Community Solutions Network

Innovations in data collection, monitoring and analysis to advance local climate resilience in public spaces

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ACKNOWLEDGEMENT OF INDIGENOUS LANDS AND TREATIES ACROSS CANADA

The sacred lands and waterways upon which Evergreen operates and the built communities and cities across the country are the traditional territories, homelands and nunangat of the respective First Nations, Métis Nations and Inuit who are the long-time stewards of these land. These lands are occupied lands and subject to inherent rights, covenants, treaties and self-government agreements to peaceably share and care for the lands and resources across Turtle Island. These regions are still home to diverse Indigenous peoples who are still fighting for their sovereign rights and tirelessly protecting their traditional territories. As uninvited guests who live and work on these lands, we have a responsibility to know the treaties that tie us together, advocate for Indigenous rights and commit to learning our responsibilities to each other.

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The Community Solutions Network is a program led by Evergreen in partnership with Open North. Our team works with communities to build capacity and improve the lives of residents using data and connected technology approaches. We deliver advisory services, workshops and online resources that focus on key areas such as climate resilience, data governance, inclusive public space, technology procurement and public engagement. The Community Solutions Network is supported by funding from the Government of Canada. The views expressed in this publication do not necessarily reflect those of the Government of Canada.

EXECUTIVE SUMMARY

This introductory research brief is intended for leaders in communities in Canada who are interested in how data collection and monitoring of public spaces can support more climate-resilient communities. Drawing from international and national research and initiatives, this brief presents an overview of the role of public space in climate resilience and principles for data and technological innovations in climate resilience efforts. The brief contains information on smart tools and innovations that can be leveraged by municipalities to build local climate resilience and highlights examples in Canada that emphasize the role of data and technology.

INTRODUCTION

Data collection, monitoring and analysis of public spaces can help communities identify and understand local climate risks to better guide strategic climate resilience planning. Public spaces such as parks, beaches, community centres, plazas, boardwalks and other spaces in a community have a unique role in local-level climate resilience. Public spaces can immediately experience the impacts of climate change (such as a flooded shoreline or a forest fire) and be part of the resilience efforts to climate change (such as bioswales or tree canopy coverage). From green spaces that support ecological services (such as flood management, water storage and carbon sequestration) and reduce the urban heat island effect to cooling and warming centres for community member use, public spaces can contribute to a community's climate resilience.

Identifying and understanding the value of existing public spaces in building climate resilience can better inform decision-making in a community. Municipal and community leaders who understand local public assets (natural and built) are better able to identify and prepare for climate-related risks by building, protecting and restoring assets to be more climate-resilient.[1] For example, a community that understands and values the flood management capabilities of an existing wetland is more likely to ensure the wetland is protected, maintained, enhanced and restored.

Data collection and monitoring tools can support a community's understanding of the existing natural assets in public spaces and how they can be best leveraged for improved climate resilience. Using technological innovations, advanced data collection and monitoring tools can analyze and predict the impacts of climate change on public infrastructure. An analysis of the data serves to inform decision-making on climate-related policies and plans but also serves to help embed climate resilience in all decision-making processes.

PRINCIPLES FOR DATA COLLECTION AND MONITORING

Decision-makers can use data to evaluate the effectiveness of services from natural assets and green infrastructure in a public space. For example, the popular usage of green public parks, the permeability of roads and pathways and the impact of green energy installations. While some data and information around public space can be as simple as measuring water levels and air temperature, other data points can be more complex or require analysis on their interrelated features and connections. Some data about public space may include sensitive information that should be proactively safeguarded from cybercriminals and privacy breeches and to ensure respectful authority of control. The Internet of Things (IoT) uses digital infrastructure to improve connectivity which can leave vulnerability gaps in how information is collected and stored. As such, data collection should include a human rights lens in how it is collected, stored and shared.[2] Evergreen's *Smart Resilience for Canadian Municipalities* research brief further explores tips for successful smart solutions.

