exogenous variables that are influencing the action arena. A set of evaluative criteria of required time, effectiveness and transaction cost were explicitly defined to assess how the GI implementation arena is shaping the outcomes. To achieve these results, the observations of the qualitative document review were mapped onto the components of IAD framework. The mapped observations then allowed formulation of interview questions. The interview questions were directly linked to the components of the IAD framework and led to collection of actors' perceptions. These actor perceptions were then used to validate the observations from the qualitative document review and to indicate the effectiveness of the institutional structures for GI implementation as measured by the set of evaluative criteria. The IAD framework thus

helped to identify the enablers and challenges in the existing institutional setup, and to suggest how they could be addressed through policy interventions.

Research questions 1-3 (Section 2.7.4.) are directly connected to individual components of the IAD framework, while research questions 4-5 (Section 2.7.4.) are aimed at an evaluation of the investigated institutional structures. The various components of the IAD framework are described below.

Exogenous Variables

The exogenous variables represent all the physical, social, cultural and regulatory aspects that influence an action arena (McGinnis, 2011). The data for the three exogenous variables: (1) the biophysical attributes or the physical setting of the action arena, (2) the attributes of the community, and (3) the 'rules-in-use' by which the participants order their relationships in the action arena (Kiser & Ostrom, 1982) were collected through qualitative document review (Appendix B). These exogenous variables influence the action arena, determine the actors and the extent of their participation in the action situation. The exogenous variables also control what information can be accessed by actors and how they can use it to influence the outcomes (Ostrom, 1990; Whaley & Weatherhead, 2014). The IAD framework also recognises the interdependence of the three exogenous variables, i.e., their effects on each other (Ostrom, 2005). Research question 1 is aimed at investigating the exogenous variables.

Biophysical Attributes – The biophysical attributes are the physical conditions of available resources. In the current study, existing GI or the green assets of the city, are the physical attributes. The action situation determines how these resources are managed. The qualitative document review (Appendix B) helped understand the physical GI assets of Brampton as well as how GI is interpreted. The same set of rules can lead to different actions when different biophysical attributes and community attributes are encountered (Ostrom, 2005). The biophysical attributes may be understood by investigating the physical characteristics of the resources. It has been found that 'complexity, size and productivity of the biophysical resource'

affect the self-organisation capacity of the resource users or actors (Ostrom 1999b; Ostrom, 2009). The interviews with the research participants provided the actors' perspective on GI and how they expect it to be managed.

Community Attributes - This exogenous variable accounts for the socio-cultural and physical attributes of the community that influence the action arena. The socio-cultural attributes factor in norms, beliefs and value systems of the community, which affect the action arena and set the tone of the interactions and outcomes (Ostrom, 2005). Cultural differences or similarities may impact the social capital of groups and their ability to participate, communicate, jointly act and benefit from social and environmental changes (Whaley & Weatherhead, 2014). The physical attributes are the demographic characteristics such as the number of actors, their age, gender, race, educational and professional backgrounds. These attributes affect the ability of the community to participate in the action arena. Whaley & Weatherhead (2014) suggest that a community's size may affect stakeholders' interest to work collectively but also that differences such as in race and gender may bring up issues of power and trust relationships. The data provided by Statistics Canada and the City of Brampton's economic and employment demographic analysis supported the analysis for the community attributes. The interviews also provided insight into community perspectives.

Rules-in-Use – These are the formal procedures and guidelines, which allow or constrain the ability of actors to act and inform their decisions. It provides information to actors on which actions they can take, which actions they should be taking, and which actions would be overruled in the action situation (Allen 2005; Ostrom, 2005). The rules-in-use are what "participants would refer [to] if asked to justify and explain their actions to fellow participants" (Ostrom, 2005). The federal, provincial, and municipal (city and regional municipal governments) rules were identified through keyword searches of all important government policy documents (Appendix B).

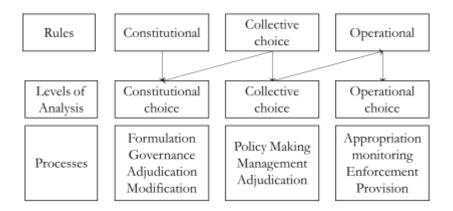


Figure 3: Diagram showing the Links between Rules-in-Use and Level of Analysis. Source: Reprinted from Clement, 2010, Ostrom 1999a.

Level of Analysis – Rules can be categorised as constitutional, collective and operational choice rules, affecting various levels of analysis of the action arena (Figure 3) (Clement, 2010; Ostrom, 1999). In the current case, the federal policies are constitutional level rules that determine rule formulation, governance and modification at lower levels. Provincial policy, such as the Planning Act and the Greenbelt Act, form the collective level rules. In turn, rules at the collective choice level determine operational decisions. Rules at the operational level affect local actions (Clement, 2010; Ostrom, 1999) such as municipal actions regarding local services. In the course of the study, it was observed that GI implementation was more pronounced at the local level and hence the research particularly focused on the operational level dynamics.

Action Arena

The action arena is the 'black box' within which actors based on the information they have, make choices and interact, to produce outcomes (McGinnis, 2011; Ostrom, 2005). The action arena comprises of actors and the action situations. Owing to the position rules, certain actors can take certain actions as agents of organisations and due to their position in the framework (Ostrom, 2010). The action situation breaks into seven working components (Figure 4) "consisting of participants who take up various positions, where any given position allows the participant to undertake certain actions that are dependent on how much information they

possess about each available action, how actions are linked to potential outcomes, the degree of control individuals exercise over these outcomes, and the costs and benefits they assign to them" (Ostrom, 2005; McGinnis, 2011; Whaley & Weatherband, 2014). The qualitative document reviews allowed the identification of primary actors at the operational level, their positions, and their control over the action situation.

Actors and action situations are separate entities within the action arena. Their relative positions lead to the emergence of structures relevant to GI implementation. However, not all actors may be linked to definite actions, some roles (but not others) may influence GI implementation, and some actors may change roles. Therefore, identifying actors and their roles was deemed important for this investigation. To ensure depth of inquiry and to account for changing actor roles, additional actors were added to the primary pool of actors through the course of the study following a snowball sampling method. Research question 3 is aimed at investigating the action arena (as well as interactions between actors).

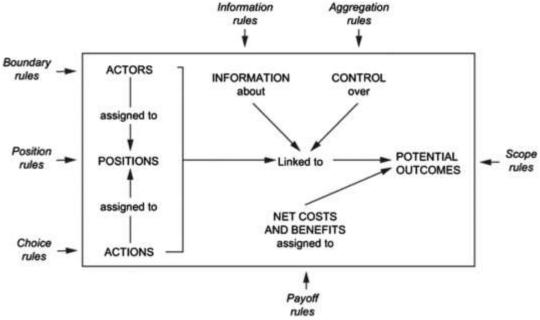


Figure 4: Diagram showing the Position Rules of the Action Situation. Source: Reprinted from Ostrom, 2005.

Interactions

Interactions are patterns of horizontal and vertical communication between actors in a particular action situation (Imperial, 1999; McGinnis, 2011). Horizontal linkages are interactions

between local groups at the lower tiers or the operational level. The vertical linkages signify interactions observed between the different scales of government and non-government organisations (Ostrom, 2005). These interactions may be in the form of formal and informal agreements and arrangements to participate in the action situation. Imperial & Yandle (2005) suggest that analysing interactions helps to understand if the decision- making process in the action situation is fair and equitable. The operational level interactions between identified actors were analysed to understand the action situation. The interviews questions (Appendix A) led to results that helped understand these interactions in details. The vertical linkages were established through document study and their implications and influence on the action situation were verified through interviews.

Imperial (1999) focussed on inter-organisational policy implementation and the associated transactional costs, and suggested the inclusion of information costs, coordination costs and strategic costs while measuring the success of institutional arrangements (Imperial, 1999). Ostrom (2005) suggested that the nature of interactions influences the outcomes, and can be modified based on the evaluative criteria to bring about the intended outcomes. Research question 3 is aimed at investigating the interactions between actors in the action arena.

Evaluative Criteria

The IAD framework allows using a flexible evaluation criteria depending on the objectives of the research and the interpretations of the researcher. However, Ostrom suggested: (1) economic efficiency, (2) equity, (3) adaptability, resilience, and robustness, (4) accountability, and (5) conformance to general morality, as examples for evaluating the overall accomplishment of an institutional arrangement (McGinnis, 2011; Ostrom, 2005 in Whaley & Weatherband, 2014). The current research employed qualitative data obtained from interviews and used (1) time requirements for interventions, (2) transaction costs, and (3) effectiveness of the proposed interventions to evaluate the action arena. Each research participant was asked two questions to

evaluate the action situation through their own perceptions. The first question asked participants to evaluate their experience on the project regarding cost, time, effectiveness and transaction costs. The second question asked participants to voice their opinion regarding performance indicators for evaluating the GI action arena that they were a part of. The action arena in the current research is not a single GI policy or intervention but multiple GI implementations by different sets of actors.

Outcomes

Ostrom (2005) suggests that the outcomes are the consequences resulting out of the institutional arrangements. By understanding all the components and their interdependencies, the researcher can observe outcomes of a policy framework and propose remedial actions to achieve desired outcomes from the institutional arrangement (Ostrom, 2005).

Since this research uses a constructivist exploratory method to understand the current status of implementation, it depends on the policy documents to understand what are the expected outcomes as stated in these documents by the various levels of government. Further using a pragmatic approach these expected outcomes are categorised into long-term and short-term goals that the government expects to achieve through GI. The research then qualitatively analyses through the evaluative framework and the interview inputs if these outcomes are being achieved through the observed action arena and interactions.

3.5 Research Methods

The current research employed a constructivist, mixed methods research design and used: (1) archival techniques for collecting and synthesizing information from documents and (2) semi-structured interviews with purposively selected informants to answer 'how'- and 'what'-type research questions (Kvale, 2007). Using this mix of methods enabled collecting information from different sources and triangulating the findings.

3.5.1 Document Review

The primary information collected for the research was sourced through content analysis (Bowen, 2009) and validated through semi-structured interviews using an iterative process. The City of Brampton's Official Plan, and other policy and plan documents, were the starting points for inquiry. Additional documents were obtained through a keyword search on the City government's website which included agenda item notes, meeting minutes, action items, policy decision and guidelines. Analysis of all the documents led to discovery of additional avenues of information such as other organisations and levels of government that influence the decisions and actions of the City government.

Information about federal and provincial government policies helped understand the constitutional and collective level rules. Content analysis of federal and provincial policies, plans, acts and legislation was limited to information available in the public domain on department and ministry websites. Organisations involved in implementation at the operational level were identified from the City of Brampton's environmental management plan. Additional sources of information at the operation level were identified through keyword searches on the websites of these organisations. Some interview participants voluntarily provided hard copies of documents for supporting their views during interviews. These documents were studied for relevancy to decide on their inclusion or exclusion from the research.

3.5.2 Semi-structured Interviews

In qualitative research, where interviews form a significant source of data, detailed planning of the interviews becomes a prerequisite for a successful inquiry. Kvale (2007, pp.5-6) suggests seven vital steps for a successful interview-based inquiry: (1) working on thematising and designing the interviews, (2) selecting and recruiting interview participants, (3) employing appropriate interview methods, and then (4) transcribing, (5) analysing, (6) verifying and (7)

reporting. This section elaborates on the methods employed for designing and conducting interviews for this research.

Thematizing is a precursor to the interviews and is guided by why, what and how questions regarding the research itself (Table 3).

Table 3: Purpose and Techniques used for the Research Study.

		Purpose in this research		
Why: Provides purpose of I		The research is being conducted to generate empirical knowledge on		
	the research	the institutional enablers and challenges in GI implementation		
What: Provides what is the The research look		The research looks at the enablers and challenges through an		
	subject being	institutional theory lens which focuses on examining the policy and		
	researched	implementation action arena. It draws attention to how GI is		
		conceptualised and implemented through the different levels of		
		governance and the factors critical for mainstreaming GI in urban		
		planning practice.		
How:	What technique is	The IAD framework informs the study technique. Content analysis,		
	being used for the	semi-structured, open-ended interviews are used to generate data.		
	research	Initial interview participants are selected through a purposive		
		sampling method. Since the research is exploratory, a qualitative		
		research approach allows recruiting new information and following		
		new leads for the research. Additional participants are recruited		
		through a snowballing method.		

Source: Adapted from Kvale (2007).

Interview Design – Design of the interview questions (Appendix A) was guided by the relevant components of the IAD framework and themes of interest within these components (Table 4).

Table 4: Interview Guide.

IAD	Themes			
Component				
Rules in Use	Adequacy of the existing regulatory framework for GI			
Action Arena	Interactions and level of interactions between stakeholders			
	Collaboration and type of collaborations between stakeholder			
	Fund flows			
	Access to knowledge, expertise and technology			
Evaluative	Efficiency in achieving the expected outcomes with respect to time, cost,			
criteria	effectiveness to outcomes			
	Transaction costs			

Connecting with these IAD framework components and themes are the research questions which were converted into interview questions. (Kvale, 2007; Farthing, 2016).

Following Kvale's (2007) interview design methodology, questions were designed to facilitate a conversation with the interview participants (Figure 5). Following this sequence allowed to have main interview questions followed by more conversational questions such as probing questions, creating a rich, informative conversation (Charmaz, 2003; Farthing, 2016; Kvale, 2007).

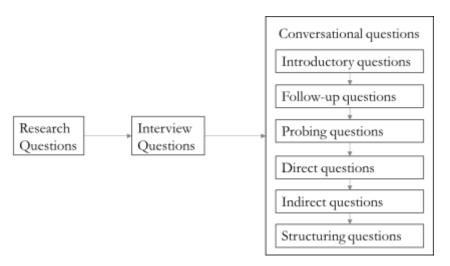


Figure 5: Flow chart showing the Sequence followed to Design the Interview Questions. Source: Adapted from Kvale, (2007).

Recruiting Interview Participants - The initial document review helped identify the preliminary set of actors in the action arena. Organisations and individuals involved in GI implementation were identified as the main actors in the action arena. The qualitative document review provided information on the positions and responsibilities of these key organisations and individuals in the action arena. Additional participants were recruited through snowball sampling by requesting a referral from the participants. On the suggestions of initial key informants, project coordinators, community coordinators and communications coordinators involved in the GI projects and programs were also contacted. The communications and outreach experts did not participate in the interviews but helped connect to the other resource persons in community associations, community garden participants and the school. Thus, out of the total of 24 participants identified and approached for the research, 16 participants were interviewed from 8 organisations.

Table 5: List of Study Participants Contacted and their Roles for the Research.

Participant	Position	Organisation	Roles for the Research. Role
ID		type	
<u>12</u> I1	Senior Advisor, Design	Municipal	Interviewee.
11	being havison, Besign	Government	interviewee.
I2	Landscape Architect	Municipal	Interviewee. Reference to
12	Landscape Mennect	Government	Participants I21 & I22.
I3	Environment Planner (Senior)	Municipal	Interviewee. Reference to
13	Environment Planner (Senior)		
T 4	E	Government	Participant I9.
I4	Environment Planner	Municipal	Interviewee. Reference to
		Government	Participant I5.
I5	Communication Coordinator	Municipal	Reference to community garden
		Government	members. No community garden
			members were interested in study.
I6	Water Resource Engineer	Municipal	Redirected to Environmental Dept
		Government	Participant I3 & I4.
I7	Park Planner, Park Planning &	Municipal	Reference to Environmental Dept
	Development Section	Government	Participants I3 & I4.
18	Water efficiency Analyst	Upper tier	Interviewee. Reference to
	water efficiency rinary of	Municipal	Participants I24 & I25.
		Government	1 articipants 12 & 123.
I9	Managar Internated Water	Conservation	Interviewee. Reference to
19	Manager, Integrated Water		
T4.0	Management	Authority A	Participant I11.
I10	Program Manager, Water Resources		Interviewee.
	Engineer & STEP Educator	Authority A	
I11	Senior Program Coordinator,	Conservation	Reference to Participants I8, I22 &
	Sustainable Neighbourhoods	Authority A	I25.
I12	Manager, Sustainable Technologies	Conservation	No response.
		Authority B	
I13	Senior Manager, Sustainable	Conservation	No response.
	Neighbourhoods	Authority B	•
I14	Project Manager, SNAP Projects,	Conservation	Interviewee. Reference to
	Watershed Strategies Division	Authority B	Participants I15 & I16.
I15	Senior Planner, Environmental	Conservation	Reference to Participant I17.
113		Authority B	reference to randelpant II.
	Development	ruthoffty D	
I16	1	C	D-C
110	Coordinator, SNAP Projects	Conservation	Reference to Participants I18 & I19.
	Sustainable Neighbourhoods,	Authority B	
	Watershed Strategies Division		
I17	Project Manager	Conservation	Interviewee.
	Sustainable Technologies	Authority B	
	Evaluation Program (STEP)		
I18	Active Member of Community	Community	Interviewee.
	Advisory Committee, Civil Engineer	Association	
	by Profession		
I19	Active Member of Community	Community	Interviewee.
	Advisory Committee, Urban	Association	
	Planner by Profession		
I20	Director Land Development	Developer	Interviewee.
I21	Project Manager	Developer	Interviewee.
I21 I22		School	1
	Principal III		Interviewee.
I23	Director of Education and Labour	Landscape	Interviewee.
	Development	Association	
I24	Environmental Coordinator	Landscape	Interviewee.
		Association	

The details of the participants, their organisations and their responses to the interview request are listed in Table 5. Participants who did not participate or were not available for the interview are also listed as they are still part of the action arena and are included in the analysis.

Conducting Interviews - While conducting interviews, the research questions helped maintaining consistency with the research themes. Modulating the interview questions allowed to specifically target the organisation and interview participants' role in the action arena (Farthing, 2016; Robson & McCartan, 2016). Individual interview questions not relevant to the organisation's work arena or already covered during the course of the conversation were not repeated as separate interview questions (Robson & McCartan, 2016). Probing techniques were used to uncover additional information and emergent themes raised by the interview participants during the interview (Charmaz, 2003; Farthing, 2016). Probing questions were particularly useful when participants raised new themes, and situations in the action arena emerged from these leads. At several times during the interviews, participants differentiated between personal views and the views of the organisations. These differentiations were noted as participants' views could not be assumed to be representative of the whole organization (Payne & Payne, 2004).

All 16 interviews were conducted in person at the interview participants' offices from May to August 2018. The interviews lasted on an average for 45 minutes and were audio-recorded using recording software on a separate and secure computer.

3.5.3 Date Acquisition and Analysis

Documents collected from official websites and provided by interview participants as well as interviews formed the main sources of data.

Data Sources and Acquisition - Material collected from official websites, plans and policy documents helped in triangulating the interview results through an iterative process. Content analysis was used to answer research questions 1 and 2. It helped to understand the factors affecting implementation and the action arena. All primary sources used for content analysis are

listed in Appendix B. Data was acquired through open sources from the websites of the Ministry of Municipal Affairs, Region of Peel, City of Brampton, TRCA and CVC. All policy and plan documents were read in complete in addition to finding content through keyword searches using specific terms such as green infrastructure, ecosystem services, ecological value, natural heritage, ecological function, ecosystem, ecosystem function. This helped identify and focus on particular policies and initiatives which addressed GI even in the broadest understanding. Besides, the reference list thus generated through the web-based search was also verified with the staff of the Environment Department at the City of Brampton.

Potential participants from the staff of City of Brampton, conservation authorities (TRCA and CVC) and Region of Peel were identified through web-based searches and approached with a request for interview. An email and telephone script to request their participation (Appendix C & C1) was prepared describing the intent and other details of the research. However, all participants were contacted through email. On receiving an interest from participants for being interviewed, they were sent an information package containing the interview guide (Appendix A), details of the research (Appendix D), and consent form (Appendix E). On receiving a signed consent an appointment was fixed as per the convenience of the participants in their agreed upon place.

If participants declined the interview request, they were thanked with an email and not contacted again. As can be seen in Table 5, some participants declined the interview but recommended another appropriate participant from their organisation to be interviewed. Additional participants were recruited through snowball sampling method through such referrals. Some participants provided further leads into their networks after the interview. Some interview participants also provided additional documents during the interview phase. Some of these documents substantiated the interview narratives and helped in triangulating the findings, validating and confirming the themes that had emerged during the initial readings.

A feedback letter (Appendix F) was sent to all participants interviewed for the research within a week of conducting the interview. The feedback letter included an offer that participants could ask for the summarised points and preliminary findings of the research.

Interview Transcriptions - Interviews were audio recorded and transcribed using 'Transcribe', an online transcription and dictation software, and proofread for accuracy. The audio-recorded material was cross-checked for accuracy and shared with the participants when: (i) there were issues with audio clarity of the recorded material or (ii) the participants had asked for a copy for verification. All participants were informed through the information letter (Appendix D), consent form (Appendix E) and verbally after the interview that they could request their transcripts and choose to withdraw part of or their entire input provided during the interview.

Analysing - Interviews were analysed using an inductive coding method for broad themes, recurring keywords and defining perspectives using Dedoose software (Charmez, 2003; Creswell, 2014). This software was used instead of other software as it provided similar functionality but was more user-friendly and less costly. The broad themes used in the interview guide were used as initial codes to categorise the interviews into themes. Additional themes emerging from the interviews were also identified during the readings that particularly helped in understanding the action arena and the challenges and enablers.

Qualitative content analysis was used for research questions 1, 2 and 3 which was supported by the inductive analysis of interview material. Qualitative analysis of interview material provided answers to research questions 4 & 5 and was supported by triangulating data observed in content analysis. The environmental management plans and other documents covered the intergovernmental and inter organisational collaboration and partnerships for implementing long and short-term GI projects. This phenomenon was captured in the content analysis and investigated using probing methods during the interviews. The probing method provided clarity in understanding the challenges and enablers in implementation. New themes emerging from the transcribed interview material was sub categorised to interpret meanings to

how the participants evaluated implementation. Throughout the report, exact quotes are used to support and validate the interpretations made during the analysis. Interview requests were sent to a minimum of two and a maximum of seven potential participants from the same organisation, resulting into capture of the perspectives of at minimum two participants from any given organisation. Interviews with multiple participants form the same organizations ensured depth and helped cross-validating recurring themes within conversations to make final interpretations.

3.5.4 Ethical Considerations

The study was approved by the University Waterloo's Research Ethics Committee with file number ORE 23052. The primary concern was to receive informed consent, to ensure confidentiality and to avoid any physical, psychological or economic stress to the participants during or after the interviews (Kvale, 2007). Further, as an added measure to ensure comfort in participating in the research, participants were provided with the scope and details of the project (Appendix D) including a list of interview questions (Appendix A). Interviews were conducted only after receiving participants' written consent (Appendix E). Participants were given an opportunity to ask question before and during the interviews, and informed that they could refuse to answer any interview question, or withdraw from the research at any time. Interview questions were designed to facilitate dialogue without the stress of providing objective or confidential information, which might have repercussions in the workplace. Meetings were scheduled at locations as per the convenience of the participants. The recorded material was anonymized and securely stored in an encrypted format. The transcribed material was anonymized by removing personal identifiers and organisation names from the stored content and only presented in anonymized form.

Section 4: Situating Green Infrastructure – Findings

4.1 Introduction

The findings presented in this section achieve the study's goal to understand GI implementation at the city-level using an institutional theory lens. The findings are linked to the two study objectives and five research questions in the following ways:

Objective 1 was to determine how municipal institutional structures are evolving as a response to the adoption of green infrastructure concepts. This objective was pursued by seeking answers to three research questions.

RQ1: What are the legislation, norms and regulations that are guiding green infrastructure implementation? This research question is addressed by findings presented in section 4.2. (Exogenous Variables), section 4.2.2 (Community Attributes), and section 4.2.3 (Rules-in-Use). The findings in these sections outline the community's socio-cultural traits and the legal framework established to protect the natural environment in the case study area. The findings show nested rules from the federal to the local municipal government as well as an emerging community norm to protect and enhance the existing GI. However, the evolving understanding of GI and related technologies around GI are causing the legal framework to readjust and evolve.

RQ2: What are the intended outcomes of the green infrastructure implementation? This research question is answered with findings presented in sections 4.5 (Outcomes). The study findings describe governments expected outcomes from GI implementation, as described in the legal plans and strategy documents of the federal, provincial and local governments. The findings indicate that different levels of governments aim to enable different outcomes through GI implementation, and point to a nested, polycentric implementation model.

RQ3: What model is emerging for implementing green infrastructure? This research question is answered with the findings in section 4.3 (Action Arena) and section 4.4

(Interactions). The findings show that the creation of new rules and strategies to implement GI has resulted in an evolving action arena. The action situations comprise of multiple strategies at the operational level, which implement GI on public, private and community centred lands. The action situations involve multiple stakeholders from government, industry and civil society who are adjusting and reorienting their roles to implement the new knowledge on GI. The changing roles and priorities are captured by the interactions between stakeholders pointing to the use of collaborative and adaptive co-management approaches (section 4.4).

Objective 2 was to determine the municipal institutional enablers and challenges in implementing green infrastructure. This objective was pursued by seeking answers to two research questions.

RQ4: Are the resultant institutional structures sufficient to integrate green infrastructure concepts into city planning practices?

RQ 5: What are the enablers and challenges for green infrastructure implementation in this particular institutional structure?

Both these research questions (RQs 4 and 5) are addressed by the findings presented in section 4.6 (Evaluative Criteria). The evaluative criteria used to identify the enablers and challenges in GI implementation included the variables of project implementation time, project transaction costs and policy effectiveness. The study findings highlight the long-term enabling effects of (i) acknowledgment of GI in the legal framework, (ii) implementation of community-led demonstration projects for GI, and (iii) adaptive co-management techniques for GI implementation. However, existing challenges include the (i) wide-ranging interpretations of GI within the legal framework, (ii) relative high costs of implementing GI with uncertainty of results, and (iii) risk to investments involved by implementing the new techniques.

The study concludes that the observed institutional structures are still emerging and that current GI policies are broad, suggestive (instead of prescriptive) and rely on voluntary approaches for implementing GI. The stakeholders still are in an experimental phase in which

they devise novel implementation strategies and research incentives-based approaches for GI implementation. Though the initial projects have shown potential for GI effectiveness, its implementation is slow owing to the lack of funding and time invested in negotiation with uncertain outcomes.

Using a qualitative research approach, the following sections elaborate on the above summary of findings within the IAD framework and substantiated with data from document analyses and interviews.

