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ASSET MANAGEMENT OF RURAL ONTARIO CORE INFRASTRUCTURE – DRIVERS, BARRIERS AND CLIMATE CHANGE CONSIDERATIONS

Kenny, Shawn^{1,2}, Dupré, Kathryn¹ and McEvoy, Amanda¹

¹ Carleton University, Canada

² shawn.kenny@carleton.ca

Abstract: Effective delivery of service-based outcomes to meet municipal strategic goals for municipal infrastructure can be realized through asset management plans. Because uncertainty exists with the potential impact of climate change effects on infrastructure performance, it is important to understand the current state of municipal readiness to address climate change effects, as well as the broader municipal needs, challenges and gaps (e.g. technical, financial, organizational factors). If municipalities do not consider the impacts of climate change in their infrastructure planning, they could experience a greater risk of damage to their infrastructure stock, and there could be significant costs and losses in the future. A preliminary assessment of climate change considerations within asset management plans for rural Ontario municipalities is explored in this study. Through directed questionnaires with asset managers from rural Ontario municipalities, the general readiness landscape was examined with respect to (1) the factors that are limiting or supporting the integration of climate change considerations in infrastructure planning and design in rural communities (e.g. funding, expertise, awareness, leadership, tool and resources), and (2) an understanding of how rural communities perceive the costs and benefits to their infrastructure associated with climate change impacts. The questionnaire explored four key elements of the asset management framework for rural municipalities including the state of local infrastructure (i.e. data), levels of service (i.e. metrics), asset management strategy (i.e. planned actions) and financing strategy (i.e. revenue, expenditures and debt management). The questionnaire also examined barriers that may limit the integration of climate change considerations within asset management plans for rural communities. Results of this study are presented.

1 STUDY BACKGROUND

1.1 Project Basis

This research project, which is supported by the Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) through the New Directions Research Program, is exploring how rural municipalities may take action in preparing infrastructure for a changing climate (e.g. IPCC, 2014). Ignoring the potential impact of climate change effects within asset management plans could result in a greater risk of damage (e.g. more intense rainstorms resulting in flooding events) to the infrastructure stock that may result in unwarranted costs, interruptions in service delivery, and loss of infrastructure (AGC, 2016; APEGBC, 2017; Engineers Canada, 2016; IBC, 2016; IPCC, 2014; Palko and Lemmen, 2017). There is a need to better understand the state of Ontario's rural municipalities in how they:

- assess risks and opportunities for their local infrastructure related to changes in climate,
- integrate climate change considerations into their asset management planning, and
- put into practice adaptive technologies/standards that may help manage climate change impacts to infrastructure into the future.

In Ontario, there are 444 municipalities, which can be sub-categorized as 173 single tier, and, within the two-tier structure, 30 upper tier and 241 lower tier municipalities. Single tier municipalities are responsible for the delivery of all local services to the residents, whereas the responsibilities of upper and lower tier municipalities vary depending on whether they form part of a region, county or district.

In this study, the term “rural Ontario municipality” is defined as a community with a population less than or equal to 100,000 people, or a population density less than or equal to 100 people/km². Based on data from the Association of Municipalities of Ontario, 409 of the 444 Ontario municipalities can be classified as rural with approximately 79% (351 municipalities) having a population less than 25,000 and only 8% (36 municipalities) having a population greater than 100,000. A majority of the Ontario population (~80%) resides within 15 urban centers.

1.2 Project Objectives and Study Goals

This paper is part of a broader overarching project addressing the asset management of core infrastructure for rural Ontario municipalities in the face of a changing climate. This broader project aims to (1) establish the current state of rural municipalities readiness to address the impact on municipal infrastructure, and (2) develop a framework for use, adaptation and integration by municipalities within sustainable management practices.

The first objective is thus to develop a clear picture of the state of readiness within rural Ontario municipalities in the context of asset management *enablers* (e.g. technologies, resources), *barriers* (e.g. constraints, risks, gaps), and *strategies* (e.g. lifecycle, financial). This will provide an informed knowledge base with benchmarks to assess the current state of readiness, in absolute and relative terms, gauge requirements for continuous improvement, and establish the path forward.

