A scoping review on the community impacts of unconventional natural gas development for northern BC: A closer look at policy, regulatory and governance strategies to maximize benefits and mitigate harms

Prepared for the Social Sciences and Humanities Research Council of Canada

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Submitted May 20, 2016

About the Cumulative Impacts Research Consortium

The Cumulative Impacts Research Consortium (CIRC) is a research and community outreach initiative at the University of Northern British Columbia that is dedicated to enhancing the understanding of the cumulative environmental, community and health impacts of resource development. For more information on our on-going research and initiatives, please visit www.unbc.ca/cumulative-impacts.

Key Messages

- The development of unconventional natural gas sources is a growing international industry as a result of improved drilling and export technologies. British Columbia is home to the largest reserve of natural gas in Canada and significant speculation exists in developing liquefied natural gas processing facilities to ship this resource around the globe.

- UNG development can yield significant impacts for communities, and those impacts differ depending on where in the supply chain a community is located.

- This scoping review presents findings from a review of 343 articles that were identified by asking: How are communities impacted by UNG development, and how do those impacts vary for 'upstream' gas producing regions, 'midstream' gas transporting corridors, and downstream gas exporting communities?

- We found four broad categories of impact (environmental, infrastructure and social service delivery, socioeconomic, and policy/regulatory responses) comprised of 28 unique sub-themes.

- The UNG literature expanded rapidly beginning in 2011 before peaking in 2014.

- A large body of literature documents and describes community impacts at the point of extraction. These 'upstream' impacts are typically expressed in terms of environmental contamination of soil, air and water, with subsequent impacts on community health and wellness. However, limited literature addresses community impacts resulting from the construction and operation of natural gas pipelines and LNG facilities.

- Midstream and downstream impacts are primarily focused on industrial and community safety resulting from spills or potential explosions. There is limited scholarly evidence on the boom and bust associated with the construction of large UNG projects and associated short term impacts on communities.

- There are numerous policy mechanisms that exist to enable local decision-making, regulation, and advocacy, and a key part of this is to ensure public participation in key decision-making processes through the engagement of diverse stakeholders (e.g. industry, First Nations, concerned citizens).

- Significant knowledge gaps exist in the scholarly literature addressing community impacts of UNG development. Examples of gaps include: a lack of equity-focused analyses of UNG impacts to understand how vulnerable populations may be impacted by booms and busts in resource development; limited understanding of the community impacts of UNG development in midstream and downstream supply chain locations; few published articles on changing population dynamics associated with the construction and operation of UNG developments across the supply chain.

Executive Summary

Background

The advent of hydraulic fracturing technology and directional drilling has increased the accessibility of gas reserves, resulting in a global boom for so-called unconventional natural gas (UNG) development. Alongside market demand in Asia, this has led to a flurry of investment proposals and a strong focus from the provincial government for natural gas extraction and export to drive job creation and revenue generation. British Columbia holds roughly half of Canada's known natural gas reserves, and the pace and scale at which liquefied natural gas (LNG) projects have been proposed in BC presents challenges for local governments, First Nations and the public in addressing potential impacts associated with UNG development. Our research responds to calls for a more constructive engagement with the socio-economic and cultural impacts of resource development by asking: How are communities impacted by UNG development, and how do those impacts vary for 'upstream' gas producing regions, 'midstream' gas transporting corridors, and downstream gas exporting communities? This report provides a summary of the methods, results and analysis of a scoping review on the community impacts of UNG development across the supply chain. While a full review of all identified impacts is beyond the scope of this report, we present a targeted analysis of policy and regulatory responses to UNG development.

Methods

Scoping reviews are a form of knowledge synthesis that aim to examine the extent and nature of research activity on a given topic by mapping key concepts, themes, and main sources and types of evidence available for a particular field of knowledge. Our scoping review methodology followed a phased process that included: (a) identifying a research question, (b) identifying relevant studies, (c) study selection, (d) data charting, (e) synthesizing and reporting results, and (f) planning for knowledge translation.

Results

We identified and reviewed 25 342 titles and abstracts for articles published between 2005-2016 that were returned through a search of seven academic databases. Of the retrieved articles, 343 met our inclusion criteria for full review. These articles were reviewed and 'tagged' according to their core focus. The tagging process sought to capture the date of publication, the geographic focus (including the supply chain focus of 'upstream', 'midstream' and 'downstream), research methods, and identified community impacts. Tagging counts were used to 'chart' the data and identify emergent themes; to map the existing literature on community impacts of UNG across the supply chain and understand what topics existing research have addressed, and what knowledge gaps remain. Emergent themes were subsequently analyzed using a narrative review method to generalize key trends within nascent bodies of literature.

We found that the number of published scholarly articles rose dramatically in 2011 before peaking in 2014-2015. The geographic focus of articles was predominantly centered on the United States which comprised 69% of all articles, and was largely driven by a well-established body of research on impacts of Pennsylvania's Marcellus Shale play (only 7% of included articles focused on Canada, and only 2% of articles focused explicitly on the context of British Columbia). A look at the supply chain focus of the articles revealed that the majority of studies (69%) analyzed community impacts at the 'upstream' point of extraction. Fewer articles (18%) focused on 'midstream' gas

transportation impacts (e.g. impacts of pipeline development) and even fewer (9%) focused on the community impacts of 'downstream' processing, liquefaction and shipping.

We also sought to understand unique populations of interest. The majority of articles had a general population focus (78%); that is, any articles that did not specify a certain population category but which documented impacts for specific communities or regions at large. Additionally, 27% of articles were oriented toward policy and government decision makers while only a small number of studies addressed impacts to First Nations, Aboriginal or Indigenous groups (4%), women (2%), children (2%), or the elderly (1%).

The identification of community impacts elicited four over-arching themes: environmental impacts, infrastructure and service delivery impacts, socioeconomic impacts, and policy and regulatory responses. Each of these broad themes are comprised of unique sub-themes or 'tags'. The most frequently occurring tags had a primary focus on water, air quality and resulting health issues at the point of extraction. In midstream and downstream areas, industrial infrastructure was a key focus, highlighting the risk of pipeline failure or explosion at LNG facilities. It is notable that socioeconomic impacts of UNG development are primarily limited to studying health impacts linked to environmental contamination. Far fewer articles focus on the positive or negative consequences for local economic development and labour trends, and demographic changes to communities during construction and operation.

'Upstream' Policy and Regulation Review

Policy and regulatory responses were comprised of four sub-themes: policy/regulation, governance capacity, advocacy and consultation/trust. Our review differentiated these sub-themes across the supply chain. For the upstream supply chain, the policy/regulation and governance capacity sub-themes highlighted differences in the application of local, state and federal law—including an analysis of local government efforts to gain more control of decision making; increasing or improving the role of the public health sector in decision-making for UNG development; and improving consultative processes with Aboriginal or Indigenous groups. Key recommendations from this literature suggest that strengthening regulations that control emissions, mandating emission inventories to track air quality changes over time and improving baseline testing for air and water are paramount. Mandating cumulative impacts assessment for water sources and setting meaningful requirements to assist with reclamation costs is also increasingly seen as industry 'best practice'. However, cumulative impacts assessment or strategic environmental assessment must be adopted at a regional level rather than across a project's footprint to better capture the impacts of upstream development.

