TITLE: Moving Toward Self-Determination with Community-Driven Approaches for Infrastructure in Indigenous Communities in Canada: A Scoping Review

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ABSTRACT

The Government of Canada has drawn criticisms for processes of funding infrastructure on-reserve. Criticisms include restrictive funding and guidelines that have not supported First Nations' self-control of on-reserve infrastructure. Incorporating community input into community designs on and off-reserve would support all Indigenous Peoples' right to self-determination. This scoping review aimed to understand the additional impacts of approaches to planning and designing infrastructure that include the voices of Indigenous community members. The authors searched five electronic databases and reference lists, finding eight relevant publications from 2010 to 2021. Identified benefits of community-driven approaches included incorporating exclusive local knowledge, aligning with community needs and culture, meeting a broader set of needs, and supporting community capacity. The most common constraints to engaging in community-driven approaches related to external funding. Additional research, tools, and efforts are needed to understand preferences and encourage uptake of such approaches.

KEYWORDS: Indigenous, North America, community design, community-driven, scoping review

Introduction

In Canada, federal government agencies have controlled infrastructure delivery in First Nation communities by implementing uniform guidelines and restrictive funding programs (Indigenous and Northern Affairs Canada [INAC] 2016). This approach has typically resulted in urban-style subdivisions for reserves in rural areas – the lowest cost alternative (Vogel 2019, Vogel et al. 2018). Many design decisions based on financial considerations are unsuitable, particularly as community infrastructure has far-reaching impacts on wellbeing (World Health Organization 2018, Stout 2018). As a result of the restrictions imposed by the federal government's funding programs and the limited exposure engineers get to inclusive design approaches (Bradford et al. 2018, INAC 2016), community preferences are often not gathered and reflected in community layouts. Community input should, at a minimum, be incorporated into First Nations community design to support wellbeing and rights to self-determination (United Nations [UN] 2008). This scoping review aimed to demonstrate the impact of including Indigenous voices in planning and designing infrastructure in Indigenous communities in published works.

Indigenous Peoples in Canada have been subject to a system of discriminatory and assimilation-focused policies, seeking to divest identities and cultures (Truth and Reconciliation Commission of Canada [TRC] 2015, Royal Commission on Aboriginal Peoples [RCAP] 1996). One of the outcomes of this system has been a lack of autonomy and input in the planning and design of Indigenous living scapes (Blackburn 2009, Bradford et al. 2018, Elliott 2018). More specifically, First Nations Peoples have a long history of the federal government controlling reserve land and infrastructure (Olsen 2016, RCAP 1996). The federal government's actions have created a dependency system for funding infrastructure on-reserve, particularly housing

(McCartney et al. 2018, Olsen 2016). As a result, the federal government has dictated infrastructure management on-reserve, with continued reliance on external, urban-centric engineering codes (INAC 2016) and little input from the people affected by design outcomes. This approach has led to infrastructure on-reserve that is typically culturally inappropriate (Stout 2018, Olsen 2016) and, ultimately, does not support rights to self-determination (United Nations [UN] 2008).

The United Declaration of Indigenous Peoples (UNDRIP) specifies Indigenous rights to self-determination internationally (UN 2008). Furthermore, the right to "freely pursue their own economic, social, and cultural development" is guaranteed (UN 2008). The Canadian Senate passed Bill C-15, the UNDRIP Act, into law in June 2021, with urgency to actualize UNDRIP within two years (Government of Canada 2021). Self-determination is critical for supporting wellbeing and reconciling Indigenous-settler relationships (TRC 2015, RCAP 1996), yet tangible steps toward self-determination for Indigenous Peoples in Canada are lacking.

Community-driven approaches are emerging as methods that support Indigenous communities in exerting self-determination within the current system. Although Indigenous communities share a colonial history, each reserve faces unique infrastructure challenges and opportunities (Standing Senate Committee on Aboriginal Peoples [SSCAP], 2015b). There is growing support for individualized, community-driven strategies and solutions for culturally appropriate infrastructure grounded in local preferences of Indigenous Peoples (McCartney et al. 2018, Larcombe et al. 2020, Stout 2018, National Collaborating Centre for Aboriginal Health 2017).

Research looking at infrastructure on-reserve focuses on housing in isolation from the planning and design of communities more broadly (Bradford et al. 2018). We suspect this theme

is prevalent because the housing need is so dire, with the latest estimates showing 94.1% of communities have a waiting list for housing with wait times averaging two years (First Nations Information Governance Centre [FNIGC] 2015). Infrastructure needs on-reserve also extend to waste management (Assuah and Sinclair 2021), water and wastewater services (Bradford et al. 2018, Black and McBean 2017), healthcare (Kyoon-Achan et al. 2021), and beyond. The same guidelines restrict infrastructure for delivering such services (INAC 2016). Thus, considering a broad scope of infrastructure may yield a better picture of the value of community-driven approaches.

