EVERGREEN

Community Solutions Network

Smart urban planning for climate resilience

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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 exploring the potential of data and technological tools in urban planning to help build local climate resilience. Drawing from international and national research initiatives, this brief presents an overview of the role of data and technological innovations that support urban planning initiatives for more climate-resilient communities. The brief also shares effective data governance tactics and considerations for municipalities and community leaders when undertaking climate-resilient urban planning.

INTRODUCTION

Smart urban planning addresses the dynamic challenges of community-building through evidence-informed decision-making.[1] Tools like Geographic Information Systems (GIS) are commonly used for mapping alongside visualization, spatial analysis and modelling components for land use management, development and other urban planning functions. [2] From simple data-sharing projects to more complex initiatives, leveraging smart innovations like artificial intelligence (AI) or digital twins can support a range of climate resilience initiatives in communities, from identifying local climate risks to analyzing public infrastructure assets (such as public parks or bioswales) that can build local climate resilience.

When working with large data sets and information related to a community (including personal information such as income, age, tax bracket, etc.), it is important to ensure that the data is rooted in a strong governance framework that guides its management.

As communities seek to improve their climate resilience through innovative urban planning, it is useful to leverage data and technological tools that can support the equitable and efficient planning, design, implementation, and management of public spaces.

ROLE OF TECHNOLOGY IN URBAN PLANNING

How communities design streets, public spaces and plan future developments is critical when talking about building resilience. Climate resilience is not the responsibility of a single staff member, team, government entity or organization but involves coordination across sectors, as well as through meaningful engagement and consultation with community members.

Use case: Mapping and modeling

The mapping and modeling of areas of increased risk due to climate change present one of the clearest potential tools for use in building resiliency. Many communities are already familiar with Geographic Information Systems (GIS) to map critical information and infrastructure in their community.

Value for communities

Using GIS to better understand areas of increased risk due to climate change is a relatively low barrier and effective use of technology that many communities already possess. Similarly to how traffic flow maps inform planning around public transportation, roadways, and safety, communities can use mapping of climate risks to assess whether current plans adequately address those risks and inform future planning efforts. With this information, communities can discourage development in high-risk areas, such as those vulnerable to coastal flooding or forest fires, while identifying other areas to invest in infrastructure to mitigate climate risks, such as integrating more green infrastructure in areas prone to poor air quality or extreme heat.

Data requirements

Like any other digital tool available to municipalities, the effectiveness of mapping and modeling tools depends on data availability. The data used for mapping and modeling will have a more profound impact on the output than the sophistication of the specific GIS product the community uses.

For example, to develop an Urban Heat Island (UHI) map, publicly available datasets can provide a higher-level picture of extreme heat risks in a community, while proprietary datasets and/or datasets generated by networks of IoT sensors can provide more localized insights.

Community leaders are tasked with balancing priorities from ensuring adequate housing developments to updating transportation networks all while ensuring climate resilience is embedded within every decision. It is understandable, then, that we see a growing interest in digital tools that could potentially reduce the cost of resources and staff time.

This is not to suggest that the first step for a solution to climate resilience should be a new digital tool. Before moving forward with any digital solution, communities should take steps to understand their specific challenges with a holistic approach. Evergreen's *Reimagining* Public Spaces: Technology-Based Solutions for Resilience toolkit is an excellent place to start when considering new tools to aid communities in building resilience to climate change.

The promises offered by new technologies often appear endless. While a more cautious approach to the adoption of some innovations is warranted, there are still valuable use cases where communities are leveraging technology to plan for a climate-resilient future.

