



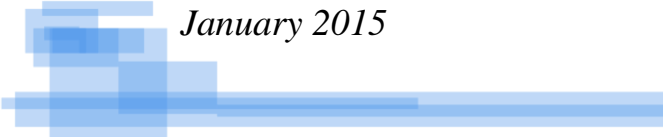
Uncertain Foundation

Infrastructure in rural Canada

*Report to the Rural Policy
Learning Commons –
Infrastructure and Services
Theme Team*

*By: Sarah-Patricia Breen,
Ph.D. Candidate, Simon
Fraser University*

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Executive Summary

Challenges and issues surrounding rural infrastructure are well recognized, as is the critical importance of infrastructure to rural communities. This report reviews a range of literature and provides an overview of: i) relevant background information; ii) the current state of infrastructure in Canada; iii) the infrastructure deficit, including potential solutions and; iv) a rural specific discussion. This report focuses on local level physical infrastructure that is publically accessible, service providing, and predominantly owned, operated, funded, and regulated by government.

In terms of importance, infrastructure provides a foundation for the economy, serving as the basis for production and competition, as well as facilitating the exchange of goods and services. Beyond its economic role, infrastructure provides services critical to quality of life, such as access to water and electricity. Additionally, there is increasing recognition of the interplay between infrastructure and the environment, highlighting the potential for infrastructure to support sustainable development and community resilience.

There is one uniform message throughout the literature – that of the critical issue currently presented by infrastructure. Beyond that, the literature reviewed illustrates how differences in definition, methods, data, approach, scope, and bias results in a wide range of reports concerning severity, causes, costs, solutions, and so on. Of the issues and challenges facing infrastructure, it is the ‘infrastructure deficit’, the gap between what is needed and what is available which is the most pervasive. This is a complex concept, as there are various combinations of factors that contribute to the infrastructure deficit, such as: infrastructure age, institutional restructuring and policy change, lack of planning and asset management, financial issues, contextual changes, and a growing disconnect with infrastructure. There are a number of ideas surrounding new approaches

and solutions for addressing the infrastructure deficit including changes in regulation, planning and management; improvements surrounding data and information; the need for long-term financial stability; potential for public-private-partnerships, and the need to account for factors such as place and climate change.

When it comes to existing data and information, an important take-away message from this literature review is that there is a clear gap in available data and information, both in terms of infrastructure quality and quantity. This is particularly relevant for rural communities because quality and access to such information informs future decisions and actions, positively or negatively.

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1. Introduction

The characterization of infrastructure in Canada as a dire problem, “of the same order as the accumulated federal debt” is common ¹. While infrastructure provides the foundation for society by facilitating economic activity, supporting quality of life, and interfacing with the surrounding environment, our infrastructure foundation is currently facing multiple challenges. As a result, growing attention is being paid to infrastructure, attempting to not only address the issues, but also to understand the breadth and depth of the situation, particularly as it applies to specific situations (e.g., rural Canada). This report is a review of current literature and is intended to:

- i. Provide pertinent background information: defining infrastructure, identifying relevant actors, and discussing infrastructure importance;
- ii. Review the state of infrastructure based on assessments and inventories;
- iii. Provide an overview of the infrastructure deficit, including potential solutions; and
- iv. Provide a discussion of the information and its relevance for rural Canada.

2. Methods

This literature review used academic and other online search engines to conduct targeted searches. Additionally, websites of specific organizations (e.g., the Federation of Canadian Municipalities (FCM)) were targeted as a result of specific involvement with infrastructure. The focus is on the Canadian context, although any resulting international examples were reviewed. While rural Canada is of particular interest, both rural and urban literature was considered. Over 130 documents were reviewed, including peer reviewed articles, books/book chapters, grey literature (e.g., reports, policy briefings), and web pages. No primary data was collected, nor were plans (e.g., Official Community Plans), political mandates, or budget documents considered.

3. Background Information

This section provides relevant background, including: defining and categorizing infrastructure, identifying relevant actors, and discussing the importance of infrastructure.

3.1. Definitions and categorizations

There are many ways to define and categorize infrastructure and while this report provides its own [definition](#), this section reviews different definitions, as well as the different categorizations of infrastructure. Firstly, it should be recognized that there is no single agreed upon definition of infrastructure, although the potential benefits of a common definition and defensible system of categorization are recognized ². In part this is because infrastructure is an evolving term, with aspects such as electronic and cultural infrastructure and services such as utilities being added to more traditional infrastructure types (e.g., roads, railways, seaports) ³⁻⁶. While the term infrastructure often brings to mind the physical element of large, long-lasting systems (i.e., ‘hard infrastructure’), infrastructure can also include ‘soft infrastructure’ (i.e., non-tangible, service related) such as education, judicial, health, as well as both constructed and natural facilities ^{4,7-9}. Infrastructure can be described as the built environment providing the foundation that supports the existence, development, and survival of society ^{10,11}. The long time frames associated with infrastructure mean that there are no good short to medium term substitutes, and the range of what is included can make it difficult to maintain inventories ^{2,12}.