Literature on public participation, consultation, trust and advocacy in the upstream supply chain focused on the use of citizen science to address gaps in industry and government monitoring of water and air resources. While there are recognitions in the literature that citizen-science initiatives are rising to fill the void left through the retrenchment of existing regulatory approaches, this is generally viewed as a positive method to engage the public in the identification and co-management of impacts, provided resources can be shared by industrial players or governments to support related activities.

'Midstream' Policy and Regulation Review

The narrative review of policy and regulation themed articles for the midstream supply chain revealed a focus on inconsistent regulations across jurisdictions which create challenges for managing pipeline risks and establishing government oversight. Recommendations from the literature include creating comprehensive management plans over large regions, increasing collaboration across jurisdictions, and restricting pipeline development in parks and near inhabited

areas. At the local government level, recommendations include using zoning/setbacks to restrict and control developments, and for land developers to consult with pipeline owners, although there is broad recognition that local governments often lack the resources to support processes of rapid industrialization and mitigate associated risks.

'Downstream' Policy and Regulation Review

The policy/regulation sub-themes of the downstream supply chain primarily focused on the siting of LNG facilities, noting that the main concern among the public is industrial and community safety. Current siting regulations in some jurisdictions lack safety management systems/plans and risk-based analysis to determine the most appropriate site for facilities. There were no studies focused on LNG facilities in Canada. In Australia, a study of the Kimberly LNG project highlighted Aboriginal participation in site selection which included an 'Indigenous Impacts Report' that assessed the potential economic, social, cultural, archeological and ethnobiological impacts.

Knowledge Gaps

The scoping review process is valuable in identifying where scholarly attention has and has not been directed. We identify several key knowledge gaps that are suitable for further investigation. Relatively few articles highlighted community impacts for midstream transportation corridors and downstream export communities. Given the number of LNG projects that are proposed for construction in BC, it is paramount that more attention be given to communities adjacent to pipeline corridors or possible LNG sites. Further, there are few articles that address the capacity of local governments to address community impacts before, during and after they happen. Longer term planning processes that are guided by adaptive management seem much more likely to be able to address concerns that emerge from the multiple points of intersection between ecological, community and health issues, yet there are few documented examples of this occurring within the literature.

Finally, there were sub-themes within the socio-economic impacts that had few citations. For example, there was limited evidence on population dynamics associated with an influx of workers which can impact waste management, social service provision, crime rates, poaching and sexual violence, and few article addressing the equity implications of UNG development. A targeted research program that addresses how fairly or justly UNG impacts are distributed, particularly among marginalized populations such as women and Aboriginal peoples, would be a significant contribution to the literature. Nonetheless, our scoping review describes the current state of knowledge on the community impacts of UNG development on (primarily rural and remote) communities across the supply chain. In addressing our research question, this knowledge synthesis contributes to a growing body of research seeking to foster sustainable and resilient communities experiencing unprecedented levels of growth and investment in the UNG industry.

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Context

Following the advent of directional drilling, hydraulic fracturing technologies, and liquefying natural gas for transportation purposes, much of British Columbia's 10 647 billion cubic meters of natural gas (roughly half of Canada's known reserves) are now accessible for extraction and development [1-2]. The promise of so-called 'unconventional' natural gas (UNG) development is to transform British Columbia's economy by diversifying its energy portfolio. Indeed, elected officials have committed to expanding the province's natural gas industry through a combination of increased drilling, pipeline development, workforce training, and approving the construction of processing facilities capable of liquefying natural gas so that it can be transported to overseas markets.

Natural gas contributed $6.4 billion to BC's economy in 2013, more than $63 billion in capital investment has been spent on natural gas development in the province since 2000, and as of 2016, 20 liquefied natural gas (LNG) projects are proposed across the province, with 18 currently approved for export licenses [3]. The *BC LNG Strategy* and *Natural Gas Strategy* commit to having at least five LNG plants operating by 2020, an achievement that could create 100 000 new jobs, garner $175 billion in industry investment, and result in a potential $1 trillion impact on the provincial economy [4]. However, these suggested benefits are speculative and debatable, signaling the need for further research [5-6]. While the economic outlook for Canada's oil and gas has been bleak through much of 2015-2016, international interest in BC's natural gas reserves has led to significant international investment, primarily from Asian markets seeking cleaner and more cost effective alternatives to coal generated electricity. Given the current political discourse on the proposed expansion of BC's UNG and LNG industry, there is a demonstrated need to understand the net benefits and impacts of UNG development on the northern rural and remote communities where this resource is being developed.

The extraction, production, and transportation of natural gas will have profound, but markedly different impacts on upstream gas producing regions, midstream transportation corridors, and processing and shipping communities. Fortunately, there are numerous jurisdictions with long histories of UNG development to learn from and help inform recommendations for BC decision-makers (e.g. the Marcellus Shale basin in Pennsylvania [7-10] and others throughout the USA [11-12], the Surot and Bowen basins in eastern Australia [13-14]). Expanding the growing focus on boom and bust economies of resource dependent Canadian towns and regions [15-18], we seek to document and describe the community impacts from UNG projects, and contribute to innovative planning approaches that sustainably anticipate regional waves of resource development [19].

Our research responds to calls for a more constructive engagement with the socio-economic and cultural impacts of resource development [20] by asking: <u>How are communities impacted by UNG development, and how do those impacts vary for 'upstream' gas producing regions, 'midstream' gas transporting corridors, and downstream gas exporting communities?</u>

This report uses results from a scoping review of the scholarly literature on the community impacts of unconventional natural gas development to characterize the extant body of literature. Specifically, we find that the literature is broadly characterized by four orienting community impact themes: environmental impacts on residents adjacent to UNG

activities, infrastructure and service delivery impacts, socioeconomic impacts, and policy and regulatory responses.

The remainder of this report briefly discusses the implications of our research question, outlines key features of our methodology and analysis strategy, and then shares preliminary results from our review. A specific focus is given to the question of how various levels of government are responding to the question of UNG development in their jurisdictions, which highlights promising regulatory and policy approaches to mitigating community impacts associated with this form of resource development. The paper ends with a discussion of the implications of our findings, the identification of knowledge gaps, and directions for future research, some of which will be addressed through subsequent phases of our scoping review analysis.