Open access data (data that is free and available for use[3]) empowers communities to access information within their region to have a more holistic and collaborative understanding of an area. For example, platforms like *DataStream* host open access water data to encourage knowledge-sharing and collaboration across Canada. Still, the ownership of data, or data sovereignty, is another important factor to embed in any data governance model and can support First Nations data sovereignty[4] and Indigenous data sovereignty.[5] The FAIR principles for data to be findable, accessible, interoperable and reusable[6] and CARE principles of collective benefits, authority to control, responsibility and ethics[7] provide guidance on how to effectively and respectfully support data management. These principles can be integrated into how data is managed and governed to help balance ownership and privacy concerns with open and accessible data.

DATA, CLIMATE RESILIENCE AND ASSET MANAGEMENT

Public spaces, both built and natural, are assets that can be measured and monitored to understand their role and usage within a community as well as their contribution to a more climate-resilient community. Climate data collection and monitoring can support resilience planning, to help analyze climate variability impacts, as well as advance research methods to improve the understanding of climate patterns and modelling of climate systems (such as biological, chemical and physical climate properties).[8]

Environmental data collection and analysis can also aid communities in identifying climate risks and can guide the development of strategic climate action plans that can limit climate stresses.[9] Environmental data can include information about extreme precipitation levels, habitat and land use changes, the identification and presence of wildlife species, solid waste pollution and water characteristics.[10]

Biocultural diversity for reconciliation

Biocultural diversity recognizes and connects biological diversity and cultural diversity for more resilient ecosystems.[11] Biocultural diversity analyses data and information about humans and nature to integrate their inherent connections for a more holistic approach to climate resilience.[12] For example, *the Great Niagara Escarpment Indigenous Cultural Map* is a multimedia online resource with photos, videos and maps exploring the Indigenous historic, cultural and natural features of the Niagara Escarpment.

Asset management is an integrated approach to sustainable service delivery. It can increase climate resiliency through proactive risk management, better maintenance of assets and more informed decision-making about climate change.[13] It is important to consider the impact of climate change on public assets, infrastructure such as buildings (commercial and residential), roads, bridges, storm sewer systems, waste management, as well as on natural assets such as public parks, lakes or rivers, aquifers and groundwater, soil and other green infrastructure. **Natural asset management** is the process of creating an inventory of existing natural assets, the public services they provide and creating a maintenance plan for the natural assets[14] in recognition of the capital value and services provided by natural assets.[15]

Measuring, monitoring and maintaining the existing assets and services in a community through a comprehensive asset management system produces more well-informed and well-equipped decision-making. Data collection and monitoring efforts can support a local understanding of existing public natural assets and their services (for example, wetlands providing flood management and coastal storm protection and forests providing carbon storage and erosion control) and green infrastructure and their services (such as raingardens or bioswales) as part of both natural and engineered infrastructure systems.[16] Effective monitoring programs, maintenance and rehabilitation can support the services of natural assets while saving capital and operating costs.[17] Natural asset management encourages the consideration of the intrinsic and ancillary benefits of natural assets in planning processes (for example, choosing to restore a green public park to improve flooding issues in an urban area rather than investing in a new impervious stormwater management system).

Data collection and monitoring innovations can also be used to understand the interconnected social, economic and cultural impacts of climate change.[18] Climate change disproportionately affects vulnerable or at-risk populations based partly on their geographical location, financial or socioeconomic status, access to resources and services and other barriers towards decision-making processes.[19] Understanding the demographics of community members and intersecting environmental factors (such as lower-income housing developments built in a flood zone) can help make more informed choices to address the impacts of climate change. For example, developing public alert systems based on the unique needs of the community or developing a relocation plan that thoughtfully reflects the cultural needs of the impacted community.