Building on these preliminary findings, the second objective will provide municipalities with guidance and enabling resources (e.g. tools, standards, best practices) to develop a flexible asset management framework that integrates considerations of climate change with other key attributes (e.g. risk, data needs, resources, technologies, financial plan, stakeholder engagement).

The study presented in this paper explores the first objective by directly engaging municipal stakeholders through a questionnaire on rural infrastructure and climate change. The survey objectives, synthesized results, and implications pertaining to the second objective are presented.

1.3 Continuity with Recent Project Studies

In a recent study, Kenny et al. (2018) conducted a preliminary assessment on the current state of readiness for rural Ontario municipalities to incorporate climate change considerations within asset management plans (e.g. ISO 55000, 2014; ISO 55001, 2014; ISO 55002, 2014; IIMM, 2015). Through a questionnaire directly engaging municipal representatives, they developed insights on the (1) status of in-place asset management plans, (2) consideration of climate change effects, (3) nature and extent of those climate change considerations, and (4) characterization of infrastructure vulnerability.

It was found a majority of municipalities (> 95%) have established asset management practices for core infrastructure, however, few communities (< 13%) had not integrated climate change considerations with the management and performance assessment of core infrastructure (Kenny, 2019). Some of the key challenges identified, which was associated with negative impacts of climate change effects on the general readiness landscape, were the finite municipal capacity (i.e. human, physical and financial resources) available, was, particularly for smaller communities, to address the scale of challenges faced (e.g. investment gap, past or current practices, community growth patterns, asset condition assessment programs) that may also be limited by local constraints (e.g. physical environment, remote location). A

weathervane path forward to integrate climate change considerations within asset management practices was identified. These challenges are not unique to small communities. For example, the formal integration of climate change considerations (e.g. knowledge base, tools) within the asset management framework is in the process of development and advancement for larger urban municipalities with relatively greater capacity and resources (e.g. Black et al., 2014; CIRC, 2016; Deloitte, 2010; ICLEI, 2010; Langford, 2013). Furthermore, there are uncertainties inherent within the current practices used to evaluate climate change related hazards and load effects on the long-term performance of core infrastructure. These limitations create barriers to informed decision-making processes that may impact practical design, maintenance and rehabilitation options, adaptation practices and mitigation strategies across the range of operational envelopes (AGO, 2015). This suggests that rural municipalities may require support to effectively integrate climate change considerations within their asset management frameworks (e.g. Kenny, 2019).

The perceptions and opinions of rural community members were also sought, as representative surveys focusing on individual support for climate change initiatives asked the opinions of rural Ontario community members (Dupré et al., 2019; McEvoy et al., 2018). The survey respondents reported their understanding and views of climate change, both in general and as they relate to their own communities. The survey was distributed to 7,600 residents of rural Ontario municipalities and data was obtained from 2,500 individuals (33% response rate). The general characteristics of the respondents were predominantly female (60%), Caucasian (95%) and married (63%) with children (74%) with an average age of 65. It was found that personal and community characteristics of stakeholders (i.e. citizens) tended to influence their openness to policy change, variability in their satisfaction with infrastructure performance or service delivery, and their perception of moderating factors (e.g. costs, benefits) that could affect the sustainability of their community in the face of climate change.