Methodology

We conducted a scoping review of the scholarly literature to uncover articles addressing the community impacts of UNG development across the supply chain. Scoping reviews are a form of knowledge synthesis that aim to examine the extent and nature of research activity on a given topic by mapping key concepts, themes, and main sources and types of evidence available for a particular field of knowledge [21-22]. Scoping reviews are particularly relevant for areas that are significantly complex and have not been comprehensively reviewed before [23]. While scoping reviews do not assess the quality of studies that meet inclusion criterion, they can serve to determine the value of undertaking a full systematic review [24-26] and can rapidly map research findings and knowledge gaps for use by decision-makers [27].

Early attempts to distill a detailed process for conducting a scoping review [26] yielded a six-stage process including: (a) identifying a research question, (b) identifying relevant studies, (c) study selection, (d) data charting, (e) synthesizing and reporting results, and (f) consultation/knowledge translation. We utilize this general framework as a starting point for our synthesis, building in subsequent attempts to refine this review method to ensure rigor and the reflexive assessment of search protocols in relation to our research question [28-29].

Our review started by generating a list of search terms to characterize elements of the UNG supply chain and potential implications for communities (see Appendix 1). The list was developed by our team of researchers and a librarian with advanced training in scoping review methodology. The list was then piloted and revised through several waves of search and retrieval trials across four interdisciplinary databases of academic literature (Web of Science, Social Sciences Full Text, GreenFile, and Geobase) published between 2005-2016. We randomly sampled 50 search results to assess the relevance of articles to our research question and revised our search terms accordingly.

Once the team was satisfied that our search terms were adequately capturing a body of literature oriented towards documenting the community impacts of UNG development, we began a full search and retrieval process (see Figure 1). We conducted searches across seven academic databases (Web of Science, GreenFile, Geobase, Social Sciences Full Text, Psycinfo, Medline, and Econlit) between the years of 2005-2016 (see Appendix 2 for full results). The initial search yielded 25 273 articles that matched our search terms, and after deleting duplicates across databases, we were left with an initial dataset of 21 523 articles to review.

Next, our team developed a list of inclusion and exclusion criteria to guide a review of titles and abstracts from retrieved articles. Appendix 3 provides a table of these criteria. Due to the costs associated with translation, only English articles were included in our retrieval process. The inclusion/exclusion criteria were initially applied independently by three researchers across a random sample of 100 articles. Researchers then compared their application process to measure the reliability of this procedure across researchers, whereby articles that were difficult to assess were discussed by the research team for ultimate decision, iteratively adapting our exclusion criteria through these discussions. After we were satisfied with the application of inclusion/exclusion criteria, we divided the 21523 articles evenly between three researchers. Through this process we excluded 20945

articles that did not meet the inclusion criteria to answer our research question, and we identified 235 duplicates not caught by Endnote, our reference management software, when we initially merged datasets. As the full text of articles was reviewed, we hand searched reference lists and key journals for additional articles not captured through our initial search and retrieval process [26, 30]. This process resulted in 343 articles meeting criteria for inclusion.

Finally, we began to review full articles and 'tag' them according to their core focus and identified community impacts. It is notable that tags were applied to impact areas that were the dominant focus of a particular article, but that articles were tagged multiple times if they referenced multiple parts of the supply chain or captured multiple impacts. The tagging process was primarily iterative and deployed an open coding system as community impacts were identified. Researchers again took a sample of articles to 'tag', comparing coding reliability and communicating as new tags were established. The tagging process sought to capture the date of publication, the geographic focus of a research article (including the supply chain focus of 'upstream', 'midstream' and 'downstream), research methods, and community impacts.

The tagging counts were subsequently used to 'chart' the data and identify emergent themes within the articles. We then utilized a narrative review method [31] that sought to generalize key trends and ideas communicated in these themed subsets of articles. Our narrative review method captured the central stories and features of key articles that emerged from themes and sub-themes identified through our tagging process. Articles within a 'tagged' theme or sub-theme were analyzed as a set by an independent researcher who read the set of articles, and using annotated notes and memos, began to develop observations about these collective bodies of work. The following section describes the preliminary results from our data charting process and the results from our narrative review on the governance, policy and regulatory capacity literature identified in our scoping review.

Results

Year of Publication and Geographic Focus

Our process led to the development of 28 unique community impact tagging categories which were captured in a 'tagging matrix' that contained each unique article and its relevant tags. We found that research articles with a community impacts focus began to increase dramatically between 2011-2013 before peaking in 2014-2015 (see Figure 2).

The geographic focus of articles was predominantly on shale plays in North America. Articles with a focus on the United States of America comprised the majority of identified articles (69%), with Canada (7%) and Australia (5%) rounding out the top three (see Figure 3). The predominant focus on the USA was indicative of a well-established body of research identifying community impacts in Pennsylvania (29% of all articles had a concentrated focus on the Marcellus Shale play), while only 2% of all articles focused explicitly on the context of British Columbia (BC was the Canadian location with the largest number of articles (N=8)).

When the level of geographic focus was expanded to describe the level of governance at which articles addressed community impacts (see Figure 4), findings indicated that approximately 62% of all articles had a state/provincial or regional level focus (35% and 37% respectively), 27% of articles addressed local levels of government, 19% addressed federal level governance structures, and 5% attended specifically to First Nations governance. Given the dynamic interplay between local, regional, state/provincial and federal levels of governance and the fact that many articles addressed interjurisdictional issues that transcended a specific focus on one level of governance, we also tagged articles with multiple levels of focus (approximately 27% of all articles tagged).

Research Methods and Data Sources

Methodologically, the majority of studies identified in our review relied on qualitative methods (i.e. interviews, participant observation, discourse analysis, policy reviews), while 40% of the literature was quantitative in nature, and 8% utilized mixed methods research (see Figure 5). The data sources for studies surfaced in our review were diverse (see Figure 6). Articles primarily utilized or reviewed already collected data (e.g. utilization of geographic information systems data, utilization of census tract information) to create new knowledge about community impacts (70% of all articles). Our results additionally indicate that there was a strong emphasis on the collection of biophysical indicators (primarily related to air and water contamination and resulting implications for human health) which were utilized in 34% of identified papers, while reviews of specific policies comprised 14% of all articles. Qualitative methodologies deployed interviews, case studies, focus groups and participant observation as their primary data collection techniques (11%, 8%, 3% and 2% of all articles, respectively). A small proportion of these articles reported on the results of impact assessment studies (N=5) or the piloting of innovative risk mitigation projects (N=1), signaling how impact assessment studies which are often proponent driven are not well communicated in the scholarly literature.

Supply Chain and Population Focus

The orienting question of our scoping review was to conceptualize how well the scholarly literature has captured and characterized the community impacts of the natural gas supply chain. Accordingly, a key analytic effort made by our team was to clarify the supply chain focus of articles uncovered through our search and retrieval phase (see Figure 7). We found that there is an overwhelming emphasis of scholarly research articles that analyze community impacts at the point of extraction. That is, 65% of all articles focused on communities that were immediately adjacent to UNG drilling and extraction operations. Fewer articles (18%) focused on midstream transportation corridors where pipelines transport natural gas from the point of extraction to other locations for processing or consumption, and fewer still highlighted the community impacts upon 'downstream' processing, liquefaction, and shipping communities (9%). We found that 31% of all articles had either a general focus on UNG, or discussed interjurisdictional issues of multiple streams across the supply chain.