A complex and nuanced approach is needed to support First Nations' right to self-determination for planning and designing infrastructure. Rather than presenting the conventional lowest cost alternative, applicant communities and external actors should push for consideration of the totality of social, cultural, environmental, and wellbeing outcomes brought on through inclusive community infrastructure design and development. Multidisciplinary support, including engineers, healthcare professionals, and others, is needed to support movements for changing the system. Healthcare professionals, such as nurses, have a role in supporting the development of a healthy built environment because of their understanding of how infrastructure impacts individual and community wellbeing and access to healthcare. Thus, the target audience for this review is broad, as many multidisciplinary actors could leverage this information to advocate for increased self-determination in Indigenous community planning and design.

The aim of this review was to explore literature that used community-driven approaches for planning and designing infrastructure in Indigenous communities in Canada. The research question “What are the benefits and constraints related to community-driven approaches for planning and designing infrastructure in Indigenous communities?” guided the study. A scoping

review published in recent years demonstrated a gap in literature on Indigenous community-driven water services and related infrastructure (Bradford et al. 2018). An additional objective of this study was to see whether this literature gap remained when considering community infrastructure more broadly.

The authors used community-driven approaches as they felt this was the most encompassing term, referring to approaches where community input is sought for planning decisions for a specific local infrastructure development project (The World Bank 2021). Importantly, progress to community-led approaches, wherein the capacity of the community is supported so that they can act on locally determined visions and goals (Veda et al. 2021), is needed to support rights to self-determination. The study does not attempt to tell a story of Indigenous Peoples' experience nor promote a solution. Both would be inappropriate since each Indigenous community is unique, and all authors are non-Indigenous and outsiders to the experience of living on-reserve.

Methodology

We followed the Arksey and O'Malley (2005) methodological framework for scoping reviews. Arksey and O'Malley (2005) outline five stages including (1) identifying a research question, (2) identifying relevant studies, (3) selecting studies, (4) charting data, and (4) summarizing and reporting results. We used the key terms listed in Table 1 to identify relevant studies. We searched five electronic databases (EMBASE, MEDLINE, Engineering Village, Web of Science, and Academic Search Complete) and reference lists to identify relevant articles.

Table 1. Search Strategy

Indigenous	AND	Community Infrastructure	AND	Community-driven
OR		OR		OR
First Nation*		Community design		Community led
OR		OR		OR
Aboriginal*		Hous* design		Community-led
OR		OR		OR
Indian*		Subdivision design		Community participat*
OR		OR		OR
Native*		Community plan*		Participatory design
OR		OR		OR
Metis		Neighbo?rhood plan*		Participatory action
OR		OR		OR
Métis		Community development		Community input
OR		OR		OR
Inuit		Social architecture		Community-based
		OR		OR
		Community architecture		Community involve*
		OR		OR
		Indigenous architecture		Co-design
		OR		OR
		Co-hous*		Co-develop
		OR		OR
		Housing		Consultative design
		OR		OR
		Infrastructure		Indigenous-led
				OR
				Indigenous-driven

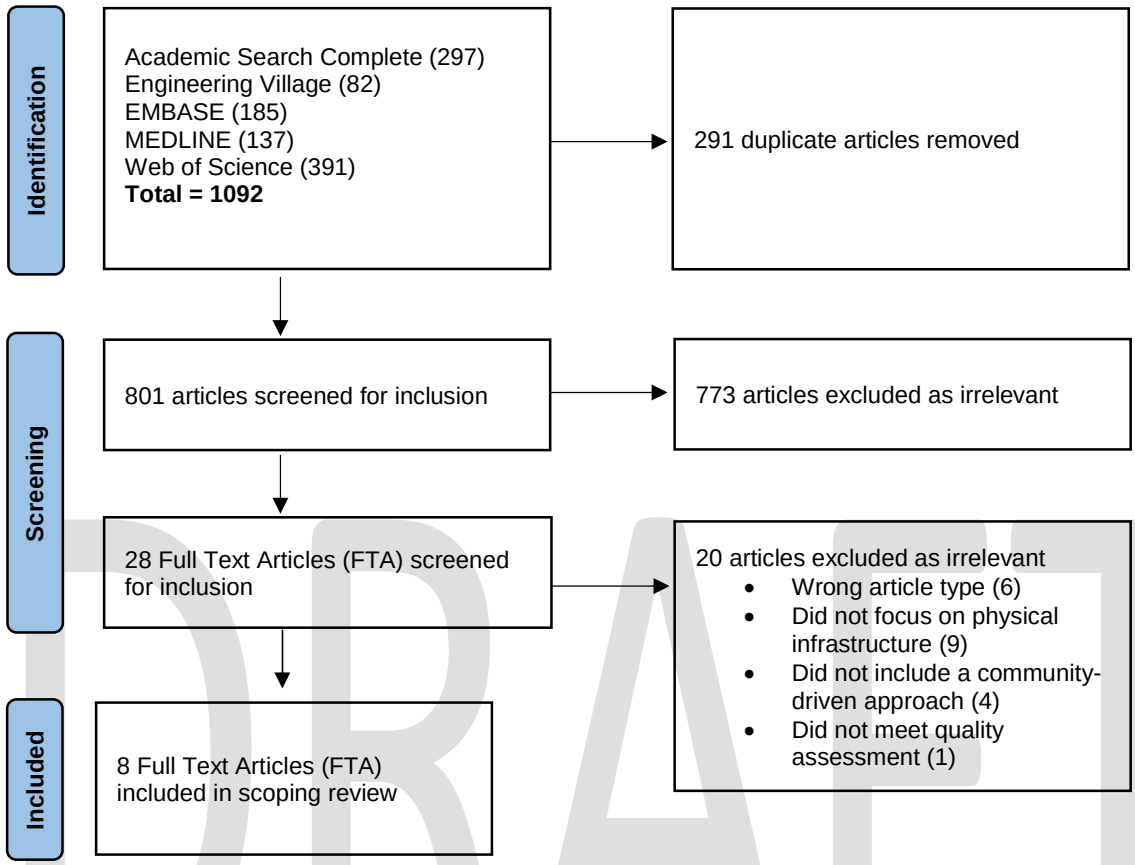
We restricted this scoping review to articles published in English between 2010 to 2021. We chose the start date of 2010 due to time restraints and because we felt that community-based approaches to planning and designing infrastructure on-reserve are relatively recent. In Canada, First Nations' control did not appear in housing policy until 1996 (Government of Canada 2018), and reports continue to describe how such efforts have largely fallen short (Assembly of First Nations 2018). Additional inclusion criteria were empirical literature or reviews with mention of (a) Indigenous, (b) infrastructure, and (c) community-driven approach. Exclusion criteria were