Natural Asset Management in Gibsons, BC

The Town of Gibsons, BC is a coastal community that has been at the forefront of municipal asset management in Canada for decades. Through natural asset management, Gibsons uses data and information about its natural assets to value the municipal services they provide for the community. For example, natural storm water ponds are used to treat stormwater run-off and reduce the impact of flooding; creeks and wetlands help manage stormwater; aquifers serve the wells and springs for drinking water; the foreshore protects the waterfront from storm surges and sea level rise, among many other ecosystem services from natural assets.[20]

In 2014, the Town of Gibsons created a municipal asset management policy that recognized natural assets and their value alongside traditional capital assets.[21] Since then, dozens of initiatives have been developed including the *Healthy Harbour Project* for eco-asset management that uses data to ensure a vibrant and active harbour, the *Costal Resilience* project to better understand the protective benefits of coastal infrastructure from storm surges and coastal erosion, the *Urban Forest Plan* which includes a *Tree Preservation Bylaw* to protect tree canopy coverage and other innovative projects.

TOOLS FOR DATA COLLECTION AND MONITORING OF PUBLIC ASSETS

Collecting data can be as simple as using pen and paper to record observations (such as the number of people visiting a public park daily). Manual observations can be transferred to computer software to create tables and graphs to help synthesize and analyze the information.

Further, smartphone applications can automatically synthesize observations input by the user into a visual display. Even more sophisticated is the use of remote data collection tools that gather and transfer information through IoT. For example, input data collected around wave and storm size, recurrence periods, flood damage, erosion damage and other quantitative factors can be interpreted and evaluated by an analysis tool, such as the *Coastal Toolbox*, to understand the role or coastal natural assets in flood and erosion management.[22]

Tools like **artificial intelligence (AI)** or other machine learning technologies can also be leveraged to analyze, forecast and interpret collected data and produce maps or scenarios to better inform decision-making. For example, pollution susceptibility mapping using AI can track pollution levels in public spaces and support governments in taking action and improving resilience in urban areas.[25] Evergreen's *AI for the Resilient City* program is a data visualization tool focused on Urban Heat Islands and extreme heat as well as their impacts on cities throughout Canada, empowering municipalities to support policy changes for communities.[26]

Data collection and monitoring innovations that use AI or other innovative technologies for their analysis can support more informed choices around climate-related risks. For example, flood modelling powered by AI data can analyze the extreme effects of sea-level rise on coastal communities by examining climate indicators such as infrastructure, topography and land use.[27] Based on this analysis, AI can determine which areas are more vulnerable to flooding and erosion events. This better informs decision-making in constructing sea walls with multi-use pathways or other resolutions.[28]

AI Reporting

The Accelerating Biodiversity and Ecosystem Reporting guide from Planet, Microsoft, the Natural Capital Project and the Gund Institute demonstrates how to streamline biodiversity and ecosystem reporting using **Earth observation (EO)** and artificial intelligence (AI).[23] The guide details the scalability and interoperability of EO and AI measurement techniques for users to integrate into workflows to enable more meaningful targets for nature-based reporting.[24]

NATURAL ASSET DATA COLLECTION AND MONITORING

Data management ranges from simple information gathering and storage to more complex data sets and data hubs that can coalesce and analyze information at large scales. IoT has improved the efficiency of data collection by remotely transmitting gathered information to wherever the data is being stored and used. Areas that may be difficult to access (such as large forests with no roads) can be analyzed by innovative technologies that collect and interpret observed inputs from a public space. Depending on the intended output, a mix of data collection methods can be used by communities to develop a fulsome understanding of a public space.

- Sensors

Sensor data "is the output of a device that detects and responds to some type of input from the physical environment."[29] Sensors can collect information based on the physical signals of where they're located measuring temperature, air quality, water levels, surrounding objects and a myriad of other parameters. Sensors can be fairly simple (such as water test strips that rely on more manual recordkeeping) or more complex (such as electronic sensors that remotely gather, store and transmit data at higher frequencies). For example, sensors can be used to understand the water quality at a public beach.