In addition to the fact that articles on UNG development peaked in 2014, it is worth noting that the supply chain focus for all three identified areas also peaked in the same year (see Figure 8). Thus, publication of articles with diverse foci on emergent community considerations of LNG and its associated infrastructure are lacking in the extant literature given that LNG continues to be an emergent possibility in numerous jurisdictions around the world. This is particularly notable in the case of BC where significant speculation continues to grow over the feasibility and plausibility of LNG development. As an understudied area, community concerns need to continue to filter into decision-making processes as this industry expands globally.

Our research also sought to identify unique populations that were identified as being differentially impacted by UNG development. Our search terms were therefore inclusive of workers who may be at higher risk of exposure to industrial accidents or other workplace hazards (e.g. respiratory conditions resulting from exposure to poor air quality), layoffs during poor market performance, or stress on their families from long distance commuting (e.g. fly-in/fly-out or drive-in/drive-out camps), as well as other unique populations that may experience multiple forms of vulnerability as a result of industrial development in the form of UNG.

In terms of unique populations of interest, we found that most articles (78%) had a focus on the general population; that is, any articles that did not specify a certain population category but which documented community impacts for specific communities or regions at large. Additionally, our open tagging process surfaced 10 unique population groups identified within the scholarly literature (see Figure 9).

For example, 27% of all articles were primarily oriented towards policy-makers and government decision-makers, primarily by reviewing old policy measures to mitigate certain risks and suggesting new policies or regulations to improve efforts like community monitoring and decision-making processes. Industry decision-makers (11%), natural gas sector workers (6%) and non-natural gas workers (6%)—primarily from service sectors responding to increases in demand for services in some communities—were also identified as populations impacted by UNG development.

Homeowners were identified as a relevant population group impacted by UNG development in 15% of all articles. Much of this literature addressed land owner mineral and surface rights in the United States. Nonetheless, homeowners are identified to be at risk due to upstream impacts including well water contamination, poor air quality if living in close proximity to drilling operations, property damage resulting from earthquakes, or associated changes in property value from being adjacent to UNG drilling operations. A smaller subset of these articles addressed industrial risk and safety from pipeline accidents or LNG facility failures as additional cause for concern for homeowners.

First Nations and Aboriginal or Indigenous groups (4%), women (2%), children (2%), men (1%), and the elderly (1%) were additionally identified as population groups of interest. This result is particularly interesting insofar as the predominant focus of the scholarly literature appears to be on promoting regulatory or policy measures to protect certain groups (mostly the 'general public') with limited recognition that the impacts of industrial development are often inequitably distributed across population groups, and groups already experiencing marginalization may be less able to adapt to rapid changes brought about by successive waves of industrialization [32].

Community Impact Identification

Our open coding process for tagging articles led to the development of four unique overarching community impact themes comprised of 28 sub-themes or 'tags'. The four theme areas that most articles attended to included environmental impacts (water supply, water quality, air quality, noise, agricultural impacts, and soils), impacts to infrastructure and service delivery (civil infrastructure, industrial infrastructure, transportation, health and social services, and emergency services), socio-economic impacts (local economic development, personal income, labour/workforce, housing, worker safety, community safety, crime, demographic changes, health, changes to local values/attitudes, social cohesion, cultural impacts), and impacts on policy, regulation and participation in decision making (policy/regulation, regulatory or governance capacity, advocacy, and participation/consultation/trust) (see Figure 10).

The most frequently occurring tags were a primary focus on health (38%) and water quality in upstream areas (34%). It is notable that these tags were often applied in tandem, whereby water contamination (particularly of local aquifers near well sites) was raised as a significant public health issue. Air quality (19%) and public health concerns were also often linked in upstream areas, as flaring, sour gas, and increased traffic to and from well pads, all pose significant respiratory health issues for workers and the general public alike. Impacts of industrial infrastructure (17%) were primarily identified as potential midstream or downstream impacts, as article focus tended to highlight the risks associated with pipeline failure or explosion at LNG facilities.

It is notable that socioeconomic impacts of UNG development are primarily limited to studying health impacts linked to environmental contamination. Far fewer articles focus on the positive or negative consequences for local economic development and labour trends, demographic changes to communities during construction and operation of specific projects, and associated implications for crime, safety and or demographic change. A full narrative review of all identified impact areas and associated tags is beyond the scope of

this short report. In the following section, we describe key findings from our narrative review of the policy/regulation and participation sub-theme.

Policy/Regulation and Participation

The importance of policy and regulation to govern the UNG industry was identified as a central theme in our analysis and was comprised of four sub-themes: policy/regulation, governance capacity, advocacy, and consultation/trust. These four sub-themes are comprised of a suite of articles that address multiple component parts of existing policies, the proposal of new robust policies, the regulation of the industry (including the enforcement of those regulations), identifying and addressing local capacity issues to respond to community stressors, promoting local participation in decision-making processes, and advocating for policy or industrial practice change based on localized impacts of UNG development.

Our analysis indicates that most policy/regulation articles focused on upstream impacts at the point of extraction (see Figure 11). This is primarily due to the requirement of UNG drilling to disturb large landscapes resulting in ecological impacts which hold potential consequences for human and animal populations.

Given that the potential for disturbance is greater when drilling multiple wells in a single play (a common practice to maximize the volume of gas able to be extracted) relative to the physical footprint of a pipeline or LNG facility and associated access roads, it is not surprising that issues around advocacy, participation in decision-making and consultation are more prominent in the literature addressing upstream extraction. Indeed, barring an industrial accident that affects natural gas pipelines or LNG processing facilities, the construction and operation impacts of this infrastructure is arguably smaller and thusly reflected as such in terms of scholarly attention. It is also possible that the scholarly literature on community impacts has yet to catch up with emergent LNG development both domestically in Canada, and globally. The next section of this report provides results from the narrative review of each of the four sub-themes according to supply chain focus.

Narrative Review of Policy/Regulation, Governance Capacity, Participation/Consultation and Trust across the Supply Chain

Upstream Supply Chain Focus (N=222)

Policy/regulation and governance capacity to respond to UNG impacts. The analysis of articles tagged with an 'upstream' policy/regulation (N=53) and capacity (N=16) focus elicited five emergent themes. First, the largest body of literature focused on unpacking state differences in the application of local, state and federal law to the question of UNG development (primarily taking place in Pennsylvania, Colorado, Wyoming, and Texas). This literature suggests there is a higher likelihood of federal oversight of UNG development in the United States than in Canada (largely due to the regulatory powers of the EPA) [33]. The bulk of this literature analyzed the implementation of 'home rule' in the US where local provisions and laws to constrain UNG operations have in some cases been superseded (and later repealed) by state statutes promoting industrial development. Recommendations for municipalities include moratoria or banning, regulating where fracking can occur, regulating how it occurs (noise restrictions, drilling fees, pollution and water use), and ensuring that local governments receive their fair share of revenues.

