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An assessment of systems, agents, and institutions in building community resilience to climate change: A case study of Charlottetown, Canada

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While climate change manifests itself as a global phenomenon, impacts are experienced most acutely at the local scale. As a result, the onus of responding to climate change impacts through planning policies and practice falls on local government decision-makers. This qualitative study, based in Charlottetown, Canada, utilizes the framework of resilience theory to examine the relationship between systems, agents, and institutions in addressing climate vulnerability to build community resilience. Findings suggest that while non-municipal agents such as senior orders of government and external organizations are championing proactive adaptation through climate impact research and adaptation initiatives, the municipality has taken a non-urgent, reactionary approach in the face of climate stressors, often implementing initiatives that further exacerbate climate vulnerability. In the face of system vulnerabilities and cascading failures, deep institutional barriers, influencing and influenced by agents, contribute to the low prioritization of climate adaptation action. Institutional and agent-induced constraints at the municipal scale have led to the lack of internal initiative to act within the municipality, undermining the efforts of external organizations and senior orders of government. This study highlights the importance of robust local government agents and institutions as a prerequisite to enable local-scale climate adaptation.

Key words: coastal communities; strategic planning; local government; urban resilience; climate change adaptation; urban planning

Highlights

- Municipal-scale action is a prerequisite to robust climate adaptation planning.
- Collaboration between governments and external organizations is needed to ensure efficient use of resources and expertise.
- Municipal agents play a critical role in responding to ongoing climate change stressors such as sea level rise.
- Reactionary plans and bylaws hinder ability of municipal agents to implement proactive climate adaptation.

1.0 Introduction

Global climate change poses an imminent, yet long-term threat to human and natural systems. Whereas climate mitigation through the reduction of greenhouse gas emissions is the typical approach to addressing climate change (Grafakos et al., 2019), historic emissions commit

the Earth to some degree of future warming, with associated impacts worsening (Warren and Lulham, 2021; Wallace, 2017). In response, governments are now considering ways of adapting to climate change by developing plans to address vulnerabilities, reduce risk, and build resilience (Lee et al. 2020). While climate change is undeniably a global issue, effects are most acutely experienced at the local scale, with municipal decision-makers often in the best position to understand vulnerabilities and manage responses (Measham et al., 2011; Boda and Jerneck, 2019; Fünfgeld and McEvoy, 2012; Dale et al., 2020).

Scholars have used practical and theoretical planning research to elucidate the dynamics of municipal climate adaptation planning. A robust adaptation framework must start with an awareness of the threat posed by climate change, followed by a relevant information base to best gauge the characteristics of community vulnerability (Berke and Ward, 2013; Lyles et al., 2018; Berke and Stevens, 2016; Baker et al., 2012). Following this, scholars recommend that the translation of information to policy commence with the adoption of a honed-in climate adaptation strategy specific to the climate hazards posing the greatest risk to the community (Lyles et al., 2018). Based on the direction of this strategy, components of the plan should be incorporated into other municipal planning processes to become imbedded within day-to-day thinking (Lyles et al., 2018; Birchall and Bonnett, 2021; Berke and Ward, 2013). Flexibility must be built into the strategy to allow for changes as new information becomes available and impacts change (Berke and Ward, 2013). Lastly, there must be a system for implementation and monitoring to ensure the objectives of the plan are diligently achieved (Lyles et al., 2018). At the backbone of municipal adaptation are municipal agents who can learn from disruptions, use available resources to enable swift action, and internalize past impacts to avoid repeated and cascading failures (Tyler and Moench, 2012; Birchall and Bonnett, 2021; Birchall et al., 2021).

On the other hand, planning for climate change adaptation at the local level can become ineffective, reactionary, or entirely absent due to a combination of factors. Conventional social and economic norms, expressed through policy or informal practice, can limit opportunities for action and influence how climate change adaptation is approached (Forino et al., 2017, Measham et al., 2011). While scholars have noted that climate adaptation action is beginning to manifest in municipal strategy, it can often be reactive, with action occurring only after a community has experienced an extreme event (Berrang-Ford et al., 2011, Birchall and Bonnett, 2020). Such measures often correspond with disaster response efforts, and do not take into account the persistent, unpredictable, and evolving nature of climate change (Wallace, 2017).

Underpinning the sluggish response to climate adaptation is a lack of urgency to climate risks and vulnerabilities (Vogel and Henstra, 2015). Even in communities where adaptation is considered important, there can be little implementation or action (Berrang-Ford et al., 2011; Wallace, 2017). The often-complicated nature of adaptation can be a major contributor to slow support for action implementation, leading local officials to downplay the risks. Adaptation involves uncertainty in both the potential risk (impacts) and the necessary future actions. Successful adaptation must therefore be an ongoing, iterative process that addresses immediate threats and prepares for long-term changes (Siders, 2017). As such, scholarship has noted a ‘local government paradox’, whereby local governments, while aware of the potential threat that will be caused by climate change, fail to act in time (Berke and Ward, 2013).

As climate change continues to place these communities in an increasingly vulnerable position, research has grown beyond the physical sciences to include social studies of risk, vulnerability, and adaptive capacity (e.g. McEvoy et al., 2013; Kehler and Birchall, 2021). Emerging from this shift is the application of resilience theory to climate change adaptation and urban planning (Nelson, 2010; Fünfgeld and McEvoy, 2012). While resilience has many definitions, evolutionary resilience, the ability of socioecological systems to adapt and transform in response to stress, has become popular in this context (Davoudi et al., 2013). Building urban resilience in a variable climate requires a proactive, forward-thinking, and all-encompassing approach to planning.

Communities need to address vulnerabilities across sectors and governments in order to develop flexibility, learning capacity, and adaptive capacity in the face of stressors (e.g. Adger et al., 2005). Tyler and Moench (2012) discuss urban resilience to climate change in terms of three generalizable elements: systems (infrastructure and ecosystems), agents (individuals and organizations), and institutions (formal or informal rules that structure human behavior in social and economic interactions). These elements can be used independently and in collaboration with one another to assess urban resilience to climate change.

While municipal climate adaptation research has grown in scholarship, additional case studies can contribute further nuance to climate adaptation planning literature, and can help to identify barriers. To add to the growing body of literature on climate adaptation and resilience, this study examines adaptation planning in the coastal island city of Charlottetown, Prince Edward Island (PEI), Canada, where sea level is rising, and storm surge and precipitation are becoming more severe. Framed through an urban resilience lens (Tyler and Moench, 2012), this qualitative study explores how municipal decision-makers in Charlottetown approach climate change adaptation. While limited to case of Charlottetown, it is our hope that insights from this work will inform beyond the local case, and contribute nuance to the broader academic discussion on the importance of proactive climate adaptation in coastal communities.

This paper begins with a short description of the study site (section 2), before highlighting the research approach (section 3). In Section 4, we uncover two major themes emerging from the research through the framework of resilience theory. In Section 5, we use literature to further investigate these three elements in the context of building resilience to climate change (Tyler and Moench, 2012).

