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Climate change adaptation policy and practice: The role of agents, institutions and systems

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Surrey, British Columbia, stands out in its efforts to go beyond the provincial mandate on climate change mitigation and incorporate adaptation into strategic planning. The community is not currently overwhelmed by climate change impacts, and has local agents and institutions in place to facilitate anticipatory climate adaptation planning. However, as seen with many other coastal communities, implementation of adaptation action is lagging in practice. Framed through the lens of resilience theory, this research investigates climate change threats and the dynamic relationship between local scale adaptation policy development, integration and implementation in practice. With Surrey as a case study, this research examines key actor narratives and strategic planning documents in order to understand how the community acts on climate change adaptation while being mandated to address mitigation. Findings suggests that while resilience building agents (e.g. senior management, elected officials) can spearhead and organize climate action, their ability to implement goals and policies in practice is largely determined by the robustness of institutions (e.g. strategic plans, policies) and systems (e.g. infrastructure, ecosystems). This case may provide decision-makers in other communities coping with similar climate threats with insight into the factors that can enable and challenge local adaptation planning processes.

Key words: Urban planning; climate resilience; coastal community; climate change impacts; strategic policy

Introduction

Global climate change is one of the most significant, persistent and highly dynamic challenges facing society. Scholars agree that the burning of fossil fuels has elevated the concentration of greenhouse gases (GHG) in the atmosphere (e.g. Hansen, Sato and Ruedy, 2012), resulting in a rise in global average temperatures. With GHG emissions reaching unprecedented levels (Rhodes, 2017), subsequent climate impacts are becoming more pronounced. In its fifth assessment report, the Intergovernmental Panel on Climate Change (IPCC) reflected on the severity of change: the climate system is warming at alarming rates, sea levels are rising, precipitation and weather events are becoming increasingly variable and glaciers are melting rapidly (IPCC, 2014).

Yet while climate change manifests as a global phenomenon, risk is perhaps most immediate at the local scale, where local government officials represent the level of government nearest to the impacts, and the communities bearing the brunt of the environmental change (Forino et al., 2017). Indeed, cities and communities are highly vulnerable to the effects of climate change, and decision-makers must offer appropriate responses if they are to aid community resilience.

Recent policy discourse has identified that a robust response to climate change must incorporate aspects of both mitigation and adaptation (e.g. Bulkeley & Tuts, 2013). Mitigation refers to efforts aimed at reducing the production and release of GHG emissions, or enhancement of GHG sinks (IPCC, 2014); adaptation, on the other hand, is a process of adjustment whereby human systems attempt to cope with actual or expected climate change and the subsequent effects (IPCC, 2014).

At a global scale, action has focused primarily on the creation of a low carbon economy, with governments from around the world adopting long-term mitigation policies, including carbon taxes, emissions trading schemes and goals of carbon neutrality (e.g. Bulkeley & Tuts, 2013; Birchall 2014a,b, 2015). Along with many other developed countries, Canada has shown a commitment to reduce its GHG emissions. The province of British Columbia (BC) in particular stands out as a front runner in climate action, largely through the passing of Bill 27, the Local Government Statutes Amendment Act. Passed in 2008, the Bill mandates that all municipalities with an official community plan (OCP) incorporate actions to reduce GHG emissions within their OCP (Province of BC, 2008). While this policy has facilitated the widespread incorporation of climate change considerations within local policy and planning documents, mitigation remains the focus with no requirement for action around adaptation (Baynham & Stevens, 2014). The lack of adaptation thinking within climate policy translates into greater vulnerability, given that regardless of the extent of mitigative efforts, continued climate change is inevitable (Klein et al., 2005).

Indeed, in BC average annual temperatures have warmed by 1.4°C per century, average annual precipitation has increased, and relative sea level has risen (BC, 2016), resulting in a range of environmental impacts. In May 2018, for instance, BC's interior experienced a one-in-200 year flood event (CBC News, 2018), and in that same year the province saw nearly 600 more wildfires when compared to the previous year (National Post, 2018). What's more, over the last decade, these events have increased in frequency and severity (National Post, 2018; BC Flood and Wildfires, 2018), forcing thousands of residents to evacuate their homes, and resulting in widespread property damage.

Efforts to adapt to climate impacts are crucial if local governments are to reduce costs, remain resilient and fulfil their role in protecting residents and assets (Noble et al., 2014). Scholarship recognizes the necessity of climate adaptation (Baynham & Stevens, 2014; Ford & King, 2015; Di Giulio et al., 2018; Poku-Boansi & Cobbinah, 2018), and research around barriers to adaptation is quickly growing (e.g. Hamin et al., 2014; Jones et al., 2016; Simoes et al., 2017; McClure & Baker, 2018). However, the literature pays less attention to specific threats and the resultant decision dynamics around the process of local adaptation planning, including how adaptation is incorporated into strategic long-term policy and actions (Measham et al., 2011; Labbe et al 2017).