The literature on the capacity of governments to respond to the perceived or actual risks of UNGD in the 'upstream' supply chain included 15 articles with common themes of desire for more local control of decision-making and decision-making that better reflects the needs and wishes of the local population [34-36]. Local communities and governments often face more of the negative impacts of development (social disruption, pressure on local infrastructure and services) while the positive benefits such as revenue generation flow elsewhere. To address these disproportionate impacts, local governments need the capacity to participate in the decision-making process and the capacity to manage and mitigate the impacts that development has on their communities [19, 34-37]. Capacity issues primarily arise from a lack of funds due to local governments not being able to capture revenue from development and/or due to downloading of responsibilities from senior governments [19, 33, 35-36]. These issues not only occur during boom times but also during times of bust when human resource capacity may need to shift away from the boom industry, or service support capacity is reduced due to a slower economy [19].

Literature situated in the United States is focused on the conflict between state governments and municipal governments. State governments are the primary regulators of UNG development while municipal governments seek greater authority to address the environmental health impacts and pressure that is put on local infrastructure and services. In some cases, state governments are more favourable to gas development than municipal governments [34]. Municipal governments are afforded some control through the use of zoning ordinances or 'home rule' to prevent or ban gas development [33-34]. However, the use of these ordinances can be pre-empted by state governments, resulting in court cases.

Municipal governments are often faced with a lack of capacity to respond to the impacts of development and a limited ability to control the regulatory and decision-making processes. In Canada, 'home rule' does not exist and in some aspects municipal governments have less regulatory control over UNG development. In the Peace region of

BC, municipalities experience waves of development and over time have learned to adapt and respond. A study that engaged local leaders identified four main capacity issues that municipal governments face: local infrastructure deficits, lack of capacity to provide human and social services as well as services to industry, and housing challenges [19]. In response to this, communities have established innovative ways to better serve the needs of their residents. For example, a fair share agreement was negotiated with the provincial government to reallocate resource royalties back to municipalities, and land use planning tools are being used to densify housing and encourage secondary suites [19].

Second were those articles analyzing the health impacts at the point of extraction (primarily air quality issues from flaring and gas seepage leading to respiratory disease or toxicological considerations of contaminated water sources). This literature primarily seeks to elevate the role of public health considerations in UNG decision-making by increasing the involvement of regional health authorities in assessing the impacts of UNG. This can be achieved through focusing on prevention of ill health outcomes rather than the treatment once they manifest, emphasizing health co-benefits of particular land use decisions that improve health, and weighing the economic impacts with other ethical issues associated with drilling (e.g. addressing implications for future generations, environmental justice and vulnerable populations, and improving public participation) [38]. This literature further suggests that public health outcomes could be mitigated through strengthening regulations that control emissions as well as where facilities are located (i.e. increasing setback distances from population centres), mandating site emission inventories to track air quality changes over time, implementing mobile monitoring and satellite tracking of emissions as well as improving baseline testing for air and water, mandating closed loop wastewater systems, and advancing testing to determine safe exposure in ways that account for low level chronic exposures to chemicals and emissions [39-40]. However, the public health policy implications remain understudied [41], and given the emerging understanding of the health implications of upstream drilling and extraction, a precautionary approach to drilling is recommended [42] whereby decisions do not move forward in situations characterized by uncertainty about the health implications of a particular form of development.

Third was a concentration on water and water contamination. Complex arrays of policy solutions to contamination of watersheds, private wells and municipal water sources (notably ground water) were the primary emphasis [43]. These include mandating cumulative effects assessment for water sources, utilizing GIS technologies to model changes to water sources over time [44], improving bond requirements to assist with waste water reclamation costs (either increasing the cost of an upfront bond, implementing a five-year severance tax, or instituting pre-drilling fees that are reflective of environmental clean-up costs for the life of the project) [45], mandating disclosure policies for the use of all and any chemicals involved in UNG development processes and being responsive in the light of community right to know policies [46]. Another focus of this literature was the requirement for longer term and more robust monitoring efforts of water resources adjacent to UNG development (including earlier baseline studies, participation by the public, and continued evaluation) [47], to consider monitoring and reporting structures for wastewater reclamation and clean-up standards for sites and access roads, and to adopt significant setbacks of operations from any floodplains[48-49]. Additional research found that moratoria on drilling were appropriate in light of long term

and irreversible consequences of UNG activity in certain areas [50]. Additional research supported the case that significant private investment is required (above and beyond municipal water treatment) in New York State to account for waste water discharge into water ways, but that adequate treatment was possible [51].

Fourth, was an emerging policy focus on BC and Indigenous rights and title in relation to UNG development. In BC, the BC Oil and Gas Commission (BC OGC) is the sole regulator and is responsible for some provincial oversight of water contamination related to UNG development in the Peace Region. The province installed six groundwater monitoring wells in the Montney Basin in 2011 and similar initiatives are proposed for Horn River and other natural gas plays throughout the province [52]. Additionally, expert stakeholder processes in BC surfaced 10 recommendations for dealing with the boom and bust associated with upstream forms of development and operation which in addition to some of those already mentioned included mandating socioeconomic impact assessment and integrating it into the environmental assessment processes, bolstering engagement between key stakeholders, leveraging existing actions and projects within the community and learning from citizens and experts in those processes, sharing information as it becomes available, applying public health strategies to support community planning initiatives, and using an evidence-based approach to policy development [54].

There is also a strong focus on improving consultation with local First Nations in BC's Peace Region. Current policy allows the BC OGC to act as a mediator between project proponents and First Nations, whereby First Nations are not typically allowed to have direct contact with industry proponents and are required to review and return land use referrals in a 5-20 day window. The challenge with this approach is that Treaty 8 First Nations received 3882 oil and gas referrals between May 2011 and April 2012, and many First Nations do not have the capacity to review applications in light of these time frames. This is due to the fact that responding to referrals can take weeks if community consultation is required with members who are not immediately available because they are in a hunting or trapping camp. No response to the referral process is equated with consent to proceed under current policy. Other concerns include that the current permitting process misses larger cumulative impacts of multiple gas wells on traditional lands and territory, often excludes First Nations decision-making processes, and that the efforts exerted by local First Nations do not necessarily equate to positive outcomes for treaty rights, title and decision-making. These issues reflect the need for early engagement, large landscape planning across industries, and cumulative impact assessment and monitoring [35]. Moreover, given recent court cases (e.g. Tsilhqot'in decision), there are legal precedents in Canada that require First Nations consent rather than consultation.