4.2 Exogenous Variables

The physical characteristics of the City of Brampton, its community and the formal and informal rules collectively form the exogenous variables (Figure 6) and influence how GI is perceived and implemented in the City. In reference to this case study, the natural heritage and physical GI of the City are the biophysical attributes. The community of the City of Brampton including all stakeholders contribute the community attributes. Finally, the formal and informal rules, which the community collectively devises through their constitutional rights, are the Rules in Use.

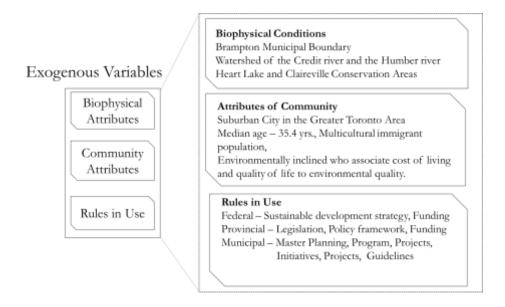


Figure 6: Exogenous Variables for the City of Brampton.

Building on the results from document and interview analysis, the following sections contextualise the exogenous variables and how they individually and collectively influence the action.

4.2.1 Biophysical Attributes

The City of Brampton (Figure 7) is a lower tier municipality in the Region of Peel and part of the Greater Toronto Area (GTA). The City is situated in the watershed of the western tributaries of Humber and Credit Rivers. In addition, the Etobicoke Creek, Fletchers Creek, Mimico Creek flow through the City in east-west direction, and drain into Lake Ontario (Official Plan, 2006, p. 2-2, section 2.1).



Figure 7: Map showing the Geographical Location of City of Brampton.

Source: Reprinted from City of Toronto, Toronto Economic Development and Culture.

Thus, Brampton's landuse and its watercourses directly impact the water quality of Lake Ontario. The City's geography is characterised by gently rolling plain made of clay, silty sand, lacustrine till and topographic moraine features (Official Plan, 2006, p.2-2, section 2.1). The City also has some significant green areas such as the Heart Lake and Clareville Conservation areas and 202.34 hectares of 'designated greenbelt'. Additionally, there is 3602 hectares of parkland which includes 850 parks, a number of playgrounds and recreation spaces, and 217 km of City-owned public trails. Brampton has an 8 km long hydrogeological feature called the Brampton esker, which has substantial reserves of sand and gravel. The esker serves as an important natural aquifer and a source of regional groundwater supply (Official Plan, 2006, p.2-2, section 2.1). Thus, the City is well endowed with biophysical features providing environmental, ecological and social services which are collectively termed as the Natural Heritage System of the City (MAH, 2014; MAH,

2017; City of Brampton, 2006). Future urbanisation if not managed effectively will put pressure not only on these resources but also affect the quality of Lake Ontario.

Moreover, regionally and globally significant bioregions like the Oak Ridges Moraine area (ORMA) and the Niagara Escarpment area (NEA) form the northwestern boundary of the City. These biophysical features, which extend beyond the City limits also influence the action arena, though are governed by the policies of different authorities whose mandates protect and nurture these regional assets. Thus, while the City government plans for the land uses within its municipal boundaries, their decisions impact the local and regional GI, making its management complex and interdependent on the policies of multiple authorities. Moreover, not only do the physical activities in the City affect the biophysical features but the decisions on how to maintain these features also affect their potential to act as GI resource. It is the very resource (biophysical features) that the action situation intends not only to protect but also to optimise and to enhance. In this case study, though the City of Brampton is well endowed with natural resources, their function to provide the necessary ecological services depends on how these resources are utilised and managed. Interviews with study participants reveal how the community's perceptions govern the management of the overall services that the biophysical features can provide.

If you look at most of our public surveys, most people in Brampton treat natural environment as one of the strong points of the City. Most people want to see it protected and improved. They enjoy green spaces, and so we conceived the project as protecting and trying to enhance these areas so that not only do these areas provide more function and respite for people, but also utilise the important ecological services that this natural heritage provides. (I3, Municipal Government)

While the above paragraph shows that most City residents prioritise their environment, their perception of what constitutes the natural biophysical environment and how it should be maintained becomes a challenge in planning actions to optimise these areas functionally. This is demonstrated by the observation put forth by an interview participant.

There is a tendency for a lot of people to think that unless it is maintained it cannot have any value and a lot of it is based on the concept that the private

space is neat and tidy and this should spill over to the park or public spaces. To get social acceptance from the public, things need to be manicured, and there is still this misconception that spirals into other things. Quite often people do not understand natural vegetation is not just weeds. There need not just be manicured flowers. Also, wildlife, though we do not have a lot of dangerous wildlife, coyotes maybe, but the number of people that call council about weeds bringing undesired wildlife into their backyard is really high. We do not have dangerous snakes in southwestern Ontario, but a lot of people are afraid of snakes. Where there is a valley right next to a residential lot, and it is not maintained, we get a lot of calls for snakes, frogs or racoons coming into the property. For them it is a bad thing. (I2, Municipal Government)

Thus, not only do community attributes influence the implementation strategies and the action situation, in this case there is also a conflict between community's perception of green spaces and on what experts suggest green spaces should be.

4.2.2 Community Attributes

The community comprises of all residents and stakeholders who have economic and non-economic interests in the City. Brampton is the ninth largest city in Canada with a population of 593,638 (2016). The City is geographically and economically well located with an international airport, a logistics and manufacturing hub, good rail and road connectivity.

Recognising this urbanisation potential, the Growth Plan for the Greater Toronto and Hamilton Area (Growth Plan), has identified the City as a growth centre in the Greater Golden Horseshoe (MAH, 2017) and the Provincial government has projected a 40 percent increase in population to 840,000 by 2031 (Statistics Canada, 2017; City of Brampton, 2017). Based on the observed population increase of 13.4 percent between 2011-2016 (Statistics Canada, 2017), this projected future growth will be partly through natural growth but majorly through immigration owing to the City's strategic location and the provincial population targets. At present, the City has 51 percent of immigrant population with diverse ethnicities while 49 percent are Canadian born (City of Brampton, 2017). Thus, the future population of the City is also expected to be socioculturally diverse, with a substantial number of first-generation immigrants. The City's present median age is 35.8 years, which is lower than most large Canadian cities (Statistics Canada, 2017).

The major part of the City's workforce (51 percent) is between the ages of 35-54 years and the workforce participation rate is 63 percent, largely employed in the manufacturing, transport, warehousing, and retail sectors (National Household Profile, 2011). Only 24 percent of the population has a bachelors degree or higher (City of Brampton, 2017b, Statistics Canada, 2017) and education levels are comparatively lower than other areas in the GTA (LEPC, 2016).

In addition to these demographic statistics, interviews with participants reveal the prevailing attitudes of the community towards GI and the physical environment, which is that that 'people want green'. As expressed by an interview participant, community consultations and opinions had encouraged the municipal government to look at GI for the ecological services it provides.

Majority people want naturalisation, and they want enhancement of their natural heritage features. Few vocal people want it more manicured, and they are against naturalisation. Some residences do not want to do that stuff on their properties, and they do not want tree planting on their properties. However, I think majority people see the value in enhancing the natural heritage and at least trying to do something on their property, like tree planting or a rain garden. (I2, Municipal Government)

However, this statement shows that the interpretation of green varies among sections of the community. The understanding of green and what constitutes GI, if left solely to the interpretation of individuals quickly translates into various environmental buzzwords such as sustainability, circular economy, planting more trees, having solar panels, biodiversity and quality of the physical environment. The problem is that these terms address very different aspects of "green". This concern came across in participants' opinions:

However, whether it is a LID or GI in a project, or it is a greywater system in a house or conservation or solar panels or conduits for solar panels or high-efficiency appliances, yes that is a good example, energy, high-energy star rated appliances. Again, you would like having that in the house isn't? I am not saying that they should not do that. They may have a different business plan [...]. (I21, Developer Organisation)

The stuff that we have experience in is different than how some of the federal or the provincial government views it. Like in a residential subdivision or commercial projects, which is what we do here. We do not have any experience like with putting solar in new subdivisions, windmill, turbine. None of that stuff, right. I think that's a little bit different then you know how to clean stormwater, how you could minimize it by putting a trench like a bioswale in the ground or some type of trench that has stone in it which acts as a waterway to store and infiltrate water into the ground instead of just having a giant storm pond. We have done that or actually will be doing that in one of our projects. (I21, Developer Organisation)

These conflicting expectations for 'green' are understood by experts as well as some of the community members. One community member explained how these expectations from the green agenda were translated into action:

What happens is that people have a different level of understanding, different backgrounds. I stand alone in 197 families living in my condominium development. However, this is a common good. Initially, I was thinking all the time that I will convert this area into green, energy efficient, sustainable. It is not easy to bring people with polar attitudes together. But there are certain things that they like. If I can reduce the price of energy bill at the end of the month or end of the year, then they like to hear that. If we talk about the same thing 20-26 people who live in the houses, they want to hear that too. So that is what TRCA is doing a phenomenal job by bringing those things and gradually step up step up. (I18, Community Association)

Thus, the interviews demonstrated how residents' desire for lower living costs and better health was a conduit to a concern for a better physical environment. This connection was swiftly and systematically channelized by environmental experts from both within and outside the government to develop actions conducive to harnessing the ecosystem services provided by GI. As suggested by one of the experts, extensive surveys and market research were instrumental in decoding this understanding and planning strategic environmental initiatives:

The initiatives and support programs we have developed have been in response to some of the market research we have done. We have been interviewing homeowners, businesses since 2014 to try to find what are their barriers and motivators. How can we as an organisation help overcome those barriers and work with the motivators, because ultimately everyone has an interest in seeing swimmable, drinkable, fishable waters? We have a vested interest in maintaining and safeguarding our watershed health for the public today and all future generations because the natural environment is our national heritage. That is our legacy that we will leave behind. So, all these different programs were developed

in response to the market research results and told us what the needs of home and business owners were and so on. (I10, Conservation Authority)

The interviews indicate that although the City's community is socio-culturally and economically diverse, the shared understanding of well-being and its association with the natural environment has been able to create some common ground within the community.

Consequently, various members of the community supported furthering the GI agenda:

If it had come from the top, it would be easier because you then have to do it, right? But, no, I think it came from a number of staff or planners who believed this is the right way to do it. I think a lot of the trigger was this alliance with public health. OPPI also had its role around 2007 to demonstrate the link between built environment, the way you live, where to live and how you live to public health. So, when here we had the approval of the community, it supported the drafting of the sustainable guidelines. We had the medical officer of health, telling the council and stakeholders in public that it is not good for your health. It is a very different argument than from you have to save the planet, which is very abstract. When this is about if you do not move, do not walk, do not have walkable streets, trees and shade, its detrimental to your health. That is why we had this alliance, though even right now, it is struggling to find its right place. The last main thing to influence was the recently unveiled Planning Vision. Through the workshops, for example, we heard loud and clear from a lot of enlightened public participants how important this is for them. So now we have the whole environment, ecology thing upfront and one of the top issues. It is much easier to respond and to put resources and move on with this when people are asking for it. Moreover, of course, lately, with the change in the federal government, the provincial government is pushing for climate change, resilience etc. Then it is much easier. (I1, Municipal Government)

4.2.3 Rules-in-Use

The Rules-in-Use are the formal rules and the regulatory framework, which empower actors to respond to situations. They will influence the ability of participants involved in their various capacities to take decision, in this case considerations of GI implementation. At the municipal level, implementation is affected by federal, provincial and local municipal rules and mandates, which provide the legal basis for the action situation. This section reviews the existing policy framework for GI at the federal, provincial and municipal level. The analysis is divided into three main categories, (i) the various legislative and regulatory provisions, (ii) the formal and

legal definition of GI and (iii) the legal tools used at the local level to institutionalise GI. The Rules-in-Use are primarily reviewed through content analysis of policy documents and wherever needed substantiated with interview inputs.

4.2.3.1 Existing Governance Framework

Constitutionally, the responsibility of protecting the environment is divided between the federal and the provincial governments. The federal government has cross-jurisdictional powers to create environmental laws pertaining to fisheries, shipping and navigation, trade and commerce, criminal law and its residual power to pass legislation on matters of peace, order and good governance and significant cross-jurisdictional issues such as climate change.³ The provincial government's powers include making laws for mining, natural and non-renewable resources, forestry, agriculture, energy, public lands and municipal institutions. All other forms of government and institutions exist and can make rules based on the powers conferred to them through the federal and provincial governments. The municipalities through the powers bestowed on them by the Provincial Planning Act are responsible for planning, development and provisions of services such as local road network planning, sewage and solid waste management that affect the quality of air and water. The municipal governments thus have powers to create laws to safeguard the local environment and maintain its quality. As per these regulatory powers, the provincial government specifies environmental standards, which a municipal government has to achieve within its jurisdictions, water quality in stormwater ponds. One interview participant expressed that over the years the provincial government has relaxed the environmental standards required to achieve and devolved the power to regulate these standards to municipalities:

I think if we talk about criteria or regulations, maybe a softening of the amount or the complexity or the rigidity of regulations and so on hasn't necessarily

³ Using its federal powers, the Government of Canada under the 2016 Pan Canadian Framework for Clean growth and Climate Change agreement to meet the GHG targets applied a Pan Canadian carbon tax to be applicable from 2018 on all provinces (MOECC, 2017). The provincial government of Saskatchewan challenged the carbon tax in the court of law. However, the highest court of the province over ruled the appeal stating that the federally imposed carbon tax was constitutional (Abedi, 2019)

resulted in sort of like a wild west quote - unquote or like a really unorganized chaotic unregulated movement in the development sector, because at the same time I think the municipalities have been given the direction from the province that they have the ability to mandate or to develop their own master planning, their own natural heritage strategies or targets and goals, their own development guidelines. That while aligned with the PPS still gives municipalities a lot of ability to tailor what their development vision looks like in the local context. So, any developers or development proponents still have to help ensure that whatever they are proposing from a development perspective is aligned with what the local vision is for that municipality within the community. (I10, Conservation Authority)

Thus, legislation gives municipalities the powers to dictate their own development vision and influence GI in their jurisdiction. In Ontario, the provincial government has also created the Conservation Authorities (CAs) to plan and manage floodplains and watersheds in the province. Since the City of Brampton lies in the watershed of two rivers, the Humber and the Credit, two conservation authorities operate in the City, namely the Credit Valley Conservation Authority (CVC) and the Toronto Region Conservation Authority (TRCA).

4.2.3.2 Defining Green Infrastructure

It is important to investigate the various conceptualizations of GI in the legal mandate to ascertain that the opinions of various stakeholders are adequately captured and to enable comprehensive evaluation of the policy framework. Therefore, the following section reviews the GI definitions applied at the various levels of government along with comparing them with the views expressed by stakeholders in the interviews.

At the federal level, GI finds a mention in the Federal Sustainable Development Strategy, 2016-2019, which defines GI broadly as "infrastructure required to protect and support Canadian communities in transitioning to a clean economy" (MOECC, 2016, p.87).

At the provincial level, The Provincial Policy Statement published in 2014 (PPS, 2014) by the Ministry of Municipal Affairs and Housing (MAH) defines GI as "natural and human-made elements that provide ecological and hydrological functions and processes. GI can include components such as natural heritage features and systems, parklands, stormwater management

systems, street trees, urban forests, natural channels, permeable surfaces, and green roofs" (MAH, 2014, p. 42). The Growth Plan, 2017, and the Greenbelt Plan, 2017, adopt this definition and carry it forward in their policies.

Apart from the PPS, 2014, several other provincial-level government and non-government agencies also define GI as per their context. The Green Infrastructure Ontario Coalition (GIOC) is an advocacy coalition of industry and government agencies such as Friends of the Greenbelt Foundation. The GIOC defines GI as "natural vegetative systems and green technologies that collectively provide society with a multiple of environment, social and economic benefits and include porous pavements, rain barrels and cisterns which replicate the functions of ecosystems, such as stormwater storage and filtration" (GIOC, 2017a, p. 4).

The Conservation Authorities (CAs) define GI as "any natural or built systems that provide ecological benefits and help to maintain pre-development hydrology and encompasses natural features like streams, wetlands, forests, and parks, as well as engineered systems that manage urban runoff" (STEP, 2018). The CAs consider LID integral to GI, as they help "mimic pre-development hydrological conditions by increasing infiltration and evaporation, and reducing runoff volumes and flow rates". The Sustainable Technology Evaluation Program⁴ identifies and suggests pervious cover, downspout disconnection, rainwater harvesting, grassed swales, green roofs, and bioretention areas as LID technologies (STEP, 2018).

Given the legal framework, the City of Brampton needs to follow the PPS, 2014, definition of GI. However, when working with the CAs and other advocacy agencies, the municipal government also aligns with their respective conceptualizations of GI. Moreover, while seeking federal and provincial assistance, the municipal government has to consider its GI definition addresses the funding criteria required by these agencies. In its own documents, the

⁴ The Sustainable Technology Evaluation Program or STEP is a multi agency team of experts formed to "support broader implementation of sustainable technologies and practices" (STEP, 2018 a). Among its various objectives of the team are research, monitoring and evaluation of low carbon and clean water

City of Brampton suggests the use of GI as a tool in creating sustainable communities. The City's Sustainable Urban Design Guidelines (SCDG) encourage the use of GI for new developments. In another application of the GI term, the City's Natural Heritage and Environmental Management Strategy (NHEMS) identifies the lands available below line infrastructures (e.g., hydro and power lines) as GI lands. Thus, the term 'green infrastructure' is used in multiple ways and is open to interpretation.

However, as argued by one expert consulted in the current study (I3, Municipal Government), the PPS, 2014, already contains a definition for natural heritage system (NHS)⁵ that overlaps with several GI definitions and supports approaches to protect and enhance the biological functions occurring within the NHS (MAH, 2014, Policy 2.0, p. 22). The PPS, 2014, recommends detailed methods for municipalities such as using the Ecological Land Classification System prepared by the Ministry of Natural Resources and Forestry to identify the natural heritage areas in their respective jurisdictions (MNRF, 2018). The municipal government can follow the methods suggested by the PPS or can develop its own methods, if it decided to go beyond the recommended methods. However, the provincial government reserves the right to approve the methods adopted by municipal governments.

For functional purposes, definitions are expected to provide a common understanding for all stakeholders to arrive at the same interpretation as others. Therefore, they can be considered working rules that affect implementation of GI in multiple ways. In the current study, experts were asked to define GI according to their industry standards and work experiences. An

⁵ Natural heritage system - "means a system made up of natural heritage features and areas, and linkages intended to provide connectivity (at the regional or site level) and support natural processes which are necessary to maintain biological and geological diversity, natural functions, viable populations of indigenous species, and ecosystems. These systems can include natural heritage features and areas, federal and provincial parks and conservation reserves, other natural heritage features, lands that have been restored or have the potential to be restored to a natural state, areas that support hydrologic functions, and working landscapes that enable ecological functions to continue. The Province has a recommended approach for identifying natural heritage systems, but municipal approaches that achieve or exceed the same objective may also be used" (PPS, 2014, p.45).

expert who said he "made a career out of working on this issue" explained the process of how GI is practically perceived and its definition constructed.

The federal definition is extremely broad. It is like everything. Soil? I would say GI are the elements of our natural and built environments that provide ecosystem services and other services to us. The CAs especially because our primary directive or mandate is managing the river valleys, we think of the rivers as being like the biggest piece of GI and probably the most valuable in any sort of settled area, which includes rivers, streams and wetlands. Where it gets fuzzy is when the different types of infrastructure that could be called GI. So, for us, whose work focuses on water management, particularly stormwater management, will throw the term stormwater management in there. So green stormwater infrastructure which is used interchangeably with LID [low impact development] is my GI. But stormwater is a much bigger thing, and LID is a part of that. Also, ponds and wetlands that can be constructed to treat stormwater as well. They are most definitely GI then. So, GI to me includes all the stormwater infrastructure but with the plants on it so with all the green stuff. Where it again gets fuzzy is to say a permeable pavement or an infiltration trench, which could be something entirely underground, there is nothing green about it. It is just gravel, geotextile and maybe some pipes. I would still call that part of GI because you are putting that in the ground to support the river and the other GI that you have. I think folks like GI Ontario and GI Communities Canada, and they are sort of all on board with this understanding. These types of LID and these practices might not be green but they all still kind of qualify. (I17, Conservation Authority)

The explanation highlights the fuzziness in the ongoing debate of what should and should not be considered GI, especially in a legal policy arena that has direct implications on GI implementation. Experts attributed this fuzziness to the broad definition and the various levels of government that were involved, and were divided in their opinion about the usefulness of such broad definitions. Some experts, especially those who dealt with policy expressed their concern regarding their difficulty to work with such broad definitions.

The definition for natural heritage system is present in the legal framework from the past 20 years, and therefore the definition of GI provided in the PPS, 2014, is very broad and not very useful from the policy perspective. Infrastructure can be ripped up and destroyed and redone. You do not rip up and destroy a valley. This is my opinion, and that is how I see it. My definition is narrower, and I know many others won't define it the way I do. I know the purpose of what they are trying to do with it, but I do not agree with their method. We deal with natural heritage with our Natural Heritage and Environment Management

Strategy and action so that we protect natural heritage. We use GI to enhance the natural heritage features. (I3, Municipal Government)

At least five of the 11 interview participants asked to define GI clearly believed that GI was broadly defined because of the focus on valuation of GI and as one participant said, "excessive attention paid to put a price value on valleys and streams. I somewhat understand why they are doing it, but currently, we do not have a general method for valuation" (I14, Conservation Authority). However, some participants suggested that the broad definitions also provide positive aspects and have given professionals and experts some "leverage and flexibility to construct their own working definitions at per their areas of work" (I10, Conservation Authority). This perspective is supported by other participants working in the integrated water management departments of the conservation authorities.

There is PPS that talks about GI, and then there is the federal definition of it. We have developed a lot of guidance documents that define GI in the context of what we do. Our work does not focus on the regulation, and we are not the permit or planning department. We are more on like ... how do we drive wide-scale adoption of GI and when you think of GI it focuses on all green and non-green elements that support rainwater harvesting and solving issues of flooding erosion and water quality. (19, Conservation Authority)

Industry experts suggest that definitions affect not only the policy and funding opportunities but also workforce development and training. Experts felt the "need to create a common language. I think its broad, but it's not a common language" (I23, Landscape Association).

So many different professionals, as well as policymakers, wouldn't understand a broad definition. It is the language; the definition could be tighter. In terms of workforce development too there's a huge misunderstanding there. We do need to narrow it and attach it to the occupations that are related. There is a real disconnect even in high school systems. We have a horticulture and landscape specials, high school skills major. Kids in grade 11 and 12 specialise in horticultural landscaping. There are separate courses in the environment, forestry and agriculture. However, those four programs at the high school level are not aligned or connected. We have many environment graduates coming out of school with degrees either at the bachelors, the undergrad or the graduate level who have no awareness of the GI industry. They are landscape horticulture

professionals, and they have a role in GI. They are not even considering this as an opportunity for a career. So, I do think there need to be some language changes and some definitions around occupations around what GI means, who designs, who installs and maintains it and who is eligible to create policy around i.t (I23, Landscape Association)

One participant said "[GI] is most definitely an umbrella term" (I24, Industry Expert) and professionals interviewed felt the need to further streamline GI definitions for better policy and implementation. This ambiguity in defining GI has implications when tools are conceived and operationalized for implementing GI projects.

4.2.3.3 Tools of Implementation

The tools that affect GI implementation are the legal mandates, protocols, laws and regulations that support or hinder the implementation process. This section investigates existing federal, provincial and municipal tools and those that are evolving out of the implementation process. At the operational level, which is the local municipal level, the tools become part of the action arena.

Federal Rules-in-Use

The federal government's primary tool is its support for GI through federal budgets, which have been funding municipal governments for a variety of infrastructure, capacity building and strategic economic development projects. As part of its priority to promote sustainable development and create a legal framework for it, the federal government developed a Federal Sustainable Development Strategy, 2016-2019 (MOECC, 2016). Investing in GI appeared to be high on the list of priorities in this strategy as a means of creating resilient communities. Under its long terms goal for 'Modern and Resilient Infrastructure', the strategy identifies "water and wastewater systems, clean energy, climate resilient infrastructure, infrastructure for protection of natural environment and support healthy and resilient communities and promoting economic growth" as its key investment areas for using GI (MOECC, 2016, p. 30). Through the strategy, ministries such as Infrastructure Canada, Ministry of Natural Resources, Ministry of

Environment and Climate Change, and PPP Canada⁶ have created long term plans and programs for funding GI projects (Infrastructure Canada, 2017; Natural Resources Canada, 2018; Government of Canada, 2016). The federal government also created the GI Bank⁷ to provide financial assistance to public sector projects undertaken by federal and provincial governments. The overall sources of funding and funding flows are shown in Figure ⁸. Municipalities can avail themselves of these funds in many ways by satisfying criteria stipulated by each program and fund. In some cases, municipalities can partner with provincial governments to apply for funding or raise matching funds on their own for certain GI projects.

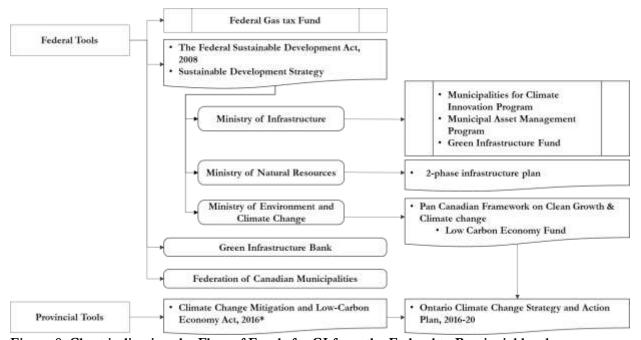


Figure 8: Chart indicating the Flow of Funds for GI from the Federal to Provincial level. Source: Infrastructure Canada, 2017; Natural Resources Canada, 2018; Government of Canada, 2016 (* the Act was repealed in 2018).

To promote innovation and use of new clean technology, many of the funds are provided through a competitive process, where municipalities compete by submitting innovative projects such as documented by one participant working on these project proposals.