With the aim of contributing to the literature, and framed through the lens of resilience theory, this research investigates climate change threats and the dynamic relationship between local scale adaptation policy development, integration and implementation in practice. With Surrey, BC as a case study, this research involves key actor narratives and

analysis of strategic planning documents in order to examine how the community acts on climate change adaptation while being mandated to address mitigation. This research may provide decision-makers in other communities coping with similar climate threats with insight into the factors that can enable and challenge local adaptation planning processes.

Resilience Theory:

Over the last few decades, planning has shifted in its focus from sustainability, to climate change mitigation, to adaptation and resilience (Woodruff et al., 2018). Scholars argue that resilience and adaptation planning can provide a more flexible, robust, and integrated approach for coping with climate variability (e.g. Woodruff et al., 2018; Borquez et al., 2017; Poku-Boansi & Cobbinah, 2018). Indeed, traditional adaptation planning approaches are challenged by the uncertainty and variability associated with climate change, and often overlook indirect effects, systematic weaknesses, or institutional constraints (Tyler & Moench, 2012). Considering adaptation planning through the lens of resilience can help address these shortcomings (e.g. Tyler & Moench, 2012).

Applied in many disciplines, resilience theory has emerged as a practical and diverse framework to unpack complexities associated with climate threats and a community's ability to adapt to these threats (Borquez et al., 2017). While several definitions of resilience exist, evolutionary resilience, which takes into account the ability of socio-ecological systems to adapt in response to stress, is frequently used in environmental and social sciences (Davoudi et al., 2013). The transformative and adaptive aspects of evolutionary resilience are particularly useful for exploring decision-dynamics related to complex system changes (Tschakert & Dietrich, 2010). In this sense, a resilience approach recognizes that vulnerability is uncertain in many cases, and encourages planning processes that allow for uncertainty, that can maintain the flexibility necessary to respond to change (Nelson, Adger, and Brown, 2007).

This framework consists of three generalizable elements: agents (individuals and organizations), institutions (formal or informal social conventions that structure behavior and interactions), and systems (physical infrastructure and ecosystems). Exploring the case of Surrey through agents, institutions and systems, and the complex interaction between these elements, can help decision-makers better understand the specific factors influencing community resilience. Indeed, a resilience framework facilitates a more thorough examination of adaptation planning by identifying local vulnerabilities to specific risks and critical enabling and constraining factors, as well as the capacities and preconditions necessary for decision-makers to be able to adapt to a range of risks (Nelson et al., 2007).

Surrey, British Columbia:

Located within the Metropolitan Vancouver region, Surrey is a largely suburban city dominated by residential land and the Provincial Agricultural Land Reserve. Surrey is defined by the coast, the Fraser River and a myriad of smaller waterways. Due to a prominence of low topography, the community is prone to flooding (City of Surrey, 2013). In 2012, the city had a population of 502,725 (City of Surrey, 2013). By 2016 this number increased to 517,887 (Census Canada, 2016), revealing a population growth of 3.0% over

four years. With a growing population, and expected continued growth, Surrey is facing the challenge of developing in vulnerable lands.

With respect to Surrey’s weather, proximity to the Pacific Ocean results in a coastal climate. This has a moderating effect that manifests in rainy conditions, wet winters and mild summers. While the city has historically been subject to mild weather patterns, variability in weather trends have become pronounced (City of Surrey, 2013). In addition, Surrey’s Climate Adaptation Strategy highlights an increase in the intensity and frequency of moderate and heavy precipitation, a rise in annual average temperature and an increase of relative sea level over the last half century (City of Surrey, 2013).

City of Surrey, British Columbia

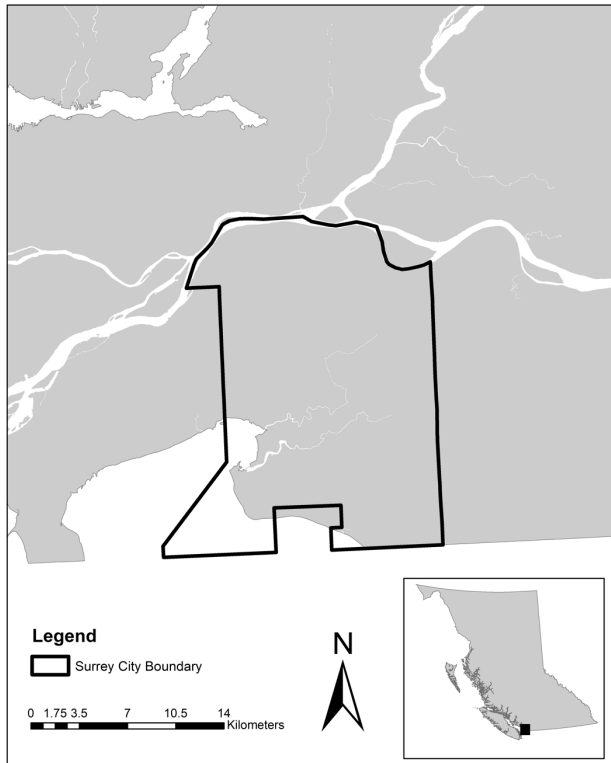


Figure 1. The City of Surrey, British Columbia.