2.0 Charlottetown, Prince Edward Island

Charlottetown is located in the province of Prince Edward Island, in Canada, where three levels of governance exist: federal, provincial, and lastly, a creature of provincial legislation, the municipal government. While all three levels of government can plan for climate change through adaptation, local-scale adaptation is most effectively executed by municipal governments. To do so, municipalities may receive financial and resource support from senior orders of government (Stevens and Senbel, 2017; Birchall and Bonnett, 2021). While the federal government is currently in the progress of developing Canada's National Adaptation Strategy (Government of

Canada, 2021), and adaptation is included as an element of the provincial climate strategies (Government of PEI, 2018), the focus of this research is to investigate climate adaptation planning at the municipal administrative scale.

Charlottetown is a community of approximately 45,000 residents, increasing in population by 7.5% between 2011 and 2016 (Government of Canada, 2016). Being a relatively old colonial settlement, Charlottetown is home to historical developments that were built along the community's waterfront. Located within a natural harbour on the southern coast of PEI, Charlottetown sits at the confluence of North River, Hillsborough River, and West River. Surrounded by water, the city is especially vulnerable to overland (or inland) and coastal flooding. With an underlying bedrock of soft red sandstone and mudstone, the shoreline is easily eroded by wave action. Charlottetown has a mild climate, with average summer and winter temperatures ranging from 20°C to 30°C and -11°C to -3°C, respectively (DEWCC, 2015). Over the past 50 years temperatures in Charlottetown have risen 0.5°C, and as climate change progresses, a further rise of 1.6°C is expected by 2050 (Arnold and Fenech, 2017).

In Atlantic Canada, the rise of temperature is expected to be associated with sea level rise and an increase in frequency and severity of precipitation events (Warren and Lulham, 2021). The rise in precipitation unpredictability encompasses both an increase in spring/summer rainfall and increased snow accumulation in winter (Arnold and Fenech, 2017). To further complicate these ongoing impacts, sea levels on the Atlantic coast have historically risen above the global average and this trend is expected to continue (Arnold and Fenech, 2017). Sea levels in the Charlottetown harbour have increased over 30 cm since 1911 (Government of PEI, 2008). The frequency and severity of hurricanes and storm surges in the adjacent marine environment has also escalated (Government of PEI, 2008). The cascading and compounding dynamics between various climate-induced environmental stressors has contributed to secondary physical impacts such as ongoing coastal flooding and erosion (Government of PEI, 2018).

3.0 Approach

We employ a case study approach to investigate how municipal decision-makers manage adaptation planning, focusing on the coastal island city of Charlottetown, PEI. While case study research draws disapproval from positivist scholars for lacking generalizability, numerous interpretivist scholars have emphasized the importance of single case study research, as it uncovers rich contextual insight grounded in the lived experiences of local key informants (Noor, 2008; Yin, 2014; Brower et al., 2000). Scholars have argued that this complexity adds further nuance and detail to social science literature , and contributes to the cumulative advancement of knowledge (Flyvbjerg, 2006).

This research is qualitative in nature, and includes an on-site (first-hand) observational component, a review of strategic planning documents, and the analysis of interview transcripts. The observational component, which took place between May and November 2017, allows for a better understanding of the physical setting of the community, and the interactions that take place in this space (Merriam and Tisdell, 2016). The review of relevant strategic planning documents (e.g. municipal land use plans, official plans, provincial climate actions plans) provides insight

into how climate adaptation is incorporated into long-term community policy and planning, and serves to supplement and validate the interview findings (Engward and Davis, 2015). Selected documents are publicly available and can be obtained online.

Criterion and snowball sampling were employed to select local decision-makers (key informants) able to speak to governance around conception and development of adaptation action as well as how adaptation is incorporated into community planning in Charlottetown. This approach led to the interview of four local decision-makers in senior administrative roles (n = 4). For the purpose of confidentiality, key informants are organized by department/ unit: Planning and Heritage (CH1; registered professional planner); Sustainability (CH2); Public Works (CH3, registered professional engineer; and outside of the municipality, a representative from the Charlottetown Area Development Corporation (CH4). While the use of a small sample size has potential to elicit criticism, scholars have given importance to the granulated and in-depth understanding achieved through a narrow pool of insight relevant to the research objectives (Crouch and McKenzie, 2006). Indeed, the informants selected for this research represent the expertise, knowledge, and contextual background required to understand municipal climate adaptation strategy in Charlottetown. Still yet, the researchers exercised caution when analyzing the interview data and reviewing documents to ensure findings are not extrapolated beyond the contextual realm evident through the interviews (e.g. municipal climate adaptation).

Discourse was facilitated by a semi-structured interview protocol which followed a hierarchy with each section beginning with broad initiating questions, followed by relevant probes. Sections were structured to generate discourse related to climate change impacts and risks, extent of adaptation inclusion in strategic policy, and the nature of action implementation. Interviews and follow-up occurred between May and November 2017. Formal interviews were conducted in-person, on site in Charlottetown; ranging in duration from 60 to 120 minutes. The interviews were digitally recorded and professionally transcribed verbatim.

The researchers individually examined the transcripts using a theme-based narrative approach. Analysis first involved an initial scan to identify key points relevant to climate adaptation. A second reading flagged major themes emerging from the data. Two major themes were discovered in the data: (1) key climate stressors and (2) response to climate change. In each theme, numerous sub-themes emerged. High level coded/emergent themes were compared, then organized to create a concise storyline that unify the data within each category (Merriam and Tisdell, 2016; Birchall and Bonnett, 2021). These themes and sub-themes are revealed below.

4.0 Results

As per the framework of resilience theory, the first theme presented here, ‘key climate stressors’, discusses Charlottetown’s systems, particularly infrastructure, and its vulnerability from climate change. The second theme, ‘response to climate change’, pertains to agents and institutions, and their role in responding to system vulnerabilities.

4.1 Theme 1: Key Climate Stressors

Informants identified extreme precipitation events and coastal/inland flooding as the key climate stressors impacting their community, and acknowledged an increase in the frequency and severity of extreme events as a result of climate change. Interviewees identified these stressors as sources of vulnerability, particularly with respect to the city's stormwater management system and waterfront assets (Table 1). In addition, interviewees discussed other impacts associated with climate change such as the increasing threat posed by hurricanes and ongoing coastal erosion.

4.1.1 Frequency and Severity of Precipitation: Stormwater Management

Climate change is expected to alter PEI's precipitation patterns. While annual precipitation totals are expected to decrease, an increase in severity of these precipitation events is anticipated (Arnold and Fenech, 2017). For example, in December of 2014, an intense rainstorm caused $9 million in damages across PEI. Such impacts are being observed more often and are expected to increase in severity (CH3; CH4; Arnold and Fenech, 2017). These changes in precipitation patterns and storm severity exacerbate the risk of overland flooding in Charlottetown. In spring and summer, heavy rain or rapid snowmelt can lead to storm line backup and overflow of stormwater and snowmelt onto streets (CH3). In winter, heavy snowfall or freezing rain can topple powerlines and collapse roofs. Furthermore, heavy snowfall and flooded roads can also restrict movement through town by blocking major transportation routes (CH1).