The findings of this community study suggest that overall, although rural residents believe they understand climate change, they do not understand the extent of climate change effects on their communities. The results further support certain individual (i.e. age, gender) and community (i.e. attachment, resilience) characteristics influence citizens' openness to green initiatives. After controlling for individual demographic variables and personal health, results show that when individuals are more concerned with the effects of climate change on their own communities, and when they believe that various events (e.g. freeze/thaw, soil erosion, damage to water system, loss of power) in their own communities resulted from climate change, they were more likely to support climate change initiatives (e.g. pay to reduce the effects of climate change, receive lower community services to improve the effects of climate change). However, simply understanding the definition of climate change, or having a generalized understanding the effects of climate change on communities was not significantly related to support for climate change initiatives. These findings suggest that it is important to ensure that individuals understand the more personal implications of climate change if municipalities desire to garner support for climate change initiatives. Finally, a key barrier to citizen endorsement for climate change considerations was related to the lack of communication or access to information on climate change effects on their municipalities' infrastructure performance, service delivery and cost implications. Improving community engagement and highlighting personal impact may be a driver for promoting the support for climate change considerations within rural Ontario municipalities.

The key finding from this rural community engagement study suggests that when individuals are concerned with the effects of climate change within their own communities, and believe that various events in their own communities are related to climate events, they are more likely to support climate change initiatives. Many organizations are in the process of developing or implementing climate change policies and practices to improve environmental sustainability. Regardless of how innovative or effective these climate change initiatives may be, without the endorsement and support of the individuals who are affected by these changes, it is challenging for these policies and practices to achieve maximal potential.

2 MUNICIPAL QUESTIONNAIRE ON “DRIVERS AND BARRIERS FOR CLIMATE CHANGE INTEGRATION”

2.1 Objectives

In alignment with the first objective presented in Section 1.2 above, an electronic questionnaire was distributed to municipal staff members (e.g. Chief Administrative Officer, Manager of Finance, Engineering Manager) of the 409 rural Ontario communities. The Carleton University Research Ethics Board approved distribution of the survey and all responses were anonymously recorded. More specifically, the questionnaire aimed to assess factors (e.g. funding, expertise, awareness, leadership, tools and resources) that may be limiting or supporting the integration of climate change considerations in infrastructure planning and design within rural communities. In reference to the respondent’s municipality, the questionnaire addressed three components including:

- (1) general background information on the municipality and delivery of the asset management framework,
- (2) drivers or enablers that may support the integration of climate change considerations within asset management plans, and
- (3) barriers or constraints that may limit the integration of climate change considerations within asset management plans.

2.2 Results

Section 1 of the municipal questionnaire on “Drivers and Barriers for Climate Change Integration” developed a profile of the survey respondents. A total of 147 rural municipal representatives responded to the survey, which is a participation rate of 36% based on the 409 possible respondents. For some of the survey questions, there was missing data resulting in a lower participation rate (31%, 127 respondents), but it is unclear why the survey responses were not entered or toggled. The key findings from Section 1 of this survey can be summarized as:

- the reported municipality structure was evenly distributed with 47% in the single tier and 53% in the two-tier (3% upper tier, 50% lower-tier) system,
- the general distribution of respondent locations was 39% northern, 22% western, 21% eastern and 18% central (excluding the Greater Toronto Region) regions of Ontario,
- the municipal population was primarily less than 25,000 (89%) and 5% with a population greater than 50,000,
- the majority of respondents (56%) indicated that the projected population change within their municipality was primarily stable or neutral ($\geq -0.5\%$ & $< +0.5\%$), whereas 21% reported their municipality experiencing accelerating growth ($\geq +1.5\%$), 15% experiencing normal growth ($\geq +0.5\%$ & $< +1.5\%$), and 8% experiencing declining or negative ($\leq -0.5\%$) growth, and
- the asset management function within these municipalities is most often delivered by finance personnel (38%) or an integrated finance/engineering team (37%), while engineering personnel (10%), external consultants (7%) were less common, and a further 6% indicated the organizational process has not yet been established and 2% reported other (e.g. in development).

In the second part of the survey, the municipal representatives were asked to consider drivers or enablers that may support the integration of climate change considerations within asset management plans specific to their rural community. The survey asked each respondent to rank the relative importance (i.e. influence) of the following factors that may help integrate climate change considerations within asset management practices: *Human Resources, Technical Resources, Financial Management, Council*

Leadership, Provincial Government Initiatives, Federal Government Initiatives, Community Awareness and Engagement, Private Industry Integration, and Professional Society Engagement.