Source: Coordinate System: NAD 1983 BC Environment Albers; Projection: Albers; Datum: North America 1983; Data Source: Statistics Canada Open Data; Date Created: February 6, 2019.

Approach

This research is qualitative in nature, and involved both narrative analysis of interview transcripts and a thorough review of strategic planning documents. This approach highly suitable for complex topics such as climate change as it enables the researchers to explore rich context-oriented discussions grounded in the lived experience of the key actors (e.g. Ford et al., 2010; Yin, 2014).

Criterion and snowball sampling were used to identify key actors able to provide expert viewpoints related to climate change impacts and local government response in Surrey. Key actors included decision-makers (n=3) who can speak to governance around adaptation plan conception and development as well as how adaptation is incorporated

into community planning (S1: City Councillor, and Chair, Environmental Sustainability Advisory Committee; S2: Sustainability Coordinator and registered professional planner; S3: Drainage Manager and registered professional engineer). While the use of a limited selection of interviewees has the potential to draw criticism, many scholars have emphasized the wealth of understanding that can come from a narrow pool of perspectives (e.g. Crouch and McKenzie, 2006). Ultimately, it can be reasoned that one single experience has the ability to provide context specific insights pertinent to the aim of the research (Brower, Abolafia, and Carr, 2000). Indeed, the actors selected for this study represent the specific context and expertise necessary to better understand the context of Surrey, BC.

During the interview, discourse was facilitated by a semi-structured interview format. This design promotes greater flexibility with questioning and enables conversation that progresses over time (XXXX et al., 2016). The interview protocol 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 June 2016 and February 2017. Formal interviews were conducted in-person, on site in Surrey; ranging in duration from 70 to 120 minutes. The interviews were digitally recorded and professionally transcribed verbatim. Following, the interviewees had the opportunity to review their respective transcript prior to data analysis, allowing for accuracy to be verified. Transparency and validity were further improved by clearly documenting the analysis process.

The authors individually analyzed the transcripts using a narrative approach. Analysis first involved an initial read to identify key points relevant to climate adaptation. The next reading flagged major themes emerging from the data. The high level coded/ emergent themes (e.g. key climate threats, climate adaptations, and strategic climate policy and planning) were compared, then organized to create more concise narratives that unify the data within each category.

Strategic planning documents (e.g. Official Community Plans, Climate Adaptation Plans, Sustainability Charters) were investigated to provide insight into the community's experience with climate impacts and the nature of policy response with respect to adaptation. Inclusion of such documents serves to supplement and validate the interview findings and increase rigour (Engward & Davis, 2015). Selected documents are publicly available and can be obtained through the municipality's home website.

Findings

The following section discusses first, how climate change is influencing Surrey, BC, and then the community's policy response.

Key threats:

Climate impacts are not a new phenomenon in BC, indeed communities have coped with coastal and overland flooding for several decades (Stevens & Hanschka, 2013). However, many climate impacts have increased in frequency and severity with some becoming emergent challenges. In Surrey, according to the interviewees, threats include warmer average temperatures/ extreme heat, intense precipitation events, and sea level rise (SLR), all of which influence coastal infrastructure. Yet, the main risks experienced in Surrey are largely associated with water, or lack of water: flooding, salt water intrusion, drought (Table 1).