A prominent climate change concern identified by key informants was vulnerability from the perceived inadequacies of Charlottetown's stormwater drainage system. As major storms increase in frequency and severity, key decision-makers view the municipality as unprepared to accommodate increases in precipitation and spring snow melt. Interviewees discussed a need to upgrade the drainage system to increase capacity; as CH3 observed:

> We're getting above average snowfalls now. Over the past three or four years Charlottetown or Prince Edward Island itself has received more snow than ever, and so now you've got to deal with the run-off in the spring… We need to have additional capacity in our system.

In 2015, the Ellen's Creek Watershed Group Inc. found that "most, if not all of the existing culverts [in Charlottetown] are unable to accommodate the more frequent and intense precipitation events [they] are now experiencing with climate change" (Harris, 2015, p.12), and outlines specific locations where infrastructure failure is expected. While Charlottetown has no explicit documentation acknowledging these infrastructure shortfalls, the province of PEI highlights developing stormwater infrastructure to accommodate projected extreme rainfall events within its 2018 Climate Change Action Plan (Government of PEI, 2018).

4.1.2 Flood Vulnerability: Waterfront

As the sea continues to rise, precipitation becomes increasingly unpredictable, and storm surges become more frequent (Arnold and Fenech, 2017), the flooding of waterfront properties, assets, and infrastructure has become one of the primary climate-related issues concerning city planners and engineers (CH1; CH3). With respect to critical infrastructure, both the city's hospital and wastewater treatment plant are located in low-lying areas and are at risk of being

flooded and/or inaccessible due to blocked access points that are vulnerable to coastal flooding (CH2; Davies and MacDonald, 2016).

One interviewee noted that historic development patterns have placed Charlottetown in a vulnerable position, with hydrological modelling studies indicating the potential compromise of existing developments as a result of storm surge (CH1). The city's historical buildings are especially vulnerable to the impacts of coastal flooding both due to their proximity to waterbodies and aged building materials (City of Charlottetown, 2019).

4.2 Theme 2: Response to Climate Change

4.2.1 Strategic Planning Response

According to the interviewees, awareness for climate change impacts has increased among local decision-makers. Despite the perception of increased awareness, interviewees did not believe that adaptation planning is being pushed by the municipality. Instead, the interviewees revealed that vulnerability assessments and adaptation initiatives tend to be driven by senior orders of government, such as the province, and external organizations, such as the Charlottetown Area Development Corporation (CADC) or University of PEI (UPEI) Climate Lab.

In 2017, the Integrated Community Sustainability Plan (ICSP) was released by the City and climate change was addressed almost entirely in terms of mitigation (City of Charlottetown, 2017). Under the Infrastructure and the Built Environment section of the document, climate change adaptations were listed as a sustainability goal to be integrated into the City's Official Plan. However, the only reference to planning for anticipated climate change stressors in the ICSP was a second goal of continuing to "plan and prepare for the impacts of climate change" (City of Charlottetown, 2017, p.27).

At the time of the research, a sustainability coordinator had recently been hired by the City and interviewees suggested that the position was viewed by some as an opportunity to address climate change impacts (CH1; CH3). Furthermore, the city planner discussed the importance of bringing attention to climate change adaptation in city council: focusing on finding funding, research, and support in order to promote future action, but went on to discuss administration's lack of ability to formulate a strong argument (CH1). Based on the content of the ICSP, climate change adaptation action is not a priority in the sustainability mandate (City of Charlottetown, 2017).

The City of Charlottetown Official Plan, one of Charlottetown's main strategic planning instruments, recognizes the threat of sea level rise along the waterfront and outlines future recommendations for adaptation. The plan states that the City should strive to raise the boardwalk over time, re-grade specific waterfront roads, and support open space development in vulnerable areas to support stormwater management and flood protection (City of Charlottetown, 2006).

However, despite the recent amendments to the city plan, interviewees suggested that municipal zoning regulations and building codes have not officially accounted for climate change impacts (CH1; CH3). CH1 acknowledged "Everything in the zoning bylaw and in the building code is a minimum requirement" and went on to question whether homeowners would be comfortable with the current zoning restrictions, asking:

> Minimum does not preclude the fact that you know we can't have a conversation and say, this is the minimum requirement. Do you really want to?... Are you so comfortable with your investment that you are not going to be dealing with problems yourself in the future?

Furthermore, despite heritage preservation being a key priority for the City (CH1; CH2; CH3; City of Charlottetown, 2018), zoning codes have not been updated to account for protection of historical buildings (City of Charlottetown, 2006).

With respect to new developments, Charlottetown's municipal development regulations for flood mitigation are largely based on requirements mandated through provincial legislation. A review of the Charlottetown Zoning and Development Bylaw revealed that a 15-meter buffer is enforced along all watercourses and wetlands in Charlottetown (City of Charlottetown, 2006), in accordance with the provincial Environmental Protection Act from 1988. Additionally, restrictions for development along the Waterfront zone mandate a minimum Ground Floor Finished Floor Elevation (FFE) of 3.76 m above sea level. According to the Charlottetown Waterfront Assessment, these elevation requirements are approximately 1m of freeboard above current 1:100-year flood elevation (2.77 m) and approximately 0.3 m of freeboard above the predicted 2090 sea level combined with the 1% probability high water event (3.43 m) (Davies and MacDonald, 2016).

Despite the more stringent development regulations for new construction, one interviewee noted that much of the waterfront area in Charlottetown has already been developed and protected heritage homes and buildings line much of the coast (CH1). Revised zoning laws will not impact historical development and therefore changes are unlikely to occur unless historical infrastructure is torn down (e.g. Antonakis and Birchall, 2019).

The Comprehensive Waterfront Master Plan has a short section on sea level rise, acknowledging the threat of future stormwater drainage issues and sea level rise in certain areas of the waterfront (City of Charlottetown, 2012). Despite this, the plan also recommends extensive development of underground parking in low-lying areas along the waterfront. This recommendation is supported by an exclusion from the minimum FFE of 3.76m for parking structures in the Zoning and Development Bylaw, allowing parking structures to be built below standard flood grade (City of Charlottetown, 2006).

Additionally, the City's design standards for stormwater drainage are currently based on 1:10 year storms. CH3 admits that they would like to see a shift to standards based on 1:100 year storms. Stormwater drainage infrastructure shortfalls are acknowledged in the ICSP. The provincial government goes one step further and lists developing stormwater infrastructure to accommodate projected extreme rainfall events within its 2018 Climate Change Action Plan

(Government of PEI, 2018). While interviewees suggested infrastructure upgrades through retention ponds, underground storage tanks, and/or increased public green space that can be allowed to flood when drainage systems are overwhelmed, these approaches have not been implemented into mainstream municipal engineering and planning practice (CH1; CH3).