Digital Twins

A digital twin is a "virtual model designed to accurately reflect a physical object."[3] Digital twins use sensors on objects to collect real-time data on operational information[4] to compile data such as temperature or energy consumption and the data is then applied to the digital model.[5] The digital model runs simulations to provide insight on performance issues and help identify areas of improvement that can be applied to the physical object.[6] For example, data collected from digital twins can provide information on how a wind turbine responds under certain conditions and guide what changes need to be integrated to improve performance.[7]

Digital twins create replications of physical environments to inform municipalities in making more effective decisions to reduce emissions and build more climate-resilient communities.[8] Digital twins can track and manage building emissions, simulate environmental impacts on urban planning initiatives,[9] support climate modeling and simulations and monitor and predict climate impacts.[10]

For example, the City of Ottawa uses a digital twin system to develop a virtual, 3D city model for planners, developers and other partners to analyze the potential impacts of new development projects.[11] The City uses an existing enterprise GIS as the basis for producing a 3D environment that connects with ArcGIS Urban to integrate photogrammetric and LiDAR features[12] among other data models such as historical weather trends.[13]

As another example, Humber College in Toronto, Ontario, is using digital twins to improve the school's energy efficiency. Smart sensors have been installed throughout the school and its operating system so that facility managers can operate lighting, heating and other systems more efficiently (such as pre-cooling buildings before peak usage).[14] Humber College's digital twins compare the actual performance to the optimal digital model and can predict the actions needed to achieve the desired outcome.[15]

Examples of Data & Technology to Aid with Smart Urban Planning

The table below offers examples of technology and data sets that communities may find helpful when planning to build for increased climate resilience.

Type	Description	Advantages	Challenges
Remote sensing data	Aerial photography, high-resolution satellite imagery capturing land cover and urban areas.	• Provides high-resolution imagery for detailed analysis. • Offers coverage of large areas, enabling comprehensive assessments. • Allows for monitoring changes over time.	• Can be costly to acquire high-resolution imagery. • Susceptible to cloud cover which can obstruct data collection. • Requires expertise to effectively process and analyze the data.
IoT sensors data	Sensors that capture air temperature, air quality, humidity etc.	• Offers real-time or near real-time data for monitoring environmental conditions. • Provides continuous data streams for trend analysis. • Can be relatively cost-effective to deploy and maintain.	• Limited spatial coverage depending on sensor deployment. • Data accuracy and reliability can vary based on sensor quality and calibration. • Requires ongoing maintenance and calibration efforts.
Administrative boundaries	Defined polygon boundary of the area under study	• Provides clear delineation of study areas. • Easily accessible from open data portals.	• Boundaries may not accurately represent natural or functional boundaries.
Socio-economic and demographic data	Data that provides insight into affected populations, income levels, visible minorities, education level, age distribution, etc.	• Provides insights into human population and societal characteristics. • Facilitates socio-economic analysis and planning.	• Privacy concerns may limit data accessibility or accuracy.
Land use and land cover data	Detailed data on the types and distribution of land cover in the area.	• Provides detailed information on land cover types and changes. • Informs policy and decision making on land management, environmental monitoring, and urban planning.	• Data may require frequent updates due to changing land use patterns. • Variability in classification methods (for example: supervised and unsupervised classification) can lead to inconsistencies. • High-resolution datasets may be proprietary and costly to acquire.

Building and infrastructure data	Information on buildings (building footprint, height), roads and other infrastructure types.	• Provides information on the built environment for urban planning and infrastructure development, disaster management and emergency response planning.	• Access to detailed building data may be restricted or proprietary. • Maintenance and updating of infrastructure data can be resource intensive.
Topographic data	Digital Elevation Models (DEMs) and terrain data to account for elevation differences.	• Essential for terrain analysis, watershed delineation, and slope modeling. • Available from open data portals and government agencies.	• Varying data resolution affects accuracy. • Requires processing and integration with other datasets for meaningful interpretation. • Limited availability of high-resolution topographic data for some regions.
Historical data	Long-term data on land use changes and urban development trends, temperature anomaly, and rainfall data	• Enables long-term trend analysis and identification of patterns. • Provides context for current conditions and future projections.	• Historical data may be incomplete or inconsistent. • Requires careful consideration of temporal and spatial biases in analysis.