- Aerial and satellite imagery

Aerial imagery captures images from aircrafts, drones or other elevated views (including satellites) to provide visual pictures of public areas. The images can be used to compare different time periods or provide visual access to inaccessible spaces. Aerial imagery is also used during emergency management as a safe means of monitoring the emergency event. While technology continues to improve in the quality of images produced, the output's image resolution is an important consideration when using aerial or satellite imagery. High, medium and low-resolution imagery have different uses depending on the coverage area and the amount of detail required. For example, high resolution imagery (such as a 30-metre resolution) can be used for capturing tree canopy coverage[30] or other vegetation monitoring. In contrast, lower resolution imagery can be used for larger land areas and understanding broader trends.[31]

- Mapping

Mapping is a powerful visual approach to understanding and analyzing climate resilience. Maps can visually demonstrate environmental factors (such as tree canopy coverage), physical infrastructure (such as building density), socioeconomic factors (such as demographics or income levels) and other factors of interest. Maps display collected data in a visual and accessible format that can also be used for education and storytelling. Geographic information systems (GIS) overlays such as wetlands, local demographics, land cover, and zoning can be mapped to visually understand how the different characteristics contribute to spatial trends that intersect and relate to each other. Further, tools like *ArcGIS StoryMaps* use GIS to creatively integrate text, photos, videos and maps to narrate data and information visually. The City of Kitchener uses a *Natural Areas Story Map* for users to explore natural areas in the region.

- Surveys

Surveys are another means of collecting data and information and can include census surveys of populations or other more direct sample surveys. Surveys can help to understand the demographics of a region (age, socioeconomic background, etc.), the use of a public space (how many people use a space, why a space is being used, when the space is most or least used), the perception or public interest in a certain topic (such as climate change) and other considerations. Surveys can be administered in-person or through web-based platforms (such as SurveyMonkey) that can also be accessed using smart phone applications (such as *CollectMobile* or *NoiseCapture*) or other creative tools for data collection. For example, a survey can be administered to monitor and measure the use of a public cooling centre during an extreme heat event to learn how many individuals are using the centre, as well as the accessibility or perceived safety of the space, among other qualitative factors.

- Public engagement

Engagement with experts, local community groups and individuals provide qualitative information to better understand the experiences and opinions of relevant parties. Interviews and public engagements can be conducted in-person, through phone calls or using online resources such as Microsoft Teams, Zoom, email or other software as well as through smart phone applications or websites. Public engagement can help understand how community members use and value a public space along a waterfront for recreation and cultural traditions.

Further, meaningful engagement with local Indigenous communities can facilitate Indigenous knowledge sharing to better acknowledge and respect the value of public spaces.

CONCLUSION

Data collection and monitoring methods support our understanding of local climate risks and the role of built and natural infrastructure in public spaces in addressing climate related impacts. Valuable insights can be gleaned from data and information about a public space to inform decision-making on the climate resilient properties of infrastructure and, through analysis and future forecasting, the potential climate-related impacts of different decisions and developments. Innovative data collection and monitoring technologies supports efficient and effective understandings of local climate risks and the role of public spaces is addressing climate change.

GLOSSARY

Artificial intelligence (AI) is the "simulation of human intelligence in programmed machines."[32] AI can play a major role in climate adaptation, mitigation and resilience efforts by collecting and interpreting large datasets in real time, which can help detect early warnings for severe weather occurrences and implement prevention efforts earlier.[33]

Climate resilience describes the capacity to respond to and adapt to or cope with climate change impacts and is "the capacity of social, economic and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity and structure, while also maintaining the capacity for adaptation, and learning and transformation.[34]

Earth Observation (EO) refers to the usage of remote sensing technologies to monitor land, marine (seas, rivers, lakes) and atmosphere.[35]

Geographic information systems (GIS) are computer-based systems for capturing, displaying and interpret geographic data.[36]

Internet of Things (IoT) refers to "the network of physical objects, or things, which are connected to other devices and systems over the Internet."[37]

Natural assets are natural resources and ecosystems that provide services and functions to people. Natural assets include resources like wetlands, forests and fields.[38]

Natural asset management is an approach that recognizes the benefits natural assets in decisions about the management of infrastructure assets.[39]

Urban heat islands are urbanized areas that experience higher temperatures than outlying areas. Structures such as buildings, roads, and other infrastructure absorb and re-emit the sun's heat more than natural landscapes such as forests and water bodies. Urban areas, where these structures are highly concentrated and greenery is limited, become "islands" of higher temperatures relative to outlying areas.[40]

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