Local agencies such as the CADC have established hard defences to mitigate the impacts of sea level rise, coastal flooding, and erosion. However, interviewees indicate that adaptation action in Charlottetown has been primarily ad-hoc and reactionary, with updates to infrastructure addressed only on a needs basis or when damage has occurred (CH1). Furthermore, interviewees identified jurisdictional ambiguity with respect to upgrading and maintaining the waterfront protection as a major barrier to waterfront adaptation (CH1). Examples of this waterfront protection includes breakwater wave attenuator which reduces the energy of the waves coming to shore, sea walls, rip rap, and armourstone (Davies and MacDonald, 2016). After installation, the Charlottetown Waterfront Assessment determined that the imported amourstone, used because of its red colouring, is "particularly ill-suited to marine environments" and prematurely weathers when exposed to salt water and freeze-thaw environments (Davies and MacDonald, 2016). Both the Charlottetown Waterfront Assessment and interviewees acknowledge vulnerabilities associated with the durability of the current hard defenses along the waterfront, with sea walls being breached and armourstone being hollowed out during storm events (CH1; CH4).

Table 1. Key climate vulnerabilities, municipal response, and resilience in Charlottetown, PEI.

Vulnerability	**Municipal Response**	**Relationship to Resilience**
Changes in precipitation severity and intensity: Stormwater management		
• "Open ditches were fine because the only time you had water was in the summer. But now, the open ditches are getting clogged and you have a freak storm and then the water's got nowhere to go so it's getting into people's houses and all that stuff." (CH3) • "Delta down here which is the hotel at the end of Queen Street, their parking garage floods; that's part of their regular… and it's not even big storms, it's lots of storms." (CH2)	• "We don't have a good knowledge on our existing storm water system." (CH3) • "Our design standards probably haven't been up to snuff as they should be. We're still allowing design standards to be… for the one in 10 [year] storm plus 10 percent... Pretty much everyone else is already ahead of the game and going to the one in 100 [year] storm." (CH3)	• In the face of system vulnerability and risk, agents are knowledgeable about imminent threats, yet fail to implement adaptation considerations into municipal institutions (e.g. zoning bylaw, infrastructure standards, etc.). For example, zoning exemption allows the construction of garages below standard flood levels (City of Charlottetown, 2006)
Flooding: Waterfront infrastructure and built area		
• "In front of Victoria Park, there's a boardwalk that comes along the waterfront. There are a number of sections of that that will flood, or is going to flood within the next few years." (CH4) • "We are a coastal city, we have a lot of infrastructure on our coast like our wastewater treatment plant, our hospitals, so the sea level rise component is definitely a component of that." (CH2) • "We have a lot of historic and old structures, and most of it has been built around the water, because that was the most attractive spot to be, and it's quite vulnerable." (CH4) • [Referring to transportation wharfs] "The problem is that their height, because of the	• "Who's the responsibility for the sea wall? Is it the property owner? Is it the municipality? Is it the province? Is it the federal government? Or is it a combination of them?" (CH1) • "We know what's at risk, we have the maps, we know what parks, we know what areas of our city, we know where the flooding happens, but what specific piece do we do?" (CH2) • "Is it a berm, is it a wall, is it a… you know, what is needed? Is it relocating? Is it more cost efficient to relocate our waste water treatment plant than protect it? I'm guessing no, but we don't know those answers." (CH2)	• Vulnerability of infrastructural systems is tied to other vulnerable systems (e.g. healthcare system, sanitary system). • Agents are knowledgeable on infrastructure risk and vulnerability, but do not know how to respond. While administrative agents recognize the importance of bringing items to the attention of Council, they often fail to do so. • Institutions either ignore the problem entirely or acknowledge it in high-level plans that do not translate into action. For instance, aspirational statements about promoting and fixing grey infrastructure is in the Official Plan (City of Charlottetown, 2006), but not

changing sea level, both of them are subject to flooding." (CH4) • "Some of the sea walls have been breaching and they have been taken out through storm events and they have to be replaced." (CH1)	• "There has been armour stone and there has been some sea walls put in but again I have only been here three and a half years but they have been having problems." (CH1) • "You know politicians, if you send them reports indicating that this part of our city was modelled and there is this problem here… I think what's hard to build the argument [for action], at least for somebody in a small planning department like this…" (CH1)	incorporated into bylaws or infrastructure plans (CH2, CH3)

Note: This table does not include all climate-related stressors or municipal responses, it serves to summarize the key points.

4.2.2 Championing Climate Adaptation

According to interviewees, the City of Charlottetown has largely relied on resources from external private and public organizations. Indeed, rather than the City, the main agents interviewees identified as championing climate change research and adaptation action are the CADC, UPEI Climate Lab, Atlantic Climate Adaptation Solutions Association, and Charlottetown Harbour Authority (CH1; CH2).

Furthermore, the City relies on funding and direction from both the provincial and federal governments for climate change research and adaptation programs (CH4). Because of a multitude of high priority budget items at the municipal level, it is often difficult to find internal funding. Interviewees stated that city officials are often happy to get involved and work with the province, claiming that "we try to partner up with the federal and provincial governments as much as we can, especially on a major project" (CH3). This can have both positive and negative impacts, with an interviewee noting that "sometimes we wait for the province to start leading the charge on certain things" (CH3).

The provincial government has developed various policies and guidelines to manage climate change impacts in PEI. They have established setbacks for coastal properties, published informative pamphlets for the public, and developed a climate change action plan (Government of PEI, 2016; Richards and Daigle, 2011; Government of PEI, 2018). Yet at the municipal level, work being done by the City is either broad and high level, such as the Official Plan that briefly acknowledges the threat of climate change, or reactionary measures in the form of managing degrading infrastructure and engineered defenses already in place (City of Charlottetown, 2017; City of Charlottetown, 2012; Davies and MacDonald, 2016).

5.0. Discussion

While Charlottetown's local decision-makers appear well-informed on the ongoing and anticipated impacts of climate change, there is an absence of climate adaptation consideration in municipal planning, hinting at the presence of adaptation barriers. Key informants acknowledged the threat posed by climate change, but did not see a need to act urgently with proactive action. Instead, local adaptation initiatives are being championed by external organizations who provide climate change research and implement certain adaptation initiatives. Despite having available resources and knowledge, research has not been implemented into municipal practice and the

City continues to implement policies that achieve opposite outcomes, such as promoting underground developments in flood-prone locations and incorporating defences prone to degradation.

To elucidate the dynamics of local climate adaptation in Charlottetown, this research utilizes the framework of resilience theory (Tyler and Moench, 2012) to examine the role of systems, agents, and institutions in the decision-making processes and implementation of local-scale climate adaptation in Charlottetown.

5.1 Systems

Systems consist of interconnected elements that are critical to urban function, such as physical infrastructure and ecosystems. According to Tyler and Moench (2012), a resilient system consists of multi-functional and spatially distributed assets to mitigate failure; redundancies of multiple pathways to enhance ecosystem and infrastructural service delivery; and, the ability to react to stressors without causing catastrophic or cascading failures.

In Charlottetown, system inadequacies contribute to climate change vulnerability. This is in part due to the lack of proactive planning to address the lack of diversity, redundancy, and safe failure in the municipality's existing and new infrastructure. Key systems that have been identified by interviewees to be vulnerable to climate change impacts are the municipal stormwater system and waterfront infrastructure in the city's core (Table 1). Whereas ecosystems are also vulnerable to climate change (Warren and Lulham, 2021), this was not a major concern identified in municipal documents or interviews.