(1) Non-empirical literature or reviews (e.g., editorials, commentaries, theoretical articles), (2) No Indigenous involvement, (2) No physical infrastructure (e.g., programs), (3) No community input in planning or design. We prioritized articles focusing on Indigenous communities in Canada, possibly expanding to include the United States depending on the number of articles retrieved. The aim of this review was explorative, and the authors felt there were enough similarities amongst Indigenous communities in Canada and the United States, such as their historical assignment of land and imposition of federal bodies, to include both. Two researchers (SH, WM) reviewed articles for inclusion, completing article screening by title and abstract scan and then a full article review. After selecting studies for inclusion, the authors charted data from the studies, a technique to synthesize and identify themes amongst data (Arksey and O'Malley 2005).

Results

Eight articles remained following the removal of duplicates, screening for inclusion criteria, and exclusion of irrelevant articles (see Figure 1). The authors did not want to reduce the key terms to ensure they captured all relevant articles; however, many articles from the initial search focused on programs rather than physical infrastructure and were removed from consideration due to irrelevance. The authors suspect this may have been because of the term "community development", which is broad, encompassing physical structures and programs to support people. Two researchers (SH, WM) completed a quality appraisal for the remaining eight articles using the Joanna Briggs Institute (JBI) quality appraisal tools, with all articles meeting the standard (JBI 2020). Articles that included Indigenous communities in Canada or the United States were included. A summary of the articles appears in Table 2 at the end of the article, including key findings.

Figure 1. Search Results



Of the eight articles, one was a review (Bradford et al. 2018), and seven were primary articles (Davis et al. 2020, Deane and Smoke 2010, Hudson and Vodden 2020, Larcombe et al. 2020, MacTavish et al. 2012, Shelby et al. 2012, Wood and Clevenger 2012). All articles focused on Indigenous communities in North America, with nearly as many focusing on communities in the United States (Davis et al. 2020, Shelby et al. 2012, Wood and Clevenger 2012) as Canada (Deane and Smoke 2010, Hudson and Vodden 2020, Larcombe et al. 2020, MacTavish et al. 2012). Bradford et al. (2018) intended to focus solely on Indigenous communities in Canada but included some global articles due to a lack of Canada-centric literature. In the Canadian context, two articles focused on First Nations communities (Larcombe et al. 2020, MacTavish et al. 2012), one on Inuit communities (Hudson and Vodden 2020), and

one on urban Indigenous families (Deane and Smoke 2010). Five of the primary articles specified using a qualitative design (Deane and Smoke 2010, Wood and Clevenger 2012, Davis et al. 2020, Hudson and Vodden 2020, Larcombe et al. 2020).

The most common type of infrastructure discussed was housing (Deane and Smoke 2010, Larcombe et al. 2020, MacTavish et al. 2012, Wood and Clevenger 2012, Shelby et al. 2012), with three articles looking at water infrastructure (Bradford et al. 2018), land use planning (Davis et al. 2020), and an array of infrastructure more broadly (Hudson and Vodden 2020). In all the articles, local community members engaged in the infrastructure planning processes; however, the approaches varied throughout the articles. Authors titled approaches as co-design (Bradford et al. 2018, Shelby et al. 2012), Geodesign (Davis et al. 2020), Indigenous planning (Hudson and Vodden 2020), collective, integrated, and participatory design (Deane and Smoke 2010), consultative design (MacTavish et al. 2012), and community-based or self-help (Wood and Clevenger 2012). Larcombe et al. (2020) did not provide a title for their particular approach.

Benefits of Community-Driven Approaches

A central component of using community-driven approaches for planning and designing infrastructure was incorporating community voices. The stated benefits of such approaches are discussed further below, grouped as follows: (a) incorporating exclusive local knowledge, (b) aligning with community needs and culture, (c) meeting a broader set of needs, and (d) supporting community capacity.