An example output of the rank selection for *Human Resources* as a driver or enabler for the integration of climate change considerations within asset management practices is illustrated in Figure 1. The results indicate human resources rank within the top 6 (out of 9 rankings) as an enabler of climate change consideration, which indicates a fairly uniform distribution across respondents. For other factors, such as the *Professional Society Engagement*, there was more clarity with 53% of respondents ranking this factor in 9th place and 82% ranking this factor as 6th or lower (i.e. weaker enabler). Thus, for the respondents in this specific survey, the results would view *Human Resources* as a moderate enabler and *Professional Society Engagement* as a weak enabler for the integration of climate change considerations within asset management practices.

This general outcome is illustrated in Figure 2, where the synthesized composite rankings are presented. The relative importance of *Human Resources* is relatively uniform and wavers at the 10% level up to rank 7 (Figure 1 and Figure 2). The view of *Professional Society Engagement* as a weak enabler is indicated by the 53% rating for a rank 9 (Figure 2). The bar height of a specific factor (e.g. *Human Resources*) at each rank (e.g. 1) indicates the percentage of total respondents that selected a specific factor for a specific rank.

The highest percentage recorded, for each rank, and the corresponding enabler or driver is summarized in Table 1. Based on this assessment, *Provincial Government Initiatives* (highest percentage in Rank 1 and 2) and *Financial Management* (highest percentage in Rank 3) can be viewed as strong enablers, whereas *Private Industry Integration* and *Professional Society Engagement* can be viewed as weak enablers or drivers. Table 2 summarizes the highest percentage recorded for each driver or enabler and the corresponding rank. The data was also analyzed and classified with respect to strong, moderate and weak enablers or drivers for the integration of climate change considerations within asset management practices. The maximum cumulative sum of percentage rank across a specific rank range was used as the metric to determine whether a factor was a strong (Rank 1 to 3), moderate (Rank 4 to 6) or weak (Rank 7 to 9) enabler. Based on the synthesized data (Table 1, Table 2, and Figure 2) from the municipal questionnaire, the factors can be broadly classified in terms of:

- strong (*Financial Management*, 56%; *Provincial Government Initiatives*, 52%; *Council Leadership*, 48%; *Federal Government Initiatives*, 42%),
- moderate (*Technical Resources*, 49%; *Human Resources*, 44%), and
- weak (*Private Industry Integration*, 93%; *Professional Society Engagement*, 78%; *Community Awareness & Engagement*, 59%)

enablers or drivers for the integration of climate change considerations with asset management practices. As stated, the percentages presented above are the cumulative sum across the rank range. Analyses were also performed to generate two alternative metrics including a maximum average score across each rank range and an overlapping rank range (i.e. 1 to 4, 3 to 6, 6 to 9). Classifications were found to be identical in each case given the current data. However, it remains important to note that there exists some uncertainty in the analysis, as the data does not suggest a distinctive differentiation between the strong and moderate factors (i.e. all cumulative percentages are close to 50% with standard deviations around 5%). As such, these differentiations should be interpreted with caution. In turn, based on this particular survey, the data suggests greater confidence in defining the weak drivers, as illustrated in Figure 2.

The municipal representatives were also asked to self-identify and note any other factors that may help integrate climate change considerations within asset management plans for their specific community. The most common responses included: engagement with conservation authorities, synthesis of best practices based on experiences with climate change effects, and considerations and accommodation (e.g. funding, resources, policies) for remote locations.