Challenges	Strategic Responses	Resilience
Flood <i>"Even if we were to build dykes higher in order to accommodate sea level rise, we would still be grappling with flooding." (S2)</i>		
<ul style="list-style-type: none"> Exposure of critical infrastructure Property damage Threat posed to resident safety and well-being 	<ul style="list-style-type: none"> Dyking system and pump stations Setbacks from water bodies and rivers (e.g. Zoning Bylaw) Flood protection strategies (e.g. Climate Adaptation Strategy) Development restrictions in flood prone areas (e.g. Official Community Plan) 	<ul style="list-style-type: none"> Agents have long coped with the challenge of flood and are aware of enhanced flood risk Local institutions recognize the threat of flooding with flood specific adaptation policies heavily integrated throughout Systems, such as critical infrastructure, are particularly vulnerable to flood and structural adaptations may not be sufficient to cope with flood risk
Salt Water Intrusion <i>"If you build the dykes...100 feet tall, the salt water table's going to migrate itself into those fields eventually into the roots somewhere." (S1)</i>		
<ul style="list-style-type: none"> Reduced quality of water supply/health of aquifers Food security and local agricultural productivity Exposure of coastal utilities 	<ul style="list-style-type: none"> Perforated pipes to minimize saltwater encroachment Saltwater intrusion is identified as a risk within the Climate Adaptation Strategy No specific policies or regulations have been developed to address saltwater intrusion 	<ul style="list-style-type: none"> Agents are less aware of the sensitivity to saltwater intrusion Institutions briefly mention the risk posed by saltwater intrusion with no adaptation initiatives to address the risk Coastal infrastructure and natural ecosystems are vulnerable to saltwater intrusion and structural adaptations are ad hoc and reactionary
Drought <i>"Last year was a huge heat wave and a drought, so that's affecting our understanding of the risk. We didn't actually think in the early days of our risk assessment that the availability of water was going to emerge as a real impact until well into the second half of the century..." (S2)</i>		
<ul style="list-style-type: none"> Water security Local agricultural productivity/food security Threat posed to resident health and well-being 	<ul style="list-style-type: none"> Water restrictions Drought related policies to enhance the resilience of the agricultural sector (e.g. Climate Adaptation Strategy) Policies that aim to address the impact of extreme heat and drought on urban tree species (e.g. Climate Adaptation Strategy) 	<ul style="list-style-type: none"> Agents are aware of drought related challenges Institutions identify adapting to drought as a priority, however, action in practice is limited Key ecosystems and food/water sectors are highly vulnerable to drought

Table 1. Climate threats, challenges, policy responses, and resilience in Surrey, British Columbia.

Note: This summary table does not cover all policy responses and strategic documents developed by the city, but rather highlights major responses.

Flooding

Flooding is a prominent climate risk in Surrey, as evidenced by the interviewees and the city's Climate Adaptation Strategy (City of Surrey, 2013). Flooding is highly complex

within the region, with a multitude of factors interacting to exacerbate the frequency and severity of coastal and overland flooding. The prominence of development in low lying areas and the concentration of critical infrastructure, such as major north-south highways and rail infrastructure located within the floodplain, raise the flood risk further.

With respect to coastal flooding, a number of significant factors are at play, including weather events, storm surge, and tidal influences, all of which are exacerbated by SLR in general. The IPCC has indicated that over the period 1901–2010, global mean sea level rose by 0.19m (IPCC, 2014). In BC, relative SLR is also influenced by tectonic dynamics, and varies depending on location (Province of BC, 2016). In the Greater Vancouver Area, for instance, average relative sea level has increased at a rate of 3.7cm per century (Province of BC, 2016). While this is lower than the global average, the interaction with high tides, extreme weather events, and ground subsidence act to increase the frequency of coastal flooding (City of Surrey, 2013). Indeed, according to the interviewees, coastal inundation continues to threaten Crescent Beach, Bridgeview, and other low lying areas.

Similarly, the interviewees outlined that there are a number of factors acting together to increase the risk and frequency of overland flooding, including a rising ground water table, increased glacial melt, and intense precipitation events. These factors often come together to overwhelm river systems, creating incidents where river banks are breached and large spans of floodplain are inundated (City of Surrey, 2013). Indeed, S1 noted historic displacement associated with such flooding in low lying sections of the community. There are four floodplains within Surrey (Fraser River, Nicomekl/ Serpentine, Campbell River, and Boundary Bay); these vulnerable areas are controlled by a dyking system, with over 100km of dykes and pump stations. However, the interviewees noted concerns with respect to the adequacy of dyke design. According to S2, for example:

...dykes are not high enough to even deal with today's standards, both in terms of seismic events as well as just keeping the water out. Even if [the city] were to build dykes higher in order to accommodate sea level rise they would still be grappling with flooding because the high tide events are actually pushing the ground water up, [such] that the water isn't coming [solely] from the shore but also from below.

Salt water intrusion

The interaction between salt and fresh water is highly dynamic within coastal regions. Saltwater intrusion (SWI) occurs when saline water is drawn into a freshwater aquifer. In aquifers adjacent to the coast, freshwater floats as a lens above the saltwater, forming a wedge that extends inland from the shoreline. The inland encroachment of the saltwater-freshwater interface is the result of a variety of factors, including groundwater pumping from wells and SLR (Klassen & Allen, 2017). Rising sea levels can lead to a diminished hydraulic gradient, which lowers the flow of fresh groundwater toward the ocean. This diminished gradient causes the saltwater-freshwater interface to react by migrating inland, resulting in SWI, which compromises the quality of coastal freshwater aquifers (Klassen & Allen, 2017).