Incorporating Exclusive Local Knowledge

Authors noted that Indigenous Peoples have deep knowledge of the community and land and better insight into what planning and design approaches will work than external consultants (Larcombe et al. 2020, Hudson and Vodden 2020). Authors described how Indigenous Peoples

showed eagerness to contribute local knowledge to improve the community for its members (Davis et al. 2020, Hudson and Vodden 2020). We found that the term *exclusive local knowledge* emphasized that this knowledge is internal to Indigenous community members. For example, one study found the involvement of community members was paramount in determining the actual need for housing; only community members knew who wanted to return to the community and who was living with family members while wishing to have their own housing (MacTavish et al. 2012). The main areas of exclusive local knowledge discussed in the articles include land and infrastructure use (MacTavish et al. 2012, Larcombe et al. 2020, Davis et al. 2020, Hudson and Vodden 2020).

Studies demonstrated how incorporating exclusive local knowledge of the land into planning can lead to more suitable infrastructure for the local environment (Davis et al. 2020, MacTavish et al. 2012). For example, Davis et al. (2020) found that community members knew a housing site proposed by the federal government was in a flood zone. Additionally, MacTavish et al. (2012) found community members knew the prefabricated housing they received was inadequate for the local climate, with building materials not made to withstand the amount of rainfall in the area. Incorporating exclusive local knowledge of the land into planning in these instances led to the selection of an appropriate housing site (Davis et al. 2020). In addition, this approach showed promise for selecting housing materials that better maintain structural integrity over time (MacTavish et al. 2012).

Community members also had exclusive local knowledge of how infrastructure, such as houses, was used (Deane and Smoke 2010, Larcombe et al. 2020, MacTavish et al. 2012). For example, members were very conscious of utility bills in one community, so they kept windows shut and the ventilation off to prevent heat loss (MacTavish et al. 2012). In this case, the housing

design was inappropriate as attempts to decrease utility bills came at the cost of increased moisture and risk of mold in the houses creating potential adverse health outcomes (MacTavish et al. 2012). As a whole, the authors demonstrated how incorporating exclusive local knowledge into infrastructure planning and design could lead to infrastructure that better suits occupants (Deane and Smoke 2010, Larcombe et al. 2020, MacTavish et al. 2012).

As demonstrated, the community-based approaches used in the reviewed articles supported the incorporation of exclusive local knowledge, otherwise not known to external authors. Types of exclusive local knowledge shared in the articles were knowledge of the land and the use of infrastructure. Authors demonstrated that incorporating such knowledge into the planning and design of infrastructure could improve structural integrity over time by selecting appropriate building locations, materials, and designs that suit occupant use.

Aligning with Community Needs and Culture

An additional benefit noted in the literature was how community-driven approaches can yield infrastructure plans that better align with community needs and culture. First, such approaches can support identifying and prioritizing community infrastructure needs (Davis et al. 2020, MacTavish et al. 2012, Shelby et al. 2012, Hudson and Vodden 2020). Two studies included the identification of sets of priorities for future community infrastructure, with items such as affordability, accessibility, storage, cultural aesthetics, and energy conservation prioritized (Shelby, Perez, and Agogino 2012; MacTavish et al. 2012). The research teams then used these priorities to create models for potential future housing developments (Shelby et al. 2012, MacTavish et al. 2012). Despite having multiple needs, community members negotiated and determined which needs they wanted to focus on first (MacTavish et al. 2012, Davis et al. 2020). For example, one community needed housing for multiple social groups, and they were

able to prioritize a key group based on community consensus (MacTavish et al. 2012). Thus, studies demonstrated that community-driven approaches could support the prioritization of community infrastructure needs (Davis et al. 2020, MacTavish et al. 2012, Shelby et al. 2012, Hudson and Vodden 2020).

Second, community-driven approaches can better incorporate community traditions and culture in planning. Three studies showed various sources of knowledge in the community, such as teachings from Elders, were respected throughout the process (A, (Hudson and Vodden 2020, Davis et al. 2020, Deane and Smoke 2010). In one study, Elders were specifically able to identify and protect traditionally important community areas (Davis et al. 2020). This study also incorporated traditional Indigenous approaches to reaching consensus and planning and negotiating in Indigenous languages.

Authors' noted that the design of infrastructure, particularly housing, can play an essential role in supporting the transfer of traditional knowledge and skills, thereby contributing to cultural identity (Larcombe et al. 2020, Shelby et al. 2012, Deane and Smoke 2010). Housing designs resulting from the studies reflected community culture through aspects such as the selection of local building materials (Larcombe et al. 2020, Wood and Clevenger 2012) the symbolism of compass direction points (Shelby et al. 2012, Deane and Smoke 2010) and circular elements (Shelby et al. 2012, Deane and Smoke 2010), the incorporation of spaces to support traditional food preparation (Larcombe et al. 2020), and other means of supporting connection to the land (Deane and Smoke 2010, Larcombe et al. 2020). Cultural design elements also included a central gathering place and transitional spaces that convert into additional sleeping spaces to support extended visits from family and friends (Shelby et al. 2012, Deane and Smoke 2010).