Being in the public sector, you are under scrutiny, and you have to do a lot with little. So anyway, if we can leverage some funding, it is still a good thing. We got money from Natural Resource Canada to do our work, and we are applying for

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⁶ PPP Canada is a crown corporation created by the Government of Canada in 2008 to promote the Public-Private Partnerships (P3) in infrastructure development

⁷ The GI bank is now called the Canada Infrastructure Bank (Canada Infrastructure Bank, 2019).

some more federal funding to build our retrofit project. We have to be innovative and efficient and really need to partner because I think partnerships is how you can step up. (I9, Conservation Authority)

Additionally, independent federal level municipal associations, such as the Federation of Canadian Municipalities (FCM), have also been providing funds directly to the municipal governments and conservation authorities on a project-to-project basis as expressed by one participant.

Ours is a relatively big CA. We have the means, but a lot of our funding also comes through grants. There is FCM, and they run a number of granting programs that are funding a lot of GI stuff. I do not know where their money comes from. I would like to know that, especially since a lot of these funds are drying out. But they have been very supportive for a long time when none of the other funds was available. (I17, Conservation Authority)

The FCM has an elaborate GI funding program through various initiatives. It indicates that GI is recognized at various levels of government. Prioritising a sustainable development strategy, making budgetary provisions for the long-term funding of sustainable infrastructure projects and recognising GI as a means of creating resilient communities are very important enablers for GI implementation. In the case of Brampton, participants indicated that the conservation authorities provided technical assistance in writing project proposals for federal funds as they have been testing and developing innovative technologies in water resource management. The City and conservation authorities have been able to secure some federal funding for innovative demonstration project through a steep competitive process.

We have prepared applications and the City processes and sent it. So, this application here where we got all the money, the Region of Peel submitted it. The money came to us to manage the project. However, we prepare the proposal, the report based on what they were asking, and then we help the municipality submit it. We can do this and receive funds because we have the means, we are in the GTA. However, I think, it is still a big thing. It will be difficult for a small CA with lots of rural areas to do these kinds of projects. (19, Conservation Authority)

However, funding for just one specific type of a GI within the broad categorisation of GI was seen as a hindrance and misappropriation of the terminology (GIOC, 2017b). As it turns

out, the bulk of the funded projects were situated in the renewable energy and clean energy sectors (GIOC, 2017b). Interview participants from both the government and professional associations expressed that the "funds are drying out" (I17, Conservation Authority) and "they could do more with more funding" (I3, Municipal government). It appears thus that despite recognising the potential of GI to provide important ecological services, which have a positive impact on the health and well-being of its residents, funding particularly in the ecosystem services sector had been scare.

We still have a lot of disconnects in terms of our conversations between ministries and between industries. Take for example green jobs and all the funding going to green jobs. It was primarily the drywall sector, which was getting the green jobs. (I23, Landscape Association)

Thus, the Federal government has taken a broader understanding of GI (GIOC, 2017b) and provides several funding opportunities, which address GHG emissions, support a low carbon economy and achieve clean and safe air and water systems. The flexibility of the term GI, enabled the government to fund the areas in most need of funding, as seen by the government.

Provincial Rules-in-Use

At the provincial level, the financial assistance received from the federal governments Pan Canadian Framework on Clean Growth and Climate Change - Action Plan (PCF-CC), helped Ontario draft its Climate Change Strategy and Action Plan, 2016-20. This strategy set targets for climate change adaptation and mitigation. GI found a place in the strategy for its multifunctionality, such as providing health and environmental benefits and providing cost-effective adaptation methods (MECP, 2015, pp. 18, 32, 33). The provincial government created several smaller funds such as the Low Carbon Economy Fund (Government of Canada, 2018a) and the Green Investment Fund (MECP, 2018) to disburse the federal funds. The Low Carbon Economy Fund intends to distribute the funds through a Low Carbon Economy Challenge where government and non-government organisations including municipal governments can

submit funding requests for local projects. The City of Brampton received provincial funding for an innovative GI project with the support of a local conservation authority.

So, we were able to secure money from the province for one of our projects in Brampton. Brampton had to put in money too, but since it was a way to leverage and showcase an innovative approach, we got money. We have case studies on our website which go into details. We were able to build some really nice features and show other stakeholders how to do it. Without this much funding, we would not be able to achieve this much. We can help the municipalities go after this money. If the government is saying we want innovative solutions, we want GI, solutions that get to the root of the problem and not a band-aid, the CA can definitely help strengthen them. (I9, Conservation Authority)

Amongst initiatives that promote GI, the Ontario Climate Change Strategy suggests using tools such as the Life Cycle Cost Tool for Community Infrastructure Planning' to estimate the cost of using alternative infrastructure approaches such as GI (MECP, 2015, p. 31).

Ontario's Ministry of Natural Resources and Forestry (MNRF) too drafted the Sustainable Forest Management Strategy from the funds and as part of this Strategy proposes to identify and protect significant ecosystems, biodiversity hotspots, and adopt conservation and sustainable natural resource management practices (MECP, 2015, p. 31). The forestry practices of the City of Brampton are expected to align with this forest management strategy, which includes identifying and securing the NHS. Thus, the funding opportunities made available by the federal and provincial governments have provided avenues to demonstrate implementation of GI technologies.

However, in addition to funding opportunities, the provincial government also has an important regulatory role in land management through the provisions of the Planning Act⁸. In

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⁸ Ontario's Planning Act provides the legislative framework for landuse planning and control through which the municipal governments have administrative and legislative powers to prepare Official Plans and enact by-laws to plan the landuse and development. The Provincial Policy Statement, 2014 (MAH, 2014) is a policy document that supports the Planning Act and contains policies that direct landuse planning and management in the province. The policies prescribed in the PPS, 2014 are followed through by all provincial and municipal plans such as the Greenbelt Plan, the Niagara Escarpment Plan (NEP), the Oak Ridges Moraine Conservation Plan (ORMCP) and the Growth Plan for Greater Golden Horseshoe, 2017 (Growth Plan). The NEP and the ORMCP are not applicable within the jurisdiction of the City of Brampton.

Ontario, GI is addressed through broad policies in the PPS, 2014, and land use planning legislation, specifically the Greenbelt Act, 2005. GI was first introduced and defined in the PPS, 2014, and it directed planning authorities to "encourage green infrastructure as complementary to conventional infrastructure" (MAH, 2014, p. 15, section 1.6.2,). Apart from the PPS, 2014, the Growth Plan, 2017, and the Greenbelt Plan, 2017 form the upper-level policy and planning framework within which the City of Brampton makes its planning decisions. Each of the Provincial regulatory tools is described below.

A. Provincial Policy Statement, 2014 (PPS, 2014) – The PPS, 2014, contains policies to safeguard and protect the hydrology, ecology and wildlife habitats in the NHS. GI is mentioned as a component of the NHS in some of these policies (MAH, 2017a, section 1.2.2). Yet in other policies combined with LID, GI is suggested as a technique to provide a variety of enabling and regulating functions such as stormwater management, climate change adaptation, mitigating GHG, creating complete communities, and air and water quality improvement. The policies, however, only suggest considering GI along with LID as a possible cost-effective alternative over grey infrastructure. The wording used for these policies mainly include phrasing such as 'may consider', 'encourage' and at very few places emphasis was given with words such as 'should'. There are no policies that mandate municipalities or infrastructure projects to investigate their ability to implement GI. Despite this broad stand, the provincial policy mechanism has been able to create some inroads for GI as evident from the projects initiated in Brampton (see section on Municipal Rules-in-Use) and explained by one of the interview participants.

The Province is perhaps, directly and indirectly, helping municipalities and lower levels of government drive GI implementation in new developments or through redevelopment. For example, the Ministry of Infrastructure has a requirement for asset management planning. So, when the existing infrastructure like sewer mains, water mains or storm sewer infrastructure were built, following the second world war and is reaching the end of its useful life. So, realising that this was a growing crisis, the Ministry of Infrastructure has made it a requirement that municipalities have an asset management plan before they go to the Province and ask for funding to help maintain those assets. So, it is kind of a good carrot and stick approach to incentivise proper asset management

planning. Now if municipalities are seeking those funds to help them offset some of the costs that are associated with operations, maintaining or rehabilitating infrastructure such as stormwater, wastewater, drinking water, now through things like the PPS, the ministry has defined what is within the scope of infrastructure and now includes GI and natural heritage like forest and wetlands and constructed forms of GI in their definition. So indirectly it is helpful in making a case for GI. (I10, Conservation Authority)

Though GI recognition in these policy documents remained broad and suggestive, avenues were created where GI can now be considered or discussed as an available alternative for grey infrastructure. Moreover, since the Greenbelt Plan, 2017, and the Growth Plan, 2017, also have to follow the policies in the PPS these plans can recommend GI strategies.

B. Greenbelt Plan 2017 – The updated Greenbelt Plan, 2017⁹, through its legislative powers has delineated ecologically and environmentally important tracts of agricultural lands and natural areas as the greenbelt for the GTHA. Over the years, the Greenbelt Plan was periodically reviewed to include new lands into the greenbelt. The greenbelt serves as a regional GI for the GTHA when seen in relation to the interconnected ecological network concept of GI. However, it has had its share of political controversies over lands identified for inclusion in the greenbelt, their ecological significance and management, and financial hardships for landowners as result of land inclusion in the greenbelt (Pond, 2009a; Pond 2009b). Separate provincial level agencies such as the Friends of the Greenbelt manage and monitor the greenbelt. Brampton has 500 acres of designated greenbelt in its jurisdiction and the policies of the greenbelt govern its protection and enhancement.

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⁹ The Greenbelt Plan was created through section 3 of the Greenbelt Act, 2005. The Plan identifies significant land parcels in the public domain comprising of a network of agriculture systems, NHS, and urban river valley lands. The Plan intends to safeguard regional ecological and hydrological linkages from urbanisation pressures (MAH, 2017a) and strengthened the Province's commitment to achieve GHG emission targets as outlined in Ontario's Climate Change Strategy, 2015 (MAH, 2017a). The Greenbelt Plan area can be viewed as a regional scale GI, which is evident from section 1.2.2-Protected Countryside Goals-point 6 on climate change, where the plan identifies the NHS as a component of GI (MAH, 2017a). Policy 4.2 says that GI is a cost-saving alternative that supports conventional infrastructure in extreme weather events (MAH, 2017a). The Greenbelt Plan categorises land for urbanisation and permanent protection, and reiterates the theory on GI of how the protected lands will help clean air, water, reduce GHG emissions and support the future sustainability of the region.

C. The Growth Plan for GTHA – The Growth Plan discusses GI for climate action and prescribes that upper and lower tier municipalities should align their official plans with the Ontario Climate Change Strategy, 2016-20. The Plan also suggests that in addition to protecting the NHS, official plans need to include policies for using GI and LID techniques to address GHG emissions and climate change adaptation (MAH, 2017, section 4.2.0).

Thus, it is observed that the provincial government has over the years created a complex enabling legislative framework that recognises GI for its multifunctional applications. Figure 9 illustrates the existing provincial tools and how they influence the regional rules-in-use.

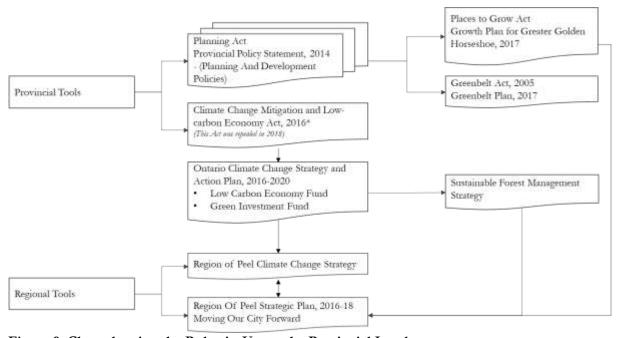


Figure 9: Chart showing the Rules-in-Use at the Provincial Level. Source: MAH, 2014; MAH, 2017; MAH, 2017a; Region of Peel, 2011; Region of Peel, 2015.

D. Other Tools – Besides the land use planning framework outline above, there are several other avenues where GI can be addressed at the provincial level. The Canadian Institute for Environmental Law and Policy studied opportunities to promote GI for stormwater management in Ontario. Their study identified the Ontario Water Resources Act, 2011, the Environmental Protection Act, 1990, the Clean Water Act, 2006, the Water Opportunities and Water Conservation Act, 2010 and the Ontario Building Code as important pieces of legislations where GI policies should be included (Matt Binstock, 2011). These Acts allow the provincial

governments to stipulate air, water and environmental quality standards and can recommend GI as an effective strategy, which may give impetus to municipal governments to consider GI in their projects. Like stormwater, there are several other environmental issues such as biodiversity, agroforestry, air quality and even parking area standards, which can recognise GI benefits.

Considering that this policy arena is still evolving, an interview participant provided insight on how the efforts of the Provincial governments in rewriting criteria documents affect GI implementation.

More directly I think, the Province is supporting GI implementation through the rewriting of criteria documents when it comes to things like stormwater management. Similarly, the Ministry of Environment and Climate Change, which is now the Ministry of Environment Conservation and Parks [MECP], put together the runoff volume control targets and included LID sort of technologies in the criteria document. That sort of lays out the new ways the stormwater management needs to be practised or kind of can be carried out in this province. There's a very heavy emphasis on using source and conveyance controls or using this thing called the treatment train approach to managing stormwater. It entails the use of LID and constructed forms of GI. Now if you listen to the MECP, they will tell you that they really seek clarification bulletins and I think in 2015 they said that the Ministry has always emphasised the decentralised treatment train approach to stormwater management. It has perhaps given some of the strongest design guidance and design criteria surrounding the sizing of things like stormwater management ponds. So, since that is where the best information and design criteria were available, where engineers tended to default to. But if you read even the 2008 stormwater planning management and design manual, there was narrative in there about LID. However, the new runoff volume targets very strongly emphasise the use of LID. So, I say that's a more direct way that the Province, I think, is working to support municipalities who are struggling with stormwater management issues in their jurisdiction. I will say its kind of top-down command and control type of tools like that. Those were required, and I would say, point to the use of GI in all new development and redevelopment projects. (I10, Conservation Authority)

Regional Rules-in-Use

The City of Brampton is a lower tier municipality in the Regional Municipality of Peel (Peel Region). One of the main objectives in Peel Region's Strategic Plan is protecting and enhancing the region's NHS, for which it has developed the Official Greenland system for identifying and securing important greenlands in the region (Region of Peel, 2018). Peel Region

has partnered with the City of Brampton and other municipal governments for the technical and financial aspects of the process (Region of Peel, 2018).

Besides, Peel Region has also prepared a five-year Climate Change Strategy devised through the Provincial climate change strategy. The strategy advocates watershed management, active conservation of NHS, stormwater management, water quality improvement as climate adaptation measures and has co-partnered on a Natural Heritage System Restoration Program (NHRP) and an Urban Forest Strategy with municipal governments in Peel Region. For forest management, Peel Region developed a Priority Tree Planting Tool which is also used by the City of Brampton and other municipal governments in the region (City of Brampton, 2018).

As suggested by one of the interview participants "GI is used by different organisations and departments depending on their mandates, and ours is water efficiency. Mandated by the provincial government as a water provider, we need to have a long-term water efficiency strategy. We typically update the strategy every five years and based on the current trends and where technology is going, we created this program" (I8, Municipal Government). Peel Region has partnered with multiple agencies to use GI to achieve these mandates.

Municipal Rules-in-Use

When looking at City level rules, it must be taken into account that these are operational level rules. The actions taken to implement these rules also are part of the action arena. During the period of this research, the City of Brampton's Official Plan, 2006, was in effect and being reviewed. The Official Plan, 2006, was amended in 2012 to conform to the Growth Plan's recommendation of incorporating a Sustainable Planning Framework (SPF) into the municipal Official Plan. This amendment led to the introduction of the term 'green infrastructure' in the Official Plan, 2006, for creating sustainable communities by promoting the use of sustainable management practices, green infrastructure and green building design standards in the 'Institutional and Public Use' designated lands (City of Brampton, 2012, p. 12,

section 4.8—Institutional and Public Uses in policy 4.8.2.2). The amendment also led to the City drafting its first environmental master plan (EMP) – the 'Green Brampton Master Plan, 2014' (City of Brampton, 2014) – to create a sustainability roadmap and address issues of climate resiliency and biodiversity improvement among many other initiatives. Again, it should be noted here, that the EMP was an action taken in response to the province's requirement for an SPF and meant to become a living document. Being a living document, this meant that the City of Brampton committed itself to periodically update the EMP, reflecting future rules-in-use. Figure 9 at the end of this section maps the various initiatives, depicts stakeholders involved in each initiative, and shows how these initiatives are supported by upper level governments. Brampton's Grow Green Environmental Master Plan - The Grow Green Plan has outlined several initiatives with the aim of 'conserving, enhancing and balancing the natural and built environments to create a healthy and sustainable city (City of Brampton, 2014). The Plan conceptualised six core focus areas of People, Air, Water, Land, Energy and Waste (City of Brampton, 2014). Among the various policy initiatives included are protecting water as a nonrenewable resource, reducing energy usage and waste management. The Grow Green Plan thus introduced GI concepts in city planning that shape the action arena. Amongst these GI concepts were the National Heritage and Environment Management strategy (NHEMS), the Sustainable Community Design Guidelines (SCDG) and the Draft Natural Heritage System Restoration Program (NHRP), which outlined various approaches for environmental management. The City of Brampton partnered with the two conservation authorities, Peel Region and industry partners for a number of these initiatives including the Sustainable Neighbourhood Retrofit and Action

A. Natural Heritage Environmental Management Strategy and Implementation

Action Plan (NHEMS) – This plan is an integrated strategy for protecting, restoring and enhancing the natural features and their functional linkages within the City. The Plan identified a

Program.

GI network comprising of the City's natural areas, open spaces, GI lands¹⁰ and urban forest, and focussed on safeguarding the biodiversity and ecosystem services within these areas. It outlined a number of phased initiatives including tree plantation, naturalisation of public green areas, enhancing the ecological functions of natural heritage areas. The strategy emphasised partnering with various stakeholder, volunteering, awareness creation and education as integral to implementing the Plan.

- B. The Draft Natural Heritage Restoration Plan (NHRP) This plan focuses on the City's land objectives and outlines actions and targets for conserving the NHS and promoting ecological diversity and services. While the NHEMS strategy focuses on securing and protecting valuable NHS land parcels to ensure connectivity and linkages at the City level, the NHRP is a subset of the NHEMS, which focuses on restoration and naturalisation actions on these lands.
- C. Parks and Recreation Master Plan This plan is a comprehensive strategy for providing a sustainable park system including the delivery of parks and recreation facilities, and services. One of the primary goals of the Parks and Recreation Master Plan is to protect and enhance the City's NHS through initiatives such as naturalisation of park spaces.
- D. The Sustainable Community Development Design Guidelines (SCDG)¹¹ These guidelines aim to promote a healthy and active lifestyle as well as address air and water quality, GHG emissions, social connectedness and increasing levels of physical activity. They are provided in a form that supports broader sustainability principles of compact built form, active mobility, natural environment, open spaces, and GI. The guidelines also feature the use of GI and LID technologies for preserving natural heritage functions combined with placemaking principles to create compact and efficient communities.

¹⁰ The lands under line infrastructure corridors such as conveying power lines, road alignments were termed green infrastructure lands in the NHEMS

¹¹ SCDGs were drafted to assist in evaluating development proposals at the secondary plan, block plan, subdivision and site plan level and examine them through the sustainability lens

E. The Sustainable Development Action Plan (SNAP project) – These projects are conceived by the local CAs to develop community-led retrofit projects that address objectives like sustainability, urban renewable and climate change adaptation at the neighbourhood and watershed scale. The City partnered with the CAs for two SNAP projects. These pilot project initiatives prepared detailed retrofit plans using GI and LID techniques at a neighbourhood level.

Thus, at the municipal level, the City has taken a master planning approach to protect and enhance the ecological services. Figure 10 below shows the various GI initiatives taken up by the City of Brampton. The NHEMS, NHRP, SCDG and SNAP are experimental and currently under implementation using various mechanisms.

Table 6: Various Initiatives and Tools used for GI Implementation at the different Government Levels.

Government Levels	Initiatives	Tools
Federal	Sustainable Development Strategy	Funding
Provincial	 Climate strategy - GHG Provincial Policy Statement – enabling GI policy Greenbelt – regional GI Growth Plan – policies for climate change Forest management strategy Criteria document for environmental standards 	 Funding Legislation – greenbelt and forests Policy documents Strategy document - climate adaptation Criteria document
Regional	 Climate strategy Greenland securement program Priority Tree planting tool Water efficiency initiatives in education and training 	 Strategy document – climate strategy Programs Initiatives – education and training
Municipal	Official PlanGrow Green Master PlanSCDGSNAP	Master planningGuidelinesDemonstration projects

The findings presented in section 4.2 (Exogenous Variables) demonstrate the community's emphasis on a pro-environmental agenda and nested rules-in-use. It shows that the

funding opportunities, nested strategies and policy interventions of the federal and provincial government have enabled GI implementation at the municipal level. Table 6 summarizes the initiatives at the various levels of government and the tools that form the rules-in-use. It is important to note that the municipal actions on GI implementation are in their early phase of drafting plans, projects and initiatives. Hence, some of them are rules-in-the-making and currently overlap partially with the action situation. Review of the Strategy and Plan document indicates that these actions are in the form of guidelines and collaborative actions.

4.3 Action Arena

The Action Arena is the central diagnostic component of the IAD framework, which allows observing all stakeholders (actors) involved in policy making process and the actions they take based on their roles and responsibilities (Ostrom, 2005). In case of the City of Brampton, the Grow Green Master Plan along with its key initiatives discussed in the rules-in-use section is the central GI implementation action, which shapes the action arena at the operational level.

Section 4.3.1 identifies all the actors involved in the action arena of implementing GI in the City of Brampton. Appendix G first lists all the GI types existing in the municipal area in hierarchical order starting from the plot level to city level. Each GI type is then analysed for (i) action tools, (ii) actors, (iii) actors' positions within the system, (iv) actors' functions in regard to GI implementation, (v) identification of actors who contribute to the cost of GI implementation, (vi) the geographic influence area of the actions, and (vii) the tools used for GI implementation. Section 4.3.2 then reclassifies all the GI types identified through Appendix G into three categories based on mode of implementation, i.e., public, private and public-private partnerships. Sections 4.3.2.1 – 4.3.2.4 then discuss (i) the current challenges in GI implementation as expressed by interview participants and (ii) the strategies (actions tools) emerging to address these challenges.

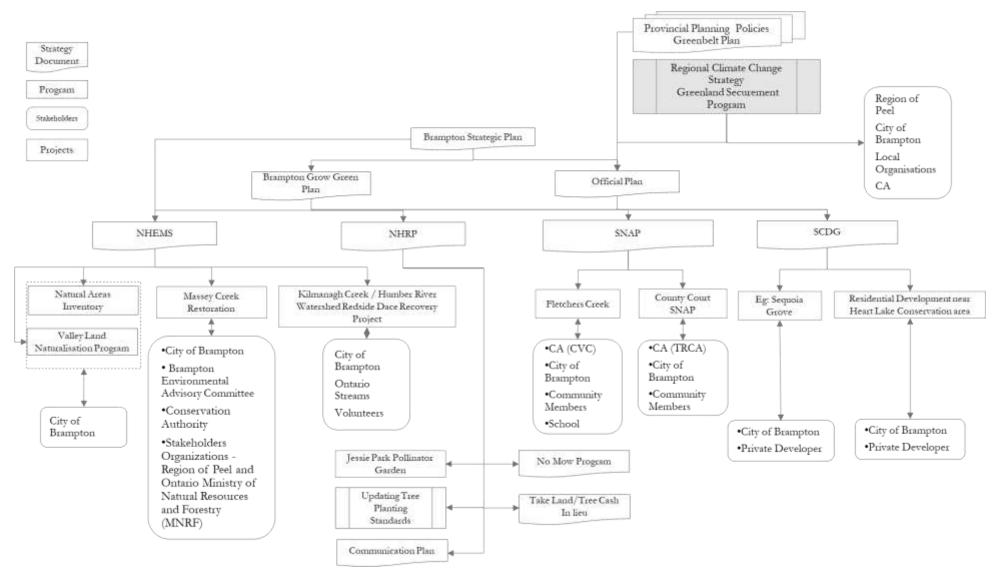


Figure 10: Chart showing the various Implementation Programs at the Municipal Level and the Stakeholders involved. Source: Adapted from City of Brampton's official website and documents.

4.3.1 Identifying Actors

The rules-in-use described in the previous section identify the primary actors in the action arena. Besides the federal, provincial, regional and municipal governments, in Ontario, the CAs are integral actors in this case study with their role in regulating and managing the watersheds and floodplains. The document analysis and interviews suggest that the CAs go beyond regulating the watershed and providing technical knowledge of hydrology, and have developed expertise on how GI can be used in the watershed.

In my experience, yes, they are watershed experts. However, the watershed is not just the actual body of water. In my dealings with the CAs, I have dealt with wildlife experts, forestry experts, naturalisation staff that really understands what re-naturalisation really should be. So, I think, their expertise is not just the water-related or fishery-related or flood plain related. I think their role goes beyond that. (I2, Municipal Government)

Since the City of Brampton straddles two watersheds, two CAs, the Toronto Region Conservation Authority (TRCA) and the Credit Valley Conservation Authority (CVC) share the jurisdiction. The importance of the CAs and the watershed was succinctly put by one participant.

The CAs are mandated to regulate flooding and development in flood-prone areas, hazard zones, regulated floodplain areas. The CAs have also been delegated responsibility from the MNRF to look after water quality through the provincial water quality guidelines and making sure that in stream water quality meets those guidelines and where it does not. The CAs work to bring up the quality to meet those guidelines. So, from that perspective, anything that infringes upon or impinges upon flood control or water quality necessarily needs to involve the CAs. The same can be said with things like the source water protection plans. These are provincially mandated plans that municipalities have to develop and CAs can help do the source water budgeting. So, we look if this municipality is relying on groundwater, what kind of infiltration targets should we have. So that the people in those communities do not run out of groundwater. So now we are talking about groundwater recharge, water quantity and flood control. So those are all the things that GI can do right. I think that all of them together underscore the importance of working with CAs to kind of bringing that overall watershed-based picture in terms of developing a management strategy or management approach. (I10, Conservation Authority)

Thus, at the operational level, Peel Region, City of Brampton, the TRCA and the CVC are primary government agencies in the action arena. In addition, action tools (projects,

programs, initiatives) influencing all types of GI in the City were identified (see Appendix G). The analysis established that community members, developers, contractors, landscape professionals and owners of private land parcels also play important roles at the operational level. In comparison, the federal and provincial governments played a limited role by providing boundary rules to the operational level action arena.