Alongside the lack of universally accepted definition of infrastructure comes differences in how infrastructure is categorized. Differences in how infrastructure is defined are often based on different categorizations, generally sub-sets of the broader definition based on characteristics such

as: scale, actors, importance, and various others. The two infrastructure categorizations most relevant to this report are municipal and public infrastructure.

‘Municipal infrastructure’ is focused at the local scale (e.g., community, municipality, region). Some definitions focus on particular types of infrastructure, such as drinking water, wastewater treatment, municipal roads and bridges, community and social infrastructure, and sports and recreation infrastructure ¹³. Other definitions are broader and include: buildings, structures, facilities, equipment, furnishings, development and purchase of land, plus many other associated items ¹⁴. Often ‘municipal infrastructure’ will focus on infrastructure owned and operated by local government ⁸. However, this is not always the case as some critical local level infrastructure is under the jurisdiction of other actors, both government and non-government.

‘Public infrastructure’ is a broader categorization. Characteristics of public infrastructure are similar to that of a public good: non-excludable, non-rivalrous, often provided free with no market price ¹⁵. In terms of scale, public infrastructure is multi-scale ^{15,16}. However, as with infrastructure generally, there is no widely accepted definition even within this category ³. Some definitions include only hard infrastructure (e.g., roads, bridges), while others include soft infrastructure as well (e.g., human and software capital) ¹⁶. One definition includes only so-called ‘core’ infrastructure (e.g., roads, water, sewer), while another includes multiple broad categories (e.g., transportation, support systems, and social) ^{15,17}. In terms of ownership and operation, public infrastructure is most often associated with government, but government at any level ¹².

In addition to municipal and public infrastructure, there are categorizations based on importance, such as critical infrastructure, defined as the infrastructure systems without which it would not be possible to operate buildings, emergency response systems, and other infrastructure

¹⁸. This also includes categorization based on function, such as: basic/primary, support, protective, high tech, amenities, knowledge based, health infrastructure, and so on, although what is included in each varies ^{2,3,9,19}.

Finally, there are various other qualities that allow for the categorization of infrastructure. For example ‘sustainable infrastructure’ is the design, construction, and operation of infrastructure in ways that do not diminish social, economic, and ecological processes both presently and in the future ^{7,11}. Sustainable infrastructure includes new infrastructure, as well as re-design, rehabilitation, re-use, and optimization of existing infrastructure ⁸. Different categorizations often overlap. For example, one source discussed consideration of factors like climate change in municipal infrastructure, illustrating overlap between municipal and sustainable categorizations ¹³.

For the purposes of this report ‘infrastructure’ focuses on hard infrastructure at the local level that is publically accessible or service providing. However, readers should note that due to the differences in definitions and categorizations, the summarization and comparison of existing literature and data can be challenging ^{3,4,10}.

3.2. Actors

There are many actors that play a role in the different aspects of infrastructure. This includes specific actors (e.g., architects, engineers, planners) and general (e.g., private industry). However, given the above [definition](#), this report focuses primarily on government actors. When it comes to infrastructure, the local, provincial, and federal level of governments share some degree of responsibility ⁸. At the federal level, Infrastructure Canada is the primary ministry responsible for infrastructure, including: investment and funding, engagement in partnerships, and the development and implementation of policies ²⁰. There are multiple ministries responsible for

federally owned infrastructure. At the provincial level there are ministries directly involved with provincially owned infrastructure, as well as ministries responsible for local level programs and funding, which differ from province to province. Both the federal and provincial levels play roles in terms of the funding and regulation of infrastructure. At the local level, municipalities own and maintain the majority the infrastructure in Canada ^{21,22}. Within municipal or regional governments, depending on their size, infrastructure can involve departments such as planning, engineering, and public works. Table 1 provides examples of core responsibilities for different actors.

Table 1: Infrastructure Actor Examples^{8,21,23–25}

Actor	Responsibilities
Federal Government	<ul style="list-style-type: none"> • Large assets: airports, railways, seaports, ferries, military/defence, national parks • Programs (e.g., gas tax fund, Building Canada Fund)
Provincial Government	<ul style="list-style-type: none"> • Large assets: highways, transportation facilities (e.g., ferries and airports), energy infrastructure, health, education, provincial parks • Crown corporations • Funding programs
Local Government	<ul style="list-style-type: none"> • Infrastructure that services the community (e.g., streets, sidewalks, water, sewer, parks, storm water)
Other	<ul style="list-style-type: none"> • Private utilities, communication • Community groups (e.g., recreation, arts, culture) • Industry

3.3. Importance

Society and infrastructure are intricately linked, “[w]here humans go, so eventually do walking trails, trade routes, highways, and communications networks. In turn, the distribution of infrastructure, whether embodied in ports, rail lines, or grain-handling facilities, steers the subsequent distribution of people and their economic activities” ⁶. The past, present, and future importance of infrastructure is well recognized across all types of literature ^{26,27}. Survey data collected within Canada suggests that alongside health care, Canadians view community

infrastructure as important to protect from spending cuts ^{28,29}. The following sections discuss the general importance of infrastructure, although it is important to understand the three interrelate.