In sum, the authors noted that community-driven approaches supported better identification and prioritization of needs and the incorporation of community traditions and culture into design processes. Authors asserted that through these approaches, it might be possible to develop infrastructure that is of highest priority to community members in a way that is supportive of the culture, allowing for infrastructure planning to overcome the bias of externally-identified priorities.

Meeting a Broader Set of Needs

The third benefit of community-driven approaches was meeting a broader set of the community's needs with the resulting infrastructure (Bradford et al. 2018). Community-driven approaches allowed community members to make decisions considering broader impacts of infrastructure development, such as its economic contributions. In particular, communities were able to assess the economic impacts of choices around infrastructure design, such as the potential to contribute to the local economy through job creation and the use of locally sourced or purchased building materials (Larcombe et al. 2020, MacTavish et al. 2012, Wood and Clevenger 2012, Davis et al. 2020, Hudson and Vodden 2020, Deane and Smoke 2010). Benefits of such economic opportunities, including financial independence from jobs for young people within the community and decreased costs of building materials, were also listed (Larcombe et al. 2020, MacTavish et al. 2012, Wood and Clevenger 2012, Davis et al. 2020, Hudson and Vodden 2020, Deane and Smoke 2010).

Along with economic impacts, community-driven approaches allowed for reflection on environmental impacts. Sustainability considerations in the studies included the identification of conservation areas and a solar field (Davis et al. 2020), development of short- and long-term

sustainability goals (Hudson and Vodden 2020), and discussion around taking advantage of passive heat gain with window placement and home orientation (Larcombe et al. 2020).

As a part of meeting a broader set of the community's needs, community-driven approaches supported local deliberations on future growth areas while making current decisions (Hudson and Vodden 2020, Davis et al. 2020). Authors noted that communities identified treasured places for protection, thereby gathering and reinforcing shared values (Hudson and Vodden 2020, Davis et al. 2020). In another study, Elders mapped traditionally important stewardship practices, cultural wellbeing, and community resilience (Davis et al. 2020). The community stored this information more permanently to reference in successive infrastructure plans (Davis et al. 2020).

The sample results demonstrated that community-driven approaches allow for different impacts of infrastructure to be considered during the planning and design phases. By creating space for conversations about topics such as economic and environmental impact and long-term planning, community-driven approaches may yield infrastructure that has the potential to meet a broader set of the community's needs.

Supporting Community Capacity

A final benefit of community-driven approaches identified in the sample was the potential to support community capacity. Community members and authors referred to community-driven approaches as empowering (Davis et al. 2020, Shelby et al. 2012, Hudson and Vodden 2020). More specifically, the authors noted that community members felt empowered to guide development and make decisions for the community (Davis et al. 2020, Shelby et al. 2012, Hudson and Vodden 2020). Community-driven approaches supported community members to reject the outsider-knows-best perspective often imparted in mainstream planning and reclaim

agency and sovereignty over land and associated infrastructure (Hudson and Vodden 2020). It appeared that when the community members could see themselves directing the future community aesthetic and dynamics, they were better supported to consider what other goals they could achieve in the community (Hudson and Vodden 2020). For example, Hudson and Vodden (2020) described how the visioning exercises and community asset mapping allowed people to connect and reflect on possibilities for the future. Additionally, having community members involved in physically building infrastructure was said to impart a sense of independence and ownership (Wood and Clevenger 2012, Deane and Smoke 2010).

Authors also referenced the potential for community-driven approaches to elevate the capacity for infrastructure maintenance and preventative care (Larcombe et al. 2020). For example, Larcombe et al. (2020) found that involving community members in housing design primed the identification of maintenance issues and provided space for education on preventative care. Furthermore, the community expressed a desire to receive housing maintenance training and employment (MacTavish et al. 2012).

In summary, the authors identified the potential for community-driven approaches to support community capacity. As demonstrated in the articles, community-driven approaches for planning and designing infrastructure can lead to personal empowerment, create opportunities to expand skillsets, and reinforce existing expertise.

Constraints

Five articles discussed constraints of engaging in community-driven approaches. A primary constraint was the funding model, including factors such as meeting funding requirements (Bradford et al. 2018), the short-term nature of funding (Hudson and Vodden 2020), and the standard approach of focusing on up-front infrastructure costs versus long-term

costs (Wood and Clevenger 2012). These funding constraints made it difficult to establish broader community engagement in infrastructure planning and design, and challenged the uptake of community-driven processes, as conventional processes typically fit better within government funding models (Bradford et al. 2018, Hudson and Vodden 2020).

Other constraints to community-driven approaches shared by authors related to location and external building codes. Davis et al. (2020) explicitly discussed low participation due to location choice, as they had fewer community members participate in workshops than envisioned. These researchers could not have workshops in the community as the technology they were using required a reliable internet connection. At the end of the study, community members shared that holding workshops in the community with someone who could speak the local language would have increased participation. Hudson and Vodden (2020) also noted the difficulty of physically accessing communities, particularly remote ones, as a challenge. Finally, one study mentioned how external building codes restrict building methods by not allowing the use of alternative materials which may be more accessible and have fewer health impacts, such as straw bale construction (Deane and Smoke 2010).