Fifth and finally, several articles highlighted the need for mandated strategic environmental assessment (SEA) or cumulative effects assessment (CEA) that addresses the environmental, community and health implications of UNG extraction at a larger landscape level [44, 55-57]. The emphasis on SEA and CEA reflects shortcomings in existing environmental assessment approaches that only assess impacts at the level of a project's footprint, or do not include an understanding of historical impacts of resource development from the oil and gas sector (or other sectors such as mining and industrial agriculture) within the project assessment. Widening the focus beyond a project's physical footprint to include elements of impact that transcend the physical space of a drilling well could therefore include the improved documentation of environmental impacts (to

watersheds and airsheds, for example) and community impacts which are not necessarily localized to the physical location of a specific well site.

Participation/Consultation/Trust. The scholarly literature on UNG development related to participation, consultation and trust in the 'upstream' supply chain included 30 articles with three key themes, 1) the use of citizen science to address gaps in industry and government monitoring, 2) how trust of industry and government information is an important driver of risk perception and, 3) characterizations of public participation processes and recommendations for reform. The majority of the literature is situated in the United States where the unconventional natural gas 'boom' has influenced community dynamics and spurred various forms of public participation.

The use of citizen science—third party, predominantly citizen-led research projects on a variety of impacts—were identified as central to improving public participation and stakeholder engagement on issues related to UNG development. Citizen-science approaches predominantly related to well site monitoring for environmental contamination and impacts across watersheds, and to a lesser degree emphasized socioeconomic impacts. According to various groups including residents, non-profit organizations and local governments, federal and state regulators are not adequately assessing the risks and impacts that UNGD poses to local communities [40, 58-61]. Examples of these citizen science initiatives take various approaches, such as addressing disproportionate health impacts among residents exposed to pollution (2), gathering baseline water quality data that would not have been collected by industry or the regulator [61], or conducting a socio-economic impact assessment to address the challenges of a boom and bust rural community [62].

However, the move to promote citizen science is problematic if it reflects a retrenchment of responsibility from government and industry, and forces civil society organizations to fill the role of monitoring [60]. In the US, common law applications before the courts have been a final measure of public participation over UNG development, siting visual impairment and nuisance as the primary causes for filing a lawsuit against a developer [63-64]. A more successful orientation to improving public awareness and participation is to have industrial or government officials provide funding support for independent third party monitoring programs to improve transparency and the sustainability of these initiatives, as well as improving conditions for dialogue and collaborative learning [62, 65-66].

Integrating diverse stakeholder concerns of civil society, Aboriginal groups, and concerned citizens can actually strengthen support for projects provided this form of consultation is conducted early and often, with multiple points of follow-up throughout the life cycle of a project or projects [56, 67].. Indeed, the emergent focus on the importance of public consultation is reflective of the fact that participation in decision-making is not necessarily supported by law in Canada [68], and where participation by stakeholders typically extends to already privileged stakeholders occupying positions of power (i.e. industry affiliates) [69]. Additionally, providing new information in consultative formats is not particularly useful for changing opinions on the operation of fracking given the polarizing nature of this debate. Thus, consultative efforts are more effective when directed towards groups of stakeholders who are undecided on the best course of action to pursue

in relation to fracking (particularly in terms of environmental and community impacts that are negative when weighed against opportunities for economic development) [70].

Key recommendations that arise from community-based monitoring and assessment efforts include increasing the distance between wells and residences [59], using community-based approaches in impact assessments [62], conducting baseline water testing [40] and increasing involvement of state health departments in decision-making [40]. Despite these recommendations, the literature does not indicate that they are being reflected in policy changes, and regulatory changes seem to be occurring at a much slower pace than the development itself [40]. However, one article provided a case study of a local community that through a partnership between citizens and municipal government, conducted its own socio-economic impact assessment. This was in response to federal and state socio-economic impact assessments only being conducted at the pre-development stage and not monitoring post-development [62]. As a result of rapid gas development, the community experienced social disruption and costly pressures on housing, infrastructure and services. The community-based assessment was used to request additional funding from the state government.

Citizen science approaches to monitoring and surveillance are helpful in promoting trust between industry, government and the public, and also have a strong role to play in characterizing risk among local stakeholders. The literature used different methods to understand perceptions of risk, including mail out and phone surveys, and analysis of themes in newspaper articles covering UNG development [56, 65, 71-74]. A common driver of risk perception is a lack of trust toward industry or government given the limitations in available information and the transparency of that information [56, 65, 74]. Major topics in the perceptions of risk include water quality, environmental health as it relates to public health, and changing social dynamics as a result of large population increases during boom times [71-73]. The public discourse surrounding perceptions of risk has influence over policy [71]. Recommendations are made to create policy that better responds to public perceptions of risk, considers cumulative risks and takes an integrative and systematic approach [56]. In order to change or influence risk perception of local stakeholders, the literature suggests that improving public participation and consultation processes are seen as central to accounting for cumulative, socio-economic and socio-cultural impacts and are required in promoting informed decision-making [54-55, 68, 75-76].

Advocacy. Literature on the advocacy efforts of communities in response to UNG development in the 'upstream' supply chain included 20 articles with a common theme of local communities, residents and Indigenous groups seeking greater power over decisions that impact their lives. Motivations for advocacy centre around an imbalance of power between who benefits from development and who bears the risks and impacts. In the United States this includes municipalities asserting power through ordinances such as increasing the setback of gas wells from residences thus making drilling nearly impossible [77].

Another example is a group of landowners that used collective bargaining to get a better return on their surface and mineral rights [78]. In Indigenous communities in Russia, Nigeria, Peru and the United States, tactics such as creating activist organizations, forming alliances, violent uprisings, and picketing are used to protect culture, quality of life and to achieve greater justice [67, 79-81]. In an example from the United States, a

neighbourhood group allied with the Onondaga Nation to have Indigenous perspectives included in the decision-making process [67]. A common tactic is for groups to share stories to develop a narrative that brings people together, such as in Alberta where a coalition of ranchers, oil workers and retirees shared 'moral tales' about country living and the 'good life' in response to sour gas development [82].

Midstream Supply Chain Focus (N=63)

Policy/regulation. Within the analysis of UNG development articles and community impacts, 63 articles focused on the 'midstream' supply chain. Of these articles, 16 focused on policy and regulation of midstream impacts according to three themes. The first theme identified that existing regulations have inconsistent or different standards across jurisdictions (within a country's own states or provinces as well as across different countries) which creates challenges for managing risks, establishing clear government oversight and keeping legislation up to date with changing technologies associated with pipelines [52, 83-84, 89].

The second theme within this subset of the literature are recommendations to improve policies and regulations which include the creation of comprehensive management plans over large regions; voluntary monitoring best practices, standards and certification; restricting developments in parks and protected areas and creating appropriate distances between natural gas infrastructure and inhabited areas and water sources [43, 85].