With SWI becoming a more visible threat, decision-makers in Surrey are increasingly aware of the associated challenges linked to food production and utilities. With respect

to food production, because salt water is harmful to most vegetation (City of Surrey, 2013), contaminated groundwater cannot be used to irrigate cropland. SWI also poses a threat to Surrey's coastal utilities, creating servicing challenges that require, for instance, pump station design to account for the altered groundwater table and the corrosive properties of salt water.

Surrey's actions thus far are largely reactive, including, as S3 explained, a strategy to use perforated pipes to manage the shifting groundwater table in order to minimize the encroachment of the salt water wedge.

Drought

In southern and interior BC, intense drought conditions and record-breaking temperatures have created a range of social, economic and environmental challenges (Hamann & Wang, 2006; Simms & Brandes, 2016). In Surrey, according to the interviewees, many of these challenges are emerging as a concern, particularly water security, residents' health, and food security.

With respect to Surrey's water security, the prevalence of drought conditions resulting from altered precipitation (e.g. diminished rain, reduced snow pack) have acted to stress the city's reservoir and prompt widespread water restrictions (S2). As for residents' health, according to S2, the recent stage three droughts experienced in 2009 and 2016 made the city more aware of associated health impacts such as heat induced illnesses and deaths. S2 stressed that in 2009 an additional 140 people died as a result of the heatwave (BC Medical Journal, 2010; BC Centre for Disease Control, 2017). This is echoed by Kosatsky et al., (2012) who report the intense heat wave resulted in a 40% increase in deaths among residents of greater Vancouver, with parts of Surrey showing high heat related deaths (Vancouver Sun, 2016).

Drought plays a key role in influencing the region's food and economic security since the agricultural sector is a significant contributor to the region's economy and serves as a source of local food for the area. With drought conditions worsening, there is a risk of decline in productivity. According to S1, "vast parts of the city are agricultural land reserve property, [but they can't be] farmed in the months of July and August, they are absolutely void of all water".

Policy:

Adaptation integration

The City of Surrey has long been recognized for its commitment to environmental stewardship and sustainability. Indeed, concepts of sustainability have been evident within Surrey's planning processes and strategies since the 1990s (City of Surrey, 2014). The widespread presence of sustainable initiatives in policy has facilitated the integration of adaptation into key planning documents. Adaptation was embedded in the process for developing the Coastal Flood Adaptation Strategy (S3), and is woven throughout the city's OCP (City of Surrey, 2014), Sustainability Charter (City of Surrey, 2016), Shade Tree Management Plan (City of Surrey, 2016), and Biodiversity Conservation Strategy (City of Surrey, 2014). According to S3, council has played a critical role in incorporating "climate

adaptation into the budget scene and dedicating money to studies”, and a highly aware public rallying for climate action has translated into adaptation as a “city philosophy”.

With the Climate Adaptation Strategy, the community set a vision for climate resilience. The strategy considers a range of climate impacts, plots out a number of actions, provides an implementation plan, and highlights the role of the different levels of government (City of Surrey, 2014). However, while the strategy is well considered, it’s language is broad and non-committal (‘encourage adaptation’, ‘advance resilience’), which may ultimately decrease the likelihood of implementation (Baynham & Stevens, 2014).

While the integration of climate change adaptation in strategic plans is important, it is also critical to incorporate adaptation thinking in other planning tools, such as zoning, development, and building regulations. The City of Surrey Zoning Bylaw, for instance, considers the risk of flooding through its general provisions on stream side protection and flood-proofing (City of Surrey, 1993). These provisions utilize exaggerated setbacks and a permit process to ‘prevent development’ in vulnerable areas (S3). As stipulated in the Bylaw, the minimum setback from high-water marks and watercourses is 7.5m from the sea, 30m from the Fraser River, and 15m from smaller rivers such as the Serpentine Rivers (City of Surrey, 1993). However, these regulations are largely based off provincial guidance, which is informed by the IPCC’s fourth assessment report, rather than the more recent fifth report, and thus according to S2, “don’t reflect the risk” associated with current flood threats. Indeed, the more recent climate report suggests that policy makers plan for a greater rise in sea level than previously recommended (IPCC, 2014).

Preparedness

S2 and S1 revealed that Surrey is not currently overwhelmed by climate change impacts. Because the community is not having to react to frequent climate threats, decision-makers can dedicate time, resources, and personnel to the task of increasing their resilience and preparedness. This growing preparedness is reflected in Surrey’s strategic planning documents, where it is evident that the community is actively considering climate change impacts and actions around adaptation and mitigation. Although mitigation remains the focus of a majority of planning documents, the city has developed an array of adaptive policies and actions in an attempt to build resilience. For instance, Surrey’s OCP includes policies that aim to avoid development in areas subject to natural hazards such as floods, and specifies that development in flood prone areas must consider and prepare for the projected impacts of climate change (City of Surrey, 2014).