Discussion

There is a pressing need to shift control of the planning and design of Indigenous infrastructure to support the rights of Indigenous Peoples (Government of Canada 2021, UN, 2008). The Government of Canada conventionally uses financial considerations as the primary driver for the planning and design of First Nations communities (INAC, 2017, INAC, 2016). In contrast, community-driven approaches incorporating community members' voices may be a method for supporting increased Indigenous control and autonomy. This review aimed to understand the impacts of community-driven approaches for planning and designing

infrastructure in Indigenous communities in North America. We found both benefits and constraints to such processes; the main points are discussed next alongside broader considerations.

A primary benefit of community-driven approaches was the inclusion of exclusive local knowledge, such as of the land and infrastructure use. Descriptions of how this knowledge could aid infrastructure planning and design in the reviewed studies often related to reducing indoor moisture. Examples included preventing building in a flood zone, selecting appropriate housing materials for rainfall, and designing ventilation to align with occupant use (Davis et al. 2020, MacTavish et al. 2012, Deane and Smoke 2010, Larcombe et al. 2020). Taking steps to prevent high humidity in infrastructure is crucial for reducing mold growth long-term (Government of Canada 2016). In houses specifically, mold is a prevalent issue across reserves, primarily described in the literature due to the design of buildings (Larcombe et al. 2011, SSCAP 2015a, Government of Canada 2016, Anwar et al. 2021).

Indigenous Peoples hold comprehensive knowledge, particularly of traditional land areas. Incorporating such knowledge into infrastructure design and planning may improve the suitability and longevity of the resulting infrastructure. In addition, connection to the land is a crucial component of wellbeing and resilience for Indigenous Peoples (King et al. 2009, Lines et al. 2019, Tobias and Richmond 2014, Hatala et al. 2020). Community-driven approaches may support Indigenous wellbeing if they lead to the development of infrastructure that reflects local knowledge of the land.

Aligning infrastructure with community needs and culture was an additional benefit of community-driven approaches. Indigenous Peoples in Canada are inequitably impacted by infrastructure needs. For housing specifically, of those who participated in the 2016 Census,

18.3% of Indigenous Peoples met the federal government's definition of overcrowded housing, compared to 8.5% of the non-Indigenous population (Statistics Canada 2016). Furthermore, 19.4% of Indigenous Peoples lived in a house needing major repairs, versus 6.0% of the non-Indigenous population (Statistics Canada 2016). Levels of crowding and needs for major repairs worsen for those living on-reserve (FNIGC 2015, Statistics Canada 2016). Infrastructure needs in Indigenous communities out-pace funding support from the federal government, particularly on-reserve (INAC 2017, SSCAP 2015b). Given that infrastructure needs in Indigenous communities generally exceed such financial resources, prioritizing infrastructure according to local perspectives is paramount. Community-driven approaches allow infrastructure priorities to be community dictated rather than externally determined, creating the potential for more significant impacts from the resulting infrastructure.

There is a long history of assimilation and discriminatory policies and practices in Canada developed to disconnect Indigenous Peoples from indigeneity (RCAP 1996). In particular, those on-reserve have a long history of the federal government controlling the land and associated infrastructure (Olsen 2016, RCAP 1996). A result of the lack of First Nations' control over infrastructure on-reserve is cultural inappropriateness, particularly in houses (MacTavish et al. 2012, Stout 2018, McCartney 2016). The articles reviewed in this study demonstrated that community-driven approaches could support the incorporation of culturally important knowledge, traditional ways of reaching consensus, and discussion in Indigenous languages (Hudson and Vodden 2020, Davis et al. 2020, Deane and Smoke 2010). In addition, designs that resulted from using community-driven approaches incorporated aspects that reflected the community culture through culturally meaningful shapes and other elements such as the use of local building materials, supporting connection to the land (Larcombe et al. 2020,

Shelby et al. 2012, Deane and Smoke 2010). As outlined in the Truth and Reconciliation Commission of Canada (2015) Calls to Action, Indigenous languages and cultures must be valued to move toward reconciliation. Community-driven approaches can incorporate community traditions and culture into infrastructure planning and design, thus aligning with this Call.

The final two benefits of community-driven approaches were meeting a broader set of the community's needs and supporting community capacity. Community infrastructure have many implications for those who live in the area. The community-driven approaches used in the reviewed articles supported considerations of broader community needs, including economic facets, with discussions of job creation and investment in local economies (Larcombe et al. 2020, MacTavish et al. 2012, Wood and Clevenger 2012, Davis et al. 2020, Hudson and Vodden 2020, Deane and Smoke 2010). In addition, the approaches supported community capacity as members felt empowered to make decisions and guide infrastructure development for their community (Davis et al. 2020, Shelby et al. 2012, Hudson and Vodden 2020). All Indigenous Peoples have a right to self-determination, which includes the right to pursue economic development (UN 2008). Actualizing this right in Canada is pressing with the passing of Bill C-15 (Government of Canada 2021). Community-driven approaches can support Indigenous rights to self-determination by creating space for community-led discussions about broad implications of infrastructure development (e.g., economic) and empowering Indigenous Peoples to control decision making.