Table 1: Highest percentage for each rank and the and corresponding driver

Rank	Enabler or Driver	Percentage (%)
1 st	Provincial Government Initiatives	19
2 nd	Provincial Government Initiatives	22
3 rd	Financial Management	24
4 th	Council Leadership	21
5 th	Technical Resources	22
6 th	Human Resources	15
7 th	Community Awareness & Engagement	31
8 th	Private Industry Integration	46
9 th	Professional Society Engagement	53

Table 2: Highest percentage for each driver and the corresponding rank

Enabler or Driver	Percentage (%)	Rank
Human Resources	15	1 st & 6 th
Technical Resources	22	5 th
Financial Management	24	3 rd
Council Leadership	23	3 rd
Provincial Government Initiatives	22	2 nd
Federal Government Initiatives	18	2 nd
Community Awareness & Engagement	31	7 th
Private Industry Integration	46	8 th
Professional Society Engagement	53	9 th

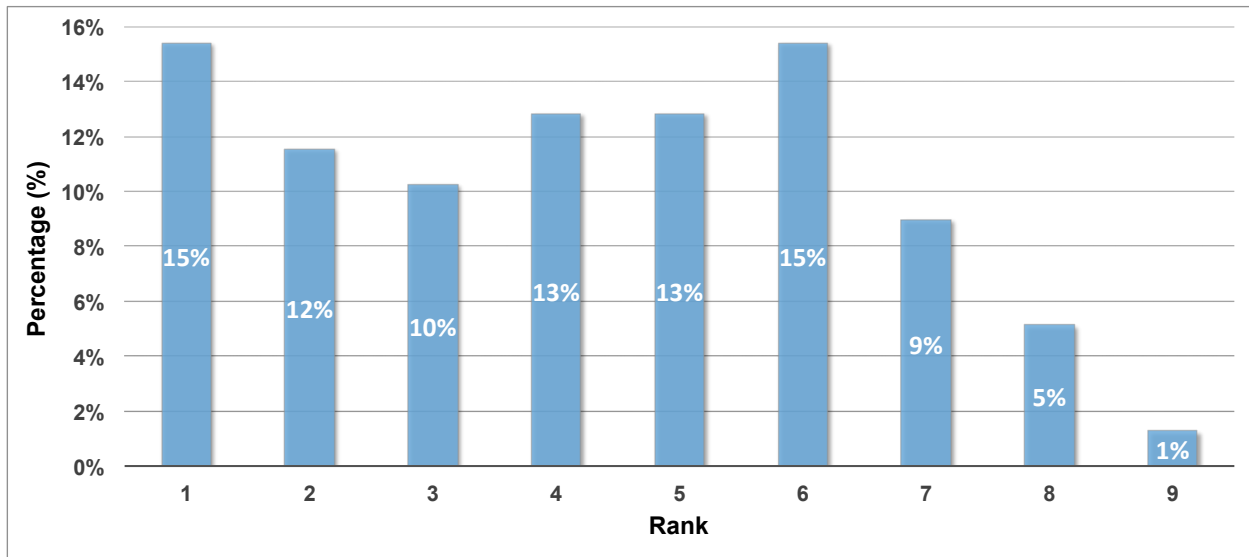


Figure 1: Distribution of the rank order selection for the *Human Resources* factor as a driver or enabler.