Systemic vulnerabilities associated with Charlottetown's waterfront are mainly associated with historical developments in areas vulnerable to sea level rise and storm surge. Charlottetown's waterfront, historically developed as heavy industrial lands, has transformed over the years into a busy public space with waterfront parks, boardwalks, and a variety of commercial developments (City of Charlottetown, 2012). The Waterfront Neighbourhood in the core of Charlottetown is the major tourist hub for the city (City of Charlottetown, 2012), making it difficult to implement changes that might restrict tourism or further economic development. With historic infrastructure, limited zoning regulations, and inadequate shoreline defenses, the waterfront area is susceptible to cascading failures that are not taken into account in municipal policy. For instance, a failure of existing hard defences often leads to failures that negatively impact other systems such as utility infrastructure, private properties, and the local economy (e.g. Birchall and Bonnett, 2020).

In the case of Charlottetown's stormwater drainage system, resilience would come in the form of increasing functionality and diversity (Tyler and Moench, 2012), and reconfiguring elements to serve multiple functions (Moench, 2014). Charlottetown needs a drainage system that can accommodate significant increases in runoff without flooding roadways or damaging nearby assets. Still, hard defenses offer limited protection to potential future impacts when ongoing development in vulnerable areas like the waterfront is still permitted (Bonnett and Birchall, 2020). The ad-hoc response in Charlottetown mirrors examples in the literature. Short-

term fixes to degrading infrastructure often do not take into account the long-term, variable nature of climate change impacts (e.g. Wallace, 2017; Forino et al., 2017).

5.2. Agents

Agents refer to individuals, governments, and private organizations (Tyler and Moench, 2012). Hence, a study of agents can be useful in understanding how key players shape on-ground adaptation on the local scale (Ekstrom and Moser, 2014). Resilient agents have the capacity to plan and prepare for climate change impacts, and to respond to a disruptive event or organizational failure quickly. To build community resilience, agents must have access to various resources to support necessary action, and have the capacity to learn from past experiences, to innovate, develop new skills, and avoid repeated failures (Tyler and Moench, 2012; Moench, 2014; Birchall and Bonnett, 2021).

In Charlottetown, agents that influence local climate change resilience are city staff, the CADC, the Harbour Authority, UPEI, city council, and members of the community at large. However, findings suggest that the different agents possess varying degrees of technical knowledge and expertise required to mainstream climate adaptation. In Charlottetown, municipal staff, specifically planners and engineers, are well-informed about the imminent and future climate change-induced vulnerabilities in the community, but lack internal expertise required to move forward with a strategy. Further, local agent response to climate change impacts is generally ad-hoc. Physical shoreline protection measures are aging or improperly implemented (Davies and MacDonald, 2016), and policy does not reflect the results of local climate studies or research conducted by local organizations. This trend is evident in the literature as well, with local government decision-makers opting towards a more reactive approach to adaptation; acknowledging the need for action but delaying investment in infrastructure upgrades and changes to policy (e.g. Berrang-Ford et al., 2011; Wallace, 2017).

In such situations, Berke and Ward (2013) apply the ‘local government paradox’ to climate adaptation, a phenomenon in which local governments fail to enact strong plans to reduce risk despite the high loss that would result from inaction. As evidenced in Charlottetown, this lack of action is not attributed to the lack of scientific or technological advances, but rather due to the low prioritization of adaptation among local government officials (Berke and Ward, 2013). While climate adaptation research is being championed by external organizations and senior orders of government, there is a lack of effective and on-going collaboration between the municipality and the organizations providing climate-relevant expertise. This is not an issue unique to Charlottetown as local adaptation is often restricted by a lack of cross-sectoral communication and cooperation (Measham et al., 2011; Oulahen et al., 2018).

5.3 Institutions

Institutions constitute formal and/or informal mechanisms crafted to ensure the continuity of social norms (Tyler and Moench, 2012). These social conventions can both influence and be influenced by agent behaviour and interaction. Institutions may include strategic plans, zoning, policy goals, or informal social norms (Campbell, 1998) and can both inhibit or catalyze local climate adaptation (e.g. Birchall and Bonnett, 2021). Often, institutions exert constraints to agent

action by discouraging action on climate adaptation. Scholars have demonstrated that embedded social narratives can constrain ability to learn and evolve in the face of change (Moench, 2014; Birchall and Bonnett, 2019).

To build urban resilience to climate stressors, institutions must enable synchronized responses to system vulnerabilities, obtain and apply scientific knowledge in decision-making, and promote the flow of information among the community (Tyler and Moench, 2012). Institutions coordinate climate adaptation action by enabling agents to leverage scientific knowledge and internal resources to respond to stressors and take proactive actions to reduce risk and vulnerability (Oberlack, 2017). Institutions should leverage different theoretical planning perspectives to allow for the integration of knowledge and community input, all while maintaining flexibility to respond to the unpredictable impacts of climate change (Berke and Stevens, 2016; Schrock et al. 2015). On the other hand, poorly crafted institutions with competing and non-integrated priorities can hinder climate adaptation by steering agent attention to alternative goals (Woodruff et al., 2018).

Municipal institutional response in Charlottetown (government policy, zoning and development bylaws, guiding documentation, and city plans) show a lack of attention with respect to building resilience to climate change impacts. For instance, development guidelines such as those that promote the construction of underground parking in flood-prone locations further exacerbate system vulnerabilities. This can be primarily attributed to lack of a central plan or strategy to guide adaptation in planning processes (Lyles et al. 2018). Scholarship recognizes the importance of commencing adaptation planning with a narrow, yet specific adaptation plan, which is then followed by the gradual implementation of adaptation components throughout the municipal planning framework (Lyles et al. 2018; Stevens and Senbel, 2017; Woodruff and Stultz, 2016). In Charlottetown, opportunity for municipal agents to improve institutions in the realm of climate adaptation is constrained by an inability to translate climate-relevant information regarding risk and vulnerability into tangible strategies of action.

Informal institutions such as social and economic norms often dictate factors that are incorporated or excluded in zoning bylaws, strategic plans, and infrastructure design standards. Hesitation to enforce new zoning restrictions along the waterfront, or to invest in long-term adaptive measures, is likely tied to engrained notions of economic development, heritage preservation, and disaster response. The literature reflects these institutional limitations as well, with many examples of entrenched historic policies and norms shaping current decisions and limiting adaptation action (e.g. Ekstrom and Moser, 2014; Forino et al., 2017).

Furthermore, informal institutions inhibit agent capacity to implement climate adaptation in Charlottetown. For instance, one interviewee stated that without something to react to there are limited opportunities for agents to enact change (CH1). In reality, the intensity of local precipitation events is getting worse and large storms like the one in 2014 have already caused millions of dollars in damages (e.g. Arnold and Fenech, 2017; Welsh, 2019). Combined, formal and informal institutions in Charlottetown provide no mechanism for climate research to be incorporated into Charlottetown's existing policy framework.

