2nd Forum on Professional Practice and Career Development
2e Forum sur la pratique professionnelle et le développement de carrier

Montréal, Québec
May 29 to June 1, 2013 / *29 mai au 1 juin 2013*

Municipal Infrastructure Authorities and Municipality Sustainability – A Canadian Perspective

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Abstract: Canadian municipalities are faced with the difficult task of operating and maintaining aging infrastructure. The citizens within these municipalities rely on this infrastructure for everyday needs including clean drinking water, safe roads to travel, and enjoyable facilities for leisure. The municipal authorities tasked with operating and maintaining this infrastructure to an acceptable level of serviceability are the directors, coordinators, managers, and municipal employees within the municipal departments. Throughout the 54 Canadian medium population centres examined and surveyed, the municipal departments varied in terms of nomenclature, delegated responsibility, division composition, and organizational structure. Research was conducted on all (54) medium centres in Canada to gather the similarities and differences between these municipalities and departments. This knowledge was then used to investigate the applicability of using a multidisciplinary team to help provide an approach for the municipal authorities to effectively improve the overall sustainability of existing infrastructure. A multidisciplinary team would offer a decision making strategy, in order to effectively implement sustainable short and long term planning decisions for municipal infrastructure operation and maintenance. In order to gain an understanding of the municipalities' perspectives on short and long term sustainability, research was also conducted on these 54 centres to compile their sustainability goals, priorities, and initiatives. Qualitative research findings are provided in this paper to demonstrate a proposed overarching categorization of municipal departments and sustainability goals and priorities. The findings suggest that the municipal authorities can be categorized within three infrastructure departments and municipal sustainability priorities can be classified under six headings. Future research will explore the multidisciplinary team approach.

1 Introduction

The first step towards a multidisciplinary approach in municipal infrastructure decision making, is to determine which departments are directly responsible for the urban infrastructure within each municipality. After gaining an understanding of the municipal departments responsible for urban infrastructure, it is important to also gain an appreciation of what these municipalities envision in terms of having a sustainable municipality. This report outlines the preliminary investigation into municipal authorities and municipality sustainability principles, priorities and goals within the 54 medium population centres across Canada. The report will first provide a brief background which influenced this research topic. After the literature review, the methodology, analysis, and results for the qualitative content analysis conducted for both municipal authorities and municipality sustainability are presented. Finally, a discussion is included in the report to provide insight on the future steps of this research, as well as a conclusion which summarizes the research findings outlined in this report.

2.0 Background

Often overlooked or even hidden from society are the physical elements of municipalities and urban environments. These urban elements allow citizens to have access to life supporting systems such as water and energy, and to be connected through transportation links. These elements are referred to in the literature as physical infrastructure, specifically urban, civil or municipal infrastructure. The literature has highlighted the importance of sustainable infrastructure for the well-being of a municipality and its community. “It goes without saying that sound civil infrastructure systems are essential to the safety, health, and welfare of the public” (Yao 1996, p.1). Infrastructure is the foundation of all municipalities and thus should be based on solid principles which will insure the resilience of the community. As stated by Marrazzo (1997): “Infrastructure is the investment society makes in its future” (Marrazzo 1997, p.37). Furthermore, the quality of urban infrastructure denotes the capability of a municipality to compete in the marketplace (Marrazzo 1997; Mirza 2006; Koo et al. 2009; Shen et al. 2011). “Sound, well-functioning infrastructure in a country is essential for its sustained economic growth, international competitiveness, public health, and overall quality of life. These characteristics are closely linked to the adequacy of the transportation infrastructure, water quality, and waste disposal” (Mirza 2006, p.641).

The literature strongly emphases the current state of municipal infrastructure as in need of repair and rehabilitation due primarily to age, overuse or misuse, and lack of maintenance, for example (Yao 1996; Adeli 2002; Mallick et al. 2002; Sahely et al. 2005; Mirza 2006; Koo et al. 2009). Infrastructure Canada (2004) has summarized the findings of 11 reports in which the ultimate objective “was to highlight the continuing deterioration of Canadian infrastructure and the rapidly increasing cost of rehabilitation” (Infrastructure Canada 2004, p.10). The *Report on the State of Municipal Infrastructure in Canada,* (1996) reported that bridges, roads, and sidewalks were the infrastructure requiring the highest level of repair with the oldest infrastructure facilities in Canada being the sewage and water distribution systems, and water supply installations (Infrastructure Canada 2004). The report entitled *A Capital Question: Infrastructure in Western Canada’s Big Six* (2003) reaffirms these findings and state that municipal infrastructure needs indicate water and wastewater systems require the largest investments; however, it states that ‘western cities biggest needs exist in the transportation sector’ (Infrastructure Canada 2004, p.5). This report indicates that half of the annual deficit from infrastructure comes from the ‘roads, bridges, interchanges, sidewalks and public transit’ (Infrastructure Canada 2004, p.5).