Along with the roles and responsibilities, the position rules in the action arena were also analysed. After analysing the action arena (Appendix G), GI implementation can be categorised into three main sectors: (i) on private lands, (ii) on public lands, and (iii) through private-public/public-public partnerships. Each actor (organisation) involved in implementing GI at this operation level is initiating these GI projects to achieve their own independent mandates. The actors are independent entities having specialised roles and positions in the governance system and have collaborated in this case to share resources and responsibilities. Thus, their individual roles and objectives in the collaboration make this GI implementation method polycentric as shown (Figure 11). The next section 4.3.2 on the action situation investigates the details and terms of these collaborations.

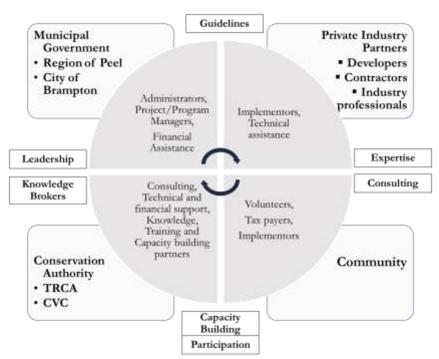


Figure 11: Diagram mapping the Actors, and their Roles and Responsibilities in the Action Arena.

4.3.2 Action Situation

The action arena can be subdivided by actions for (i) public lands, (ii) private lands, and (iii) other, community-centered lands such as rights-of-ways, schoolyards, and community gardens. Table 7 re-classifies GI types into the above three action situations and the action tools used to deal with each situation.

Table 7: Categorising GI Types and Actions Tools by Action Situation.

Action Situation	GI Types	Action Tools
Public Lands	Conservation areas, public parks, natural heritage systems, streets and rights-of ways, stormwater retention ponds	The Natural Heritage and Environment Management Strategy (NHEMS)
		Conservation Area Master plans
Private Lands	Front & back yards of residences, commercial and institutional open spaces, other privately-owned open spaces including farmlands	Land Securement program
		Healthy Yards, Greening Your Yards program, greening corporate grounds
		Buffer area plantation program, tree distribution
		Fusion Landscape program
		Landscape designing by students
		Development guidelines
Centered Lands detention along stree	Right of ways, stormwater	SNAP
	detention ponds, LID retrofits along streets, school yards, community vegetable gardens	Treatment train ¹² method for stormwater management.
		Innovative co-management communal infrastructure

¹² The Treatment Train tool is used to analyse and manage the annual and event-based stormwater runoff volumes to design stormwater systems that remove pollutant loads using LID techniques. The tool was developed by the Lake Simcoe CA, the CVC and the TRCA collectively to assist developers, consultants, engineers, municipal governments plan and construct their stormwater systems as per the watershed (STEP, 2018b)

4.3.2.1 Implementation on Public Lands

The NHEMS and the NHRP, which are aimed at naturalising, protecting and enhancing ecosystems services, are the main municipal strategies for implementing GI on public lands. The strategy document lists many long-term revitalisation and greening projects, which will be implemented in partnership with other government agencies. The municipal government is funding most projects initiated by it. However, for specific components the municipality may seek assistance from project partners, and some even through federal and provincial grants.

Participants suggested that "funding is an issue, but they [municipal government] try to allocate whatever little funds they [municipal government] have to as many tasks as possible and span it over many years" (I4, Municipal Governments). Community volunteering is sought in support of certain aspects such as tree plantation drives. The funding dilemma is expressed by one participant:

GI projects have a tendency to be assumed as greening/plantation project and funds are made available for them. But LID technologies, which have no tree component and yet help mimic nature and pre-development hydrology, experience scepticism. (I3, Municipal Government)

Besides long-term strategies like the NHEMS, sometimes there are opportunities to propose GI in new public infrastructure projects such as road repairs with approved capital investments, if they are examined with a GI perspective in mind. With the persistence of the CAs and the municipal departments, some GI elements are integrated into such projects, especially if the project lies in a flood plain.

A capital project is a big one. If the City or the region have a capital project coming up for the area, it's perfect because then we can piggyback and say you were planning to replace the road, why don't we partner and bring funding to do a bioswale or GI in the road right-of-way. People get excited about it, partners, residents. So, it's a way for us to complement what the City was going to do. (I14, Conservation Authority).

However, experts consider that in the absence of a strong government mandate or not even financial incentives, most of such projects only are driven by motivated professionals who believe in the benefits of GI.

Not for natural heritage. There are no incentives for us to do it. We did it because we think its important value and asset to the City. We want to make sure that the natural heritage is fully healthy and diverse and provides the most ecosystem services that we can get. (I3, Municipal Government)

Participants suggested that the hesitation to fund GI arises because GI projects are evaluated based on their costs as compared with conventional infrastructure project costs without considering the whole suite of benefits they are providing. Participants cautioned that the currently available methods of valuing green assets are insufficient.

There is no precedence for GI projects since we are doing it for the first time. It is going to be more expensive, and it is going to take more time because, though we have the expertise, we do not have all the experience yet. We do not know all the barriers yet. Once we have the first project, that will be the benchmark. So now if Brampton wants to implement a second bioswale, they can always compare it with this one and see how much money it costs and how much time. That is how we have to compare, between different GI projects. Instead, we compare them to traditional projects. I think to compare; you need to compare everything. Right now, it is hard to evaluate the co-benefits. No one is really considering them. We have developed a set of quantifying socio-economic inventories to quantify other impacts. Environmental benefits are easy to quantify but what about social belonging, community pride, public health or being connected to your neighbours or of being outside. These are benefits of natural planting and even has financial benefits. I think currently they are not well-developed methods for it. So, we compare GI to the traditional approaches. It is hard to compare at this point in terms of a dollar figure. (I14, Conservation Authority)

What this suggests is that even though some of the environmental and financial benefits of GI are quantified, there are still barriers in valuing and quantifying many of the other GI benefits. However, decision makers investing additional public funds on such GI projects may be justified in doing so through public consensus. In the case of the City of Brampton, the community attribute analysis suggests that overall there is community support to initiate projects like the NHEMS and NHRP. Still, investing in these projects is a financial risk in the absence of

performance of the project, it is observed that in case of City of Brampton, the risk of using public funds on GI projects is shared between different government agencies through partnerships "because when we partner with the municipality in terms of technical expertise or funding or maintenance, we also share the risks" (I14, Conservation Authority). Table 8 summarizes the above findings on the current issues experienced in implementing GI on public lands and the current approaches emerging to address these issues. It is inferred that issues such as cost of projects and valuation methods can be addressed in due course with more experience in GI projects. However, creating the motivation and consensus required for successful GI implementation calls for new capacity building efforts.

Table 8: Approaches for GI Implementation on Public Lands

Issue	Approach adopted by stakeholders
Shortage of funding	Partnerships
	Piggybacking on capital projects
	Annual Capital Budget Requests
	• Having a Development Charge on new projects for Valley land Naturalization Program.
	• Having a Tableland Tree Cash-in-Lieu Program. Developments unable to do compensatory tree planting for the tableland trees cut for a project, pay money to the City for tree plantation elsewhere in the City.
	• Providing Perpetual Maintenance Fees of \$5,000 per ha of NHS dedicated to the City. (City of Brampton, 2018)
Insufficient valuing	Developing methods and valuing tools
methods	Documenting GI projects costs and comparative analysis
Responsibility of investing public funds	Public consensus
Absence of mandate and incentives	Motivation and awareness of professionals

4.3.2.1 Implementation on Private Lands

Participants from government organisations said that "they cannot rely on public lands alone because of the competition for using land for parks, playground and sidewalks that there is no room for trees unless they are planted on people's backyards" (I14, Conservation Authority).

Moreover, "whatever happens on private yards and soil impacts the water and environmental quality at the entire neighbourhood and the City" (I4, Municipal Government). Therefore, participants from the government organisation and even professional organisations suggested that ensuring ecosystem services on private lands is equally important as on public land.

Because if the municipality were to build a pond to treat the water, they would have to buy the land. The land is really expensive, and the City would have to maintain that infrastructure to eternity, which then falls back to the taxpayer as residents. Moreover, if there is a more cost-effective way to do it on private property and incentivise them, then the City also gets a good return on their investment because this is infrastructure that they do not have to maintain. (19, Conservation Authority)

Thus, for above cites reasons, it is important to look at GI implementation on private lands. All local government agencies have initiatives and support programs that promote GI on private lands based on their mandates for land management or achieving water efficiency. The programs targeting private lands can be categorised as: (i) creating awareness and providing technical assistance through tools such as the Greening Your Yards program or the Healthy Yards program and (ii) hosting free events that provide free trees or landscape design services by students, and (iii) policy mechanisms such as the Greenland Securement program and Greening Corporate Grounds program (see Appendix G for details of each program). Participants believed that for people to respond to such initiatives, the focus should be to "bring about change from within as against forced" (I14, Conservation Authority). One participant narrated their experience in hosting tree distribution events for achieving greening objectives.

Sometimes programs have a very low uptake, and people wonder how can it be so low when we are giving it for free. However, I feel we have to work with the residents, on the logistics. Sometimes the tree is free, but residents cannot go to the City hall or don't want to dirty their car, or the tree will not fit inside their car. These things may sound meaningless for us, but for the residents, it is deciding whether they are going to do it or not. We want them to do it, so we need to make it as easy as possible by simplifying the details for them. In Brampton, we are not asking residents to go to the nursery to get the trees. We are taking the trees to their neighbourhood park from where they can pick it up. So, they still have to sign-up, do the paperwork but the tree is out there. Most times we even deliver it to their homes and help them on planting details. We

see people reacting well when we make efforts to make it easy for them. More and more people get on board when they see us in the neighbourhood. [For example], some cities do not offer fruit trees, but people want to have fruit trees. So, we can work with organisations who provide fruit trees and make it relevant for them. There will always be a percentage of people who do not want to have a tree. So, you can't go and busy them. You have to say ok. That's it. (I14, Conservation Authority)

Regarding large private land holdings, participants expressed that it is a process of negotiation. A municipal official gave an example of how promoting GI on a one-to-one basis with a large corporate client had worked favourably:

They figured out that it is going to save them money not to mow their place. It was environmentally conscious and so the naturalisation program sort of met the corporation's objective. They are going to go ahead with it. I do not know if it was a direct result of our meetings with them 2 to 3 years ago. But we might have dropped a spark of an idea, and they followed through with it. (I3, Municipal Government)

These projects and successes become examples and instruments of negotiation with other clients and developers. Both the City and the private developers believe that "negotiations work, but one has to have patience and one has to sit with them and show it to them" (I2, Municipal government). Participants from the development industry pointed out that "if projects are straightforward such as including a bioswale or having a rain garden along the street edge, we will go ahead and do it. Even we want to be responsible citizens and do the right thing.

However, a lot of this technology is new, and there is an uncertainty of the outcomes which drive the project costs high" (I20, Developer Organisation). Developers involved in developing subdivisions are have the opportunity to integrate GI at the planning stage. While the open spaces in developments are later subsumed to the municipal government, developers can consider GI in an integrated manner for private residential and public spaces. One developer organisation who is actively using GI for their projects explained that time is an important cost factor for them and that uncertainty of the GI technology drives project costs higher making houses expensive:

Because we often are in situations where the environmental department, whether it is engineering or whomever it is in the municipality who would like to try something and so would the CAs. Often, they have ideas or they have seen it somewhere else, but then when it gets to the maintenance and operations department they are like, woh woh woh!!! How are we going to figure this out? Because then they are the ones who, years from now once the subdivision is assumed, are actually going to have to figure out how to maintain it forever. If they cannot figure it out how to maintain it, then what the reality of it is, they are just going to remove it. They just pull the components out of it, and it just becomes a standard catch basin or whatever it is so. (I21, Developer Organisation)

Both the developers as well as municipal participants agreed that operations and longterm maintenance are still an unresolved issue, as many technologies are still untested.

So, the developer is eager and all fine and dandy. They say, just tell me what exactly I have to do and need, I will do it. What developers want is speed with regard to approval of their applications. Time is money from them. [......] Also, some of the GI approaches are relatively new. So, there is a hesitation of taking something new because planning for the long term takes time. Considerations like whether it will succeed, how much more it will cost to maintain it? [....] Is it attractive? Would we have people complaining from the community more often because it requires more maintenance? (I4, Municipal Government)

Participants also expressed that negotiating with corporate clients or developers with large land parcels is facilitated by the smaller number of stakeholders involved. In contrast, negotiating with every private homeowner in a neighbourhood would require much more resources. Moreover, there is no legal mandate for such a process. In the absence of precedence and shortcomings in the operations and maintenance part, to ease negotiations while evaluating projects, the City of Brampton has developed a sustainability score. "Instead of regulations, the City has developed guidelines to help developers, who can come up with their own decisions to achieve specific environmental quality targets. The programs act as incentives, guidelines are less regulatory and the sustainability score acts as a 'carrot and stick approach"(I1, Municipal Government). Through this method, the municipal government and CA hope to propose certain GI technologies and developers can improvise them depending on their resources and specific conditions.

Other than the developable land in private ownership, there are also environmentally sensitive lands in private ownership. For such land parcels, Peel Region and the City of Brampton have partnered for the Greenland Securement program. These lands are identified as environmentally significant or undevelopable through provincial or local environmental impact assessment studies (EIA) processes because of their proximity to water bodies and other environmental features. The program offers matching funds from both municipal governments to help buy the land from private landowners, provide stewardship initiatives, or offer tax benefits to owners of such environmentally significant lands in return of keeping them naturalised.

Some participants pointed out that for many years there had been a disconnect between the lot level or the private lands and the public lands:

There has been a disconnect there for many years. The connection between private property and public property is very important. It needs to happen in a more consolidated and concerted effort, and I think that it is an opportunity for growth for the GI industry. Certainly, that is something perhaps we have not done a good job as we could. That conversation needs to start, and it should be that merging of elements and facilities to reduce stormwater. (I24, Landscape Association)

The effort to connect the public and private realms is increasingly observed in the third type of implementation model discussed below. Table 9 summarizes the issues and the currently adopted approaches in promoting GI on private lands. The approaches adopted for GI implementation on private lands indicate a move towards less regulatory approaches to encourage more experimental projects currently required for projects with no precedent. They demonstrate a fair amount of negotiation and persuasion from GI promoters to encourage GI implementation by the private sector. Most often, cost and time required for experimenting with new technologies are deciding factors for adoption of these technologies.

Table 9: Approaches for GI Implementation on Private Lands.

Issue	Approach
Motivating people's interest in GI	Free events, programs and working on the logistics, one-to-one negotiation.
Time and uncertainty of untested technology	More experimentation and demonstration projects.
Operations and maintenance	
Absence of legal mandate	Sustainability score
Persuading landowners with environmentally significant lands to keep it naturalised.	Greenlands securement program

4.3.2.3 Implementation of Community Centric Projects

Lands with community-centric projects are at the interface of public and private lands and show complex ownership. Though a particular private or public agency technically may own the lands, there is still an associated sense of belongingness to these lands for other stakeholders that lay a claim to them.

The school and its infrastructure are from the 1950s, and there aren't sufficient green spaces especially within the community where our school is. So, the school premise takes on different importance for the community because essentially it is a large expanse of greenery, and there isn't that much green in this area. So also, from a stormwater retrofit perspective, the system is outdated, and it does not clean the stormwater as well as you would find in a newer subdivision. So, looking at the need for the infrastructure to be updated, looking at the fact that the school field is important to the community, the two came together. The City of Brampton and CVC approached us to ask if the school would be interested in being part of a stormwater retrofit greening project on the property. (I22, School)

In the City of Brampton, increasingly government agencies try to capitalise on this sense of shared ownership and belongingness to promote collective action. Thus, the action arena is shaped by collaborative partnerships, co-management practices and increased involvement of the community to facilitate implementation and sharing of co-benefits. The initiatives observed are both in the public and private realm and comprise of projects such as installing GI in a school playground for improving the water quality of a stream, inserting a bioswale using the treatment train method in a residential neighbourhood, or starting a community garden. The process of involving the community to develop projects was explained by a community member:

Before this thing happened, I believe in 2009-2010, TRCA was here, trying to make the connection. They set up a fair to provide information and were talking about Pioneer Village. At that time the environment awareness was not the same as now. So those five years preceding this period are very important. In this neighbourhood, we see a juxtaposition of 2200 families, plus 197 units, in the condominium building who use the same facilities, the same area but are aloof. But I could make the connection, because I knew TRCA and what they did. Even in our initial meetings I found, different people stood for different things, which kept them apart. However, now here you are getting toilets pots for free. So, you get them together. TRCA was the instigator who asked what we can do to improve this area. There was a dry pond close to highway 407, and people were misusing it. It was dry and abandoned. So, people were throwing old furniture into it and abusing that space. In Planning, you know what you need to do at that time. Bring in some experts. So, there was Brampton, Peel and TRCA who got together, and there were some interested parties like the two of us. We got together and said that there needs to be actual water in the pond. Make it pleasant and hygienic. That is how the project started. (I18, Community Association)

Participants believed that instilling collective ownership and belonging to the lands is more effective for the success of such projects than regulation. Apart from the public consensus for such projects, the community becomes a resource and monitors the project. All participants involved with such projects expressed that such programs not only help with environmental objectives, they also create long-term ownership, social cohesion, and stewardship attitudes regarding the environment within the community. Interviews highlighted that the SNAP projects in the City of Brampton created new neighbourhood associations. The School project helped demonstrate the school curriculum to the children, provided hands-on practical knowledge, and the children became entry points for sustainability ideas in their communities. Participants explained that each SNAP is unique and has different outcomes.

In Toronto people are growing their own food in their backyards and with the water from the rain barrels we provided them because basement flooding was a priority in that area. With the rain barrels, we just helped in holding the water from their roofs, and they save that water and grow their own food. They give the surplus food to the people living in towers who do not have their backyards and cannot grow their own food. It is like a great system in which 100 pounds of food is donated from single-family houses to towers. But food might not be a priority for some people. So, we need to be careful while designing the key

elements of SNAP and customise them. It depends on the residents, their values, motivations. We cannot really force [it]. (I14, Conservation Authority)

One SNAP project was initiated by TRCA and Credit River CA each in their respective watershed areas in the City of Brampton, and implemented through community participation.

The CAs invested in the research, development and implementation of SNAP with support from the municipal government, and the community supported the projects through participation.

One participant explained how they expect such programs to provide inputs for reducing barriers and incentivize business opportunities.

Our team focusses on the engineering GI in urban areas that deals with flooding, erosion, water quality problems and we feed it into the SNAP program. As the evolutions happened, we have done demonstration projects where we got a lot of experience on how to plan, design, construct, operate and maintain different GI, LID projects. We used to hear that it does not work in a cold climate or they do not work in heavy soil. So, we took barriers and challenges as lessons learned and developer guides. Their guides are meant to help streamline and make implementation easier. But we haven't seen the wide-scale adoption. The City of Mississauga came out with a stormwater charge, very similar to Kitchener-Waterloo. What we were hoping was that when this charge came about, it will incentivise businesses. (19, Conservation Authority)

While the SNAP projects served as learning and demonstration opportunities for GI technologies, they have not led to as much subsequent adoption of the technologies as hoped. To encourage wide-scale adoption, the CAs are now also researching on legal frameworks that will allow municipalities to incentivise GI implementation. For example, research by the Credit River CA found that the Drainage Act, which dates back to 1835 and predates the Provincial Planning Act, can be instrumental in developing decentralised community-based LID without the municipal governments having to invest heavily in buying land for stormwater management (CVC- STEP, 2018). However, individual-level retrofits remain expensive even after invoking incentives such as through the potential for reduced stormwater charges.

A lot of our existing urban areas were developed before stormwater management was thought about. The stormwater charge should act as an incentivise for landowners to put in GI. Whether it is green roofs, bioretention, permeable pavement or underground storage. But the landowners say that

even after they are paying a charge of \$2,000 or \$3,000 or \$10,000 per year, it's cheaper for them to pay this charge. Because, if they retrofit their property on an individual lot basis, the return on investment would be something like 20 to 30 years. So, they do not want to spend \$100,000 if it's going to take 20-30 years to get it back based on the current stormwater charge. (I9, Conservation Authority)

Interviewed participants said that an iterative process is required to support GI implementation along with enabling legislation to make GI mainstream. To offset the cost of individual GI retrofits, CAs provided methods of how community-level GI projects could reduce the cost of implementation.

What we started to realise that instead of each property owner building their own little system, why don't we do a communal system. So rather than one person hiring an engineer and building it and another person hiring another engineer and so on and so forth. Instead, they do it together, and they get economies of scale. So instead then taking 20 years to pay it back, if you share across four owners, it could be cost-effective in 5 years. If you go even further enough, if these properties drain through multiple properties you can actually aggregate more. For example, [pointing to a map] rather than each property doing their own thing, bring these properties together and design one system. And what's good about that is that it is cost effective for them, but it is also cost effective for the municipality. So, these guys can get a credit on the stormwater charge, which helps reduce the operation and maintenance burden on them. So again, if you have one contractor coming in to build and maintain that system, then you can share the operation and maintenance cost across the property. So, it is not even just on the construction, its also on if you and I are landowners and you have to maintain the system yourself, that cost goes to you. However, if we have one system the cost is shared. (I9, Conservation Authority)

Essentially these projects are designed to address issues of basement flooding, managing increased precipitation at the neighbourhood level, improve the water quality and reduce the temperature of water before it reaches the stream or lake. While simpler components of the project like tree plantations may be easier to implement, innovative ideas again are resisted by city engineers and face issues of operations and maintenance costs. However, new policy approaches are experimented with to try overcoming policy and decision-making barriers:

Here is where the City gets hung up. The City will be like well we don't like the idea of infrastructure on private property because we don't know if the infrastructure is being maintained, its being looked after; we don't know how

to aggregate, how to make sure if the landowners are paying their fair cost and the City is paying their fair cost. So now we are looking at this piece of legislation called the Drainage Act. What this does is it gives the municipality a framework to support landowners with aggregation. Also, then under the Drainage Act, the infrastructure is adopted under the bylaw, and that bylaw is the means in which the City ensures that the operation and maintenance is getting done and that the landowners are paying into it and it is all fair, equitable and transparent. So, one of the things we are looking at is trying to build a communal system. We are working with 14 properties in another area, and they are very interested in how they can do a communal design. So, we want to show that it is very cost effective for the landowner and the City if they do a communal system. (I9, Conservation Authority)

The preceding materials demonstrate that the GI projects currently being initiated are decentralised and are helping to make the experimental, new technologies financially feasible as well as building community consensus. Government agencies increasingly are shifting their focus toward incentivising such GI projects, while still dealing with issues of accountability, cost sharing and long-term monitoring and impacts. More research is being carried out on voluntary versus mandatory approaches through these initial projects. Simultaneously, to increase acceptance and create awareness of GI technologies among various public and private stakeholders, government agencies are also exploring market transformation strategies by training and building capacities of professionals from the landscape, design and horticulture industry.

4.3.2.4 Capacity Building and Market Transformation

In an effort for capacity building, Peel Region, the CAs and Landscape Ontario – a horticultural trade association – have partnered for a training and certification program called Fusion Landscape for the landscape industry. The governments of the Regions of Peel and York have funded the program, and the CAs have helped develop the course content for the program. Landscape Ontario will run Fusion Landscape for its members to equip them with the knowledge and tools to assess landscapes, and design and retrofit them with GI solutions.

Interview participants expressed that they are developing such partnerships and programs to facilitate transformations in the wider real estate market:

With the Fusion Landscapes program, we are trying to achieve market transformation. We want private landscapes to be able to take in and utilise all the rainwater on their property itself rather than pushing it into the stormwater. We need this to become mainstream for which we need buy-in from the marketplace and also buy-in from the industry, who should be able to deliver those programs. For this, what has to be done is to generate demand within the marketplace. So as a homeowner, you would desire to have these types of landscapes. That is part of the marketing. We have to market these types of landscapes as beautiful, as trendy and this is what you want for your property, which is the market transformation piece. So, if there is some demand in the marketplace, then there should also be a service sector to meet that demand. So, we have been working on providing training of the service sector to be able to deliver and sell these types of landscape to their clients. Through our Fusion Landscapes, both Peel and York Region are basically trying to encompass water efficiency and stormwater management within our municipalities, because it also had a strong connection to offset the use of potable water. (I8, Municipal Government)

Peel Region's Climate Change Strategy emphasises taking on co-leadership roles for funding, technical and knowledge support, community engagement, communication and awareness building (Region of Peel, 2011, p.18). Peel Region has also planned investments for collaborating with colleges, universities and other industry partners on research and technology for adaptive risk management modelling and monitoring, expanding capabilities and techniques of conservation, enhancing key habitats of terrestrial and aquatic species, developing flood mitigation capacities through groundwater recharge and recycling systems (Region of Peel, 2011, p. 19). In addition, Peel Region is supporting a university landscape design program where students are engaged to help private homeowners design private GI landscapes to attain water efficiency.

Thus, the above description of the action arena shows that GI implementation is moving away from traditional regulatory approaches towards a more collaborative approach. GI is being implemented through demonstration projects and experimentation and is still only utilized at the neighbourhood scale. However, policy and decision makers are researching methods to aggregate

these small-scale implementation models to city-wide implementation through legislative support.

Interview participants from both the government and private sector suggested that "they could always do with more training and more research" (I3, Municipal government) to inform the most effective implementation approaches. Industry professionals suggested that "though it is understood that green infrastructure can help, there still needs to be more quantifiable data to allow making choices such as selecting trees, performance of certain technologies" (I23, Landscape Association). They also felt that unlike is the case for conventional grey infrastructure, awareness creation, knowledge dissemination, communication and capacity building are still required to promote GI. This perspective was expressed by industry participants:

In the last five years, the awareness around the opportunity in GI to support solutions to climate change has never been greater. We are starting to get some momentum behind that. However, the research is not quite there yet in terms of what are the quantifiable, the performance metrics behind that. How many trees does it take to reduce the carbon footprint of a certain pollution-based activity that might be central to the economy? How do we neutralise some of the things that we are doing by using and leveraging GI? It is a two-way street, and it's not all government. I think its industry needing to do a better job of communicating and government being ready to hear the message as well, and research behind the facts so that we understand the environmental impacts and the environmental opportunities. Some of the research and R&D needs to come into place in terms of the value that GI brings. We know that juvenile trees are not contributing to air quality until they reach certain size and age. So, whether it's the five-year tree or a fifteen-year tree? Science and research is happening now and there needs to be a similar effort and focus as is [done for] grey infrastructure such as asset monitoring and value. We need to apply some of the same principles to GI also and actually quantify the value and then the economic impact of that. (I23, Landscape Association)

In the City of Brampton, the conservation authorities seem to provide many of these services of researching technologies, developing tools from the watershed perspective, providing training and building capacity.