3.3.1. Economic

The economic importance of infrastructure is highly visible within the literature. The quality and quantity of infrastructure is seen as a foundational element of the economy and a driver of prosperity, productivity, and growth, necessitating both investment and attention ²⁹⁻³³. Much research has been done on this subject, such as the exploration of links between public infrastructure investment and economic productivity^{15,31}, as well as how infrastructure helps to determine an economy's capacity for production and consumption ³⁴. Infrastructure supplies critical services, allowing goods to be produced, and goods and people to move efficiently ^{9,20,33}. The literature reviewed clearly identified that without the necessary infrastructure systems (e.g., electricity grids, drinking water pipelines) economies will not grow to meet their full potential, nor will they be as competitive ^{30,35-37}. Infrastructure is linked with the exchange of knowledge and information, as well as innovation, all key elements of the economy ^{11,33,38}. Additionally, infrastructure is linked to strengthening the economy through job creation and attracting skilled workers ^{20,32,39,40}. The economic element also links with quality of life, as communities that provide a high quality of life, which is also linked to infrastructure, are therefore able to attract, retain, and create the required human capital to remain economically competitive.

Conversely, inadequate infrastructure has been shown to drive away foreign investment, even more so than quality infrastructure attracts, highlighting that it is critical to not allow infrastructure to fall into disrepair ⁴⁰. The costs associated with infrastructure issues include: higher operating costs, lost economic potential and productivity, potential of rising costs in the future,

traffic congestion, lost time, and other foregone economic activities^{3,16,41}. Simply put, “[a] modern economy cannot function without modern, adequate, and efficient infrastructure”³³.

3.3.2. Quality of Life

Much of the literature reviewed noted that high standard of living and quality of life is dependent on infrastructure, which contributes to the health, safety, security, and well-being of individuals and communities^{2,7,11,14,30,31,36,42,43}. This includes infrastructure that facilitates the commodities and services required to meet basic needs, as well as those required to maintain or improve quality of life, including the more typical infrastructure systems (e.g., water), as well as social and cultural infrastructure (e.g., libraries, parks, community centres)^{9,33,44}. Beyond the tangible elements, there are also psychological benefits associated with infrastructure, particularly in a country like Canada where nation building is linked with infrastructure (e.g., railways)^{45,46}.

3.3.3. Environment

Infrastructure is important to ecological well-being, in part because of the negative impacts infrastructure can have on the surrounding environment, necessitating more thoughtful design, investment, and maintenance^{11,32}. The cost of failing to address these issues includes negative impacts on the environment, as well as potential threats to the economy and public health and safety^{3,41}. However, while the need to consider the environment is recognized, surprisingly little attention is generally paid to the role of infrastructure relative to the environment^{7,47,48}.

Infrastructure can play a role in locking communities onto unsustainable paths where infrastructure investments result in long-term unsustainable infrastructure systems that subsequently become tied to other investments^{11,49}. From a resilience perspective infrastructure can act as an inhibitor, where the loss of infrastructure and reliant services can inhibit use of other

community strengths, decreasing resilience⁵⁰. However, infrastructure can conversely increase resilience, acting as a strategy or tool to reduce impact on the environment, aid in mitigation and adaptation, and facilitate sustainability^{40,50-52}.

4. The state of infrastructure: assessments and inventories

The literature review yielded a number of infrastructure inventories intended to provide a list and assessment. Throughout these inventories, infrastructure is defined, sub-divided, and assigned an assessment such as a letter grade or dollar figure required. Table 2 provides an overview of the more comprehensive inventories.

In addition to these inventories, the literature review examined many different assessments, including inventories specific to certain infrastructure types or certain locations, studies of the causes of infrastructure issues, surveys, and so on. For example, there are specific analysis of drinking water infrastructure, such as the estimated \$250 billion in investment required in the United States², or the consolidation of water and waste water deficit estimates and inventory reports by the Canadian Water and Waste Association⁵³. In terms of location, there are provincial specific examples, such as a survey from the Union of British Columbia Municipalities⁵⁴, or a report focused on infrastructure in western Canadian cities³. There are also attempts to agglomerate and analyse multiple assessments, such as the overview produced by the TD Bank Financial Group examining range of deficit numbers and discussing how these numbers were achieved¹⁶. Infrastructure is also included within more general reports, such as the FCM reports on ‘The State of Canada's Cities and Communities’^{19,55}. Overall, the examples reviewed indicate a ubiquitous message that infrastructure requires attention. Beyond that however, there is a wide range of statuses, estimates, and other messages (see Section 6.1).