The third theme addresses land use practices that local municipalities can employ to reduce the risk of pipeline hazards within their jurisdictions. As noted in the literature, pipeline hazard mitigation and planning procedures are often missing from local government agendas as they may not be aware of the risks associated with pipelines in their jurisdiction [86-88]. These land use practices include regulatory tools such as using zoning/setbacks to establish a 200 meter corridor or 660 foot planning zone to restrict and control developments within the zone, and for developers to consult with pipeline owners (and vice versa) [48, 53, 87-88]. Other land use practices include acquiring pipeline information to identify locations and create maps, and using incentive programs to discourage developers from siting developments near pipelines [88].

Capacity. Within the articles with a 'midstream' tag, three main themes emerge from five articles addressing regulation or governance capacity. The first theme represents the risks and pressures that local governments experience during boom and bust periods from the natural resource sectors. New demands for UNG developments put communities at risk in terms of meeting demands for rapid industrialization, providing housing options for a growing population and meeting the service demands of industry [19, 36]. Lack of federal funding and the uneven distribution of costs and benefits from UNG developments further reduces local governments' ability to respond to periods of industrial boom or to maintain aging infrastructure during industrial busts [19, 36]. Recommendations to increase the long term capacity of communities to respond to industrial impacts includes long term investments over an entire community or region and the need for information and transparency from industry [36].

The second theme addresses the need for collaboration and relationship building to increase regulation and governance capacity addressing pipeline hazards and for First Nations to readily respond to natural resource development applications. Local and regional governments need to take a collaborative approach to address major pipeline hazards across their jurisdictions. This approach requires planners and emergency managers across jurisdictions to have ongoing communication, share access to information and technical support to address pipeline hazards and to create mitigation and emergency plans for pipelines which are currently not on the agenda for many local governments and planning departments [86].

The third theme addresses the regulation and governance capacity of states in the U.S. there gaps arise in dealing with substance regulation, compliance from industry, establishing monitoring activities and ensuring the public is aware of state enforcement and inspections [37].

Advocacy. Articles addressing advocacy with the 'midstream' supply chain of unconventional natural gas developments (N=6) speak to how communities mobilize to get their voices heard. The majority of this literature dealt with problems arises from environmental justice movements where Western funded pipeline projects are developed in countries where there is little regulation and government oversight [81, 89-90]. Many of these mobilization efforts involve local residents, government, politicians and international organizations and often resulted in violent actions to get their interests heard through protests, blockades, workshops, kidnapping or peaceful actions such as letters to the editor and networking with allied groups [81, 89, 90-91]. One method employed by a community to create change is described as popular epidemiology where residents themselves investigate the risks associated to a perceived environmental threat [91].

Participation, Consultation and Trust. Articles within the 'midstream' supply chain focus of unconventional natural gas mention various methods used for public participation and consultation. Articles with this focus (N=10) document the use of workshops with the public, project proponents, governments, First Nations, academia and other stakeholders [53-54, 84]. One article detailed the importance of using illustrative tools for improved communication such as GIS analysis methods for consulting the public on the design and planning of large scale changes to the landscape such as pipelines [84]. This method with the addition of small group discussions allows for more interactive dialogue between the public and workshop hosts [84]. First Nations communities in British Columbia, Canada expressed their frustrations with the consultation process utilized by governments for proposed unconventional projects and these concerns are well-aligned with those expressed in above sections on this topic [35, 84].

The establishment of trust is important for any unconventional gas developments to occur between all parties involved. Lack of trust in industry during 'midstream' development is recorded to occur when communities are not compensated and are not given enough knowledge to make accurate and informed opinions on unconventional gas developments [65, 90, 95]. In order to establish trust one article highlights the need for the consultation and public participation process to get the right science, get the science right, get the right participation, get the participation right, and to develop accurate, balanced and informed synthesis [65].

Downstream Policy/Regulation Article Review (N=32)

Policy and Regulation. A total of nine articles recorded a policy and regulation community impact type within the 'downstream' focus of unconventional natural gas development. Majority of these articles focused on the regulations for siting LNG terminals at either on or offshore locations [92-96]. Within the United States the Federal Energy Regulatory Commission has jurisdiction over LNG terminal locations and onshore facility locations are required to meet the following regulations: National Fire Protection Association 59A, European Norm 1473 Standard, Title 49 Code of Federal Regulations (CFR) Part 193, Title 33 CFR Part 127 [92, 94, 96]. As shared in the literature the current regulations within the United States for siting LNG terminals lack safety management systems/plans, computational fluid modeling for determining the most compatible location and risk-based analysis which is also similarly missing from regulations in Norway [92, 94-95]. Improvements to the missing pieces of regulation can create certainty within United States legislation as the demands for LNG terminal and facility locations increase [94, 96]. It is also noted that many countries do not have strong regulations or any requirements for offshore LNG facilities and onshore regulations are outgrowing public concerns for safety [92, 94-95]. The best practices in Europe use a case-by-case risk based analysis for determining sites which is performance based in nature whereas the United States uses minimum standards [93].

Capacity, Advocacy and Trust. Given the limited articles on policy and regulation community impacts of 'downstream' unconventional natural gas development, few articles explicitly deal with capacity (N=2) or advocacy issues (N=4). Those that do, however, are strongly integrated into the public participation and consultation literature addressing 'downstream' development. The main concern identified to be brought forward by the public is their concern over LNG terminal and facility safety. These safety concerns are expressed in the form of risk for explosion causing physical and environmental harm as well as the level of risk for acts of terrorism [96-98].

The risks associated to LNG terminal and facility locations are local in nature and propose the greatest costs to the host community [96]. A proposed LNG project on the east coast of the United States was advocated against by local groups who elevated the terrorist threat as a means to increase their case against the project by expressing their opinions to elected officials, comments on public documents and through public rallies outside public hearings [98]. Within the United States, the public consultation process as part of the Federal Energy Resource Commissions site application process has three avenues for public participation to occur before final decision; first, information is shared to the public during the pre-filing stage; second, when the governor appointed agency of the site state location is consulted; and third, when a note and comment period is open for the formal application [96]. This federal process has been documented to have enough breadth to it to ensure communities are adequately consulted and do not skew final decision making [96]. Improvements to this federal process include local participation proportional to costs on communities, state agencies becoming more involved and to extent the time periods to review applications, reports and information ([96]. Other improvements to public

consultation and inclusion processes include planners to build and maintain relationships, understand public safety concerns need to be addressed and collaborative research with First Nations groups [97, 99].

These concerns are echoed by scholarly articles focussing on the Indigenous contexts in Australia. For example, Aboriginal groups in Western Australia participated in a Strategic Environmental Assessment (SEA) of gas development that included the creation of their own 'Indigenous Impacts Report' and a list of conditions required for their consent [55]. Kimberly Aboriginal people have title control over 65 percent of the Kimberly region. Title designation does not allow them to control development but it does give them the right to negotiate when development is proposed on their lands. In the case of the SEA for the Kimberly LNG Precinct, the state government made a policy commitment that LNG would only proceed with informed consent from Kimberly Aboriginals. However, there was a change in government part way through the process and Aboriginal consent was no longer sought.