4.4 Interactions

Within the IAD framework, interactions constitute the horizontal and vertical dialogues between the various actors. In this case study, the interactions are important because they allow observing how actors are changing their roles and responsibilities to implement GI.

Documenting these interactions also may provide a basis for predictions about which future rules and actions may emerge. It also allows preliminary evaluation of enablers and challenges for such interactions.

The action situation, in the case of the City of Brampton, is giving rise to horizontal interactions between stakeholders at the operational or municipal level. In contrast, the vertical interactions between higher and lower orders of government are limited to funding, broad policy directives and setting of certain environmental standards. GI policy at the provincial level is broad and descriptive and left to the interpretation of the local governments. The horizontal interactions, however, are characterised by collaboration, negotiation and experimentation.

During interviews, participants were asked about the emphasis on a collaborative approach stated in plans and policy documents. Participants expressed that inter-organisational collaborations were most important in pooling their resources, sharing knowledge, cost and risks of the projects. This was a recurring theme in all interview conversations:

It is important to be able to work with people rather than just tell people what they need to do. I think collaborations are very important to be able to understand the differences between partners. Cross-boundary collaborations, maybe there is some connection to their programs or their desired outcomes. There are always connections, and if we make that connection with cities or CAs and the community, we want to be able to collaborate and leverage resources, that are important. So, if we can pull out a larger number of resources to reach a common goal, I think its important. And that is the way that we typically try to. (18, Municipal Government)

Forming partnerships and collaborating on projects was essential considering ownership of lands and mandates of organisations:

If CAs had resources to work with the municipal partners to go after funding together, then we make a stronger, more compelling reason as to why we need

to do this project. If we work together in partnerships and we can leverage that too. We go after these funds as much as we can. However, sometimes CAs are not allowed to apply for money because we are not considered as managers of infrastructure, we do not own the infrastructure, the City does. (I9, Conservation Authority)

Moreover, it appears that the municipal sector as a whole is moving towards a more collaborative approach as conventional methods of setting norms and regulations increasingly are seen as unproductive.

The City doesn't need to work with us, they want to. So, there is this collaborative process, and I could say that overall all of them are going in that direction. You cannot really set the norms and expect the people will follow them, and then like there is always room for negotiation, room for improvement and I think that the collaborative process is gaining more and more importance in our municipal sector. So, I would say, it is a clear decision and direction from all the organisations. (I14, Conservation Authority)

The terms of collaborations were dependent on the individual mandates of local governments and other partners. For example, water efficiency is the mandate of Peel Region, water quality and flood prevention in the watershed are the mandates of the local CAs, and since the City of Brampton owns the stormwater ponds, it has the mandate to maintain them. If organisations were able to offset the costs related to using a GI project, they collaborated on that project, pooled their resources and divided their costs and risks involved. Participants also emphasised that collaboration helped in gathering perspectives, involving and working with people rather than regulating and monitoring enforcement. Some participants strongly felt that drafting more regulations is no longer helpful and instead there is a need for instituting systems focused on assisting stakeholders in achieving the end goals of regulations:

Sometimes they feel that their norms are there and we should enforce them more strongly, regarding maintaining our ecosystems or standards for stormwater. I know that more and more people are complaining that [the standards] are not high enough, the amount of rainfall we ask the developers to hold, or there could be higher standards for rainwater harvesting, or regarding the soil management or tree canopy. I know that there could be higher standards, but again it is a negotiation even there. You can't just set the standards and hope that they would do it. (I14, Conservation Authority)

However, participants remained divided on their opinion on mandatory versus voluntary action:

I think voluntary does not work. For example, voluntary roof leader disconnection. Nobody does it. Unless its mandatory, then people are more inclined to do it. I think it can be a combination of bringing to life something like the Drainage Act, which has the regulations of its own to do this, but also the municipality finding ways of incentivising it on private property. (I9, Conservation Authority)

Conventionally regulatory approaches require municipal drawings and technical specifications to provide details such as pipe widths. The private sector accordingly uses these as baselines to prepare their layouts. Once drafted these drawings are not updated frequently, which presents a problem given the changing climate needs of stormwater runoffs. However, instead of updating these technical specifications, participants suggested that environmental quality standards should be kept high, and flexibility should be given to reach those standards. The professionals and private industry would be free to suggest cost-effective methods and involve GI to achieve those higher targets of environmental standards such as water quality.

Grey infrastructure projects have standard drawings, which then never get updated with changing scenarios. But with green infrastructure, providing certain quality targets and flexibility to achieve those targets is more important. There are still more associated benefits that we get from green infrastructure. (I3, Municipal Government)

The above materials show that current interactions are determined by prescriptive guidelines, but that there is scope to achieve higher environmental quality standards with the help of GI and LID technologies. However, apart from the differences between regulatory versus prescriptive approaches (outcome focussed), projects like SNAP are clearly being designed to facilitate a collaborative and consultative approach with scope to experiment where experts are in initiator roles and community members participating in the implementation. The importance of this approach is explained by a participant:

So, in our case, it is a collaboration, and we negotiate because whatever projects we have, we need to understand the perspectives and take consent from the municipality who maintain and pay for it. So, sometimes we need to create new

agreements within the City or new partnerships. Traditionally governments used to do it, and half of our programs were enforced on them. What we understand now is it has to be relevant. It may work in the Black Creek, but maybe in Brampton, the people might not want to grow food. They do not have the time. For SNAP it's based on their priorities, their interests. (I14, Conservation Authority)

Decision makers are relying on collaborative interactions to promote GI. However, a real dilemma exists for the operations and approvals teams, because of the risk associated with decisions about GI implementation especially in the absence of a clear mandate. In the face of these challenges, inter- and intra-organisational negotiations help establish roles, responsibilities and feasibility of GI projects.

It is important to recognize the different kinds of negotiations; the parties involved and anticipated outcomes. Organisations negotiating on technical matters are separate from communities negotiating a project in their neighbourhood. Negotiating with the public is a part of an extensive education and awareness building exercise as described by one participant from the municipal government:

It is very difficult to make the public understand that a non-manicured park has a recreational value and there is a lot of resistance from the public and the politicians to accept that. Still, there is a push to have publicly used places to be manicured. We get calls for valleys to be manicured because people do not want to see the weeds; they want to see nice clean grass, which is not at all the mandate for a naturalised area. So yes, there some challenges, a lot of them are based on education. You have to educate the public that there is nothing wrong with naturalizing certain areas. But on the other hand, yes, to have a park function as a playing field or for people to have a picnic, you require a certain level of maintenance. (I2, Municipal Government)

Participants from the landscaping industry expressed how they create awareness and educate people about adopting GI elements on private lands by training professionals as well as through consumer forums:

Enabling the contractors to have the tools and resources is one part. But the market demand is just so heavy, it is hard for them to find the time to educate their clients. So, we are also approaching it from a consumer side as well. We actually had a consumer garden, at Canada Blooms where 160,000 went through the doors last year. So, we are exposing the consumers and promoting

contractors that can support these Fusion Gardens. We try to fully inform folks on how certain fusion elements could be implemented and how they work; these are the benefits. And I think the argument for consumers is, and it is going to hit upon them, with the heat we are suffering in summer, and they say it's typical to the future of climate. We are also looking at flooding and those extremes. So, in terms of how Fusion Landscape and LID elements can support mitigating some of the risks to flooding and some of those other situations that are causing insurance costs to go up. So, there is an economic impact piece to education as well as the return on investment piece. I think it is starting to hit consumers a little bit and when the insurance industry starts to come on board and recognise some of those opportunities on why Fusion Landscape elements are designed and installed by professionals, perhaps there will be some incentive around the insurance realm as well. (I23, Landscape Association)

Such negotiations and initiatives are leading to the creation of new roles, responsibilities, and job profiles. CA participants expressed that they acquired new and transdisciplinary roles emerging from GI project implementation such as bridging engineering, stormwater management and geotechnical sciences. Other new roles emerged such as communication specialists, outreach coordinators and field instructors were created, while some other capacities were outsourced to academic researchers. The City of Brampton decided to considerably increase the environmental staff and strengthen the environmental expertise of individuals in other allied departments as explained by one participant:

If we are going to be ripping up a road to repaving a road or a boulevard, this is a good time to come in and also consider putting GI in that project. So, when the planner typically reviews the planning application, they could incorporate GI in that planning application. So, you will need those specialities of stormwater engineering, landscape and ecology. But you also need the bigger picture thinkers as well to bring together the different lenses and bring in other people that might help with the project, like public relations or corporate communications. You do not want to do this in all isolation. You need to show the community why it is important, why the public dollars are beings spent on these types of projects or why it is important to incorporate some aspects into planning projects in new communities. To help people understand that this is not going to look like a typically kept area, we are not manicuring as much as we used to. There is a good reason why we need to let things naturalise and be "wild". That has to be accompanied with a lot of outreach to the public so that they know what you are doing and why you are doing it. (I4, Municipal Government)

Providing training to landscape professionals, contractors and even community members is a type of interaction that creates trust through sharing of a common knowledge base.

Equipping trusted professionals with the required tools and training is also an avenue to create the necessary community confidence in the actual feasibility of GI projects:

The great thing about leveraging the service sector is they are the trusted professionals. The community does not come to the government and say how should I landscape my property. What and how do I maintain this? It is the service sector that is trained on how to design it properly, how to construct or manage it. How to even sell it to your customers. So, the contractor or the designers are trained to educate the resident on the benefit of such landscapes here. This is how beautiful it is going to look, these are the maintenance requirements afterwards, and this is how much it is going to cost. It is really not up to the government to decide what it's going to be. It's the service sector that will actually be able to educate the homeowner. (I8, Municipal Government)

Involving community members in the GI project planning process right from the start of project inception was also a part of building trust. One interview participant suggested that he was enrolled because he knew the language spoken in the community.

So basically, when TRCA even proposed this neighbourhood retrofit plan, they started by doing some consultation in the area. This is where I got involved, and I started working for them. They hired a consulting firm who was looking for somebody who could speak Hindi or Punjabi from this neighbourhood, because they knew the demographics of the neighbourhood was predominantly Punjabi or Hindi speaking along with English speaking households. From there it basically started by asking the residents of the neighbourhood how they felt about certain things around waste management, stormwater management, stormwater retention and greening initiatives. They were able to then look at the feedback from those surveys and those interactions with the public. They then came back saying these are the concerns of the neighbourhood and so these are the things we should be looking at. So, fast forward, a couple of years later we are talking about this stormwater retention pond. (I9, Community Association)

This participant, whose initial GI project role was to engage the community and build trust, later went on to become a founding member of the neighbourhood association, which became the voice of the neighbourhood in local planning and development projects. The neighbourhood association now hosts an annual festival for the community, businesses and various clubs in the neighbourhood, on topics such as sustainability, circular economy and

biodiversity giving rise to even more new opportunities for interactions. Thus, the interactions at the operation level are evolving and characterised by collaboration, negotiation and experimentation with the goal to develop trust, awareness and shared responsibility.

Figure 11 shows the horizontal and vertical interactions described in this section along with the roles of actors in the action arena. The interactions show that the municipal governments of the Region of Peel and the City of Brampton have partnered with the Conservation Authorities who provide the knowledge and technical support required for GI implementation. The City of Brampton is utilising its networks in the private sector to encourage GI in projects through negotiations and incentives given a project-by-project basis. Further, for achieving the objective of GI implementation, the three government agencies have also included professionals from the horticultural industry and informed community members to help them create awareness about GI. This network is activated through funding support on programs, projects and initiatives from the government agencies that pool their own resources for the projects. At present, teams such as the STEP within the conservation authorities are providing the research support required for the new technologies and the industry is being able to absorb these technologies through courses and webinars (STEP, 2019). Thus funding, technical knowledge, awareness and capacity building are currently being managed through these interactions.

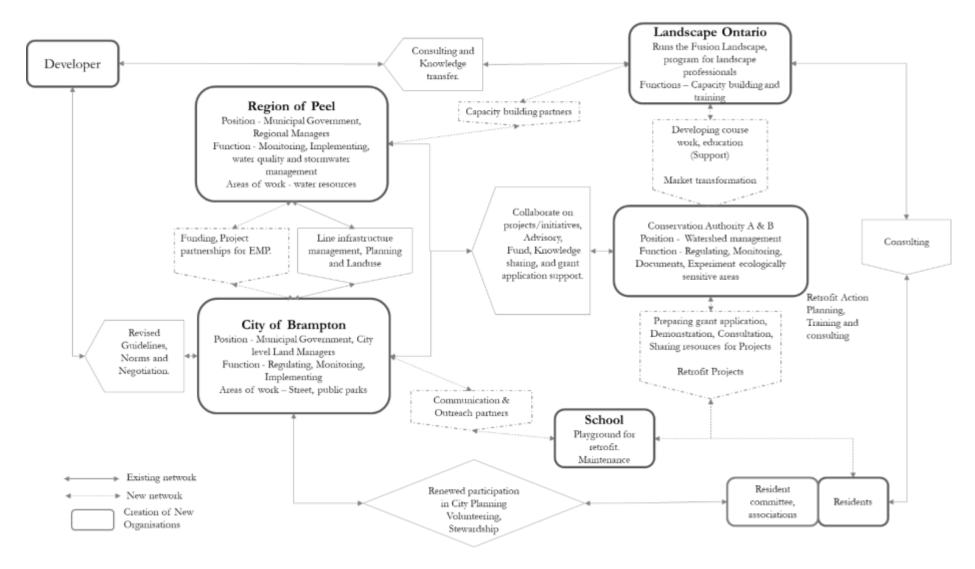


Figure 12: Chart showing the Existing and Newly forming Horizontal Linkages (Interaction) between various Stakeholders involved in Implementation.

4.5 Outcomes

In the IAD framework, the outcomes are the result of the interactions within an action arena. The IAD framework organizes various system components (Action Arena, Biophysical attributes, Interactions) to enable observation of desired and undesired outcomes. The outcomes are judged based on the evaluative criteria used and can form the basis for recommendation of policy changes. In this case study, however, the action arena and interactions are emergent. Nevertheless, the document analysis and interviews indicate expected outcomes. The expected outcomes at all levels of government are revealed through the stated goals and objectives of what these governments and other actors expect to achieve using GI. The sections below describe these goals and objectives as set by each level of government. The analyzed materials use phrasing of words and terminology such as 'recommend' and 'may use' to synthesis these expectations and indicate that policies are suggestive (instead of prescriptive).

At the federal level, GI is suggested for water and wastewater systems, clean energy, climate resilient infrastructure, protection of the natural environment, support of healthy and resilient communities, and promotion of economic growth under the long-term goal for 'Modern and Resilient Infrastructure' (MOECC, 2016, p. 30). The various funding priorities of the federal government (Table 10) suggest that a large portion of the funds may be going towards wastewater, energy and solid waste management. The Green Infrastructure Fund has a substantial portion of the fund dedicated to wastewater (GI Fund, 2018).

Table 10: Funding Priorities at the Federal Level.

Federal Ministry/Fund	Funding priority areas/categories
Infrastructure Canada	Wastewater, solid waste management, green energy, carbon transmission
	and storage, Clean Water and Wastewater Fund (CWWF)
PPP Canada	Wastewater, green energy, solid waste management projects (from the P3
Green Infrastructure fund	Canada Fund), but must be delivered as public-private partnerships
Natural Resources Canada's	Green technologies, largely supported carbon capture and storage
Clean Energy Fund (CEF)	projects, which were eligible but not funded by the GIF
INFC's New Building	Green energy, solid waste and wastewater management, other "green"
Canada Fund	categories - brownfield remediation, drinking water, disaster mitigation
FCM's	'Municipalities for Climate Innovation Program' and 'Municipal Asset
Green Municipal Fund	Management Program' for reducing greenhouse gas emissions

Source: Infrastructure Canada, (2018 a).

At the provincial level, GI is expected to provide multifunctional benefits for health, environment, climate change and creation of complete communities (PPS, 2014; MECP, 2015; MAH, 2017). The PPS, 2014, directs planning authorities to "promote green infrastructure to complement infrastructure" (MAH, 2014, p.15), whereas the Ontario Climate Change Strategy suggests GI for cost-effective climate adaptation. (MECP, 2015, pp. 18, 32 & 33). The Growth Plan recommends integrating GI with LID to help support urban growth and stormwater management, address climate change, and achieve complete communities (MAH, 2017, pp. 14 & 31). Moreover, the Growth Plan contains policies to protect the NHS and water resources for its potential to address excessive flooding (MAH, 2017, p. 52).

Within the framework provided by the Provincial government, the CAs consider GI along with LID for its capability to mimic and maintain pre-development hydrology. The STEP team¹³ within the CAs has developed a method called the 'treatment train tool' and considers it a GI technology. The CAs advocate using the tool to address urban flooding, improve water quality as well as reduce the temperature of water before it reaches rivers and lakes. This tool is also expected to help with carbon sequestration as well as terrestrial and aquatic biodiversity.

At the municipal level, Peel Region expects to achieve water efficiency targets using GI. The City of Brampton has a range of expectations for GI and proposes to use GI for creating complete communities, increasing green canopy, stormwater management and climate change adaptation. With its naturalisation program, the City hopes to increase the green cover, biodiversity and ecosystem services in the community. With the urban design guidelines, the City is including infrastructure such as cycle tracks, sidewalks and clean energy as GI to create sustainable communities. The NHRP has outlined targets for restoration of natural environment features, which are being monitored and measured through individual organisations that have initiated the program (City of Brampton, 2018).

¹³ The STEP team is a multi-agency initiative formed by various experts from different Conservation Authorities working towards developing sustainable technologies appropriate for the Canadian conditions (STEP, 2018 a).

Thus, on the local level (i.e., the municipal and watershed level) organizations are focusing on GI use for stormwater and water quality improvements along with allied benefits achieved through naturalisation (e.g., biodiversity). However, at higher levels (i.e., the federal and provincial level), governments were more inclined to pursue the clean energy, carbon sequestration and carbon cap-and-trade potential of GI. While implementing GI is the expected outcome of the action arena, the GI policy itself is proposed to achieve several other end goals (outcomes presented above). Therefore, implementing GI becomes a tool to achieve these desired outcomes. And while evaluating the effectiveness of implementing GI for achieving these individual goals should be the objective of the individual organisations, the objective of this study is to see if the action arena is sufficient to integrate GI concepts into city planning practices (research question 4). At present these policies are suggestive and provide GI as one approach to achieve these goals. Moreover, in the absence of a clearly associated overall mandate regarding who is monitoring or overseeing GI implementation, interview analysis suggests that GI is still considered on a case-by-case basis:

Right now, there isn't a systematic way to ensure that GI is always considered as the first opportunity. It is really case by case. There is no like clear system. I know that in our team a colleague has been working on a neighbourhood screening tool which tries to look at all the jurisdictions in all the watersheds and identify early on where GI can be integrated with projects. But, right now, there is no system. It depends on the municipality, the specific event, sometimes its the specific staff involved. You know some people are more willing to take risks, try new things, others are not. (I14, Conservation Authority)

Long-term and short-term objectives.

Evaluating policy with so many diverse sectoral targets is complicated and perhaps possible only when analysed sectorally. The above expectations at the different levels of organizations and governments demonstrate the hope that GI will help achieve overarching aspirations for climate change adaptation and mitigation, long-term sustainability and cost-effective infrastructure. Objectives such as complete communities, reductions of urban flood risk, stormwater management, and water quality improvement are tangible and may be

achievable in the short term. However, other objectives such as improving biodiversity, ecosystem services, carbon sequestration, and climate change adaptation and mitigation may require long-term institutionalization of GI. The CAs have developed substantial capacities to provide GI alternatives from the watershed perspective. However, considering the individual mandates of the various agencies, study participants suggested that Peel Region, or Provincial legislation addressing climate change, should be employed to focus on appropriately institutionalized interventions to monitor GI implementation at larger scales:

Well, there is a provincial sort of group, the Ontario Climate Consortium, which ironically, I think is housed out of TRCA and they are supporting those sorts of broader issue that even go past municipal boundaries. I think one of the things they did was the thermal mapping, looking at urban heat island effect in the most affected parts of the GTA. I think that is a reasonable level. They have a provincial scope or provincial mandate funded by the Province. I think that is the right level to be attacking those issues. Watersheds are only relevant to anything to do with water. Doesn't even really work that well with terrestrial-like biology, because birds and whatever don't fall in the water all the time. The only thing that management at the watershed level makes sense for is water, and even then, groundwater sometimes doesn't follow watershed boundaries. So, I would say an organisation with the watershed mandate probably is not at the right level because there are broader issues. But we are doing it, because nobody else is doing it. (I17, Conservation Authority)

4.6 Evaluation Criteria

Ostrom (2005) suggested a flexible use of the evaluative criteria as discussed in section 3.4.2. For this study, the indicators chosen are: (i) time required for implementation, (ii) transaction costs, and (iii) the effectiveness of the strategies. These indicators are used to assess the outcomes and interactions connected to the action arena.

In this case study, evaluation of policy for GI implementation is complicated for a number of reasons including that GI is conceptualized in the broadest terms and by various organizations. Therefore, a multitude of policies and strategies would have to be analysed.

Moreover, the action arena is emergent (i.e., not fully formed yet) and the evidence presented so

far only shows some of the initial phases of the developing action situation. Nevertheless, the IAD framework helps evaluate the outcomes of the action arena using a flexible set of indicators.

The analysis indicates that GI implementation is slow because of the experimental nature of currently untested technologies, the lack of funding sources to invest in these GI technologies and a collaborative model with room for negotiation. The collaborative model to some extent has reduced transaction cost through partnering as well as through sharing of costs and responsibilities. Yet there are still considerable transactions costs involved such as uncertainty and lack of precedence of the technology and accountability measures for use of public funds. These costs are currently being transacted through negotiations and developing incentive-based programs for implementation. Interviews indicate the existence of the technical expertise and know-how for implementing GI at a decentralised neighbourhood scale following a collaborative planning approach. Interviewed experts suggested making investments and creating policy initiatives, which promote an incentive-based, decentralised model for effective implementation.

4.6.1 Time

The current case study indicates that GI projects at present are considered time-consuming, which leads to some element of risk to investment. Long gestation periods are observed in public as well as private projects. Participants suggested that, since GI projects in the public domain rely mainly on public funds, their budgets are smaller. With tight budgets, projects take more time as funds are distributed to each of the planned projects. Additionally, the collaborative nature of the projects with multiple stakeholders increases the required time overall. Participants pointed out that one could not expect GI projects to be cheap, fast and efficient while accommodating the requirements of all stakeholders:

If you want to collaborate and want things to go fast, and also want the result to be better, there's no way you can do it cheaper. That is my sincere belief and if you have to do things cheaper, which in the public sector is quite often we do, because we have quite limited budgets, it's not possible to be both faster and better as well. So, this idea of collaboration is complex. It is challenging, and it requires a lot of consultation and consensus-building. As a result of that you

know with limited budgets quite often it is tough to be faster. (I10, Conservation Authority)

However, at the same time, participants suggested that there has been some success for GI implementation through a collaborative process that fosters long-term community ownership and builds consensus among stakeholders.

Collaboration is hard. It takes a lot of work, especially in our large complex society. There are so many different groups, somewhat different kinds of stakeholders with different priorities and you trying to balance the needs of many people while still seeing your own work through to successful completion. However, that kind of collaborative spirit is absolutely necessary. I heard from a friend of mine, he said if you want to go fast go alone, but if you want to go far go together. And nothing really underscores or summarises the need to collaborate better than that African proverb. So, working within this sort of complex, messy, swirling stakeholder group of people helps me build consensus along the road to developing a good design for the community. It will help me understand specific needs or requirements they have that I should work into the design of my project. It ultimately helps buy into the project and ultimately at the end of the day despite how complex and challenging it can be to bring everybody forward together, working with those stakeholders helps me to kind of build a consensus around my project. I am leading, but make people feel like they came up with it. They can buy into a solution for the community because they had a say in how it was developed. And they feel like as a result of their help, they own it. It's not just my idea now, it's the community's idea. So that is part of the statement that if you want to go far go together. (I10, Conservation Authority)

The available evidence suggests that it is like-minded GI advocates who take the initiative to support GI projects in the absence of a clear mandate. They use whatever available policy avenues available, such as the Drainage Act, to make a case for GI. Additionally, interview participants described that the collaborative process facilitated developing and creating access to proven technologies and consolidated inputs and resources for future projects. Thus, the collaborative process has provided several benefits for GI implementation but takes more time in the absence of sufficient financial resources. Moreover, participants said that considering current climate change scenarios, urban flood occurrences and increasing summer temperatures, the cost of inaction is more than the cost of implementing GI.

4.6.2 Transaction Cost

North (1992), divided transaction costs into three broad categories: (i) search or information costs, (ii) bargaining costs, and (iii) enforcement costs. The following section evaluates the enablers and challenges in the collaborative model observed in the case of Brampton.