The common practice within the engineering and infrastructure industry is to focus on specializations and introduce different infrastructure types in a piecemeal approach (Hunt et al. 2005). The current infrastructure industry is thus suffering from systems which are not optimized through integration (Wright 1996; Sparrow 2001; Engel-Yan et al. 2005). “[…] our cities have been planned and built by a diversified group of public agencies and private enterprise companies. In general, each of these groups is primarily focused on performing a specific function, offering specialized services, and responding to local political priorities” (Wright 1996, p.112). Furthermore, Sparrow (2001) states the current built environment “is the combined product of a laissez-faire public philosophy, generous public spending, and specialists (planners, architects, engineers, and builders) who carry out the work” (Sparrow 2001, p.298).

In order to successfully implement sustainable practices within municipal infrastructure, this fragmentation of infrastructure specialization needs to become an integrated approach with emphasis on holistic and multidisciplinary understandings of the assigned projects (Adeli 2002; InfraGuide 2003; Engel-Yan et al. 2005; Meyboom 2009). “While no one set of sustainable design guidelines exists, it is clear that sustainable neighbourhood design is a holistic concept requiring the integrated design of transportation, water, and building infrastructure, as well as urban forestry” (Engel-Yan et al. 2005, p.48). For example, a systems approach will benefit the development of water solutions, thus reducing water use and reducing wastewater and stormwater runoff (Engel-Yan et al. 2005).

With this need of infrastructure sustainability and implementation of an integrated approach, comes the important role of those responsible for managing the existing built environment. Civil engineers have the technical capability of solving municipal problems; however, their roles in society need to change from

technicians to agents which promote sustainability, specifically sustainable infrastructure (Wright 1996; Yao 1996; Sahely et al. 2005; Johnson et al. 2010; Hasna 2010). “The engineers’ role is to be the manager of sustainability – to see that technological applications incorporate sustainable development concepts” (Wright 1996, p.114). Yao (1996) argues that civil engineers are in a position which allows them to contribute to sustainable futures through environmental engineering and infrastructure systems (Yao 1996). Brintnall supports this thought and states that civil engineers “are at the heart of efforts to contain air and water pollution; maintain infrastructure systems; deliver clean, affordable energy to the public; mitigate impacts of natural disasters; and get us all to work on time” (Brintnall 2001, p.283). Finally, the critical role of the civil engineer is to instill and advance sustainability at the government level (Johnson et al. 2010).

The needed changes identified in the literature strongly suggest a shift in how infrastructure is planned, designed, operated, and implemented. As Meyboom (2009) argues, today’s infrastructure cannot be built as it was in the past. “Developing sustainable infrastructure systems will require a greater understanding of their complexity and dynamics, using an interdisciplinary approach” (Boyle et al. 2010, p.4837). As previously stated, the scale of a municipality will influence the infrastructure needs, therefore during the development of long-term planning of infrastructure, the infrastructure needs, problems, deficiencies, and related issues’ (Mirza 2006, p.641; Boyle et al. 2010) need to be considered. A neighborhood-scale planning analysis can allow for the evaluation and development of “more efficient and sustainable local urban infrastructure, including buildings, transportation, urban vegetation, and water (*i.e.,* water supply, wastewater, and stormwater) systems” (Engel-Yan et al. 2005, p.45).

Infrastructure changes can come in many forms and through the many systems of the built environment. They are implemented based on municipal decision makers and their respective financial allocations for infrastructure projects. However, Boyle et al. (2010) argue that there may be a need for abrupt change: “While incremental changes were necessary, disruptive, path-breaking changes may be essential to developing sustainable infrastructure systems that may require 10-20 years before implementation” (Boyle et al. 2010, p.4839). These new forms of change should include the integration of new sustainability practices and trade-offs analysis (Johnson et al. 2010).