Table 2 Inventory Examples

Report	Reference (author/org/year)	Focus	Details
Report card for America's Infrastructure	American Society of Civil Engineers, 2013 ⁵⁶	<ul style="list-style-type: none"> • 16 infrastructure categories • Multiple scales 	<ul style="list-style-type: none"> • Methods: infrastructure assessed using grading criteria and recent aggregate data sources • Findings (letter grades): <ul style="list-style-type: none"> • Dams: D (poor: at risk) • Drinking water: D (poor: at risk) • Hazardous waste: D (poor: at risk) • Levees: D- (poor: at risk) • Solid waste: B- (good: adequate for now) • Waste water: D (poor: at risk) • Aviation: D (poor: at risk) • Bridges: C+ (mediocre: requires attention) • Inland waterways: D- (poor: at risk) • Ports: C (mediocre: requires attention) • Rail roads: C+ (mediocre: requires attention) • Roads: D (poor: at risk) • Transit: D (poor: at risk) • Parks and recreation: C- • Schools: D (poor: at risk) • Energy: D+ (poor: at risk) • Infrastructure Deficit: notes cost of deferred maintenance to be \$3,100 per family per year. Includes needs, funding, funding gap for each category • Rural: Comments on rural/urban differences
Canadian infrastructure report card Volume 1: 2012 Municipal Roads and Water Systems	FCM, 2012 ⁵⁷ Update underway	<ul style="list-style-type: none"> • 4 asset categories • Municipal scales 	<ul style="list-style-type: none"> • Method: Consolidates data from voluntary survey • Findings (1-5 rating system): <ul style="list-style-type: none"> • Drinking water: 4 “good” – adequate for now • Wastewater systems: 4 “good” – adequate for now • Stormwater systems: 5 “very good” – fit for the future • Roads: 3 “fair” – requires attention

Report	Reference (author/org/year)	Focus	Details
			<ul style="list-style-type: none"> • Infrastructure Deficit: cited as \$123 billion for municipal infrastructure and offers specific estimates for each of the above • Rural: rural statistics on assets and infrastructure life
Roads to Rinks	Roy, 2008 ⁵⁸ Statistics Canada	<ul style="list-style-type: none"> • Macro regions (Atlantic, Quebec, Ontario, Prairies, British Columbia) • 15 government owned infrastructure categories 	<ul style="list-style-type: none"> • Method: analysis of government investment 1961-2005 • Findings (trends): <ul style="list-style-type: none"> • Region: infrastructure per capita below peak • Government type: decline in ownership by province or federal government relative to municipal • Asset type: differs by type across regions • Infrastructure Deficit: NA • Rural: NA
The State of Infrastructure in Canada: Implications for Infrastructure Planning and Policy	Mirza, 2003 ²² McGill, FCM	<ul style="list-style-type: none"> • Municipal scale • 5 municipally owned infrastructure categories 	<ul style="list-style-type: none"> • Methods: i) literature review, ii) survey of sample municipalities to provide a snapshot of current municipal infrastructure needs, iii) analysis of survey results and conclusions • Findings (estimated debt): <ul style="list-style-type: none"> • Water and wastewater: \$31 billion • Transportation: \$21.7 billion • Transit: \$22.8 billion • Cultural, social, community and recreation: \$40.2 billion • Waste management: \$7.7 billion • Infrastructure Deficit: \$123 billion for municipal infrastructure • Rural: mentions rural factors
Age of Public Infrastructure: A Provincial Perspective	Gagnon <i>et al</i> ¹² , 2008 Statistics Canada	<ul style="list-style-type: none"> • Multiple scales • 5 key public infrastructure categories 	<ul style="list-style-type: none"> • Methods: statistical analysis • Findings: <ul style="list-style-type: none"> • Since 2001 the average age of public infrastructure in Canada has been falling

Report	Reference (author/org/year)	Focus	Details
			<ul style="list-style-type: none"> • Differs by province with Nova Scotia as the oldest and BC as largely newer • Water supply noted as youngest, with wastewater treatment oldest relative to useful life • Infrastructure Deficit: NA • Rural: NA
A Capital Question Infrastructure in Western Canada's Big Six	Ploeg ³ , 2003 Canada West Foundation	<ul style="list-style-type: none"> • Urban (6 cities in western Canada) • Municipal infrastructure 	<ul style="list-style-type: none"> • Methods: i) literature review, ii) construction of 3 databases on past capital spending, iii) economic model • Findings (deficit by city): <ul style="list-style-type: none"> • Winnipeg: \$289 million • Edmonton: \$188 million • Regina: \$167 million • Calgary: \$150 million • Saskatoon: \$147 million • Vancouver: \$87 million • Infrastructure Deficit: cities: \$564 million, municipal: \$57 billion, all governments in Canada: \$125-\$130 billion • Rural: issue of aggregating rural and urban data
The Canadian Productivity Review Infrastructure Capital: What is it? Where is it? How much of it is there?	Baldwin and Dixon ² , 2008 Statistics Canada	<ul style="list-style-type: none"> • Public infrastructure (8 categories) • Multiple scales 	<ul style="list-style-type: none"> • Methods: i) literature review, ii) statistical analysis • Findings: <ul style="list-style-type: none"> • Defines public infrastructure • Analysis by type, owner, functions, spending, etc. • Infrastructure Deficit: NA • Rural: NA
Public infrastructure in Canada: Where do we stand?	Harchaoui <i>et al</i> ⁵⁹ , 2003 Statistics Canada	<ul style="list-style-type: none"> • Public infrastructure 	<ul style="list-style-type: none"> • Methods: statistical analysis • Findings: capital stock assessment by infrastructure type, size and value of public infrastructure stock in Canada, historical trends • Infrastructure Deficit: NA • Rural: NA