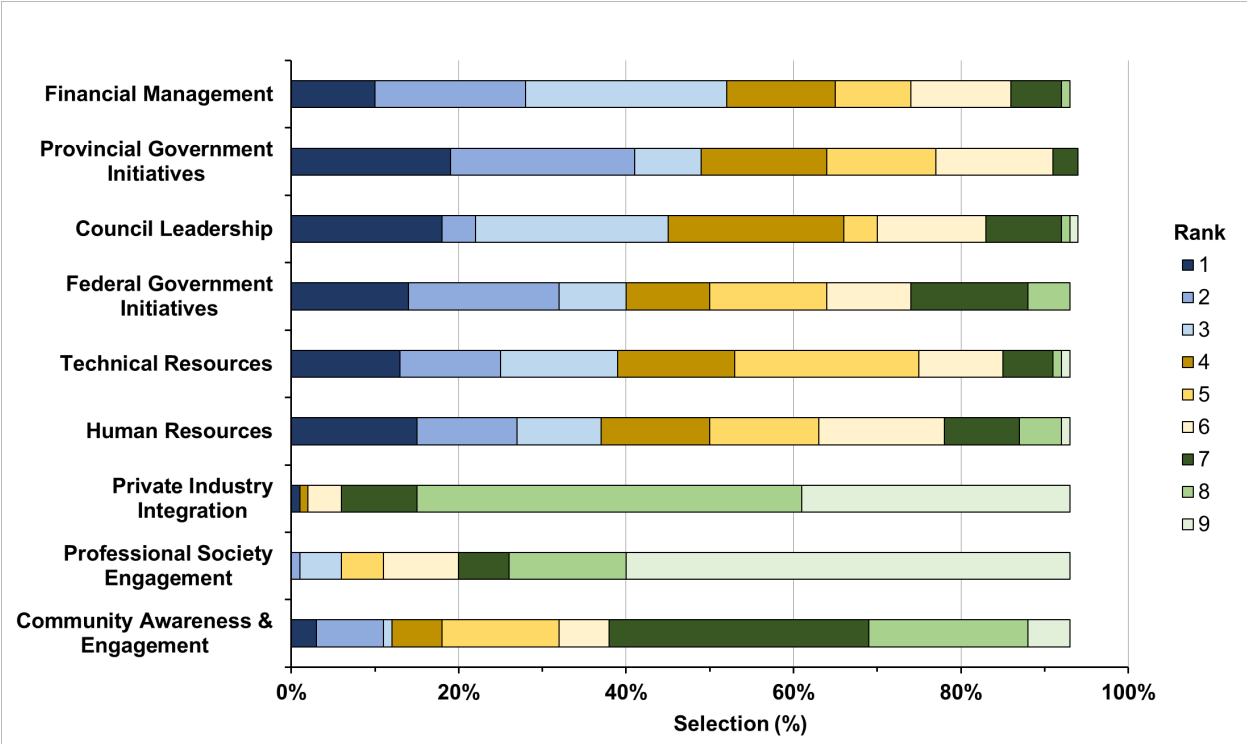


Figure 2: Relative importance rank order of 9 factors as a driver or enabler for climate change integration with asset management practices. (Note: Rank 1-3 Blue, Rank 4-6 Yellow and Rank 7-9 Green)

In Section 3 of the questionnaire, the municipal representatives were asked to report on four key elements within the asset management framework including: (i) the state of local infrastructure (i.e. data), (ii) levels of service (i.e. metrics), (iii) asset management strategy (i.e. planned actions), and (iv) financing strategy (i.e. revenue, expenditures and debt management). In reference to their specific municipality, the respondents were asked to consider barriers or constraints that may limit the integration of climate change considerations within asset management plans for their rural community. In the questionnaire, the barrier was also framed as something that may have a positive influence on asset management framework but may currently be limited or constrained by other factors (e.g. technical and human resources, funding).

For barriers hindering climate change integration within asset management practices, with respect to the state of local infrastructure and levels of service, the respondents were asked to rank order four factors including *Asset Condition Assessment*, *Financial Valuation*, *Demand or Utilization*, and *Level of Service*. These were analyzed using the same analysis method (i.e. cumulative sum of percentages) described above. The questionnaire results indicated identified *Financial Valuation* (54% Rank 1 or 2) and *Asset Condition Assessment* (49% Rank 1 or 2) as comparatively stronger barriers, and *Demand or Utilization* (49% Rank 3 or 4) and *Level of Service* (54% Rank 3 or 4) as comparatively weaker barriers.

With regards to the asset management strategy (i.e. planned actions), the survey responses identified *Organizational Capacity* (67% Rank 1 or 2 out of 7) which includes staffing, external support, tools and resources, as the key barrier for the integration of climate change considerations, whereas *Stakeholder Engagement* (55% Rank 6 or 7), which includes public-private partnerships on green infrastructure technologies, public communication and education, was viewed to be the least influential barrier. The studies by Dupré et al. (2019) and McEvoy et al. (2018), however, suggest *Stakeholder Engagement* to be a more influential moderator when there is greater integration across all levels (e.g. vision, strategy, tactics, operations) and stakeholders (e.g. public, private industry, council, senior management, staff).