DATA GOVERNANCE CONSIDERATIONS

With the increased reliance on data analytics to enhance operations and more informed decisions, municipalities and communities need to be more intentional about how data assets are managed. [16] A holistic approach to data governance considers how data is used, who is responsible for it and how they are held accountable for their decisions across the data life cycle (from acquisition, storage, usage and disposal).[17] Proper data governance ensures that the collected data is reliable and does not get misused and it is a key aspect in strategic data management.[18] FAIR principles (findability, accessibility, interoperability and reusability)[19] and CARE principles (Collective Benefit, Authority to Control, Responsibility and Ethics)[20] are frameworks that can be applied for open and equitable data management. Integrating FAIR, CARE or other data principles in data management and governance enhances the reusability and equity of the information. Municipalities, businesses and organizations should consider the following when implementing a data governance framework:

- Data collection and quality - Central to any data-driven project is achieving adequate data quality and establishing correct collection processes to ensure that high-quality data is collected.
- Data sharing – Where possible, communities access the data through collaborative efforts (collaborative procurement) or access existing data held by another community or organization. In both instances, data sharing agreements will need to be created and put in place.

- Data storage and security –Consider questions such as where will the data be stored, who will have access to it and how will access be secured? This includes usages and access regulations as well as cybersecurity compliance.
- Data privacy – While some data may not contain personal identifiable information (PII) there are instances, particularly when assessing the equity of climate impacts to community members, where communities will be handling PII and need to abide by data privacy laws, policies and cultural values and communicate their privacy policy to the public. For example, some communities may prefer not to collect or store data about the location of ceremonial sites or burial grounds while others may have oral traditions that may prefer not to codify their data. These cultural values should be considered and respected when developing a data governance framework.
- Public engagement – Communicating how the collected data will be used is essential to public engagement and consultation. This can be particularly important in instances where sensors are placed throughout a community. Community members will often have questions about the use and scope of such sensors, so it is important to be proactive in communicating how and why they are being used.

CONCLUSION

Including climate-resilient efforts in urban planning is essential for communities to respond to urban growth and climate-related risks proactively. It can also help decrease vulnerability to climate change by maintaining improved access to services, resources, and facilities.[21] It also supports public space design, increases public awareness of the need to create sustainable communities, and supports the ability to adapt to negative climate effects. Data governance can guide proper data-driven decision-making, and predictive data modelling technology can aid planners in determining different types of vulnerabilities, preparing for climate impacts, and creating effective climate mitigation strategies.[22] The use of data and technology has the potential to strengthen current strategies in ways that are both efficient and beneficial, but embedding these technologies requires significant investment, commitment and successful collaboration within communities.[23] As cities develop new strategies using technology to address climate change and reduce its impacts, the redesign, revamping and planning of cities will play a key role in ensuring a sustainable future for all.[24]

GLOSSARY

Artificial Intelligence (AI) is the "simulation of human intelligence in programmed machines."[25] 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.[26]

Data Governance is the process of managing the integrity, use, security and availability of data. Data governance can organize our complex and evolving relationship with data as a matter of public policy.[27]

Digital Elevation Model is a digital model or 3D representation of a terrain's surface created from terrain elevation data.[28]

Digital twin is a virtual replica of physical assets, processes and systems in a community.[29]

Geographic Information Systems (GIS) are computer-based systems for capturing, displaying and interpret geographic data.[30]

Internet of Things (IoT) refers to "the network of physical objects, or things, which are connected to other devices and systems over the Internet."[31]

Machine learning is a form of artificial intelligence where computers use data and algorithms to "learn" over time, improving the performance of tasks over time and mimicking how humans learn.[32]

Personal identifiable information (PII) is any representation of information that permits the identity of an individual to whom the information applies to be reasonably inferred by either direct or indirect means.[33]

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.[34]

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