5. The Infrastructure Deficit

There are various issues and challenges related to infrastructure. While some are place-specific, others are more ubiquitous. Of these, the ‘infrastructure deficit’ is likely the most oft cited and well-studied as it is an issue faced by all levels of government⁶⁰. Thus, while the infrastructure deficit is not the only challenge, and is indeed not even a singular challenge unto itself, the infrastructure deficit will be the primary focus of this section: what it is, its causes, influencing factors, resulting issues, and potential solutions. It is important to note that there is no single ‘smoking gun’ in terms of cause, nor a single ‘silver bullet’ in terms of solution.

5.1. Definition and size

The infrastructure deficit was initially noticed in the 1990s as awareness grew surrounding the neglect of infrastructure assets within Canada, as well as within other OECD countries and around the world^{15,29,61}. Unlike infrastructure, the infrastructure deficit enjoys a largely agreed upon definition: the gap or shortfall between what is needed and what is available to meet required maintenance, bring existing infrastructure to acceptable levels, or replace existing infrastructure^{3,16,17,31,41,49,62–65}. Some authors specify between the annual deficit and the total accumulated debt, or backlog of required infrastructure maintenance and replacement^{3,41}. What is not included are those shortfalls pertaining to what new infrastructure is needed or required^{3,62}.

Throughout the literature the infrastructure deficit is noted as growing, often estimated at a rate of \$2 billion per year^{8,22,66–68}. Estimates of the deficit size varies, in part due to differences in variables such as the definition and categorization of infrastructure, time frame, methods used, and data included^{16,30,41}. Within Canada an oft cited calculation is a \$123 billion deficit of municipal infrastructure, plus an additional \$115 billion in new municipal infrastructure required, and a total

of between \$300-\$400 billion if provincial and federal infrastructure is included ²². Regardless of the exact figure, what is critical is that the total exceeds what most governments could viably address under the status quo ¹⁶.

5.2. Causes and influencing factors

Understanding where the infrastructure deficit came from is acknowledged as critical in order to move forward ⁴¹. As noted previously there is no single cause of the infrastructure deficit, but rather different combinations of factors. Additionally, the interrelationships between factors can further exacerbate issues, making it difficult to fully separate causes from other influencing factors. For example, a change in technology, need, regulation, or standard both contributes to infrastructure issues as a cause, as well as altering the situation ¹⁶. A generalized consolidation of commonly cited causes and influencing factors are presented below in no particular order.

- **Infrastructure age** ^{8,16,22,31,41,43,44,49,65}: average age has been increasing since the 1970s, with rapid aging due to neglect and systems reaching the end of their useful life. As this develops over time it makes the infrastructure deficit more of a chronic issue than a crisis.
- **Institutional restructuring and policy change** ^{1,8,14,16,22,30,35,41,43,44,62,63,65,68-72}: these changes have both deliberate and unintentional impacts, including: i) downloading of responsibilities to the local level without reliable funding, required capacity, greater flexibility, or power; ii) changes in regulations and standards increase requirements on already burdened actors, as well as creating complex, timely, and inappropriate processes; iii) lack of meaningful and appropriate program design.
- **Lack of planning and asset management** ^{11,16,29,35,41,61,63,66,70,71}: i) poor maintenance of infrastructure; ii) lack of life cycle costing and incorrect pricing (e.g., difference between cost, price, and value); iii) inadequate management approaches; iv) short term focus; v) a lack of integrated planning; vi) a disconnect between planning and implementation; vii) a need for accountability and innovation; viii) a lack of use of best practices.
- **Financial issues** ^{3,8,14-16,22,29,31,41,44,49,55,60,62,65-68,70,71,73}: decreased investment was not unexpected following initial investment, however the expected echo wave of re-investment and renewal has lacked. Financial issues include: i) chronic underinvestment relating to fiscal restraint, austerity measures, and recessions; ii) inadequate financial tools, both in terms of funding (e.g., incremental funding geared toward new assets at the expense of

exiting, short term funding based on upper level priorities) and reliance on inappropriate fiscal tools (e.g., property taxes which are not guaranteed to rise alongside the cost of services; iii) inability to run deficits at the municipal level; iv) increasing project cost; v) growing fiscal imbalance between levels of government; vi) competing budget priorities.