Funding was the most mentioned constraint to using community-driven approaches for infrastructure planning and design in the reviewed articles. The short-term nature and focus of funding were among these constraints (Hudson and Vodden 2020, Wood and Clevenger 2012,

Bradford et al. 2018). Such funding approaches for infrastructure in Indigenous communities, particularly for First Nations living on-reserve, are widely critiqued (SSCAP, 2015b, INAC, 2017). Funding models that are not supportive of involving community members in infrastructure planning and design do not adequately weigh the potential long-term gains. Although the benefits in the reviewed articles mainly focused on positive social and environmental impacts, these also translate into future economic savings. For example, building culturally appropriate infrastructure and meeting community needs may reduce the need for expensive repairs or replacements before the intended lifecycle. Thus, funding models with increasingly flexible requirements and longer-term funding periods are needed to support community-driven approaches and, ultimately, Indigenous self-determination.

An additional common constraint identified in this review was location. In one study, location choice for workshops impacted participation (Davis et al. 2020), while in another, authors noted that physically accessing remote communities can be difficult (Hudson and Vodden 2020). Infrastructure needs, particularly for housing, are most acute in northern and remote communities in Canada, where costs of transporting building supplies, economic opportunities, and physical access are a challenge (SSCAP 2015b). The accelerated rate of climate change exacerbates the need for adequate infrastructure in such communities (Flynn et al. 2018). As such, incorporating local knowledge in future planning is pressing in northern and remote communities (Vogel and Bullock 2021, Flynn et al. 2018). Additional innovative efforts are needed to support participation in infrastructure planning and design in community-determined locations.

The federal government acknowledges the right to self-determination for Indigenous Peoples in Canada (Government of Canada 2021) while influencing much of the infrastructure

planning and design on-reserve (INAC 2016). Thus, the urgency for advancing self-determination and tools meant to reinforce that right have not breached infrastructure planning and design for such communities. The overall limited sample of articles found in this review, only eight peer-reviewed articles between 2010 to 2021, emphasizes a need for researchers across all fields to continue to work toward the Truth and Reconciliation Commission of Canada (2015) Calls to Action, with engineering as a discipline needing to accelerate such research and training.

Conclusion

This review provided evidence of numerous benefits of community-driven approaches for infrastructure planning and design. Along with the benefits, there are challenges to charting a new path for Indigenous infrastructure in Canada. This review provides three recommendations.

- First, Indigenous voices are needed in planning and designing infrastructure in Indigenous communities. Collaborative efforts, including government agents, consulting engineers, community members, and Chiefs and Band Councils on-reserve are needed to ensure the use of such processes.
- Second, further community-based research to identify best practices and the development of tools that support the inclusion of Indigenous voices in planning and designing infrastructure in Indigenous communities are needed. Such research and tools could inform both government policies and engineering education.
- Finally, policy change is needed to support processes that engage Indigenous voices in planning and designing infrastructure in Indigenous communities, particularly for funding.

Limitations

There are a few notable limitations of this scoping review. First, this review was a snapshot in time and only included peer-reviewed literature, which was limited in nature. We speculate that the lack of publication may be because consulting engineers typically involved in community-based projects may not publish their work. It is worth noting that although the authors are from multiple disciplines and did their best to include a variety of search terms, it is possible that some relevant articles were not captured, given that infrastructure design is such an interdisciplinary field. Second, the initial intent of this review was to specifically focus on connections between community-based approaches to planning and designing infrastructure and Indigenous wellbeing. However, literature in this area is lacking. Community infrastructure has far-reaching implications for wellbeing; research exploring connections between community-based approaches and wellbeing may support the inclusion of considerations beyond financial for planning and design. Third, because this review only included eight articles and each used a different community-driven approach, it is impossible to compare processes and identify strengths and areas for improvement. Identifying strengths is critical in progressing toward more appropriate approaches for planning and designing infrastructure with Indigenous communities. Ultimately, the identification and evaluation of related policies and practices need to be Indigenous-led and differ for each community, given each's uniqueness.

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Table 2. Summary of Included Articles