Surrey’s strategic documents emphasize the importance of anticipatory thinking in building resilience. The Climate Adaptation Strategy, for example, stresses the importance of proactivity, noting that “by taking informed and proactive action, the City of Surrey is positioned to make the right decisions within the timeframes necessary” (City of Surrey, 2013, p. 92).

However, while the desire to be prepared for climate change is evident, the city is not yet “entirely prepared” (S2). The Sustainability Charter, for instance, reiterates interviewee

concerns noting that Surrey's infrastructure, particularly the dyking system, is not sufficient to respond to SLR and overland flooding (S2; City of Surrey, 2016). Similarly, Surrey's response to SWI may be insufficient, given that the community's strategic planning framework lacks specific policies aimed at addressing this issue; with ad hoc adaptations on the ground only beginning to take place. Unlike SWI, drought *is* considered a priority, as evidenced by its widespread incorporation in Surrey's strategic planning documents. Yet, despite the presence of policies addressing drought, according to S1, adaptive actions remain minimal in practice.

Capacity

The ability of local governments to effectively adapt to climate change is strongly influenced by the availability of personnel, knowledge, and financial resources. The interviewees revealed that internally the city accepts climate change as a stressor and appreciates the need to respond accordingly. As S2 suggested, environmental threats such as flooding are not new to Surrey as the community has been coping with this stressor for many years. While climate change is an exacerbating factor, because of this experience, the city has the expertise to respond. Yet as the risk increases, the interviewees noted the need for further support.

Surrey's financial capacity to act is multifaceted. While the community has access to a large tax base that brings in revenues from property tax and user fees, its internal budget may not be sufficient to address major adaptive efforts that require significant financial investment. This highlights the important role the province plays through their provision of different funding streams and strong policy direction.

Interview findings revealed contrasting perspectives on the level of financial support received from the province. For example, while S2 emphasized that financial assistance has "not yet occurred", S3 stated that the city has been provided with important grants but "could [use] better funding from various levels of government". The interviewees attributed the poor financial support to a lack of provincially-driven climate change specific funding streams. Yet, as highlighted on the provincial home website, various sources of climate related funding for local governments are indeed offered. In addition to the provision of climate related funding streams, the province has developed numerous climate change and adaptation documents intended to assist local governments in their adaptation efforts (e.g. *Preparing for Climate Change: An Implementation Guide for Local Governments in British Columbia*).

Characterizing Planning Response to Climate Stressors

Surrey is susceptible to a range of climate stressors, including risks associated with flood, SWI, and drought. The City has leveraged its planning framework and processes to address its vulnerabilities, however, approaches to addressing specific risks vary. Surrey uses a more systematic and anticipatory approach to address flood risks. This is evidenced by widespread adaptation policies aimed at mitigating flood threats, and the presence of flood adaptations in practice. Similarly, drought features prominently in Surrey's strategic documents, although implementation isn't to the extent of flood adaptations. Finally, a reactive planning approach is employed to cope with SWI. While

SWI is generally not reflected as a priority within policy, ad hoc responses are translating into practice. Despite variation in the City's planning responses to climate stressors, and rates of adaptation policy implementation, progress on resilience building is being made.

Discussion

While communities across BC continue to focus on mitigation alone (Baynham and Stevens, 2014), Surrey stands out in its effort to go beyond the provincial mandate and incorporate adaptation thinking into local planning (Lyles et al., 2014). Surrey faces key climate threats, including more frequent and intense flooding events, and emerging challenges associated with SWI and drought. Vulnerability is accentuated further by expected population growth. However, the community is not currently overwhelmed by climate impacts and has made significant strides on adaptation. While Surrey has taken important steps to enhance their resilience, the community nevertheless exhibits a lag in adaptation action implementation, hinting to the presence of key adaptation barriers. Barriers or adaptation challenges refer to obstacles that can impede anticipatory adaptation or that can reduce the effectiveness of adaptation planning (Moser and Ekstrom, 2010). To better understand climate adaptation planning in Surrey, this research uses a resilience framework to examine the role of agents, institutions, and systems, and their effect on adaptation policy conception, integration, and implementation in practice.

Agents:

Climate adaptation planning is complex and often subject to a range of barriers, including a lack of political support, along with challenges associated with agents' ability to facilitate meaningful action (Lonsdale et al., 2017). The case of Surrey is unique, in that agent capacity does not constrain adaptation planning; agents in Surrey have been key in balancing the importance of climate adaptation planning with mitigation.