- **Contextual changes** ^{7,8,16,22,35,41,60,62,63,66,68}: this includes i) changes in population; ii) change in the size and shape of communities (e.g., sprawl and suburbanization); iii) economic changes; iv) changes in demands for services; v) climate change. These changes occur without commensurate budget increases or additional capacity.
- **Growing disconnect** ^{6,41,70,74}: infrastructure systems are often ‘out of sight out of mind’ and face challenges like free ridership, highlighting a growing need for education and leadership.

5.3. Resulting issues

The importance of infrastructure was highlighted in Section 3.3, along with some indication of potential costs and consequences, many of which are related to the infrastructure deficit. Many of the factors discussed above result in increased risk and liability surrounding infrastructure systems ^{7,8}. This is further complicated by the need to consider constant change and an increasingly global world ⁶¹.

Cost and economic impacts are prominent in the literature. For example there is the cost of deferred maintenance. Capital spending is noted as one of the first to be cut in during periods of austerity, potentially because while infrastructure spending has long term benefits, it also has short term political consequences ³. In this way it is possible to see the infrastructure deficit as an indicator of a larger fiscal imbalance, where all or part of a financial debt is transferred to a physical one ^{44,67}. De Sitter’s ‘Law of Fives’ indicates that if required maintenance is ignored the eventual cost of rehabilitation will equal five times that of the original maintenance costs, resulting in overall higher costs for government, business, and individuals, as well as potential environmental and social impacts ³. Canada’s eroding infrastructure presents a serious risk not only to the

economic competitiveness of the country, but to quality of life ^{16,17,67}. It has been acknowledged that existing infrastructure facilities are inadequate when it comes to meeting present requirements, as well as those required by projected growth and development, and underinvestment in infrastructure has been linked to loss in real GDP growth ^{29,60}. The infrastructure deficit is also noted as impeding sustainability, in part as a result of the path dependency created by past decisions and the long term nature of infrastructure ^{30,69}.

5.4. Potential solutions

Attempts to address the infrastructure deficit, as well as other infrastructure issues are not new. For example, the FCM initially established an infrastructure task force in 1983 and continue to work on this issue today ⁶⁰. A number of solutions, strategies, and approaches are offered throughout the literature, including applied and theoretical approaches, as well as both specialized and general ideas. While the size of the financial cost and concerns over where money will come from are critical elements, the common refrain that the solution is more money is incorrect, as the overall infrastructure deficit is complex, requiring a mix of innovative and creative solutions supported by a long-term, multi-disciplinary approach that includes improving planning, delivery, and operation, and involves multiple actors ^{18,22,29,35,41,42,61}. Often it is not the case of picking one approach or the other, but combining approaches, as despite commonalities, the needs of each situation and place are shaped by local factors such as demographics, geography, and the economy ⁶³. Actions at one level (e.g., increased efficiency at the municipal level) will not negate actions needed at another (e.g., the need for new funding sources provided by the provincial or federal government), nor will maintaining existing infrastructure negate the need for modernization ⁶⁸.

There are many examples of past and present programs addressing infrastructure, illustrating the variety of the approaches available, the different actors involved, the potential for innovation, as well as the differing expectations and perspectives (e.g., the existing PS 3150 inventory requirement, and various infrastructure guides and best practices)^{13,14,21,39,40,64,75–83}. This section presents a generalized overview of ideas and solutions, in no particular order, some of which are beginning to appear in more recent programs and policies (e.g., the new Building Canada Plan appears to reflect suggestions for the need to have dedicated funds for rural communities⁸⁴). It should be noted that while many ideas work in combination, some are contradictory, demonstrating the differences of opinion that exist. Nor are the ideas listed without challenges.

- **Change in regulation, planning, and management**^{8,14,16,18,30,31,35,36,39,41–44,49,55,60–63,68,70,71,73,82,85–87}: this wide reaching category includes action by all levels of government. Included is the need for i) asset management and asset management planning (e.g., attention to life cycle, full cost accounting, and rehabilitation of deteriorating infrastructure); ii) long-term integrated planning; iii) gains in efficiency and improved service delivery through improved productivity, reduction in cost, and boosts in capacity; iv) ongoing analysis and evaluation; v) more efficient use of existing capacity and resources (e.g., merges or consolidation); vi) partnerships and collaboration; vii) a national infrastructure plan; viii) use of best practices (e.g., transparency, accountability, equity); ix) clarity in regulation and streamlining of processes; x) changes in the power structure (e.g., increased control at the local level); xi) building capacity; xii) demand management.
- **Data and information**^{3,14,16,18,30,42,63,66}: approaching the infrastructure deficit requires i) further research surrounding issues and solutions; ii) use of evidence based, expert led solutions; iii) creation of infrastructure inventories (e.g., use of GIS); iv) availability of credible and comparable data; and v) knowledge dissemination and engagement.
- **Long-term financial stability**^{11,14,16,29–31,35,36,41,43,60,62,67,68,71,86}: infrastructure requires stable and predictable investment and revenue sources. This includes: i) attention not only the quantity of investment but how investment is made (e.g., strategic investment, such as priority for infrastructure that enhances economic performance); ii) reforms to the available financial tools (e.g., taxes); iii) accurate pricing; iv) increase in funding and clarity in terms of funding programs; v) new and innovative financial tools (e.g., green bonds, community benefit agreements, Infrastructure Banks); vi) alignment of responsibilities with fiscal capacity as well as policy.