Search or Information Costs

In the City of Brampton, all organisations in the GI implementation action arena have introduced programs that provide at least to some extent components of education and awareness related to GI. Project partners periodically met to discuss lessons learnt and costs incurred after project implementation. They also networked for support through associations such as the GI Coalition that served as their platform to inform the government. Information, case studies and technologies are made freely available through guides, websites, conferences and regular meetings by the public sector. In this way, networks of information have been able to make GI feasible:

We also try to get together through conferences and share knowledge, insight, information on challenges and lessons learnt from things like SNAP or other initiatives. We are looking to transfer or translate what we have done to our sister CAs without having them reinvent the wheel. Lastly, through things like STEP, we bring together some of the best work done in the design and implementation of different kinds of GI. It is testing, lessons learnt and so on. So that we can replicate without having to suffer the same kinds of challenges and or failures in other parts of the Province, in another CA's. All that stuff is made freely available and really what its intended to do is help streamline the process and help smaller CAs and municipalities who don't necessarily have the financial resources or the time to redo what's already been done. (I10, Conservation Authority)

Moreover, programs like SNAP are specifically designed to create awareness and to involve the community while implementing GI projects. This suggests that information search costs already are addressed through such programs or by partnering with CAs and industry professionals. Moreover, development of programs such as STEP also indicates that organisations make investments in research and development that address local conditions:

We all kind of have a role in our own way. The CAs have an amazing outreach to consumers as well as the science behind it. We come more at the industry level, and the regional governments are to all homeowners. So, I think we kind of all make a good team. The three of us together, we all kind of have our own outreach and our own network we tap into. It is a network approach, and it is a holistic approach. They have already been looking at the consumer market, the residential market, the industrial- commercial-investment (ICI) real estate market and now the professional industry market. That holistic approach is going to lend to and as well driving some of that science, providing some of the training, research and outreach, and development behind the knowledge that we now have ... enabling the knowledge transfer that is happening. (I23, Landscape Association)

Interview participants suggested that multiple co-benefits of GI implementation compensate for the slight increase in co-ordination cost due to time required for educating and creating resource materials. For instance, a community event has a multiple co-benefit for place-making, creating new neighbourhood associations, incorporating information about GI into the existing school curriculum, and even increased land use efficiencies:

I guess the costs change. What is the long-term cost, the upfront capital cost to implement the project might be more expensive but does it lead to cost savings down the road? Moreover, I assume it also leads to more developable land, which then is also better for the municipality. (I4, Municipal Government)

For the CAs and the City, the increase in coordination cost is often compensated by information cost incurred for experimenting, data collection and so forth. Demonstration projects provide learning opportunities, inputs and data for future projects.

There are feedback systems, and they exist and operate on many levels. So, for example SNAP first developed and implemented the County Court Boulevard project. We are looking to emulate the good things that came out of that project and build on their lessons learnt so we can avoid some of the same challenges. With the work I do in property aggregation, design optimisation, I am in the process of putting together an aggregation methodology like a guidance document or handbook. So, as I work for the process, I am documenting every new kind of the way I am designing, every kind of unique twist to the design process that maybe I will say conventional engineers do not deal with. When they develop designs of either new build or retrofit on a lot by lot basis, that information is all going to be made freely available on our website for anyone to download [......]. So that is meant to help others jump the curve so to speak. So, they can avoid some of the same challenges that we have to go through as part of the normal learning process. (I10, Conservation Authority)

The available evidence demonstrates that an open, collaborative model with components for education, communication and awareness building has been effective in reducing some of the search and information costs. This addresses to some extent the need by municipal staff who "could always do with more training and more research" (I3, Municipal Government).

Bargaining Cost

In this case of the City of Brampton, three approaches to negotiating or bargaining are used to persuade developers and landowners to adopt green and sustainable practices. Interview participants pointed out that for private greenfield developments, such as residential subdivisions, the municipal government had formulated guidelines and a sustainability matrix to score new projects. These guidelines and scores help the municipal government build arguments when negotiating with private developers about introduction of GI and LID technologies in projects, while giving developers the flexibility to how to do so. However, since the sustainability score also includes the provision of GI such as cycle tracks, sidewalks and clean energy, developers can choose to achieve these scores without using natural features and the municipal government has limited powers to direct developers toward specific solutions.

From the perspective of the private sector, developers and municipal participants all suggest that uncertainty connected to the performance of these new GI technologies drive project costs up.

No, it's not easy. It's tricky, very tricky. We are in the early days of implementing GI. Very early days in our business and the CAs like it because it is sexy, intuitively it makes sense. However, they are very tricky to deliver on the ground. The calculations, the science behind that infrastructure is heavy duty, and I do not even profess to understand it all, okay. It relates to surface water, groundwater, and it relates to water balance calculations, the water balance targets. We are supposed to manage stormwater on-site versus off-site. In this case, managing stormwater to feed a wetland. So, the wetland should not dry up. So, there is no point protecting if the wetland dries up. So, creating a system that manages the stormwater but also feeds the wetland. So, that is called the feature-based water balance work. That science is in its early days, relatively early days. (I20, Developer Organisation)

Largely because of the currently inadequate approaches for valuing GI projects, participants expressed that sometimes it is difficult to make a business case for GI projects beyond tree plantation exercises.

Most people have a positive response but the positive response is that we can plant trees and make things better. The response is there. However, the implementation is not always there because the implementation costs money, time and resources and the business case is not always there. (I3, Municipal Government)

However, the interviews revealed that negotiations have been successful as long as the suggested technologies were relatively easy to implement or there were appropriate bargains. Developers insisted that there are financial risks involved in using some new GI technologies. These risks had to be reasonably bargained through relaxations of other stringent regulations such as land required for building a stormwater pond in a subdivision:

So, we weigh up the use of GI as a line item cost to a project, no different to a park, a playground, an entry feature, wetland protection, woodlot protection. All of that has a cost, and all of that adds to the cost of the house. [...] So, GI is one of the many inputs to that project. Many, okay, and if we take a project like the one, we were working on recently, we had a wetland. So, we put a 30-metre buffer lock all the way around the land now which we cannot develop. Two acres of land gone. A big green band from here for a walkway connection to a park, that is half an acre gone. Ponds? Two stormwater management ponds, 1.7 acres, 0.96 acres. So, 2.7 acres gone. So, these lands taking all they do is shrink the land that is left for us to develop. So, in this project, this is a GI project, what we tried to do here as we tried to introduce infiltration trenches. Rear yard infiltration trenches and a bioswale in the walkway block. In exchange for getting smaller stormwater management ponds because since ponds need to perform both the quantity control and a quality control function. So, we are using GI, LID to manage the quality and these two ponds, the 2.7 acres will manage the quantity. The city and the CAs really liked this project. They liked the GI we were proposing here. However, it only made sense because we were able to shrink the storm ponds so that they were quantity only and the LIDs were quality. However, often they are not willing to concede or give up the quality control size of the ponds. I pushed for that. If we do all this costly GI and we don't get a credit by shrinking our storm ponds then why would we do it? It is just a cost for us. It's just another one of those 72-line inputs to our project, and there's not enough market appeal for the average home buyer. I hate to say it, but they don't care. They really don't. They just want a house. (I20, Developer Organisation)

Also, the Greenlands Securement Program can be used as a tool to negotiate with landowners to introduce ecological conservation practices on environmentally significant land in the private domain. The program supports stewardship projects and acquisition of lands identified as environmental significant through bequests, easements, donations or purchase (Peel Region, 2018b). Participants explained that when land is identified as environmentally significant through the EIA process, it cannot be developed and will not fetch a market price. Through the Greenlands Securement Program, the municipal government offers to negotiate fair compensation to bring such land parcels under conservation. If the municipal government cannot match market prices for these lands, it offers tax rebates and other incentives to the landowners. However, the success of this program entirely depends on the landowners' decisions on what to do with their land parcels.

Finally, negotiations can occur where professionals or contractors need to motivate private residents to install GI elements in their yards. Such situations occur because the responsibility for making GI elements desirable for private residents is devolved to the private sector and the market. The success of these negotiations thus relies on industry professionals' ability to generate and fulfil market demand for GI installation, long-term operations and maintenance. Speaking from past experiences, participants stated that such a strategy would be more effective than forcing people to adopt certain GI practices. These participants also pointed to growing demand for GI generated through this approach:

I think there's a general awareness amongst the consumer and the public too. I guess, there is starting to be a demand. [...] Our clients are very in tune with the environment and many are asking for green infrastructure pieces whether they are using the language or not. You know it's probably not there yet for many of them but I think that the next generation is likely going to be a little smarter as we study some of the impacts of the industrial revolution. Some of the things that have happened to our environment are because of that lack of the caretaker mode that we've had around our environment before. We are understanding the human health impacts of having, preserving and maintaining a great environment. So, I think that's it's going to be consumers, its going to be people with health issues, its going to be the government watching some of those costs

and we need to then be able to come back to them and speaking the same language. (I23, Landscape Association)

The above evidence suggests that the success of implementing GI relies to a large extent on negotiation between different agents such as the municipal government, private sector and private landowners. Also, it shows that while the CAs and municipal governments are in the supporting roles, the responsibility and cost of implementing GI on private property is being transferred to residents. Under such conditions, the choice of opting for GI implementation depends on the affordability of the implementation as well as of the operations and maintenance post-implementation. Participants expressed their support for GI implementation on public and private land, such as "I am also a big advocate of doing it as much on the public land as you can because some landowners just won't do it" (I23, Conservation Authority), but the success of balanced approach depends on the willingness of the private landowner. Though economies of scale mean that the cost of GI implementation on individual private lots is higher than on public land, there is scope to implement GI on private properties:

The costing I guess to the homeowner is usually higher for these fusion elements. So I guess trying to do the cost-benefit analysis and get that across to the client would be the challenge, but I know a lot of our certified companies they do get a fusion element in every project they do somehow or someway [...] well GI can solve a problem, like, if someone has ponding in their backyard a rain garden can fix that problem. I think what it requires is the right knowledge to implant, to design and implement a successful functional aesthetically pleasing element. We can hide them too, and I think that is so for some of the languages around communicating. If you identify the aesthetic that your client prefers, and as far as you are speaking their language, you might be incorporating a GI element. They may or may not know it until after. Clients would say, 'Oh I got less puddling over here. I did not realise this garden would do that.' and then you might explain. So, there's going to be some different methodologies concerning communicating that. (I22, Landscape Association)

The evidence provided demonstrates that by providing scope for negotiation options can be explored that can lead to GI implementation and achievement of higher environmental quality standards. However, negotiations are time-consuming and therefore some participants suggested working on ways to provide GI implementation incentives for residents.

Monitoring and Enforcement Cost

Incentives as well as enforcement approaches both have shown mixed results for GI implementation. However, participants stated that even incentives can be used by governments as an enforcement tool for landowners' GI implementation and maintenance:

I think to get it reliably maintained, and they either have to have a stormwater utility in place and a fee and credit system. So, there's a stormwater utility, and you have to pay a fee every year. However, if you put [this GI] on your property, you are going to pay less because you are managing stormwater yourself. In order to keep the private landowners maintaining it, they have to have an incentive like, we are going to take away your credit. (I17, Conservation Authority)

Unfortunately, since the first GI projects have only been implemented recently and are approached on a case-by-case basis, there is no comprehensive data available on monitoring and enforcement cost. Participants also expressed the opinion that monitoring of GI projects should be viewed as an opportunity for job growth and creation or a new employment market. Some participants even speculated how current municipal services and functions might evolve in response to this demand:

I think the municipality's operations department should see it as a growth opportunity. This is new work that they can be given to growing their department [...] For a small size municipality, I think it will be cheaper to hire a contractor who is well experienced at this than to develop the in-house means. Maybe as municipalities grow and their capacities grow up, they will have to build capacity to maintain this stuff. (I17, Conservation Authority)

However, the responsibility for maintenance and upkeep of GI still lies largely with the residents:

I have written a guide on inspection and maintenance of these things and for what you want the private landowner to be doing is really just reporting that, yes, it still exists, yes, these critical components still work and are functioning. Then you are just providing that information every now and then [...] However, every five years, you know, looking at it and just saying look it still exists, all of these things are still there. If there are problems, they are going to manifest themselves. They are going to be pretty evident on the surface. (I17, Conservation Authority)

4.6.3 Effectiveness

The effectiveness of a policy is evaluated by analysing whether (1) the policy achieves its stated goal and (2) what systems are in place to self organise effective rules (Imperial & Yandle, 2005; Ostrom 2005). The effectiveness of the system to self organise rules also depends on procedures and protocols that guide the system (Imperial & Yandle, 2005; Ostrom 2005). Having said that, for the case study of the City of Brampton it is not possible yet to evaluate if the created systems can attain the expressed policy goal of GI implementation because the process still is in the initial phases and tools are still being developed. However, interview participants asserted that the capacities and expertise required to implement GI are present in Ontario and can be activated through partnerships:

We definitely have an extremely talented pool of engineers, environmental scientists, biologists and people who could make it happen in Ontario. Landscapers, I would say, people who can take something that's been drawn up that has never been done before, and you can look at it and think through it and can deliver it very quickly on a massive scale. So, I do not think that is the problem. I think it is just the sheer time that none of the projects has. Every project is individual, and there is no cookie-cutter solution there. There's no stamp that you just pop down on the plan and say good we can have two types of LIDs in it and go for it. Like, each one of these has to be sorted and it takes a lot of time. Just technical time to grind through it. However, the talent is there. It's not a talent problem. It's the process and the pushes and pulls and the many people who are participating in that process. (I20, Developer Organisation)

Some participants suggested that a "more concise, higher-level GI implementation plan would be very useful. It would guide the secondary plan, the block plan and side guidelines, the subdivisions" (I2, Municipal Government). However, most participants believed that a decentralised implementation approach is more practical:

I mean there are many different agencies with many different mandates with many different projects and different aims with their projects. I welcome having more of a decentralised approach to doing projects. Provides a more robust program, because one partner cannot do something because of budget requirements, then the other one picks up some of the slack. There are also different perspectives on the project. So, you have different projects, you are looking at different techniques, it is more diverse, it's not one centralised

bureaucracy doing all the projects. Any good system has redundancies. (I3, Municipal Government)

Considering all evaluation criteria, the evidence suggests that the availability of funds and to some extent the lack of precedence is resulting in more time required for GI project implementation thus slowing down progress overall. Interview participants also believed that collaborations are being productive and that Ontario has the necessary local expertise required for GI implementation. However, this expertise still needs to be channelized better for faster implementation processes. Participants also suggested that a decentralised process for the pursuit of GI implementation goals would be more stable and effective in the long run.

Thus, using the IAD framework for this case study helped organise the approaches, tools and policy interventions currently operational for implementing GI in the City of Brampton as the action arena. It helped understand the influences that affected the action arena and the interactions between actors by compartmentalising them into individual components of the exogenous variables and interactions. This enabled the understanding of barriers and enablers through these individual components by using a flexible set of criteria of time, transaction cost and effectiveness of these interventions. Figure 13 summaries the implementation of GI into the IAD framework components for a comprehensive overview.

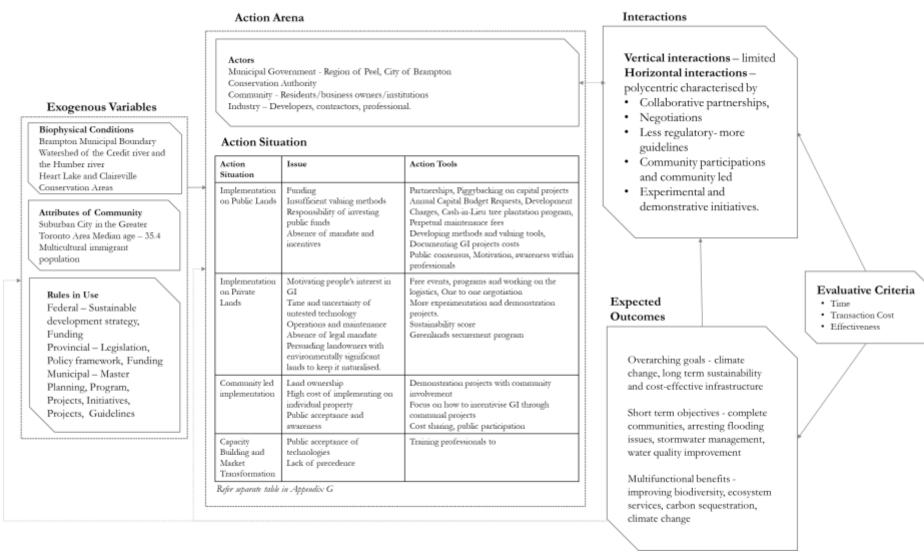


Figure 13: Schematic Diagram - IAD Components.

Section 5: Discussion and Recommendations

The goal of the research was to understand GI implementation at the city-level using an institutional theory lens, which led to two research objectives: (i) Determine how municipal institutional structures are evolving as a response to the adoption of green infrastructure concepts. (ii) Determine the municipal institutional enablers and challenges in implementing green infrastructure. Using the case study of Brampton, Ontario, this thesis found that the municipal governments (at the city and regional level) have started adopting GI concepts and are supported by various governmental and non-governmental organisations through multiple strategies and policy initiatives.

The use of the IAD framework helped to situate the study findings by applying a systems' lens and to understand the complexity of GI implementation by tracing the various stakeholders and levels of policy making processes, along with synthesizing the challenges and enablers experienced at the operational level. By situating the study findings within the IAD framework, it can now be understood how, given exogenous variables, GI implementation processes are emerging as result of actors interacting in the action situation in their pursuit of desired GI implementation outcomes. Each component of the IAD framework was linked with the two research objectives and the five research questions within the context of the case study:

The observed Rules-in-Use of the IAD framework as elaborated in section 4.2.3 responded to RQ 1. The findings show that nested rules from the federal government to local governments influence GI implementation. These rules are guided constitutionally to protect the environment as well as to respond to national emergencies such as climate change. Through these rules, GI is recognised as a tool for using nature-based ecosystem processes to provide important services in urban areas. The upper levels of government have made broad policy and funding provisions that are enabling municipal governments at the operational level to introduce and experiment with GI. However, the rules remain suggestive instead of prescriptive.

The findings presented in section 4.5 responded to RQ 2 and detailed the outcomes of actor interactions as specified in the strategy and policy documents of various levels of government. These findings show that though GI is considered as a useful tool for its multifunctionality by all levels of government, each level of government hopes to achieve different outcomes from GI.

The findings presented in section 4.3 describe the action arena (i.e., the actions taken by the actors) and respond to RQ 3. The findings reveal a polycentric action arena, at the local municipal level, along with a collaborative approach that has enabled and operationalized multiple strategies for GI implementation. In the case of the City of Brampton, currently, GI means a combination of land-based naturalisation strategies and LID technologies for water management.

The findings presented in section 4.6 speak to the evaluative criteria of project implementation time, project transaction costs and policy effectiveness and address RQ 4. These findings also respond to RQ 5 and depict the enablers and challenges for GI implementation observed through this case study. The findings indicate that the current GI implementation approach draws on collaborative co-management and adaptive planning (Armitage, Berkes, & Doubleday, 2010) approaches. These approaches have considerable transaction costs and are time consuming. However, the action arena is still emerging and new institutional mechanism such as incentives-based implementation strategies are being developed that promise to be effective if more decentralised community-led projects are initiated.

5.1 Discussion

5.1.1 Enablers and Challenges for Green Infrastructure Implementation

The findings of this study indicate that GI initiatives at the municipal level were enabled by the priorities of the community for increased health and well-being as well as for reduced cost of living, which mirrors the results of other studies (Elmqvist, 2015; Lafortezza et al., 2009; Mell,

2007; Tzoules et al., 2007; Wolch, 2014). However, the findings also suggest that decision-makers have faced several barriers for motivating private landowners to implement GI on private lands. These barriers stem from prevalent community perceptions of "green" (as also observed in Barnhill & Smardon, 2012; Derkzen, et al., 2017) and the currently high costs of implementing GI retrofit technologies at the individual plot level. To overcome these barriers, policymakers have investigated neighbourhood level cost efficiencies for implementing GI projects and have advocated for a consultative and collaborative GI implementation approach, supplemented by training, awareness creation and market re-orientation efforts.

In line with the findings of the current study, many prior studies have advocated for participatory and consultative approaches of GI implementation (Biggs et al., 2015; Schiappacasse & Muller, 2015; Mekala & Hatton-Macdonalds, 2016) involving stakeholders from multidisciplinary backgrounds (di Marino & Lapintie, 2017; Dupras et al., 2015; Mekala & Hatton-Macdonalds, 2016), and for awareness creation, training and changing horticultural practises of urban green spaces (Falxa-Raymond et al., 2013; Mekala & Hatton-Macdonalds, 2016; Young, 2011). However, the current study goes beyond investigating such advocacy by demonstrating how these concepts are being operationalised in practice and the challenges they are experiencing.

The findings of the current study also captured how a collaborative approach served to enable practitioners' access to scientific knowledge on multiple GI types, which previously was identified as a barrier for GI implementation (Ahern et al., 2014; di Marino & Lapintie, 2017; Digiovinazzo et al., 2011; Dupras et al., 2015; Haase Frantzeskaki et al., 2014; Niemela et al., 2010; Kopperoinen et al., 2014; Ugolini et al., 2015). However, while most prior studies investigated challenges of institutionalising particular types of GI, for example tree planting (Young, 2011) or greenbelt creation (Dupras, 2015), the current study demonstrated that successful implementation of the various types of GI requires a complex system of policy interventions at various levels of government.

Table 11 summarises these enablers and challenges for GI implementation as observed through the IAD framework. The subsequent sections then discuss these enablers and challenges observed for the City of Brampton and compares the findings the wider GI implementation literature.

Table 11: Enablers and Challenges for GI Implementation in the City of Brampton.

IAD	Enablers	Challenges
Component		
Biophysical Attributes	- Each level of government recognises GI services and is devising strategies to protect and enhance GI.	However current methodologies of valuation of these green assets in insufficient and require more research and policy need to incorporate this value of GI.
Community Attributes	- Consensus on protection of green and its association to human health and well being	-Knowledge on what is GI, the ecosystem services it provides and the various types of green technologies is lackingDue to lack of knowledge and ability to classify 'green' assets, action is limited.
Rules in Use	- Introduction of relevant legislation that enables the use of GI retrofit technologies as infrastructure and inclusion of GI policies at various levels of government	- Existing policies are broad and suggestive. GI is defined broadly with inclusion of nature-based technologies providing ecosystem services along with renewable energy projects and other green technologies. - Wide scope to interpret the policies creates room for negotiation and uncertainty - Funding opportunities made available for GI shared with allied green sectors such as renewables
Action Arena	- Investment in technological innovation through federal and provincial funding programs - Pilot demonstration projects - Investment in market reorientation strategies - Polycentric model reduces transaction costs, helps share knowledge, expertise, implementation costs, positively influences policy making from all sectors, builds trust amongst actors and shares risks to investment and responsibility of the project Proactive approach of community-led demonstration of GI projects Decentralised practise-based learning opportunities.	- Lack of precedence and experimental nature causing scepticism of long-term outcomes of the technologies - High cost of implementation - Uncertainty and risk of the investment - Long term costs of maintenance - Ability of community to self-organize is not yet known - Absence of regulatory approaches and mandates to encourage GI on private lands
Interactions	 Collaborative adaptive approach Emphasis of all implementing agencies towards awareness, capacity building, training Demonstration projects including community participation enabled social organisation and consensus for projects 	Collaborative model increases time required for consultation and negotiation Lack of funding slows implementation process Voluntary suggestive policies do not necessarily translate into uptake of GI implementation

5.1.2 Green Infrastructure Planning Scale

While the current case study of the City of Brampton centres around the watershed as the functional unit for GI knowledge and implementation, study participants advocated a regional- or provincial-scale approach to GI implementation, partially because of the GI opportunities for climate action. Many prior studies have recommended a metropolitan level of GI administration (Dupras, 2015) as well as a watershed perspective for GI implementation (Jarden, 2016; Spatari, Yu, & Montalto, 2011). Some other studies have employed a city-level (Barnhill & Smardon, 2012; Falxa-Raymond et al., 2013; Young, 2011; Young, 2014) or neighbourhood-level perspective (Young, 2014; Kroll & Cray, 2010) to investigate single GI types. However, the current study showed how even decentralized, local GI implementation was affected by the interactions of policies at various levels and sectors of government and by biophysical knowledge at larger geographical scales.

5.1.3 Broad Interpretation of Green Infrastructure

The findings indicated that currently enacted policies are broad, suggestive and create much room for negotiation. Recognising the potential of GI, all levels of governments have created such policies, which recognise the importance of GI and thus legalise its use as an intervention for various urban issues. In line with these findings, the academic literature acknowledges benefits stemming from a plurality of understandings of GI (Lennon, 2014; Mell, 2010; Wright, 2011). The current study shows that the broad understanding of GI provided in the policy framework and the experimental nature of the various GI innovations, has left a wide scope for interpretation. At the operational level, therefore, GI projects are being initiated collaboratively to overcome the challenges of risky GI investments that stem from this uncertainty.

The current approach has been effective in building trust between actors and establishment of networks, which helped with sharing of costs, resources and knowledge.

However, the findings also revealed that the current approach often involves a wide range of

negotiations with uncertain outcomes. Study participants were of the view that municipal teams involved with infrastructure operations and maintenance show scepticism regarding the long-term feasibility of GI projects. Some participants even expressed concerns that voluntary approaches are not leading to enough GI project uptake. Moreover, forming collaborations was found time-consuming thus slowing down the GI implementation process.

5.1.4 Collaboration and Adaptive Management for Green Infrastructure Implementation

The currently employed GI implementation approach shows similarities with collaborative co-management and adaptive management approaches to governance (Armitage et al., 2010). Collaborative co-management involves interactions and systematic learning by engaging all stakeholders in the problem-solving process. The collaborative co-management approach observed at the operational level is useful under conditions of uncertainty by bringing various stakeholders together as equals and developing innovative solutions by sharing local knowledge, experience and technical expert knowledge (Cardinal and Day, 1999). Adaptive management focuses on scientific learning by doing and constant adjustment of policy and practise to incorporate the new knowledge (Armitage et al., 2010; Guderson et al., 1995; Holling, 1978; Lee, 1993; Walter, 1986). This approach is useful under conditions of constant change such as encountered in resource management and socio-ecological systems (Armitage et al., 2010; Capra, 1996; Levin, 1999). Collaborative co-management and adaptive management in combination have given rise to adaptive co-management and other hybrid management approaches, which allow iterative decision making under conditions of change, uncertainty and complexity, especially in the case of resource management (Armitage et al., 2007).

Practically speaking, collaborative co-management and adaptive co-management principles are applied in the City of Brampton. These principles are used to address the complexity of GI projects within urban planning systems, to increase efficiency and effectiveness of the existing and newly created natural assets of the city, to express respect between

stakeholders and equity in cost sharing, to enable negotiations (Borrini-Feyerabend et al., 2004; Armitage et al., 2010). The results from this study also show parallels with the adaptive comanagement literature to showcase how GI projects are providing scope for practice-based learning and implementation opportunities (Berkes, 2007).