Sustainable infrastructure, as referenced in this paper, refers to the concept of the triple-bottom line. The triple-bottom line, also referred to as the pillars or dimensions of sustainability, consists of environmental, social, and economical aspects (Perdan et al. 2000; Sparrow 2001; Hunt et al. 2005; Sahely et al. 2005; PERSI 2006; Mihelcic et al. 2008; Koo et al. 2009; Johnson 2010; Fischer et al. 2011; Kevern 2011; Shen et al. 2011). Although there is a challenge in establishing a definition for sustainability, these three pillars are commonly accepted as the needed elements for sustainable infrastructure practice. In fact, ‘infrastructure projects should be developed to bring benefits across all aspects, including economic, social, and environmental’ (Shen et al. 2011, p.442). The National Science Foundation (NSF) 1992 report continues by stating that “the solutions to infrastructure problems are probably 5% technical and 95% social, political, environmental, and economic” (Sparrow 2001, p.299). Hunt et al. (2005) refers to sustainable development pillars as environmental protection, social progress, and economic growth. This statement is supported by Sahely et al. (2005) who state: “Sustainable development is truly about achieving a balance between several objectives (environmental, economic, and social) over dynamic time and spatial horizons” (Sahely et al. 2005, p.73).

The triple-bottom-line is also included when referencing sustainability approaches, practices and assessment techniques for infrastructure. “The main objective of enhancing sustainability is to integrate interlinked elements of economics, social, and environmental efficiency into a system that can be maintained in a healthy state” (Koo et al. 2009, p.766). PERSI (2006) continues by stating that techniques for practice assessment should apply a whole life-cycle approach which considers all three pillars of sustainability. Furthermore, although no standard definitions are found for the sustainability of infrastructure types, such as ‘sustainable transportation system’, Johnson et al. (2010) state the common use of addressing the three pillars is made to describe a sustainable system (Johnson et al. 2010). “Determining whether a transportation system is sustainable or not involves figuring out how well the system is dealing with economic, environmental, and social well-being concerns” (Johnson et al. 2010, p.304).

3.0 Municipal Authorities

The first step towards achieving the desired multidisciplinary approach in municipal infrastructure decision making is to determine which departments are directly responsible for the urban infrastructure within each municipality. The urban infrastructure included within the scope of this research includes water, waste, transportation, parks & recreation, urban forests, and energy. The municipalities referred to in this report consist of the 54 medium population centres across Canada, which have populations of 30,000 to 99,999 (Statistics Canada 2011). Medium population centres were selected as they provide the opportunity to establish a multidisciplinary decision making approach that could be used as a benchmark for potentially over 95% of all population centres. In 2006, 9% of the Canadian population was located in 6% of the population centres, meaning this population was located in 54 medium scale centres. At this same time, 32% of the Canadian population lived in 812 small scale population centres. These centres represent over 90% of the population centres in Canada and thus, looking forward in population growth, a significant percentage of these small centres will reach the medium scale in either the short or long term (Statistics Canada 2011). Therefore, setting a strategic plan benchmark at the medium scale has the potential to instill sustainable development for both current medium centres and in small centres while they are growing.

3.1 Methodology

In order to identify the departments responsible for the urban infrastructure within each medium population centre, research was conducted for each centre independently. The information collected for this research was public information found on the municipality websites. All municipal departments responsible for the municipal infrastructure included in the scope of this research were listed and categorized under the municipality name and province. Each municipal department was then reviewed further to identify each division within these departments. These divisions were then listed and organized accordingly. For the purposes of this research, the departments were categorized as a Level 1 authority, while the divisions within these departments were categorized as a Level 2 authority. This was repeated for each 54 population centre. Once the data compilation was completed for all municipalities a qualitative content analysis was performed to identify common categorization and organization of municipal authorities (i.e. departments) across Canada.

3.2 Analysis

The qualitative content analysis was a directed content analysis with the unit of text analyzed being one word. Coding was checked (and rechecked) to assure consistency between all medium population centres. The steps for this analysis were organized under seven consecutive tasks as recommended by Johnson and Christensen (2008). These tasks are as follows:

Table 1: Municipal Department Qualitative Analysis Process.

STEP	PROCESS	FINDINGS
1	Data Entry	Compiled in Excel sheets, under Municipality name and province
2	Segmentation	Level 1 (Department Names), Level 2 (Division Names)
3	Coding	Planning, Community, Development, Engineering, Parks, Recreation, Culture; Operations; Public Works; Public Services; Infrastructure; Environmental (major themes)
4	Categories	Community Services, Planning & Development Services, Engineering & Operational Services (resulting categories)
5	Relationships	See Table 2 for examples of Level 1 and Level 2 counts and relationships
6	Diagrams	*Not shown in this paper.*
7	Validation	Coding consistency and survey questionnaire (next research step)

Table 2: Level 1 (in bold) and Level 2 Categorization Snippet for Municipal Infrastructure Authorities.