- **Private investment and public-private-partnerships** ^{1,11,14,16,36,41,66,71}
- **Accounting for additional factors in design, policy, planning, regulation, and operation:**
 - **Place** ^{12,16,18,32,72,73,85,88,89}: includes consideration of: infrastructure right sizing, scale (e.g., community, regional), local geography, culture, purpose, density, etc.. Need for consultation and avoidance of one size fits all approaches.
 - **Sustainability** ^{7,10,11,44,49,60,62,85,88}: includes: life cycle assessment, full cost pricing, integration in planning and physical systems, knowledge dissemination, use of sustainability frameworks, and integrated community sustainability plans.
 - **Environmental and ecological factors** ^{7,36,71,73}: use of ecological scales (e.g., watershed), integration of source water protection, and consideration of climate change.
 - **Quality of life** ¹: prioritization on infrastructure related to health.

6. Discussion

The following section discusses the literature reviewed, beginning with a discussion of the limitations and issues of available information, followed by a discussion of the literature in relation to the rural context, and finishing with an overview of the international context.

6.1. Limitations and issues

Infrastructure is widely studied and discussed. A large amount of detailed literature from various sources exists surrounding infrastructure and infrastructure issues, both specific to Canada as well as elsewhere. While it is clear that i) there is a problem, and ii) the problem is growing, there remains a wide range of available information, creating both limitations and challenges to interpreting and using what exists.

Differences in how infrastructure is defined and categorized means that inventories and assessments differ in terms of what kinds of infrastructure is included. Differences can also be found in analytical methods, data sources, and other parameters. For example, simplified or agglomerated data can inadvertently be misleading. Provincial or national assessments can neglect to present the details of the range as well as the average, inadvertently smoothing reality. The

combination of urban and rural data also poses a challenge, with such agglomerated data presenting a picture which is not an accurate reflection of either. Such is also the case when multiple types of infrastructure are combined or multiple communities are presented together, as opposed to a detailed analysis of each infrastructure type or community. Additionally, there are clear cases of institutional bias, particularly within the grey literature (e.g., financial institutions favouring financial measures). The result of these issues is a wide range of conclusions, from different financial estimates of the infrastructure deficit, to conflicting reports over the status of infrastructure, to favoring of different solutions. Studies can also fail to account for variables such as rapidly aging infrastructure, demographic changes, climate change, growth, user fee structures, and other context based factors, as well as a failure to account for opportunity costs and other trade-offs – all of which would impact the final results ^{3,16,22}. Even among the suggested solutions different methods and calculations yield differences in projected results, as well as creating additional issues. For example, it is one thing to suggest that those who benefit from infrastructure are those who pay, but how do you calculate benefit, and what role does equity play ^{14,35}?

There are additional challenges with regard to the quality and availability of the data upon which inventories and assessments are made, something which is recognized by some as a highly subjective process ^{3,16,53}. The data and information reviewed ranged from surveys to spending reports. Examples such as the American report card based their assessment on a combination of sources, while the FCM assessment chose a representative survey. One report illustrated six different methods of estimating the infrastructure deficit, all yielding different results ³. Finally, only data and information that exists can be included, suggesting there is data missing where governments, particularly communities, do not participate in surveys or do not track assets.

Overall, an important take away with regard to what is available is that there is a clear gap in available data and information, both in terms of quality and quantity. There is a need for data that is accessible, scalable and searchable.

6.2. The rural context

While this report is intended to focus on the rural Canadian context, there are limitations in terms of what information is available. Documents reviewed acknowledged challenges specific to rural areas (e.g., a rural specific lack of bridges, highways, and airports ⁷¹), as well as rural specific impacts, and rural specific programs. However, the literature lacked in terms of a rural specific ‘state of’ report or inventory, a clear gap in terms of what is available as there were urban specific reports reviewed. Although rural–urban interdependencies make consideration and understanding of both important, there were many general reports including rural and urban, that do not accurately reflect either ^{3,69}. For example, it is suggested that investments in urban areas tend to pay higher returns, while it is also known that resource development requires a certain amount of rural infrastructure to be in place ³¹. One article noted that whatever problems exist for large urban areas tend to be magnified in remote and rural communities, pointing to a need for targeted financial assistance ⁸⁹. However, other literature indicated that while there are infrastructure challenges unique to rural areas, there are also those unique to urban areas ^{56,57}. As noted above, there are some inherent limitations in terms of rural participation. For example, reports based on surveys of municipalities rely on accurate asset management data, something which is more likely to i) exist, and ii) be accurate in larger municipalities due to increased capacity. Some research noted rural specific barriers surrounding capacity, data, and asset management ^{35,90,91}.