5.4 Moving Forward: What can be Done to Enhance Resilience?

In order for local adaptation action to be successful, agents and institutions need to facilitate vertical and horizontal collaboration across different sectors and levels of government (Clar and Steurer, 2019; Holscher et al. 2019; Zen et al., 2019). Leadership at the local level is needed, with both political and administrative champions pushing for education and policy action (e.g. Measham et al., 2011; Pasquini et al., 2015). Research conducted by external organizations can also serve to promote awareness in Charlottetown, but need to be supported by municipal staff to help increase support for adaptation action within the community and amongst city councillors. Ultimately, such collaborations can facilitate local leadership to create more robust institutions. On the community end, Berke and Stevenson (2016) note that an integrative approach that combines scientific knowledge with community buy-in is also required to craft a robust adaptation plan. Resulting policy can then ensure that future development incorporates adaptive measures that are responsive to system threats and stressors such as sea level rise and changes in precipitation patterns (Birchall and Bonnett, 2021; Tyler and Moench, 2012; Oberlack, 2017).

Creating an adaptation strategy and mainstreaming adaptation in existing priorities and goals can help Charlottetown overcome institutional barriers that limit implementation of adaptation (Di Giullo et al., 2018; Nalau et al., 2015; Vogel et al., 2020; Wolf, 2011). Lyles et al. (2018) recommend that municipalities start with an adaptation plan that is narrow in focus to a prominent climate-related natural hazard, setting the stage to actionize specific strategies to reduce risk and vulnerability. An effective municipal adaptation strategy can pave the way for the mainstreaming of adaptation into other planning processes (Berke and Ward, 2013). For instance, in Charlottetown, the City should focus on creating a honed-in plan to address the increasing vulnerability associated with its stormwater management system and waterfront infrastructure. While Charlottetown's Official Plan recognizes the threats of climate change at a high-level, a separate, stand-alone strategy dealing with the most pressing climate vulnerabilities is urgently needed to guide the municipality's land use framework (Woodruff and Stultz, 2016; Berke and Stevens, 2016). A honed-in climate adaptation strategy will further ensure that climate adaptation is not siloed and becomes well-integrated with other municipal priorities, such as environmental sustainability (Ford et al., 2007; Wallace, 2017; Prasad and Sud, 2019; Tanner et al., 2019; Birchall and Bonnett, 2021).

Addressing formal and informal institutions that constrain government decision-making and action can facilitate agents to make impactful change in response to the changing climate, as institutions that support agents' ability to learn and adapt are central to resilience (Berkes, 2007; Folke et al., 2002). In Charlottetown, agent action is required to change the City's existing institutional framework (Birchall and Bonnett, 2019). Berke and Ward (2013) propose a three-step framework for adaptation planning that can be applied to build resilience in Charlottetown: (1) develop a knowledge base that presents multiple future outcomes; (2) formulate flexible adaptation policies to respond to climate-induced vulnerability; and (3) create a program for implementation and progress monitoring. In Charlottetown, the major roadblock occurs at the first step. While municipal officials possess knowledge of existing and future vulnerabilities, primarily due to information compiled by the provincial and federal governments and external organizations, a lack of effective and on-going cross-sectoral collaboration impedes the municipality's ability to use this information to create adaptation policies. Municipal staff will

have to take the initial step of championing climate adaptation to city council and the public, to increase buy-in for climate adaptation action at the municipal level. Going forward, we recommend that municipal agents in Charlottetown collaborate with other sectors, organizations, and the community to develop a robust, honed-in, and specific climate adaptation strategy, with flexible policies, a roadmap for implementation into other municipal planning processes, and a monitoring program to ensure the objectives of the plan are being met (Berke and Ward, 2013; Berke and Stevens, 2016).

6. Conclusion

Charlottetown is facing ongoing system-based vulnerabilities in its stormwater management infrastructure and waterfront communities, resulting from the compounding impacts of an increase in precipitation severity and flooding due to sea level rise and storm surges. As climate change progresses, heritage properties continue to age, and waterfront development expands, local vulnerabilities are expected to further intensify.

While municipal agents are in the best position to respond to climate vulnerabilities, the City's approach to climate change adaptation has been largely reactionary, with much of Charlottetown's climate-related research and adaptation action is being championed by the provincial/federal governments and external organizations. However, this research can result in no tangible outcome if municipal administration fails to take action. Aside from the low prioritization of adaptation in mainstream strategic planning, the City has implemented several policies that further increase system vulnerability to climate change. The lack of internal expertise compounded with the absence of cross-sectoral collaboration between municipal and non-municipal agents is the primary factor preventing climate information from being translated into a tangible strategy.

As such, Charlottetown stands out as an interesting case study in which despite having external resources and support, climate adaptation action is hindered by agents and institutions at the municipal level. While this study is limited to the local case study of Charlottetown, many coastal cities are experiencing similar climate change-induced stressors, yet continue to maintain a lack of urgency; we hope this article can be useful to other communities grappling with the intensifying impacts of climate change. Moving forward, we recommend that City of Charlottetown, and similar municipalities, take internal initiative to mitigate local climate-induced vulnerabilities in the community by collaborating with organizations already championing climate adaptation; ultimately, this should result in the creation of an adaptation strategy that facilitates implementation into other planning processes.

Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the University of Alberta's Human Ethics Committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Declaration of competing interest

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References

Adger, W. N., T. P. Hughes, C. Folke, S. R. Carpenter, and J. Rockström. 2005. "Social-ecological resilience to coastal disasters." Science, 309(5737): 1036-1039.

Antonakis, V., and S. J. Birchall. 2019. "Community planning challenges: Climate change impacts on cultural heritage." In WL. Filho, PG. Özuyar, PJ. Pace, U. Azeiteiro and L. Brandli (Eds.), Climate Action, Encyclopedia of the UN Sustainable Development Goals. London: Springer. https://doi.org/10.1007/978-3-319-71063-1_82-1.

Arnold, S. and A. Fenech. 2017. "Prince Edward Island Climate Change Adaptation Recommendations Report." University of Prince Edward Island Climate Lab. Charlottetown, Canada. Report submitted to the Department of Communities, Land and Environment, Government of Prince Edward Island, 172.

Baker, I., A. Peterson, G. Brown, and C. McAlpine. 2012. "Local government response to the impacts of climate change: An evaluation of local climate adaptation plans." Landscape and Urban Planning, 107(2): 127-136.

Berke, P., and L. Ward. 2013. "Public risks and the challenges to climate-change adaptation: A proposed framework for planning in the age of uncertainty." A Journal of Policy Development and Research, 15(1): 181-208.

Berke, P.R., and M.R. Stevens. 2016. "Land use planning for climate adaptation: Theory and practice." Journal of Planning Education and Research, 36(3): 283-289.

Berkes, F. 2007. "Understanding uncertainty and reducing vulnerability: lessons from resilience thinking." Natural Hazards, 41(2): 283-295.

Berrang-Ford, L., J. D. Ford, and J. Paterson. 2011. "Are we adapting to climate change?" Global Environmental Change, 21(1): 25-33.