Taken together, the findings of these two studies suggest that municipal representatives might underestimate the influence of stakeholders, which may have implications for municipalities (e.g. election results, policy development, sustainability plans, community, business plans). The other 5 factors (*Engineering Options, Plans and Policies, Lifecycle Cost Analysis, Vulnerability Assessment, and Benefits and Cost*) were found to be reported as moderate or weak barriers.

The questionnaire also explored barriers influencing the financing strategy (e.g. revenue, expenditures and debt management). The survey responses identified *Financial Plan, Policies and Capacity* (64% as rank 1 or 2 out of 6), which includes municipal population and economic growth direction staffing, as the key barrier limiting the integration of climate change considerations within asset management plans for their community. The influence of *Stakeholder Engagement* (57% rank 6) was viewed to be the least influential barrier, which is not consistent with recent research findings (Dupré et al., 2019; McEvoy et al., 2018). The other 4 factors (*Fiscal Plan, Policies and Capacity, Regulations and Legislation, and Predictive Financial Tools*) were considered to be moderate or weak barriers.

3 CONCLUSIONS

A questionnaire was distributed to 409 rural Ontario municipalities to assess moderating factors (e.g. funding, expertise, awareness, leadership, tools and resources) that may be supporting or limiting the integration of climate change considerations within asset management practices. An improved understanding on the state of readiness landscape with respect to enablers (e.g. technologies, resources), barriers (e.g. constraints, risks, gaps) and strategies (e.g. lifecycle, financial) was established.

Synthesis of the survey responses indicated the most influential drivers or enablers were considered to be:

- *Financial Management*: e.g. debt, revenue, & reserve assessment, long-term financial plan integration,
- *Provincial Government Initiatives*: e.g. climate change & green infrastructure programs, regulations & policy, funding & taxation, tools & best practices,
- *Federal Government Initiatives*: e.g. climate change & green infrastructure programs, regulations & policy, funding & taxation, tools & best practices, and
- *Council Leadership*: e.g. long-term strategic plans, sustainability plans, policies & regulations.

The primary barriers, which hinder climate change integration within asset management practices, were considered to be:

- *Financial Valuation*: e.g. replacement cost including climate change uncertainty, adaptation requirements & technology changes,
- *Asset Condition Assessment*: e.g. data quality & certainty, regulation requirements, human or technology resources,
- *Organizational Capacity*: e.g. staffing, external support, tools & resources, and
- *Financial Plan, Policies and Capacity*: e.g. municipal population and economic growth direction.

Representative surveys conducted across rural Ontario communities (see Dupré et al., 2019; McEvoy et al., 2018) suggest *Stakeholder Engagement* to be an influential moderator when there is greater integration amongst all stakeholders. However, in this study that sought the opinion of municipal asset managers, the questionnaire results suggested *Stakeholder Engagement* was viewed as a weak enabler or barrier for climate change consideration and integration within asset management plans. Thus, stakeholder buy-in was considered to be relatively less important. Further research is needed to elucidate this apparent contradiction.

These findings represent the first step in a broader project that aims to provide support to rural Ontario municipalities as they engage in asset management planning in coming years. The effects of climate change are likely to have a marked effect on infrastructure and service delivery in rural Ontario municipalities. The current results suggest that though municipalities may feel compelled and supported to engage in beneficial adaptations (e.g. through federal and provincial initiatives), there are still many unknowns (e.g. financial valuation, financial planning) and a need for resources (e.g. technology, tools, staff).

These results further highlight important implications for the second objective of this ongoing project; namely, to develop a framework for use, adaptation and integration by municipalities within sustainable management practices. For instance, providing climate change models/projections to aid financial valuation processes may help municipalities overcome one of their primary barriers, whereas the development of regulations, tools and best practices may further reinforce important drivers. Building upon the findings presented in this paper, more directed advice and support can be provided to asset management teams within rural Ontario municipalities.

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