The literature further suggests that the success of co-management and community-based management depends on self-organisation and problem solving (Barrett, Brandon, Gibson, & Gjertsen, 2001; Folke et al., 2005), as demonstrated by the CA-led SNAP program that assists communities to self-organize. However, demonstration projects such as SNAP are not yet rolled out widely and depend on the availability of supportive funding for their success. Moreover, the long-term success of neighbourhood level projects regarding the sharing of benefits and costs incurred for maintenance and upkeep is yet to be confirmed. Since responsibility for implementation and upkeep of future GI projects seems to be shifting to the private sector and to community-led initiatives, changing community characteristics may call for external coordination and support of community self-organization. While the success of past collaborations provides cause for optimism, continued policy guidance will be needed and the role of municipalities will have to evolve.

Collaborative co-management theory suggests that flexible institutional and policy arrangements that provide room for negotiation and social organisation are conditions for successful collaboration (Woodhill & Roling, 1998; Armitage, 2005; Armitage et al., 2007). The theory also suggests that collaborative co-management approaches have to be based on consensus between the various stakeholders rather than dominated by the direction provided by domain experts (Bruner et al., 2005; Armitage et al., 2007). Considering that GI is being encouraged by government as a tool for creating resilient and sustainable communities and as an adaptation technique for climate change, the functions of consensus building, expert knowledge and negotiations need to be investigated more critically. While the current flexible institutional and policy arrangement did provide initial opportunities for GI project implementation, GI

needs to be better defined in the policy discourse to allow for better GI policy integration. The results from this study as well as the literature (Ahern, 2013; Chini et al., 2017; di Marino & Lapintie, 2018; Mell, 2010; Mell, 2016) indicate that GI encompasses a very broad spectrum of tools, features and approaches. However, necessarily a policy for renewable energy would have to be very different from a policy for natural heritage or LID technologies.

GI principles are applied within an urban ecosystems context and are utilized to harness nature-based services for urban areas (Gomez-Baggethun & Barton, 2013; Mell, 2010; Ahern, 2013; Ahern et al., 2014; MEA, 2003). This reality not only needs to be acknowledged in policy making, but also in the creation of funding opportunities and the assignment of resources to support management innovation. However, at current all ecosystem management funds come from the same share of federal GI funds that also support stormwater management, clean energy and other approaches (Infrastructure Canada, 2018a). While there are overlaps between the objectives pursued with various kinds of GI, policymakers need to delineate different kinds of GI more clearly. Without doing so, GI policies run the risk of convenient inclusion of various kinds of GI on official agendas, while in practice not maximising their full potential.

5.1.5 Climate Change and Green Infrastructure

The currently employed GI implementation approach needs to provide for greater acknowledgment of knowledge and expertise of climate science and how GI can be used (di Marino & Lapintie, 2018) at the local level to address climate change adaptation needs. During the processes of consensus building and negotiation, the CAs and industry experts can play the role of knowledge brokers and mediators for community-led initiatives. However, in the long-term it is critical for stakeholders from government and industry to be knowledgeable of relevant environmental and climate science, advocate for this science and communicate it in GI projects. The current GI implementation model of negotiation presents a risk for economic barriers and the experimental nature of GI to become deterrents, especially if GI adoption is voluntary.

Therefore, more evidence is required regarding the performance of voluntary adoption of GI versus regulatory approaches, where clear policies, bylaws and standards facilitate GI at the individual level. This tension between regulatory and voluntary approaches highlights the need to evaluate the efficacy of GI projects on public lands alone compared to GI projects rolled out on public as well as private lands.

Ultimately, the current consultative approach to GI implementation is time-consuming. The results of the current study show that, though consultative approaches are advocated by practitioners, it is unclear whether this approach is the most efficient. Some study participants have suggested that voluntary approaches have not been effective and suggested using legislative tools such as the Drainage Act (CVC-STEP, 2018) to regulate GI implementation. Some other studies have advocated for removing legal and policy barriers, emphasis on quantitative methods and regulatory reforms for GI implementation (Dunn, 2010; Weitman, 2010). There are initiatives which also explore the role of natural asset management for GI implementation (Brooke et al., 2017; Molnar, 2018). Bearing in mind that GI projects also are considered climate adaptation tools (Baró et al., 2014; Gill et al., 2007; Government of Canada, 2016; MOECC; 2016; MECP, 2015), it has to be decided whether there is sufficient time for slow GI implementation or whether the reality of climate change is requiring more rapid action to be taken.

5.2 Recommendations

5.2.1 Municipal Level Recommendation

The City of Brampton currently has a naturalisation strategy through their NHEMS and NHRP, which reflects the interconnected ecosystems principle of GI. The City also has several GI and LID projects implemented either by private developers or by CAs at a neighbourhood level. Through its Planning Vision, 2018, the City is committed to plant one million trees on

public lands and to support planting an equal number of trees on private land (City of Brampton, 2018a).

Green Infrastructure Master Plan

Along with the above approaches, I recommend that the City develop a comprehensive GI Master Plan, which bridges these naturalisation efforts and supports the watershed objectives of the CAs. Such a GI Master Plan would be more effective at consolidating the City's open spaces and park strategy, and various other kinds of GI such as front and back yards, outdoor amenity areas in developments, subdivision level right-of-ways and stormwater bodies, to provide an integrated and comprehensive GI vision. Further more, a GI Master Plan would help sharpen the City's focus on the benefits that can be derived from GI in terms of flooding risks, water quality improvement, heat island effects, biodiversity and ecosystem health, while consolidating lands with high development potential and lands that need environmental protection. Such a GI Master Plan could build on the existing Climate Change Strategy (Region of Peel, 2011) and other work done by Peel Region.

Drafting a GI Master Plan would help the City estimate the costs required for developing its sustainability vision along with the connected resiliency objectives. It would enable generation of budgetary estimates and an understanding of the initiatives that can be financed by municipal budgets and the initiatives that need to be transferred to private landholders. Private lands initiatives could then be translated into tangible bylaws for rainwater harvesting, tree plantation standards, lawn mowing, LID in parking areas, green roofs, buffers for urban forests and urban farming at the lot or neighbourhood level. The GI Master Plan would also suggest which communication and awareness materials need to be developed for informing the community about these interventions. The GI Master Plan could then also inform a municipality-wide strategy for incentivising GI projects on private residential lots. With the help of the CAs, the City could investigate methods to aggregate some of these interventions at the neighbourhood level, thus further minimizing implementation costs. The CAs are already developing a tool to

review neighbourhoods for GI retrofits. The City should consider using this, or a similar, tool and apply it for GI planning at the scale of the entire municipal area.

Importantly, a GI Master Plan could articulate what kind of GI interventions are required on new greenfield developments and reduce the time needed for negotiations on such new projects. A GI Master Plan could help defining soil depth, canopy cover, and other environmental standards, which can be conveyed to private developers with the onset of new development projects. A GI Master Plan could also help as a tool to support financial planning, because it would enable the City estimate costs required for GI implementation. These cost estimates could then be translated into development charges, becoming a revenue stream for the City required to finance GI implementation. GI development charges could also be employed by the City as a new negotiation tool and could be an offset if developers would implement the required GI.

A GI Master Plan would also help set biodiversity goals, define environmental targets, develop appropriate scientific indicators and plan for their long-term monitoring. Informed formulation of such goals, targets and indicators would require regional understanding of biodiversity, movement of flora and fauna as well as urban ecosystem functioning. The City already has defined open space hierarchies from the front and back yards to the NHS and urban riverine systems. Building on this understanding could enable development of an ecosystem services overview. This ecosystem services overview could be utilized for the creation of an ecosystem-based asset management, system, which would roll natural assets into the existing asset management framework of the municipality (Saini, et al., 2018; MNAI, 2018). The natural asset management system could determine the value of green assets, which would help determine the capacities of the existing green assets to support new developments and bring future investments to the City.

Green Infrastructure First Policy

I also recommend that the City of Brampton consider a GI First Policy, which is being advocated by many organisations such as the GIOC (GIOC, 2016, p.1, para 6). Such a policy would support the evaluation of all municipal infrastructure projects with a GI lens. Thus, any project in the public or private domain could be reviewed for opportunities for integration of GI elements. It would be useful to build a municipal core GI team with the necessary knowledge, skills and resources to evaluate projects and to build GI capacities within other departments. In the long term, the core GI team could also monitor urban ecosystem health, valuate GI benefits generated for the City and develop strategies for optimization of GI benefits for the City. Such a core GI team should be able to coordinate with other departments and align the policies of different municipal sectors.

As part of the GI First Policy, the City of Brampton could investigate the creation of a support infrastructure that could encourage private landowners to introduce GI for its various services such as food production and economic value. For example, the current GI interventions have already indicated residents' preferences for fruit trees. With enabling policies for urban farming and support infrastructure like warehousing, collection units and neighbourhood farmers' markets, the municipal government could provide incentives to encourage activities such as urban farming and home composting. This may have a reciprocal effect on waste management, rainwater harvesting and carbon sequestration on private lands. These spinoff effects might even be able to help creating new employment opportunities and strengthen the local economy involved in the horticultural sector and other services. Next to private properties, the City could also investigate public parks and other publicly owned GI assets for their economic value beyond recreation.

Community Mobilization

Next to the direct interventions, the City of Brampton should tap into its network of existing co-management partners to foster community consultations. While fostering two-way

exchanges between the municipality and residents, these consultations should also serve to create an ecosystems services thinking in local communities that clarify GI benefits for public health and long-term economic value such as reduced residential flood risk. Currently, evidence to support the creation of such GI co-benefits at the local level is scarce. However, investing in community awareness of GI benefits could support the creation of communities' vision for GI and potentially self-initiate community interventions. The municipality and its partners have already developed their capacities to support and provide scientific understanding of GI interventions. It is now time for the City to move further into the communities, build community awareness, and reward best GI management practices in neighbourhoods.

Green Infrastructure Definitions

Lastly, the municipal government should, through their capacities and legal powers, coordinate with the provincial government to create sectoral definitions of GI. Distinguishing the
various kinds of GI, as defined in the academic literature, can help municipalities to better
allocate funds to different kinds of GI such as wetlands, open water bodies, forests, gardens,
right-of-ways and others. Moreover, the newly created federal Green Infrastructure Bank can
help channel funds appropriately for the kinds of GI projects that apply an ecosystem
perspective, while coordinating with other green sectors.

5.2.2 Learning from the Case Study of Brampton

Apart from the above recommendations, this case study of the City of Brampton provided many learning opportunities that may be of interest for other municipalities.

Creating Institutional Capacities

The case study of the City of Brampton shows that GI interventions were enabled by collaboration and partnerships that were initiated by government-led co-management efforts where the municipal governments acted as facilitators and the CAs as a knowledge broker. These primary actors then involved the community and industry representatives in partnering for small, experimental GI initiatives. These partnerships not only aided in solving challenges regarding

finances and other resources, but also helped sharing risks and creating learning opportunities. These partnerships served moving GI projects through the various mandates of the different agencies, built confidence for funding agencies to provide the initial financial assistance necessary for experimental projects, and built trust and confidence in the various industry and government stakeholders to invest in similar projects. Thus, this case study provides a good example of collaborative and adaptive management in planning practise, which is appropriate to deal with the complexity in GI implementation.

In this study, the scale and multifunctionality of GI are addressed through a nested policy framework at various levels of government. For example, the abutting regional GI network in the form of the Greenbelt is governed by a separate set of provincial institutions. The provincial legislation and policies have enabled creation of the city-level NHS, which serves as an extension of the larger surrounding Greenbelt. From this larger spatial scale, the City and the CAs are now moving to extend the science and philosophy of GI to the smaller spatial scale of the neighbourhood level through retrofits and LID design interventions. Stemming from the federal and provincial level, funding and policy support has provided the necessary impetus for developing many of the smaller scale initial projects. However, a watershed or regional level understanding of the hydrology and ecology of the municipality as driven by the CAs have been instrumental in providing the research and science behind GI implementation.

Developing Technical and Research Capabilities at the Local Level

Given their existing watershed management mandate, the CAs were able to mobilise the technical and research capacities necessary for GI projects from a stormwater management perspective. But irrespective of the spatial scale of this mandate (regional or watershed level), research and information on the local ecology, hydrology and climate were imperative for GI implementation. Developing the capacities and means to disseminate this technical and scientific knowledge were essential for GI centric planning. The existing literature advocates for building knowledge networks of interdisciplinary experts including academics, researchers and practioners

to contribute knowledge and support GI initiatives (Pickett et al., 2016; Conway, 2017). It suggests the coordination and involvement of experts in the decision-making process through a co-governance model (Childers et al., 2014; Chapin et al., 2011; Pickett et al., 2016; Conway, 2017). In parallel to these literature findings, collaborations in the City of Brampton were government-led but engaged the community and industry professionals.

Fostering Community Awareness, Communication and Involvement

The study findings indicate that community awareness increased about the natural environment and its role in the City of Brampton. However, awareness had to be generated though government-led initiatives and channelized through a coordinated effort. Moreover, while the environment was used as an overarching term in these efforts, more leadership is required for creating awareness and understanding of ecological planning within the urban context. In the case of the City of Brampton, the municipal governments and the CAs have been able to fill this gap to some extent. This has also created new responsibilities and opportunities for communication and coordination between experts, professionals and newly emerging community leaders who supported such initiatives.

Importance of a Proactive Municipal Government

Most importantly, this research has been able to highlight the importance of the proactive approach taken by municipal and CA staff, and collective efforts of the community and its leaders, which provided the necessary momentum for GI projects and programs. Study participants suggested that a consultative process helped city managers to translate the community's expectations into actions. While community consultation is mandated in Official Planning processes, taking these inputs forward into other municipal projects and activities indicates the City's proactive approach towards GI. A collaborative decision-making process may have enabled this outcome.

5.3 Contributions of the Study

The case study was useful for demonstrating the ability of the IAD framework's theoretical lens to synthesize the institutional structures emerging from GI implementation in the City of Brampton. The institutional structures that emerged from this study may be prototypical of the institutional structures emerging in other municipalities under the influence of Ontario Planning legislation and the presence of a CA. In the current case, issues highlighted had regard to naturalisation and water management. However, there may be cities within the Ontario context with a similar set of actors but other GI priorities such as climate change adaptation or biodiversity protection.

Using the city level as the focal unit for this case study helped shedding light on the micro-operational level while still synthesising the influences of the macro-constitutional level. Thus, this approach enabled investigation of the horizontal and vertical linkages that affect GI implementation. By comprehending GI in its broader context, the study considered a wide range of policy and institutional systems that govern GI. The study highlighted GI as an important resource and brought together findings about the various policies and actor roles (existing and emerging) involved in governing and managing this resource. Since GI implementation is still emergent in this context, the findings of this research provide first but significant insights into the complexities of scales (geographical and administrative), mandates of existing institutions and understandings of what constitutes GI.

The current study also brought to the forefront the role of GI as a tool for the municipal government to further its goals for climate change adaptation as well as for sustainable development. Given its strong foundation in theory and evidence, this research can serve as a best practise case study and be used as a comparative for future studies in institutional capacities, challenges and enablers for GI. Moreover, the findings of the evaluative criteria have been able to highlight the strengths and weakness of the currently employed GI implementation model.

By aligning the employed GI implementation research with a systems approach, the study has created further scope for future, more detailed investigations of each component of the conceptual IAD framework. Such additional investigations would provide more nuanced information of GI implementation challenges and enablers, which in turn would support drafting more appropriate strategies for the utilisation of the GI resource.

5.4 Limitations and Further Research Opportunities

The presented research limited itself to a qualitative approach without quantifying progress in GI implementation. The research relied on the perspectives of study participants and analysis of policy documents in relation to experiences with several GI projects. This exploratory approach was adopted to develop a broad understanding of what constitutes GI in the context of Ontario's municipal policies, how municipal structures are evolving in this context and what the general institutional challenges and enablers are. Alternatively, a quantitative study could have been designed to investigate relationships between community characteristics, environmental conditions and existing institutional structures to determine how municipal institutional structures facilitating GI implementation are affected by variable circumstances. This, however, would have required a much larger study based within the IAD framework. A comparative case study approach might enable this kind of research.

The presented research was unable to capture individual challenges and enablers related to many policies and programs identified in the course of the study. For example, Greenbelt policies suggest that the City of Brampton can identify significant NHS components and recommend their addition to the Greenbelt. This may be an interesting approach for the municipal government, since limited funding has been constraining the municipal government's ability to implement and govern GI in the public domain. Transferring NHS components to the Greenbelt also would mean transfer of the decision-making rights and responsibilities for these lands to the provincial government. Such an approach would therefore upload some of the

regulatory and managerial burden for GI from the municipality to the Province. However, the study has not been able to document evidence regarding participants' assessment of such a strategy.

This research highlighted several other research areas that need attention. It shows that in a well-informed community with a high level of environmental concern, enabling legislation and collaborative public-public partnerships can lead to long-term planning for GI. But, the results also demonstrated that increasingly strategies are favoured that transfer the responsibility for adopting GI practices to private residents and industry. Further investigations are needed to understand the implication of devolving such responsibilities to the private sector. Also, in this context, the study raises questions about appropriate institutional enablers for the promotion of private sector GI adoption. It would be of great interest to research community responses to individual programs such as the Green Yards Program and SNAP.

Some interview participants also highlighted areas that need further research. For example, participants indicated:

- 1. the preference of community members for certain, fruit bearing tree species,
- 2. information needs about trees species that are suited best for climate change mitigation, and
- 3. more research needed regarding ground water balance required for improving water quality, reducing its temperature and maintaining the water table.

5.5 Conclusions

This study contextualised environmental planning for city planning practises and the need for a GI based approach. Further, it briefly traced literature on GI concepts, benefits, approaches and application to find a gap on how scientific knowledge of GI is applied in planning practise. The study then reviewed literature to understand the policy context of GI in the context of Canadian cities. Academic literature also indicated that GI policy studies were

taking a systems' view at institutionalising GI. To build on these knowledge needs using a single representative case study and a theoretical framework, this research project was conceived to understand the evolving institutional structures that are operationalising GI in city planning processes and the enablers and barriers in these processes. The case study indicates that all levels of government acknowledge GI and have created legislative tools and planning approaches to adopt and operationalise the concept. However, the policies are exploratory and are operationalised at the local level through mutual networks and negotiations. To truly institutionalise a GI approach and an ecosystem-based thinking in city planning practises, better policies and planning strategies need to be implemented through by-laws and capacities to evaluate projects through a GI lens. The terminology needs to be better defined and integrated into the planning framework to avoid the risk of how the term sustainable development (Portney, 2003) was appropriated to have several interpretations. For better integration, GI planning needs to be an iterative process of planning, monitoring and evaluating the services GI is providing as opposed to the current practises of carrying out environmental impact assessments at the beginning of projects. However, this is a single case study, at the municipal level. There needs to be more study on the subject at varying geographical scales (municipal, regional, watershed level) and a comparative study of institutional structures to bring about a GI based thinking into planning processes.

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Appendices

Appendix A. Interview Guide

Participants role in the organisation

Number of years of experience

Previous area of work

I. Interview Questions with the City of Brampton and Conservation Authorities

(The Environmental Planning team, stormwater management engineers, Parks and Forestry department, Landscape department and Urban design department are identified as key informants from the City of Brampton. The two conservation authorities are identified as key informants for the questionnaire)

Rules in Use

- 1. How do you define green infrastructure?
- 2. (Only for City of Brampton staff) Why and how did the City decide to initiate these plans?
 What was the response of the various stakeholders such as the various depts, councillors and the community?
- 3. Was it a conscious approach to move away from conventional planning methods of zoning and regulations? Do you think green infrastructure especially requires new collaborative and participatory planning initiatives? What are the advantages or disadvantages of such techniques? In retrospect, do you think another approach would have been better? Which one and why?
- 4. How do you see the role of the various stakeholder in the plan? How do you see the role of Conservation Authorities in the city level implementation of the environmental plan?

Action arena and Interactions -

5. What was the experience in creating the expertise and databanks needed for using green infrastructure? Did it give rise to new collaborations, partnerships or relooking at existing expertise and skills of employees? What was the community's response towards volunteering and stewardship opportunities offered in the plan? What were the opportunities and hardships in developing such transdisciplinary expertise?

- 6. What are the platforms which are used for collaboration between various stakeholders public consultations, plan review, workshops? What has been the response? Is there a feedback loop within the Plans that helps share key learnings for subsequent plans? What are the elements of the feedback loop and the details captured? e.g. scheduled monthly meetings, routine reports, GIS and online platforms? Is the loop inter-department or inter agency?
- 7. (Only for conservation authorities) What has been your experience with the program such as healthy yards program where information is imparted through workshops, guides and the private landowners have to implement green infrastructure projects at their own cost? What has been the response to such workshops and similar activities? Do workshops translate into actual implementation?

Evaluative framework-

- 8. In this case study of the City of Brampton, a polycentric and collaborative model for implementation seems to be emerging involving the City of Brampton, the conservation authorities and the community as the main actors.
- 9. What do you think are the strengths and weakness of this model in terms of time and cost efficiency? How do you measure that the goals and objectives of resiliency, climate change adaptation and stormwater water management and improving water quality are achieved?
- 10. Your thoughts on creating a performance framework such as the NHRP Performance framework and the importance of it. What are the challenges in having such framework and what kind of institutional capacities are required for having continued systems for monitoring, evaluating and modifying?

II. Interview Questions with participating community members and Developers Rules in Use

Boundary rules - Several initiatives are being taken at the municipal level by the City and
Brampton and the Conservation Authorities combined. There are certain broad level policies
and funding opportunities by the provincial and federal government. Do you think they are

sufficient to address the green infrastructure needs of municipalities? How are they contributing and what more would support the implementation?

Action Arena and Interactions

- 2. When the City initiated the Brampton Grow Green plan, how did you decide to participate and get involved it in?
- 3. Did you receive any training, information about the projects, its implementation and its outcomes? Do you think such information and training will be useful?
- 4. The City of Brampton's Environmental Plan comprises of several small initiatives and collaborative interventions involving the City and the residents are partners in the plan. These initiatives differ from the conventional planning tools such as zoning, regulations etc. What is your opinion on this approach? Do you think such participatory involvement is crucial for the success and how? What are the advantages or disadvantages of such techniques?
- 5. How do you see the role of Conservation Authorities in the city level implementation of the environmental plan?
- 6. What are the platforms which are used for collaboration between various stakeholders public consultations, plan review, workshops? What has been your involvement in such collaborations? Do you think you need to be involved more?
- 7. Are you aware of the program such as healthy yards program where information is imparted through workshops, guides and the private landowners have to implement green infrastructure projects at their own cost? What do you think about these workshop and similar educational initiatives?

Evaluative Criteria

8. Brampton's environmental plan states that it is flexible to strengthen it from future adaptation based on the previous experiences from implementation? Are you involved in providing such feedback? What is your opinion on such voluntary involvement?

9. Do you think this model of implementation is cost and time effective? For e.g., – time and costs required in operationalizing the Plan, cost and time required in achieving the desired effects.

Appendix B. Material used for Document Analysis			
Policy Hierarchy	Data	Data source	Data Acquisition
Provincial	 Ontario Planning Act, Provincial Policy Statement, 2014 Growth Plan for the Greater Golden Horseshoe, The Greenbelt Act 2005 and The Greenbelt Plan, 2017 	Ministry of Municipal Affairs	
Region	 2015-2035 Strategic Plan for Region of Peel Peel Region Official Plan Peel Climate Change strategy Region of Peel Priority Tree Planting Tool guide Regional Greenlands System for Region of Peel 	Region of Peel	Website download
Municipal	 City of Brampton's Official Plan 2006, its amendment "Brampton Grow Green" Environmental Master Plan, Sustainable Community Development Guidelines, Sustainable Neighbourhood Retrofit Action Plan, Parks and Recreation Master Plan, Stormwater Management Retrofit & Enhancement Study 	City of Brampton	Website download
	Other relevant documents related to the "Brampton Grow Green" Environmental Master Plan are also reviewed which include: 1. The Conservation Authority Natural Heritage System Mapping for the City of Brampton- Final technical report- 2014 (CANHS) 2. The Natural Heritage and Environmental Management Strategy (NEHMS) Background report and Implementation Action Plan 3. The Draft Natural Heritage System Restoration Program Report 4. City of Brampton Green Gateways Design Guidelines for Stormwater Management Ponds 5. The City of Brampton's Greening Policy.	City of Brampton	Website download
Conservation Authority	Two conservation authorities namely the Toronto Region Conservation Authority (TRCA) and the Credit Valley Conservation Authority (CVCA) govern the watershed areas of the Humber river and the Credit river respectively. Online searches of the websites of both organisations provide data on their key initiatives.	CVCA	Website

Appendix C. Recruitment Cover Letter/Email

Dear (Participant name)

I am a second year Master's student at the School of Planning, University of Waterloo and am undertaking a research study for my final year thesis. The research titled, 'Study of the Institutional Barriers and Enablers for Green Infrastructure Implementation.' and is supervised by Dr. Michael Drescher.

The study explores the barriers and opportunities that affect the implementation of green infrastructure (GI) concepts within the current institutional framework in city planning with Brampton as the case study area. The research is focussing specifically on the barriers and opportunities faced by the various stakeholders involved in planning, monitoring and implementing Green infrastructure in the City of Brampton. The key stakeholders include City of Brampton staff, Conservation authorities, developers and voluntary citizen groups who are committed to implementing specific GI initiatives.

My preliminary study has identified that your role as (role) with the City of Brampton has key decision-making responsibilities that involve and influence the use and implementation of green infrastructure. I would, therefore, appreciate your participation in this research to provide your insights into the influences, opportunities and challenges that are faced while considering green infrastructure in city planning process. I would like to inform you that participation in this study is voluntary and your identity will be confidential.

I have attached the details of the study along with this email and would be happy to provide any further information regarding this project. Please feel free to contact me via email at kghadge@uwaterloo.ca or my supervisor, Dr. Michael Drescher, at mdrescher@uwaterloo.ca. I would like to request a 60-minute interview on a suitable date, time and location. With your permission, I would like to audio-record the interview for analysis purposes.

This study has been reviewed and received ethics clearance through a University of Waterloo Ethics Committee (ORE#23052). If you have questions for the Committee, contact the Office of Research Ethics at 1-519-888-4567 ext. 36005 or ore-ceo@uwaterloo.ca.

Thank you for your time extended to this project and look forward to your response.