Birchall, S. J., and N. Bonnett. 2019. “Local-scale climate change stressors and policy response: The case of Homer, Alaska.” Journal of Environmental Planning and Management. 62(13): 2238-2254. https://doi.org/10.1080/09640568.2018.1537975.

Birchall, S. J., and N. Bonnett. 2020. “Thinning sea ice and thawing permafrost: Climate change adaptation planning in Nome, Alaska.” Environmental Hazards, 19(2): 152-170. https://doi.org/10.1080/17477891.2019.1637331.

Birchall, S. J., and N. Bonnett. 2021. “Climate change adaptation policy and practice: The role of agents, institutions and systems.” Cities, 108. https://doi.org/10.1016/j.cities.2020.103001.

Birchall, S.J., S. MacDonald, and T. Slater. 2021. “Anticipatory planning: Finding balance in climate change adaptation governance.” Urban Climate, 37. https://doi.org/10.1016/j.uclim.2021.100859.

Boda, C. S., and A. Jerneck. 2019. “Enabling local adaptation to climate change: towards collective action in Flagler Beach, Florida, USA.” Climatic Change. https://doi.org/10.1007/s10584-019-02611-6.

Bonnett, N., and SJ. Birchall. 2020. Coastal communities in the Circumpolar North and the need for sustainable climate adaptation approaches. Marine Policy. https://doi.org/10.1016/j.marpol.2020.104175.

Brower, R.S., M.Y. Abolafia, and J.B. Carr. 2000. “On improving qualitative methods in public administration research.” Administration and Society, 32: 363-397.

Campbell, J. L. 1998. “Institutional analysis and the role of ideas in political economy.” Theory and Society, 27(3): 377-409.

City of Charlottetown. 1999. “Official Plan.” Amended October 8, 2019. Retrieved from: https://www.charlottetown.ca/UserFiles/Servers/Server_10500298/File/Resident%20Services/Bylaws%20and%20Regulations/Official%20Plan%20and%20Zoning%20and%20Development%20Review/City%20of%20Charlottetown%20Official%20Plan%20-%20PH-OPA.1-003.pdf

City of Charlottetown. 2006. “Zoning and Development By-Law.” Amended August 1, 2018.” Retrieved from: https://www.charlottetown.ca/UserFiles/Servers/Server_10500298/File/Resident%20Services/Bylaws%20and%20Regulations/Bylaw%20Index/Zoning%20and%20Development%20Bylaw%20(Amended%20January%2024,%202017)/Zoning%20%20Development%20Bylaw%2024%20September%202018.pdf

City of Charlottetown. 2012. “Comprehensive Waterfront Master Plan.” Retrieved from: https://www.charlottetown.ca/common/pages/DisplayFile.aspx?itemId=12052866

City of Charlottetown. 2017. “Integrated Community Sustainability Plan.” Retrieved from: https://www.charlottetown.ca/UserFiles/Servers/Server_10500298/File/sustainability/Integrated%20Community%20Sustainability%20Plan-%202017.pdf

City of Charlottetown. 2018. “Heritage Preservation Bylaw.” Retrieved from: https://www.charlottetown.ca/common/pages/DisplayFile.aspx?itemId=14467316

City of Charlottetown. 2019. “Future Land Use Map.” Retrieved from: https://www.charlottetown.ca/UserFiles/Servers/Server_10500298/File/Resident%20Services/MAPS/Future%20Land%20Use%20Map%20-%20October%208,%202019.pdf

Clar, C., and Steurer, R. 2019. “Climate change adaptation at different levels of government: characteristics and conditions of policy change.” Natural Resources Forum, 43: 121-131.

Crouch, M, and H. McKenzie. 2006. “The logic of small samples in interview-based qualitative research.” Social Science Information, 45(4): 483–499.

Dale, A., J. Robinson, L. King, S. Burch, R. Newell., A. Shaw, and F. Jost. 2020. “Meeting the climate change challenge: local government climate action in British Columbia, Canada.” Climate Policy, 20(7): 866–880.

Davies, M. H., and N. J. MacDonald. 2016. “Charlottetown Waterfront Assessment.” Charlottetown Area Development Corporation.

Davoudi, S., E. Brooks, and A. Mehmood. 2013. “Evolutionary resilience and strategies for climate adaptation.” Planning Practice and Research, 28(3): 307-322.

Department of Environment, Water and Climate Change (DEWCC). 2015. “Island Climate and Weather.” Retrieved from: https://www.princeedwardisland.ca/en/information/communities-land-and-environment/island-climate-and-weather

Di Giulio, G.M., A.M.B. Bedran-Martins, M.P. Vasconcellos, W.C. Ribeiro, and M.C. Lemos. 2018. “Mainstreaming climate adaptation in the megacity of São Paulo, Brazil.” Cities, 72(B): 237-244.

Ekstrom, J. A., and S. C. Moser. 2014. “Identifying and overcoming barriers in urban climate adaptation: case study findings from the San Francisco Bay Area, California, USA.” Urban Climate, 9: 54-74.

Engward, H., and G. Davis. 2015. “Being reflexive in qualitative grounded theory: discussion and application of a model of reflexivity.” Journal of Advanced Nursing. https://doi.org/10.1111/jan.12653.

Flyvbjerg, B. 2006. “Five misunderstandings about case-study research.” Qualitative Inquiry, 12(2): 219-245.

Folke, C., S. Carpenter, T. Elmqvist, L. Gunderson, C. S. Holling, and B. Walker. 2002. “Resilience and sustainable development: building adaptive capacity in a world of transformations.” AMBIO: A Journal of the Human Environment, 31(5): 437-441.

Forino, G., J. von Meding, G. Brewer, and D. van Niekerk. 2017. “Climate change adaptation and disaster risk reduction integration: strategies, policies, and plans in three Australian local governments.” International Journal of Disaster Risk Reduction, 24: 100-108.

Fünfgeld, H., and D. McEvoy. 2012. “Resilience as a useful concept for climate change adaptation?” Planning Theory and Practice, 13(2), 324-328.

Government of Canada. 2016. “Census Profile, 2016 Census.” Retrieved from: https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/details/page.cfm?Lang=E&Geo1=POPC&Code1=0159&Geo2=PR&Code2=11&SearchText=Charlottetown&SearchType=Begins&SearchPR=01&B1=All&GeoLevel=PR&GeoCode=0159&TABID=1&type=0

Government of Canada. 2021. “Adapting to the Impacts of Climate Change in Canada: an update on the National Adaptation Strategy.” Retrieved from: https://www.canada.ca/en/services/environment/weather/climatechange/climate-plan/national-adaptation-strategy/report-1.html

Government of PEI. 2008. “Prince Edward Island and Climate Change – A Strategy for Reducing the Impacts of Global Warming.” Retrieved from: http://www.gov.pe.ca/photos/original/env_globalstr.pdf

Government of PEI. 2016. “Prince Edward Island Coastal Property Guide.” Retrieved from: https://www.princeedwardisland.ca/sites/default/files/publications/prince_edward_island_coastal_property_guide.pdf.