Parks, Recreation, Culture (22)	**Community (27)**	**Planning (33)**	**Development (25)**	**Engineering (25)**
Recreation (12) Parks (10) Facilities (6) Culture (4) Centres (2) Events (2) Planning (2) Leisure (Dev.) (2) Vie Communautaire* (2) Building Permits (1) Business Operations (1)	Recreation (15) Parks (14) Cultural (13) Centres (10) Planning (8) Transportation (7) Economic (Dev.) (6) Community (6) Social Planning (6) Facilities (6) Building (5)	Planning (27) Building (23) Development (6) Community (5) Economic (Dev.) (5) Special Projects (2) Animal Control (1) Construction (1) Engineering (1) Environment (1) Housing (1)	Planning (30) Building (17) Development (9) Engineering (5) Community (4) Economic (Dev.) (4) Heritage (3) Utilities (2) Sustainability (2) Infrastructure (2) Environmental (2)	Engineering (12) Transportation (11) (Capital Public) Works (9) Water (8) Building (7) Roads (7) Planning (6) Construction (5) Environmental (4) Sanitation (4) Parks (3)
Operations (12)	**Public Works (15)**	**Public Services (16)**	**Infrastructure (8)**	**Environmental (6)**
Water (9) Transportation (7) Public Works (5) Engineering (4) Roads (4) Fleet (4) Utilities (3) Parks (3) Solid Waste (3) Building (2) Airport (2)	Water (15) Transportation (11) Roadways (8) Municipal (Public) Works (6) Engineering (6) Sanitation (6) Environmental (4) Building (4) Fleet (3) Operations Management (2)	Water (9) Roads (9) Parks (7) Public Works (5) Mechanical (5) Building (4) Community (4) Planning (2) Recreation (2) Emergency Services (2) Green Spaces (2)	Public Works (5) Planning (5) Engineering (5) Environmental (4) Transportation (4) Water (4) Fleet (3) Parks (2) Utilities (2) Urban Construction (2) Building (2)	Water (7) Transportation (4) Environmental (2) Engineering (2) Sanitation (2) Building (1) Construction (1) Horticulture* (1) Interception* (1) Mapping (1) Operations (1)

* Words from the Province of Quebec; these remained French during the analysis.

3.3 Results

After performing the qualitative content analysis, the words within the Level 1 and Level 2 categories were coded and categorized. The Level 2 authorities were organized under the Level 1 category which received the highest count for that authority. For example, if the word 'planning' (Level 2) had 30 counts under Development (Level 1) and lesser counts in the remaining Level 1 categories, it was categorized under Development. Similarly, if two groups of Level 1 categories had similar Level 2 categories, such as Planning and Development, these were then formed into one Level 1 category. In result, the Level 1 categories were organized under three overarching department names. The resulting Level 2 categories with the highest counts were also organized accordingly. The final resulting Level 1 and Level 2 authorities are listed in Table 3.

Table 3: Infrastructure Authority Level 1 & 2 Categories for Canadian Medium Population Centres.

Community Services	**Planning & Development Services**	**Engineering & Operational Services**
Recreation & Leisure	Planning	Engineering, Design, & Construction
Culture & Heritage	Building	Transportation, Roadways, & Fleet
Parks & Cemeteries	Development	Public Works & Infrastructure
Centres & Events	Special Projects	Water & Flood Protection
Community & Emergency	Sustainability	Environment & Horticulture
Facilities & Property		Waste Management
Social Planning & Housing		
Economic Development		

4.0 Municipal Sustainability

After gaining an understanding of the municipal departments responsible for urban infrastructure, it is important to also gain an appreciation of what these municipalities envision in terms of having a sustainable municipality. Given the strong link acknowledged in the literature between infrastructure and municipal sustainability, it is crucial to guide municipal infrastructure decisions toward achieving sustainability. In order to achieve and continuously improve towards the dynamic goal of sustainability, the principles, priorities, and goals of each municipality should be carefully reviewed and understood. As these will provide a good foundation for the changes needed within municipality decision making.

4.1 Methodology

In order to identify the sustainability principles, priorities and goals of each medium population centre, research was conducted for each centre independently. This data was also organized under the Municipality name and province. Each municipality was reviewed individually to identify sustainability themes and categories. Once the data compilation was completed for all 54 Municipalities, the data was organized under the three headings (principles, priorities, and goals) for each province, as shown in Table 4. This information was then analyzed through a qualitative content analysis to identify major and supporting themes for the sustainability of the Canadian medium population centres.