Adaptation advocates in Surrey, including progressive senior management and council members, have taken initiative to embed adaptation within their strategic priorities, and have made efforts to ensure resources are dedicated to climate action items. The literature confirms the importance of adaptation advocates. Pasquini et al. (2015), for example, highlight that strong leadership within senior management and at the political level is crucial for facilitating rapid change and ensuring that adaptation thinking is broadly integrated across all departments. Indeed, agents advocating for anticipatory climate action have the ability to put in motion the process of adaptation, provide guidance, and ensure that momentum is sustained over time (Ford & King, 2015).

Further, in Surrey climate adaptation is described as a 'city philosophy' rather than the strategic priority of a single local champion. While a single champion can be beneficial (Birchall, 2014a,b), collaboration between agents - with a range that include elected officials, senior management, and residents - can more effectively facilitate the uptake of adaptation into local strategic priorities (Lonsdale et al., 2017). Indeed, in Surrey the presence of such agents may explain the city's dedication to enhance resilience and undertake adaptation planning, while being mandated to address mitigation. Moreover, Surrey's high capacity agents have access to sufficient internal resources and have facilitated the development of key institutions that integrate action on climate change. This

suggests a greater potential for translation of adaptation goals into on the ground reductions in vulnerability, given the priorities of agents and their access to necessary resources.

Institutions:

Institutions can involve social conventions that structure behavior and interactions and may include strategic plans, guiding policies, and support tools (Tyler & Moench, 2012). Key elements that influence resilience relate to rights and entitlements linked to system access, decision-making processes, information flows, and application of new knowledge (Tyler & Moench, 2012). Institutions can act as a coordination device, allowing decision-makers to leverage internal knowledge, skillsets, and other critical resources necessary for adaptation planning (Oberlack, 2017). Conversely institutions can constrain planning processes and adaptation actions (e.g. Oberlack, 2017; Woodruff et al., 2018).

In Surrey, highly aware and responsive agents have shown commitment to advancing community preparedness to climate impacts by integrating adaptation within local institutions, including the development of key adaptation documents and initiatives (e.g. Climate Adaptation Strategy, Sustainability Charter). These agents understood early on that action on climate adaptation could be initiated and streamlined through use of the City's deep-rooted commitment to environmental stewardship and sustainability. Scholars make a clear connection between sustainability and climate adaptation, noting that local adaptation planning is often strengthened by linking actions with existing sustainable development priorities (Carmin, Anguelovski, & Roberts, 2012; Di Giulio et al., 2018).

While Surrey has effectively transitioned their planning processes to facilitate anticipatory adaptation action, many goals and policies have not translated into practice. This trend is evident worldwide where although understanding of the need for local climate action is clear, there nevertheless remains a gap in implementation (Wise et al., 2014; Woodruff et al., 2018). The process of adaptation planning in Surrey has not been significantly hindered by a lack of political will, financial resources, or data. This suggests the lag in adaptation implementation may be the result of distinct formal and informal institutional barriers.

Planning is inherently proactive through its intent to manage and guide future growth and strategic priorities. However, given the high-level nature of strategic planning, the presence of adaptation in local institutions does not guarantee action or a reduction in vulnerability (Berrang-Ford et al., 2019). While Surrey has used a mainstreaming approach to adaptation by seeking synergies between existing policies and resources (Di Giulio et al., 2018), opportunities to better link adaptation to granular planning processes have received less focus.

Within the process of planning, fine scaled planning tools, including development regulations and bylaws, can be utilized to implement a community's broad vision and priorities in practice. Surrey would benefit from efforts to translate current overarching adaptation goals found in high level strategic documents into specific regulations and bylaws. Indeed, more granular regulations and plans are promising approaches to

adaptation as they can effectively steer development out of hazardous locations (Lyles et al., 2018), and may offer greater legislative support for justifying the dedication of resources to adaptation strategies and actions in practice.

Moreover, local strategic documents do not equitably reflect critical climate stressors and exhibit a prominence of non-committal language, hinting to additional institutional intricacies. According to the literature, weak and broad language or a lack of detail around how actions translate into granular scale outcomes such as planning and development regulations, can stymie implementation in practice (Ford & King, 2015; Birchall, 2019; XXXX & XXXX, 2019).

Local adaptation planning and resilience can also be enhanced by addressing institutional factors at the provincial level. While it is largely accepted that local governments should play a leading role in adaptation, given their proximity to both the impacts and the population, support stemming from higher governments can have a significant impact on sustained local climate action (Nalau et al., 2015).

The government of BC has made available several streams of funding and guiding policy documents that are intended to assist local decision makers with their efforts to respond to climate change. However, there is an overwhelming focus on mitigation within these institutional support tools - not surprising given the provincial mandate to address climate mitigation (e.g. Baynham & Stevens, 2014). A similar commitment for climate adaptation would go a long way to build institutional momentum around climate resilience in general. Scholars often emphasize that local governments are generally unwilling to take action on climate change in the absence of state/provincial leadership (e.g. Senbel, Fergusson, & Stevens, 2013), and stress the influence of state/provincial informal institutions on local government priorities.