Some economic-related infrastructure gaps are more prominent in rural areas. For example, the importance of telecommunications infrastructure for rural, remote, and northern communities “cannot be overstated”¹³, however the absence of broadband in rural areas is noted⁴⁴. Additionally, areas that are rural, remote, or indigenous, can face difficulty attracting and retaining technical skills, capital, and staff, resulting in capacity shortages⁵². Additionally, in rural areas it is noted that a lack of reliable and affordable transportation reduces mobility and creates barriers for access, acting as an obstacle for community development and adding costs and barriers for businesses^{40,47}. This also crosses into impacts on quality of life, as inadequate health infrastructure, a common rural issue, is both serious impediment to economic development and a detriment to quality of life⁴⁴. Other social and cultural infrastructure plays a key role whether communities are able to attract and retain people⁴⁴. Consequently, a lack of infrastructure can decrease quality of life and can make it difficult to ensure the health, security, and safety of residents¹⁶.

Challenges unique to smaller communities were noted, such as the need to build and maintain a full range of infrastructure regardless of population size⁴⁰. Factors such as demographic change (e.g., population loss or aging), limited economies of scale, limited revenue sources, shrinking tax bases, and rising service expectations can all present challenges for rural areas, combined with typical challenges such as aging infrastructure and institutional changes such as the loss of the Rural Secretariat^{19,44,92}. Also found within the literature were examples of past or existing rural specific infrastructure programs developed to address challenges facing smaller communities, as well as rural-specific suggestions for new programs (e.g., infrastructure programs designed to respond to the unique needs and circumstances of rural and northern communities)^{13,19,44,54,71,78,92}. For example, while public-private-partnerships have potential, not all projects will

be attractive to investors due to the slow returns on projects that can be associated with remote and rural areas ¹⁷. It is because of the differences in context between communities, rural and urban alike, that one-size-fits-all approaches should be avoided.

6.3. Domestic versus International

While it was not the purpose of this report to review the international setting, some international literature was found. It is clear that Canada is not alone in facing this challenge. Globally, the estimated infrastructure deficit is in the trillions of dollars in countries like Japan, the United States, and Russia ^{3,31,60}. Additionally, infrastructure issues occur in developed and developing countries alike. Globally it is recognized that a failure to meet infrastructure needs will stifle economic growth and human development ³⁵. Some articles highlight that in developing countries rural areas face challenges like basic electrification, with the absence of infrastructure acting as a key barrier to development ^{35,93,94}. Challenges like a lack of financial resources are global, as is recognition of the importance of sustainability and the environment.

Regarding Canada relative to the rest of the world, one report pointed to the better management of infrastructure as well as better funding availability in Europe relative to North America, with Canadian municipalities receiving less assistance per capita than European municipalities ⁶⁰. The United Kingdom instituted a national infrastructure plan in 2010 including: a pipeline of projects, details on funding tools, a framework for evaluation, and prioritization investment ³⁰. The Netherlands have been actively involved in setting strategic infrastructure plans since the 1960s and are ranked first for quality of port infrastructure and electrical supply, and fifth overall for global competitiveness ³⁰. Beyond Europe, in Australia research included the role of private industry in maintaining the public infrastructure that is instrumental to private profits ⁶⁰.

7. Conclusions

During the co-called ‘Golden Age’ of infrastructure investment in Canada (post WWII-late 1960s) the idea that the key to prosperity was through the continued upgrading of infrastructure was reflected in the importance economic policymakers placed on investing in infrastructure projects ¹⁵. After a drop in investment for a number of decades, the annual public capital spending in Canada has been increasing, albeit not at a rate sufficient to offset issues ¹⁶. In order to keep pace with projected global GDP growth an estimated \$57 trillion in infrastructure is needed globally by 2030, an almost unfathomable number ³⁵. While Canada’s estimated infrastructure deficit is a fraction of this, there are many negative impacts, both in the present and future, from infrastructure that has not been maintained, as well as infrastructure that remains to be built ³⁰.

There are many reasons to deal with the infrastructure deficit now. Some are short-term, such as low interest rates and the benefits of short term stimulus of infrastructure investment during periods of economic downturn ^{4,30,31}. Others are more long-term, highlighting that while the infrastructure deficit is a challenge, it is also an opportunity to re-imagine infrastructure in a more sustainable fashion, helping to ensure future resilience ^{7,30,36,49,62}. However, the benefits associated with addressing the infrastructure deficit are not automatic. For example, it may be possible to overinvest, and some infrastructure types (e.g., energy, communications, transportation) are more valuable economically ³¹. In order to ensure that effective and efficient approaches are used, attention must be paid to understanding those factors influencing infrastructure issues, as well as to what information is available upon which to make decisions. From a rural perspective there is a clear need for improvements in both data quality and quantity in order to better establish the best course(s) of action.

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