Regards,
Kanchan Ghadge
Candidate, MES
School of Planning,
University of Waterloo
Email – kghadge@uwaterloo.ca

Appendix C1. Script for Recruitment of Participants over Phone

Hello,

I am a second year Master of Environmental Studies (MES) student at the University of Waterloo and am undertaking a conducting a research study for my final year thesis under the supervision of Dr Michael Drescher. The research is titled, 'Study of the Institutional Barriers and Enablers for Green Infrastructure Implementation.'

My preliminary study has identified that your role as (role) with the City of Brampton as a key professional influencing the use and implementation of green infrastructure (GI) in the City. I would, therefore, appreciate an hour of your time to be interviewed in person and provide your insights into the influences, opportunities and challenges that are faced while considering green infrastructure in city planning process.

To provide further information on my study, the study explores the barriers and opportunities that affect the implementation of green infrastructure concepts within the current institutional framework in city planning. The research is focussing specifically on the institutional barriers and opportunities faced by the various stakeholders involved in planning, monitoring and implementing Green infrastructure in the City of Brampton. The key stakeholders include City of Brampton staff, Conservation authorities, developers and voluntary citizen groups who are committed to implementing specific GI initiatives.

This study has been reviewed and received ethics clearance through a University of Waterloo Ethics Committee (ORE#23052). If you have questions for the Committee, contact the Office of Research Ethics at 1-519-888-4567 ext. 36005 or ore-ceo@uwaterloo.ca.

If you are interested in participating, I will email you further details about the study and a copy of the interview questions.

Please feel free to contact me via email at kghadge@uwaterloo.ca or my supervisor, Dr. Michael Drescher, at mdrescher@uwaterloo.ca.

Thank you.

Appendix D. Letter of Information

University of Waterloo

Date 19 June 2018

To Dear (Participants name),

This letter is an invitation to consider participating in a study I am conducting as part of my Master's degree in the School of Planning, Faculty of Environment at the University of Waterloo under the supervision of Dr Michael Drescher. I want to provide you with more information about this project and what your involvement would entail if you decide to take part.

Green infrastructure is an emerging subject of research and practice for the various benefits it offers in urban areas. Academics, professionals and city planners advocate the use of green infrastructure to address several urban issues ranging from improving the quality of life to climate change adaptation. However, literature study indicates that there are several implementation issues in applying and upscaling green infrastructure projects. This research aims to understand the barriers and enablers while implementing green infrastructure concepts at the municipal scale using an institutional theory lens. Using the case study of the City of Brampton, the research focuses on the planning approaches adopted to use green infrastructure concepts in city planning and how new institutional tools are shaping its implementation.

My preliminary study indicates that recently the City of Brampton has taken several initiatives such as the Natural Heritage and Environmental Management System (NHEMS) - Implementation and Action Plan, the Sustainable Neighborhood Retrofit Action Plan (SNAP), Development of the Sustainable Community Development Urban Design Guidelines (SCDG) and the Natural Heritage Restoration Program (NHRP). These initiatives actively use and promote the concept of green infrastructure for long-term resiliency and sustainability of the City. I have therefore chosen the City of Brampton as my case study for the research. I believe that because your organisation is actively involved in the management and operation of these initiatives, you are best suited to speak to the various issues.

As part of the academic research requirements, I also need to inform you that participation in this study is voluntary. It will involve an interview of approximately sixty minutes in length to take place in a mutually agreed upon location. You may decline to answer any of the interview questions if you so wish. Further, you may decide to withdraw from this study at any time before the thesis is submitted, without any negative consequences by advising the researcher. With your permission, the interview will be audio recorded to facilitate the collection of information and later transcribed for analysis. Shortly after the meeting, I will send you a copy of the transcript to give you an opportunity to confirm the accuracy of our conversation and to add or clarify any points that you wish. Your identity as a participant in this study will be kept entirely confidential

and will not be linked to the organisation. The names of participating organisations and their characteristics (e.g., size, # of employees, location) will be included in the final report but comments of individual participants will not be linked to a particular organisation or comments will not be identified with a specific organisation. Your name will not appear in any thesis or report resulting from this study, however, with your permission anonymous quotations may be used. Data collected during this study will be retained for at least two years in a locked office in my supervisor's lab. Only researchers associated with this project will have access. There are no known or anticipated risks to you as a participant in this study.

This study has been reviewed and received ethics clearance through a University of Waterloo Ethics Committee (ORE#23052). If you have questions for the Committee, contact the Office of Research Ethics at 1-519-888-4567 ext. 36005 or ore-ceo@uwaterloo.ca.

I would be happy to provide any further details regarding this study. You can contact me regarding this project at kghadge@uwaterloo.ca or my supervisor, Dr Michael Drescher, at mdrescher@uwaterloo.ca.

Once all the data are collected and analysed for this research, I plan on sharing this information with the research community through seminars, conferences, presentations, and journal articles. I hope that the results of my study will be of benefit to those organisations directly involved in the study, as well as other organisations not directly involved in the research but involved in green infrastructure implementation, as well as to the broader research community.

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

Yours Sincerely, Kanchan Ghadge Candidate, MES, School of Planning University of Waterloo

Appendix E. Consent Form

By signing this consent form, you are not waiving your legal rights or releasing the investigator(s) or involved institution(s) from their legal and professional responsibilities.
I have read the information presented in the information letter about a study being conducted by Ms. Kanchan Ghadge of the School of Planning, Faculty of Environment at the University of Waterloo. I have had the opportunity to ask any questions related to this study, to receive satisfactory answers to my questions, and any additional details I wanted.
I am aware that I have the option of allowing my interview to be audio recorded to ensure an accurate recording of my responses.
I am also aware that excerpts from the interview may be included in the thesis and/or publications to come from this research, with the understanding that my name will not appear on the thesis or the resulting reports and the quotations will be anonymous.
I am aware that the names of participating organizations and their characteristics will be included in the final report but comments of individual participants will not be linked to a particular organization or comments will not be identified with a particular organization.
I was informed that I may withdraw my consent at any time before the thesis is submitted, without penalty by advising the researcher.
This study has been reviewed and received ethics clearance through a University of Waterloo Ethics Committee (ORE#23052). If you have questions for the Committee, contact the Office of Research Ethics at 1-519-888-4567 ext. 36005 or ore-ceo@uwaterloo.ca.
For all other questions contact [insert researcher's name and contact information]. With full knowledge of all foregoing, I agree, of my own free will, to participate in this study. □YES □NO I agree to have my interview audio recorded. □YES □NO I agree to the use of anonymous quotations in any thesis or publication that comes of this research. □YES □NO
Participant Name: Participant Signature: Witness Name: Witness Signature:

Appendix F. Feedback Letter

University of Waterloo

Date:

Dear

I would like to thank you for the meeting we had on (date) and giving time for my research study entitled "Study of the Institutional Barriers and Enablers for Green Infrastructure Implementation". I want to reiterate that the purpose of this study is to identify the key factors that are enabling or are posing challenges in the implementation of green infrastructure concepts at the municipal level. Your inputs to this study are greatly appreciated.

The data collected from the interview will contribute to a improve the understanding of green infrastructure implementation at the municipal level.

This study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Committee (ORE23052#). If you have questions for the Committee contact the Office of Research Ethics, at 1-519-888-4567 ext. 36005 or ore-ceo@uwaterloo.ca.

For all other questions contact me, Kanchan Ghadge at kghadge@uwaterloo.ca, or my supervisor, Dr. Michael Drescher, at mdrescher@uwaterloo.ca.

Please remember that any data pertaining to you as an individual participant will be kept confidential. Once all the data are collected and analyzed for this project, I plan on sharing this information with the research community through seminars, conferences, presentations, and journal articles. If you are interested in receiving more information regarding the results of this study or would like a summary of the results, please provide your email address, and when the study is completed, anticipated by 2018-09-30, I will send you the information. In the meantime, if you have any questions about the study, please do not hesitate to contact me by email as noted above.

Sincerely,

Kanchan Ghadge Candidate, MES, School of Planning University of Waterloo

Appendix G. Action Arena Analysis

GI Types	Action Tool	Actors	Position	Function	Costs	Influence Area	Implementation Tool
Urban forests	SNAP	City of Brampton	Land Manager	Mobilizing, Funding	Cost sharing between	Neighborhood	Pilot project
comprising of street trees (ROW), front yards, backyards and private property		CVCA	Initiator	Funding, Knowledge and Expertise partner, Awareness and Information Dissemination	City of Brampton, TRCA and CVC in respective watersheds	level	
		TRCA	Initiator	Funding, Knowledge and Expertise partner, Awareness and Information Dissemination	and neighborhood community		
	Citizen Community	Initiator, Volunteer	Community participation at neighborhood level				
		Individual Prop Owner	Land Owner	Volunteering, Implementing			
	SCDG	City of Brampton	Land Manager	Drafting the SCDG	Private developer	City wide	Guidelines
		Private Sector	Private Land Developer	Implementing, Funding	bears the cost		
	Boulevard Bulb Planting Initiative	City of Brampton	Land Manager	Mobilizing, Funding on public lands	from capital costs for	City wide	Initiative
		Private Sector	Private Developer	Planting management, funding in new subdivision	public lands. Pvt. developer in new developments		
	Tree Preservation	City of Brampton	Land Manager	Regulator	City of Brampton	City wide	Regulation
	By-law	Private Sector	Private Developer, Implementor	Implement in new sub division development.	from capital costs. For public lands. Individual property		
		Citizen Community	Land Owner	Implementation	owner bears the cost.		
		Individual Property Owner	Land Owner	Implementation			
	Street and Park Tree Replacement Program	City of Brampton	Land Manager	Implementation on public lands. Create standards and instructional guides for private land owners and developers.	City of Brampton from capital costs for public lands. Land Owner and	City wide	Program
		Private Sector	Private Developer,	Implement in new Sub Division development.	implementor bears the cost.	2	

GI Types	Action Tool	Actors	Position	Function	Costs	Influence Area	Implementation Tool
			Implementor				
		Individual Prop Owner	Land Owner	Implementation			
	Ice storm and Emerald Ash Borer Tree Recovery Program	City of Brampton	Land Manager	Tree monitoring & cutting. Drafting guidelines & execution on public lands. Creating information material for private lands.	Individual costs	City wide	Initiative
		Individual Property Owner	Land Owner	Implementation			
	LID Green Infrastructure in private residential yards	CVCA	Initiator	Your Green Yard programs.	Individual costs.	In their respective watersheds	Program
				Workshops and resources on native plant gardening; environmental maintenance; and, green outdoor building	Cost of resource material and workshops sponsored by Conservation Authorities		
		TRCA	Initiator	Healthy Yards program			
				training and demonstration workshops, information guides			
		Individual Property Owner	Land Owner	Implementation			
	Tree Planting and Forestry	CVCA	Initiator	Naturalization Planting Program	The Conservation Authorities fund	In their respective	Program
				Providing financial and technical assistance for restoration and improvement of private property. Providing native plantation material such as seedlings and saplings.	certain aspects and the individual land owners bear certain costs.	watersheds	
		TRCA	Initiator	Private Land Tree Planting and Forestry			

GI Types	Action Tool	Actors	Position	Function	Costs	Influence Area	Implementation Tool
				Providing financial and technical assistance for restoration and improvement of private property. Providing native plantation material such as seedlings and saplings.			
		Individual Property Owner	Land Owner	Implementation, funding for implementation			
Stormwater	SNAP	City of Brampton	Land Manager	Mobilizing, Funding	Cost sharing between	Neighborhood	Pilot project
Management Pond		CVCA	Initiator	Funding, Knowledge and Expertise partner, Awareness and Information Dissemination	City of Brampton, TRCA and CVC in respective watersheds and neighborhood community	level	
		TRCA	Initiator	Funding, Knowledge and Expertise partner, Awareness and Information Dissemination			
		Citizen Community	Initiator, Volunteer	Community participation at neighborhood level			
		Individual Prop Owner	Land Owner	Volunteering, Implementing			
	Stormwater Management Facility Maintenance Program	City of Brampton	Land Manager	Management, maintenance and monitoring for invasive species, water quality in public stormwater ponds	City of Brampton from capital costs for public lands. Pvt. developer in private	Site Level	Projects
	CVCA	Consultant, Support	Stormwater management planning and prepared design guidelines. Low impact stormwater management planning support and consulting	lands			
		TRCA	Consultant, Support	Low impact stormwater management planning support and consulting			

GI Types	Action Tool	Actors	Position	Function	Costs	Influence Area	Implementation Tool
		Private Sector	Land Manager	Management, maintenance and monitoring for invasive species, water quality in stormwater ponds in private lands.			
	Species at Risk Act	Federal	Regulator	Implementing the Act	Cost of preparing list	City wide	Regulation
		City of Brampton	Enforcement authority	cognizance to the Act	borne by Provincial government		
		CCVA	Enforcement authority	cognizance to the Act			
		TRCA	Enforcement authority	cognizance to the Act			
		Private Sector	-	cognizance to the Act			
		Individual Property Owner	-	cognizance to the Act			
	Endangered Species Act	Provincial. Ontario Ministry of Environment and Climate Change.	Regulator	Implementing the Act	Cost of preparing list borne by Provincial government	City wide	Regulation
		City of Brampton	Enforcement authority	cognizance to the Act			
		CCVA	Enforcement authority	cognizance to the Act			
		TRCA	Enforcement authority	cognizance to the Act			
		Private Sector	-	cognizance to the Act			
		Individual Property Owner	-	cognizance to the Act			
Community/City Parks, Gardens, Amenity Areas	Community Gardens Program	City of Brampton	Land Manager	Facilitating, creating instructional guides for gardening knowledge. 4 gardens currently maintained		wide	Initiative
		Citizen Community	Volunteers	Stewardship and volunteering.			
	Community Tree Planting Program	City of Brampton	Land Manager	Facilitating, Mobilizing, Funding,			Initiative
		TRCA	Initiator	Funding, knowledge and expertise dissemination		replicability	

GI Types	Action Tool	Actors	Position	Function	Costs	Influence Area	Implementation Tool
		Citizen Community	Volunteer	Student volunteering, community participation			
	Invasive Species Management Program	City of Brampton	Initiator	Funding, implementing, knowledge and expertise dissemination	Each agency bears costs in respective areas	City wide	Program
		CVCA	Initiator	Funding, knowledge and expertise dissemination			
		TRCA	Initiator	Funding, knowledge and expertise dissemination			
	Street and Park Tree Replacement Program	City of Brampton	Land Manager	Implementation on public lands. Crating standards and instructional guides for private land owners and developers.	City of Brampton from capital costs for public lands. Private sector bears cost in their lands One-time maintenance fee paid by the developer. Maintenance through taxes by the property owners.	City wide	Program
		Private Sector	Land Developer, Implementor	Implement in new Sub Division development.			
	Parklands Dedication By-law	City of Brampton	Land Manger	Prepare standards for land acquisition. Acquire and maintain land for the creation of open spaces in new sub division		City wide	By Law
		CVCA	Consulting and support	Provide planning and consulting services to the city and developers to develop the existing parklands through LID and ecosystem services principles			
		TRCA	Consulting and support	Provide planning and consulting services to the city and developers to develop the existing parklands through LID and ecosystem services principles			
		Private Sector	Land Developer, Implementor	Develop and provide parkland as per by law provisions in new developments			

GI Types	Action Tool	Actors	Position	Function	Costs	Influence Area	Implementation Tool
	Parks and Recreation Master Plan	City of Brampton	Land Manager and Initiator	Blueprint for developing parks, open space, recreation and sport facilities as important services for the City. Creating these facilities as an integrated green infrastructure for the City.	Parkland dedication by law and Cash in lieu		Plan, Amendment to the Planning Act for enacting new legislation enacted through Ontario Bill 73.
		CVCA	Support	Partnership with City of Brampton for development on the principles of the SNAP program			
		TRCA	Support	Partnership with City of Brampton for development on the principles of the SNAP program			
	Buffer Planting and Land securement	Region of Peel	Administrator	Matching funds for the Land securement program	Land securement program, Land donations in lieu of	Watershed level	Program
		City of Brampton	Land Manager	Restoring buffers on public lands and adding new lands in buffer areas through Land securement program	tax rebates.		
		CVCA	Consulting and Support	Restoring buffers. Consulting, implementation support and information guides			
		TRCA	Consulting and Support	Restoring buffers. Consulting, implementation support and information guides			
		Citizen Community	Volunteer	Volunteering in tree plantation on public lands and stewardship			
		Individual Property Owner	Land Owner	tree planting and creating buffers on private property			

GI Types	Action Tool	Actors	Position	Function	Costs	Influence Area	Implementation Tool
	Ice storm and Emerald Ash Borer Tree Recovery Program	City of Brampton	Land Manager	Tree monitoring and cutting. Drafting guidelines and execution on public lands. Creating information material for private lands.	Individual costs	City wide	Initiative
		Individual Property Owner	Land Owner	Implementation			
	NHSRP (Pollinator Gardens, Reduce	City of Brampton	Land Manager	Initiator, facilitator, funding, implementation		Site level, City Wide	Plan
	Mowing). Naturalizing buffer area linkages with open spaces to	CVCA	Consulting and Support	Funding, knowledge sharing, providing expertise and creating information material			
	provide greater ecological functions.	TRCA	Consulting and Support	Funding, knowledge sharing, providing expertise and creating information material			
		Citizen Community	Volunteer	Volunteering in tree plantation on public lands and stewardship			
		Individual Property Owner	Volunteer	Volunteering in tree plantation on private lands and stewardship			
Infrastructure corridors comprising of gas, hydro, water,	Invasive Species Management Program	Federal & Provincial	Regulator	Generating Federal & provincial list of invasive species	Cost sharing between City of Brampton, TRCA and CVC in	Infrastructure corridors	Program and regulation
utility corridors, road networks, stormwater management		City of Brampton	Initiator	Initiator, funding, monitoring, knowledge and expertise dissemination	respective watersheds and individuals		
facilities, parkway belt west lands		CVCA	Initiator	Initiator, funding, monitoring, knowledge and expertise dissemination			
		TRCA	Initiator	Initiator, funding, monitoring, knowledge and expertise dissemination			
		Private Sector	Utility managers, Implementors	Monitoring and maintaining respective utility corridor lands			

GI Types	Action Tool	Actors	Position	Function	Costs	Influence Area	Implementation Tool
	NHSRP (Pollinator	Region of Peel	Administrator	Fund sharing	Capital budgets,	Infrastructure	Program and
	Gardens, Reduce Mowing, Tree planting and LID)	City of Brampton	Initiator	Enhance ecological functions, linkages, implementation and funding	Development charges, tableland tree cash in lieu, perpetual	corridors	regulation
		CVCA	Consulting and Support	Habitat and ecosystem knowledge sharing, providing subject matter expertise on restoration.	maintenance fund per hectare of NHS dedicated to the city.		
		TRCA	Consulting and Support	Habitat and ecosystem knowledge sharing, providing subject matter expertise on restoration.			
		Private Sector	Utility Managers	Collaborations, Stewardships			
		Citizen Community	Volunteer	Volunteering in tree plantation	-		
	Hydro One Native Plant listing	Pvt. Sector	Land Manager	Managing utility lands as per the list	Utility manager pays for land management.	Infrastructure corridors	Program and Regulation
Conservation Areas	Invasive Species Management Program	Federal & Provincial	Regulator	Generating Federal & provincial list of invasive species	Cost sharing between City of Brampton, Corridors TRCA and CVC in	Infrastructure corridors	Program and Regulation
		City Of Brampton	Initiator	Initiator, funding, monitoring, knowledge and expertise dissemination	respective watersheds and individuals		
		CVCA	Initiator	Initiator, funding, monitoring, knowledge and expertise dissemination			
	Endangered Species Provi Act 2007 Minis Envir	TRCA	Initiator	Initiator, funding, monitoring, knowledge and expertise dissemination			
		Provincial. Ontario Ministry of Environment and Climate Change.	Regulator	Listing and protection of endangered species	Provincial govt.	Provincial	Regulation
	Ontario Regulation 166/06 –	Federal		Creation of the Conservation Authorities Act.	Watershed level	Provincial	Regulation

GI Types	Action Tool	Actors	Position	Function	Costs	Influence Area	Implementation Tool
	Development, Interference with Wetlands and Alterations to Shorelines and Watercourses	TRCA	Authority	Administering the regulation. Planning, development and creating information material			
	Clairville	Provincial		Legislative protection	Sharing of cost	Site level	Management Plan
	Conservation Area Management Plan	City of Brampton	Land jurisdiction	Cost sharing in key infrastructure	between key stakeholders		
		TRCA	Initiator	Management Plan Conservation, restauration, management			
		Citizen Community	Volunteer	Claireville Stewardship Group, Friends of Claireville in volunteering, stewardship			
	Heart Lake Conservation Area Management Plan	Regional Development Agency	Program funding	Canada 150 Community Infrastructure Program	Sharing of cost between key stakeholders	Site level	Management Plan
		Region of Peel	Land jurisdiction	Cost sharing in key infrastructure			
		City of Brampton	Land jurisdiction	Land jurisdiction, cost sharing in key infrastructure			
		TRCA	Initiator	Master Planning, Conservation, Restoration, Management			
		Citizen Community	Volunteer	HLCA stewardship committee,			
				local community service groups and local businesses in volunteering, fund raising			
Natural heritage systems comprising of woodlots,	Natural Heritage Environment Management	City of Brampton	Initiator	Plan preparation, implementing, funding and communication	City of Brampton through capital costs. TRCA and CVC providing indirect fund sharing for information brochures, workshops,	Natural heritage system	Plan and Strategy
wetlands, valleys, land and lakes	Strategy (NHEMS)	CVCA	Project partners and Support	Knowledge support, implementation, partnering in funding, creating subject material			

GI Types	Action Tool	Actors	Position	Function	Costs	Influence Area	Implementation Tool
		TRCA	Project partners and Support	Knowledge support, implementation, partnering in funding, creating subject material	knowledge and awareness creation and expertise support		
		Citizen Community	Volunteer	Stewardship and volunteering.			
	NHRP (Pollinator	Region of Peel	Support	Fund sharing	Capital budgets,	Natural	Plan and Strategy
	Gardens, Reduce Mowing, Tree planting and LID)	City of Brampton	Land Manager and Initiator	Enhance ecological functions, linkages, implementation and funding	Development charges, tableland tree cash in lieu, perpetual maintenance fund per	heritage system	
		CVCA	Consulting and Support	habitat and ecosystem knowledge sharing, providing subject matter expertise on restoration	hectare of NHS dedicated to the city.		
		TRCA	Consulting Partners and Support	habitat and ecosystem knowledge sharing, providing subject matter expertise on restoration,			
		Private Sector	Utility Manager, private organizations	Collaborations, Stewardships			
		Citizen Community	Volunteer	Volunteering in tree plantation			
	Brampton Valleys Re-Naturalization Planting Program	City of Brampton	Land Manager	Planning, implementation, maintenance, monitoring and funding	Capital costs	Natural heritage system	10 year program
	(BVRPP)	CVCA	Program Partners and Support	Providing expertise for planning and design, and performance monitoring			
		TRCA	Program Partners and Support	Providing expertise for planning and design and performance monitoring			
	Tableland Tree Assessment Guidelines	Region of Peel	Program Partners and Support	Compensatory planting in place of the removed trees as capital projects. Create plantation areas within the region. Preparing tree preservation Plan.	Cash in lieu	City wide	Guidelines

GI Types	Action Tool	Actors	Position	Function	Costs	Influence Area	Implementation Tool
		City of Brampton	Land Manager and Initiator	Preparing technical standards to guide development applications for compensating tree loss in projects. Preparing tree preservation plan. Monitoring and scrutiny.			
		Private Sector	Land Developer	Should compensate as per standards to remove tree during development of projects			
		Citizen Community	Volunteer	Volunteering in tree plantation			
		Individual Property Owner	Land Owner	Should compensate as per standards if a tree from property s removed.			
	Woodland Management Plan Guidelines	City of Brampton	Land Manager, Regulator	Policies for preparing guidelines, monitoring	Developer pays for the plan preparation	City wide	Guidelines
	Guidennes	Private Sector	Land Developer	Preparing the Woodland Management plan for new development as per the guidelines	and implementation		
	Community Tree Planting Program	City of Brampton	Land Manager	Facilitating, Mobilizing, Funding,		Site level, City wide	Initiative
		TRCA	Initiator	Funding, knowledge and expertise dissemination		replicability	
		Citizen Community	Volunteer	Student volunteering, community participation			
	Woodland Restoration	City of Brampton	Land Manager, Initiator	Plan preparation, implementation and monitoring, funding	Capital budgets, Development charges, tableland tree cash in	Natural heritage system	Plan and Strategy
		CVCA	Support	Knowledge support and collaboration	lieu, perpetual maintenance fund per		
		TRCA	Support	Knowledge support and collaboration	hectare of NHS dedicated to the City.		
	Wetland Restoration	City of Brampton	Land Manager, Initiator	Plan preparation, implementation and monitoring, funding	Capital budgets, Development charges, tableland tree cash in	Natural heritage system	Plan and Strategy

GI Types	Action Tool	Actors	Position	Function	Costs	Influence Area	Implementation Tool
		CVCA	Support	Knowledge support and collaboration	lieu, perpetual maintenance fund per		
		TRCA	Support	Knowledge support and collaboration	hectare of NHS dedicated to the City.		-
	Lake Enhancement	City of Brampton	Land Manager, Initiator	Plan preparation, implementation and monitoring, funding	Capital budgets, Development charges, tableland tree cash in	Natural heritage system	Plan and Strategy
		CVCA	Support	Knowledge support and collaboration	lieu, perpetual maintenance fund per		-
		TRCA	Support	Knowledge support and collaboration	hectare of NHS dedicated to the City.		
Greenfield lands	Greenfield legislation	Provincial – Ministry of Municipal Affairs	Regulator	Regulator	Provincial Designated Government for administering, surveying, dissemination of information and	greenfield	Regulation
		Regional Development Authority - FedDev	Administrator and Implementor	Implementation and			
		Region of Peel	Jurisdiction	Land use policies in consonance	consulting.		
		Ind. Porp. Owner	Land Owner				
River courses & creeks	Downtown Etobicoke Creek	Federal		Infrastructure Canada. Part funding		Etobicoke Creek	Initiative
	Revitalization	Provincial		Min of Infrastructure, Ont. Funding			
	City of Brampton		Urban Design & Land-use Study, project planning and implementation				
		TRCA		Flood Mitigation Study, project planning and implementation			
	Citywide Watercourse Erosion Study	City of Brampton	Initiator	Initiating the study, plan preparation		Watercourses throughout Brampton	