Authors	Country	Purpose	Title of Approach	Infrastructure Focus	Design & Methods	Relevant Findings
Deane and Smoke (2010)	Canada	Describe a four-year process of consultation on cultural concepts in the design of multiple buildings intended for Indigenous families in urban communities in Manitoba	Collective, integrated, and participatory design	Housing	Qualitative Interviews, group discussions, physical scale models or hand sketches of designs, community mapping, and home modeling	***Benefits*** *(b) Aligning with Community Needs and Culture* • One or two-story homes rather than apartments support connection to the land • Flexible bedroom arrangements provide space to support friends and family in a transition • Houses designed in a circle around a communal space • Significance of the four directions (may differ for different nations) *(c) Meeting a Broader Set of Needs* • Keeping work and profits within the community creates a sense of ownership and responsibility, opportunities for employment ***Constraints*** • Current building codes do not provide opportunities for alternative construction approaches
MacTavish et al. (2012)	Canada	Engage with the community to develop a culturally appropriate, environmentally responsive, and energy-efficient housing type that the community could implement in the future development of housing	Consultative design	Housing	Qualitative, Descriptive Community workshops	***Benefits*** *(a) Incorporating Exclusive Local Knowledge* • Many young men want to return to the community but cannot due to long waitlists; many young people live with parents or grandparents but want own accommodation • Prefabricated homes not designed to withstand heavy rainfall in the area • House occupants very conscious of utility bills, which led to them keeping windows shut and turning off ventilation systems to prevent heat loss (eventually leads to increased moisture in the house) *(c) Meeting a Broader Set of Needs* • Identified list of priorities for future infrastructure projects and priority social group for housing • Considered economic implications of a community-based sawmill *(d) Supporting Community Capacity* • Strong interest in education and training for home maintenance
Hudson and Vodden (2020)	Canada	Report on Community Governance and Sustainability Initiative (CGSI) piloted in 3 Inuit communities in NunatuKavut to facilitate opportunities for communities to think about sustainability and future	Indigenous planning	Water, sewer, and an array of infrastructure elements	Qualitative, Indigenous Employment of sustainability coordinator, focus group, interviews, survey, community gathering, written submissions, workshops	***Benefits*** *(a) Incorporating Exclusive Local Knowledge* • Indigenous Peoples and communities are experts on the land *(b) Aligning with Community Needs and Culture* • Community members valued coming together and sharing knowledge • Valued contributions of Elders *(c) Meeting a Broader Set of Needs* • Identified what is most important for planning for the future • Identified goals fundamental to economic development *(d) Supporting Community Capacity* • Asset mapping reinforced expertise that already existed • Empowered community members to reject the history of an outsider knowing best and reclaim agency on the land ***Constraints*** • Short-term external funding and geography as participating communities were not easily accessible to each other or the research team
Larcombe et al. (2020)	Canada	Engage university students and Dene senior-high-school students to create	NA	Housing	Qualitative "Housing week" workshops,	***Benefits*** *(a) Incorporating Exclusive Local Knowledge* • First Nations Peoples have deep knowledge and understanding of the community and environment, including knowing what will work

		and articulate Dene healthy housing so that concepts, plans, and designs are ready for future housing interventions			exchange programme between university students and Dene senior-high-school students	*(b) Aligning with Community Needs and Culture* • Housing materials reflect a connection to history, teachings, and regional identity • Housing design can support activities that lead to a transfer of history, skills, traditional knowledge and support cultural identity (e.g., traditional food preparation areas) *(c) Meeting a Broader Set of Needs* • Considered opportunities for employment (e.g., using local materials creates jobs for local harvesting), how to maximize passive heat gain and energy from the sun (e.g., window placement) *(d) Supporting Community Capacity* • Involving household owners in the design process supports them in identifying maintenance issues and learning preventative care
Shelby et al. (2012)	USA	Understand the sustainability and environmental needs of the partnering community to provide recommendations for housing designs	Co-design	Housing	Cross-sectional Group discussions, analysis of climatic features, workshop, interviews	***Benefits*** *(b) Aligning with Community Needs and Culture* • Included circular shapes for the floor plan (significant for traditional beliefs) • Accounted for cultural and traditional respects for the four directions • Aimed to resonate with historical yurt-like structure while accommodating contemporary needs of larger families (e.g., visiting family members) • Incorporated a central spiritual gathering space *(c) Meeting a Broader Set of Needs* • Identified list of prioritized needs for housing *(d) Supporting Community Capacity* • Community felt empowered to make informed decisions
Wood and Clevenger (2012)	USA	Document experiences of individuals involved in community-based housing efforts	Community-based or self-help	Housing	Qualitative Interviews	***Benefits*** *(b) Aligning with Community Needs and Culture* • Valued using local materials as they reduced costs, were readily available, and familiar *(c) Meeting a Broader Set of Needs* • Need to build community capacity, not just houses *(d) Supporting Community Capacity* • Being involved in physically building a house led to increased feelings of independence and ownership of the house ***Constraints*** • Focusing on up-front infrastructure costs rather than considering long-term implications of not meeting the needs of house occupants with design
Davis et al. (2020)	USA	See if the Geodesign approach, technologies, and framework supports and enhances land use plan-making in Native American communities	Geodesign	Land use planning	Qualitative, Case Study Surveys, key informant interviews, field notes, workshop, land suitability analysis	***Benefits*** *(a) Incorporating Exclusive Local Knowledge* • Local knowledge is vital for identifying actual needs within a community and preserving the community • Community members identified the federally proposed housing site as a flood zone, moved to an area determined in the workshop *(b) Aligning with Community Needs and Culture* • Community negotiated in own language, incorporated community values to make decisions, used traditional Indigenous approaches to reach consensus • Valued contributions of Elders, who identified land areas of traditional importance *(c) Meeting a Broader Set of Needs* • Identified economic opportunities, including the ability to create jobs for young people to stay in the community *(d) Supporting Community Capacity* • Empowerment through consensus-driven decisions

						Constraints • Low participation; fewer community members participated in the workshop than expected due to workshop location and restrictions to English language
Bradford et al. (2018)	Global	Explore the state of knowledge on co-design of water infrastructure in Indigenous Canada	Co-design	Water	Scoping review	***Benefits*** *(c) Meeting a Broader Set of Needs* • Involving communities at meaningful levels and incorporating traditional knowledge allows for meeting broader needs of the community ***Constraints*** • Funding framework