Table 4: Snippet of Sustainability Data Compiled per Province

Province	**Principles**	**Priorities**	**Goals**
British Columbia	Waste Diversion I Water Conservation I Triple-Bottom-Line III Leadership I Innovation I	Sustainability Planning II Waste Reduction II Energy Conservation IIIII Renewable Energy II Food security II	GHG Emissions Reduction II Pesticide-free I Reduction resource use I Pollution reduction I Protect Air Quality I
Ontario	Sustainable community III	Community Sustainability I	Infrastructure investment I

	Creative community III Community Pride II Responsibility II Beautification I Environment III	Conservation I Economic development IIIII Financial Stability I Connected community I Green initiatives I	Transportation networks III Waterfront acquisition II Showcasing community I Tourism destination II Visual appearance I

4.2 Analysis

The qualitative content analysis was a directed content analysis with the unit of text analyzed being a theme, namely any size of text which represent a theme. Coding was checked (and rechecked) to assure consistency between all medium population centres. The steps for this analysis were organized under seven consecutive tasks as recommended by Johnson and Christensen (2008). These tasks are as follows:

Table 5: Municipality Sustainability Qualitative Analysis Process.

STEP	PROCESS	FINDINGS
1	Data Entry	Compiled in Excel sheets, under Municipality name and province
2	Segmentation	Canadian municipalities' principles, priorities, and goals
3	Coding	Environment, Economic, Social/Cultural, Transportation, Community, and Leadership (primary themes)
4	Categories	Air, Energy, Environment, Natural Systems, Sustainability, Waste, Water, Economy, Financial, Fiscal, Social, Cultural, Heritage, Access, Networks, Fleet, Community, Qualities, Governance, and Planning
5	Relationships	See Table 6 for examples of theme categorization relationships. This was conducted for each principles, priorities, and goals. Table 4 illustrates the theme count analysis for sustainability principles
6	Diagrams	*Not shown in this paper.*
7	Validation	Coding consistency and survey questionnaire (next research step)

Table 6: Example of Data Analysis for Sustainability Themes within Municipality Principles

Community/Qualities	Economic	Environment
Citizen Engagement IIIIII Creative Community III Sustainable Community III Accountability III	Diverse Economy I Economic Prosperity I Fiscal Affordability I Sustainable Economy I	Energy Management I Environmental Conservation I Environmental Sustainability III Resource Management I
Leadership	**Social/Cultural**	**Transportation**
Innovation III Leadership IIIIII Partnership III Integration I	Culture IIIIII History I Social Equity I Social Security I	Accessibility II Connectivity I Accessible Parks & Green Spaces I Well-connected Bike/Pedestrian I

4.3 Results

After performing the qualitative content analysis, the major and supporting themes where categorized accordingly to the final counts. The supporting themes were organized under the major themes which received the highest count for that theme. If two groups of major themes had similar supporting themes, such as Community and Quality, these were then formed into one major theme category, named Community. In result, there were six major themes and nineteen supporting themes. The final resulting categorization of major and supporting themes are listed in Table 7.

Table 7: Final categorization for Sustainability Principles, Priorities, and Goals

Categories	Sub-Categories
Community	Development; Community Quality
Economic	Economical; Financial
Environment	Air; Energy; Environmental Quality; Natural Systems; Sustainability; Waste; Water
Leadership	Governance; Planning
Social (& Cultural)	Cultural; Heritage; Social
Transportation	Accessibility; Networks; Fleet Management

5.0 Discussion

The findings presented in this report illustrate the preliminary investigation of municipal infrastructure authorities and municipal authority. The results provide a good foundation for the next research step, which is a survey questionnaire. This questionnaire will be sent to directors and managers within all Level 1 departments throughout the 54 medium population centres. Therefore, through the survey questionnaire, the results for both municipality decision making and sustainability in this report will be validated and further investigated. The findings from the survey will then serve as the foundation for a multidisciplinary decision making framework that will be validated through multiple case studies in three of the 54 medium population centres. The case studies will allow the decision making framework to be put into practice and molded based on professional experience, practice, and municipality needs.

6.0 Conclusion

This report presents the preliminary research findings for 54 medium population centres in Canada. The results demonstrate that the municipal authorities responsible for the infrastructure decision making can be categorized into three stems, while sustainability themes for municipal principles, priorities and goals can be categorized in six major themes. These findings will be further validated through a survey sent to directors and managers of the municipal departments responsible for urban infrastructure.

7.0 References

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