Further, although provincial strategic planning documents balance the risk of fire and flooding, funding for local action is largely around wildfire prevention and asset management. Wildfire is an increasing risk throughout the province. Yet in Surrey and other coastal communities, risk is primarily associated with coastal and overland flooding (e.g. Province of BC, 2013), and funding should thus reflect these local environmental conditions.

Systems:

As a key element of resilience, systems provide critical services to local populations and can contribute to community preparedness for climate variability. A resilient system retains functionality during disturbances through flexibility, system linkages, and diversity (Tyler & Moench, 2012).

Despite ecosystems being highly susceptible to drought and SWI, limited adaptations aimed at responding to drought have been undertaken, and SWI is addressed in an ad hoc manner. The literature suggests that the preservation and protection of natural systems is a key aspect of community resilience given the potential for healthy

ecosystems to provide a range of services that may contribute to flexible adaptation strategies (e.g. Cheong et al., 2013; Bonnett & Birchall, 2019).

Findings suggest that protective infrastructure intended to address climate hazards are lacking diversity and robustness. For instance, Surrey's dykes are not adequate to cope with SLR and overland flooding, and reactive efforts to address utilities' susceptibility to SWI may be insufficient to mitigate contemporary and projected risk.

Specific interventions that can be undertaken by decision-makers in Surrey largely relate to addressing the fragility and diversity of systems by implementing protective adaptation strategies. Implementation of adaptation actions should focus on areas where the city is most at risk, such as flood-prone low-lying subdivisions like Bridgeview and Crescent Beach, and areas impacted by drought and SWI.

Addressing these threats may involve upgrading the city's hard adaptations/infrastructure (e.g. the dyking system) and implementation of soft adaptations strategies such as a managed retreat from the coast, or ecosystem-based approaches (e.g. Heang & Birchall, 2019; Cheong et al., 2013). This is supported in the related literature, which highlights that robust systems are not reliant on hard protective structures or the strength of individual components, but rather retain functionality through system linkages and diversity (Moench, 2014). Dependence on hard protective infrastructure is common in coastal communities grappling with climate stressors, yet this can lead to complacency and contribute to greater vulnerability (Betzold & Mohamed, 2017; xxxxx & xxxxx, 2019).

With population growth in mind, and the need for new development to accommodate growth, decision-makers must align their growth management goals with a climate adaptation agenda. This may involve the avoidance of new development in vulnerable lands, or at a minimum, incorporation of non-structural adaptations such as including exaggerated setbacks (which reflect the latest science) in zoning policy. It is critical that core infrastructure integrate resilient design standards with sufficient system linkages, and natural ecosystems must be protected to enhance the provision of key ecosystem services (e.g. drainage services, wave attenuation).

Conclusion

The City of Surrey stands out in its efforts to go beyond mitigation and incorporate adaptation in strategic planning. Indeed, this is a particularly interesting case to examine since, unlike many other communities, Surrey is not currently overwhelmed by climate change impacts, and has local agents and institutions in place to facilitate anticipatory climate adaptation planning. However, as seen with many other communities, implementation of adaptation action is lagging.

Surrey faces intensifying climate stressors that include coastal and overland flooding, saltwater intrusion, and drought. Moreover, with further population growth and continued climate change, vulnerability is likely to be accentuated. In recognition of this, high capacity agents in Surrey have triggered the process of adaptation planning through the identification of climate vulnerabilities, and development of a strategic planning framework

that considers climate variability. With sufficient internal resources, the city has been able to incorporate resilience into strategic planning and policy, and prioritize a climate adaptation agenda while being provincially mandated to address mitigation.

While the case of Surrey sheds light on the factors that facilitate the uptake of a climate adaptation agenda, it also identifies key institutional barriers that may contribute to a lag in adaptation action implementation. For instance, this research highlights that an imbalance in climate action priorities, or lack of an adaptation focus, within provincial government policy and guidance may delay local adaptation plan implementation. Further, a lack of committal language and detailed policies tailored to specific climate impacts within local institutions can significantly impact local resilience building in practice. Indeed, this case study emphasizes the importance of translating broad adaptation goals and policies into granular regulations and bylaws.

The need for adaptation is becoming increasingly urgent in communities across the globe. As a result, decision-makers must build the capacities of agents to anticipate and effectively plan for climate change, address local institutional challenges so as to enhance the ability of agents to implement (in practice) adaptation strategies, and bolster systems in order to sustain critical services and improve community preparedness for climate variability in general.

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.

Disclosure statement

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