Government of PEI. 2018. “Taking Action – A Climate Change Action Plan for Prince Edward Island.” Retrieved from: https://www.princeedwardisland.ca/en/information/environment-water-and-climate-change/climate-change-action-plan-2018-2023.

Grafakos, S., K. Trigg, M. Landauer, L. Chelleri, and S. Dhakal. 2019. “Analytical framework to evaluate the level of integration of climate adaptation and mitigation in cities.” Climatic Change. https://doi.org/10.1007/s10584-019-02394-w.

Harris, M. 2015. “City of Charlottetown Brook Trout Conservation and Protection Plan.” Prepared for the Ellen’s Creek Watershed Group Inc., Charlottetown, PEI. Retrieved from: http://ellenscreekwatershed.ca/index_htm_files/1508-CityCharlottetownBrookTroutConservationProtectionPlan.pdf

Holscher, K., N. Frantzeskaki, T. McPhearson, and D. Loorbach. 2019. “Tales of transforming cities: Transformative climate governance capacities in New York City, U.S. and Rotterdam, Netherlands.” Journal of Environmental Management, 231: 843-857.

Kehler, S., and S. J. Birchall. 2021. “Social vulnerability and climate change adaptation: The critical importance of moving beyond technocratic policy approaches.” Environmental Science & Policy. https://doi.org/10.1016/j.envsci.2021.07.025.

Lee, T., H. Yang, and A. Blok. 2020. “Does mitigation shape adaptation? The urban climate mitigation-adaptation nexus.” Climate Policy, 20(3): 341-353.

Lyles, W., P. Berke, and K.H. Overstreet. 2018. “Where to begin municipal climate adaptation planning? Evaluation two local choices.” Journal of Environmental Planning and Management, 61(11): 1994-2014.

McEvoy, D., H. Fünfgeld, and K. Bosomworth. 2013. “Resilience and climate change adaptation: the importance of framing.” Planning Practice and Research, 28(3): 280-293.

Measham, T. G., B. L. Preston, T. F. Smith, C. Brooke, R. Gorddard, G. Withycombe, and C. Morrison. 2011. “Adapting to climate change through local municipal planning: Barriers and challenges.” Mitigation and Adaptation Strategies for Global Change, 16(8): 889-909.

Merriam, S.B., and E.J. Tisdell. 2016. Qualitative Research: A Guide to Design and Implementation (4th ed). Jossey-Bass.

Moench, M. 2014. “Experiences applying the climate resilience framework: Linking theory with practice.” Development in Practice, 24(4): 447-464.

Nelson, D.R. 2010. Adaptation and resilience: responding to a changing climate. WIREs Climate Change, 2(1): 113-120.

Nalau, J., B. L. Preston, and M. C. Maloney. 2015. “Is adaptation a local responsibility?” Environmental Science and Policy, 48: 89-98.

Noor, K.B.M. 2008. “Case study: A strategic research methodology.” American Journal of Applied Sciences, 5(11): 1602-1604.

Oberlack, C. 2017. “Diagnosing institutional barriers and opportunities for adaptation to climate change.” Mitigation and Adaptation Strategies for Global Change, 22: 805–838.

Oulahen, G., Y. Klein, L. Mortsch, E. O’Connell, and D. Harford. 2018. “Barriers and drivers of planning for climate change adaptation across three levels of government in Canada.” Planning Theory and Practice, 19(3): 405-421.

Pasquini, L., G. Ziervogel, R. M. Cowling, and S. Shearing. 2015. “What enables local governments to mainstream climate change adaptation? Lessons learned from two municipal case studies in the Western Cape, South Africa.” Climate and Development, 7(1): 60-70.

Prasad, R. S., and R. Sud. 2019. “Implementing climate change adaptation: Lessons from India’s national adaptation fund on climate change (NAFFC).” Climate Policy, 19(3): 354-366.

Richards, W., and R. Daigle. 2011. “Scenarios and Guidance for Adaptation to Climate Change and Sea Level Rise – NS and PEI Municipalities.” Prepared for Atlantic Climate Adaptation Solutions Association. Retrieved from: https://www.princeedwardisland.ca/sites/default/files/publications/scenarios_and_guidance_for_adaptation_to_climate_change_and_sea_level_rise_-_ns_and_pei_municipalities.pdf

Schrock, G., E.M. Bassett, and J. Green. 2015. “Pursuing equity and justice in a changing climate: Assessing equity in local climate and sustainability plans in U.S. cities.” Journal of Planning Education and Research, 35(3), 282 –295.

Siders, A. R. 2017. “A role for strategies in urban climate change adaptation planning: Lessons from London.” Regional Environmental Change, 17(6): 1801-1810.

Stevens, M.R., and M. Senbel. 2017. “Are municipal land use plans keeping pace with global climate change?” Land Use Policy, 68: 1-17.

Tanner, T., R. U. Zaman, S. Acharya, E. Gogoi, and A. Bahadur. 2019. “Influencing resilience: The role of policy entrepreneurs in mainstreaming climate adaptation.” Disasters, 43, S388-S411. doi:10.1111/disa.12338

Tyler, S., and M. Moench. 2012. “A framework for urban climate resilience.” Climate and Development, 4(4): 311-326.

Vogel, B. and D. Henstra. 2015. “Studying local climate adaptation: A heuristic research framework for comparative policy analysis.” Global Environmental Change, 31: 110-120.

Vogel, B., D. Henstra, G. McBean. 2020. “Sub-national government efforts to activate and motivate local climate change adaptation: Nova Scotia, Canada.” Environment, Development and Sustainability, 22: 1633-1653.

Wallace, B. 2017. “A framework for adapting to climate change risk in coastal cities.” Environmental Hazards, 16(2): 149-164.

Warren, F.J., and N. Lulham (editors). 2021. “Canada in a Changing Climate: National Issues Report.” Government of Canada. Retrieved from: https://changingclimate.ca/site/assets/uploads/sites/3/2021/05/National-Issues-Report_Final_EN.pdf

Welsh, M. 2019. “The Siege of PEI.” The Star. Retrieved from: https://projects.thestar.com/climate-change-canada/prince-edward-island/

Wolf, J. 2011. “Climate change adaptation as a social process.” Climate change adaptation in developed nations (pp. 21-32). Springer, Dordrecht.

Woodruff, S.C., and M. Stultz. 2016. “Numerous strategies but limited implementation guidance in US local adaptation plans.” Nature Climate Change, 6, 796-802.

Woodruff, S.C., S. Meerow, M. Stults., and C. Wilkins. 2018. “Adaptation to Resilience Planning: Alternative Pathways to Prepare for Climate Change.” Journal of Planning Education and Research: 1-12. doi: 10.1177/0739456X18801057

Yin, R.K. 2014. Case study research: Design and methods. Fifth. London: Sage.

Zen, I.S., A.Q. Al-Amin, and B. Doberstein. 2019. “Mainstreaming climate adaptation and mitigation policy: Towards multi-level climate governance in Melaka, Malaysia.” Urban Climate. https://doi.org/10.1016/j.uclim.2019.100501

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