The Indigenous Impacts Report was included in the SEA and a number of studies were conducted to assess the potential economic, social, cultural, archeological and ethnobiological impacts. Studies were conducted by the Kimberly Land Council and included community meetings in different parts of the region. The report faced limitations due to time constraints that were determined by the state government. Despite this, the Indigenous Impact Report was the most comprehensive impacts assessment done in Australia. This study notes the important role that community mobilization played in demanding a collaborative decision-making approach that included Aboriginal community participation. If the Kimberly Land Council had not advocated for its community, they would not have been included in the SEA for Kimberly LNG [55].

Knowledge Gaps

A strength of our scoping review methodology is its ability to 'map' a given literature in a relatively limited amount of time. This exercise is therefore highly valuable in producing an understanding of where significant attention is or is not given to topics. Given the overview provided above, we now present several key knowledge gaps that are suitable for further investigation.

Stream Focus. Our review surfaced that relatively few articles highlighted community impacts for midstream transportation corridor communities (i.e. communities that are located adjacent to pipelines and pump stations) and downstream export communities (i.e. places with LNG facilities). There are currently 20 LNG facilities approved for export licenses in BC, and the construction and operation of those facilities—not to mention the pipelines that will serve them—will bring considerable changes to coastal communities. It is therefore paramount that more attention be given to the changing community dynamics associated with LNG infrastructure projects.

Given that the impacts of mid and downstream development appear to be understudied relative to upstream impacts, we were surprised to also see limited studies addressing increased traffic and safety, particularly on rural access roads, on visitors and residents. For downstream communities, there were no studies assessing LNG traffic in relation to commercial and recreational marine use and its implications for community development. More study is also required to understand how local governments across the supply chain manage booms and busts associated with construction of projects given that following construction of UNG facilities, few jobs remain in midstream and downstream locations. Better accounting for the local economic benefits across the supply chain should be seen as a paramount exercise for future research in this area as currently, upstream locations have the most to gain from continued UNG development due to stable employment opportunities.

Community Impacts. Despite surfacing a significant body of literature documenting the socio-economic impacts of UNG development on communities, there were certain sub-themes that had relatively few citations. For example, there have been numerous accounts in the media of changing population dynamics from fly-in/fly-out camps and the results of rapid population influxes on local services (particularly during a project's construction), living costs, and local economic development, but there are few published studies on how UNG affects such dynamics. The impacts related to population pressure from work camps adjacent to all forms of UNG development are also significant and may include implications for waste management, social service provision, crime, poaching, and increased sexual violence [99]. However, we found that few studies addressed impacts to worker populations, particularly initiatives that provided retraining opportunities during times of economic bust.

Indeed, the lack of studies on municipalities' ability to address issues such as civil infrastructure, possible increases in criminal activity, real estate speculation and emergency services holds additional implications for the voluntary sector. The voluntary sector plays an important role in small communities; to provide services that local

governments are unable to deliver. Moreover, we found that there is a paucity of articles addressing the capacity of local governments to address impacts before, during and after they happen, and that there is significant need for more proactive planning for effects before they emerge; to mitigate risks and promote community wellness across the supply chain. Longitudinal impact studies that both qualify and quantify relevant changes over time relative to some set of baseline operating conditions in a given community could assist in better measuring and planning for impacts that may manifest during the speculation, construction, operation and closure stages of UNG-related development. Longer term planning processes that are guided by adaptive management seem much more likely to be able to address concerns that emerge from the multiple points of intersection between ecological, community and health issues. As an example, the Kispiox Valley in BC is a world-renowned location for steelhead trout and salmon fishing. What are the potential ecological impacts associated with increased sedimentation in the watershed associated with clear-cutting for access roads and right of ways and the economic consequences for local guiding outfits? By creating new ways of assessing risks and attempting to develop planning processes that are capable of being responsive to emergent behavior in these complex systems, governments and communities will be better able to reduce the risks posed by UNG development, determine whether UNG development is suitable given current conditions, and provide meaningful engagement opportunities for the public and First Nations.

Population Focus. We found that there were relatively few studies on the equity implications of UNG development and understand this to be a significant gap in the literature. We know from the public health literature that those populations that already bear a disproportionate array of ill-health effects from their local environments are more vulnerable to subsequent changes in their communities. Building on this line of questioning, it will be important to address the question of whether a rising tide does indeed raise all ships. In other words, how are the benefits of local economic booms distributed across local populations? What impacts does rapid UNG development hold for women, children and families, particularly given that UNG workers are predominantly male? What impact does an influx of workers have on the safety of women in the community? Does UNG development alleviate poverty? And do Aboriginal groups or other populations that have historically experienced multiple forms of marginalization experience impacts more intensely than other populations? A targeted research program that addresses how fairly or justly impacts of UNG development are distributed would be a significant contribution to the existing literature.

Implications

Our scoping review describes the current state of knowledge on the community impacts of UNG development on primarily rural and remote communities located across the supply chain. To our knowledge, no review currently exists to conceptualize community impacts across the supply chain, particularly in relation to the emergent global LNG industry. Second, our review outlines relevant knowledge gaps and assesses the suitability for conducting a full systematic review on nascent community impacts identified through the review. Key areas of future inquiry are the investigation of how impacts are distributed across unique populations, and the need for longer-term community impact assessments for UNG development. In addressing our research question, this knowledge synthesis contributes to a growing body of research seeking to foster sustainable and resilient communities experiencing unprecedented levels of growth and investment in the UNG industry. A key strength of our methodology is that it provides a rigorous and transparent way of mapping the literature that characterizes the community impacts of UNG development.

Moreover, this work is timely. In the wake of concerns voiced by local governments and First Nations groups regarding the socioeconomic impacts of LNG projects—and at the behest of local decision-makers [54]—the BC Ministry of Community, Sport and Cultural Development (MCSCD) was recently tasked with on-going and prospective impact monitoring for industrial developments as a part of the environmental assessment process. The MCSCD has begun to develop socio-economic effects management plans (SEEMPs) as a part of the broader assessment architecture and as a legally binding condition of Environmental Assessment certificates [100]. The SEEMP framework includes a variety of recommended assessment indicators, but no guidance on reasonable baseline metrics or impact thresholds and associated mitigation response strategies. The continued analysis of this dataset should leverage suitable metrics and benchmarks to contribute to the SEEMP framework.

Knowledge Mobilization

In order to share the knowledge produced through this review, several subsequent steps will be taken. First, it is important to recognize that the analysis presented here in this report is partial, and has only adequately explored one of four nascent themes that were uncovered through our review. Accordingly, we will continue our analysis on targeted community impacts and knowledge gaps that emerged from this review.

In terms of communicating results and moving this knowledge into practice, our knowledge mobilization strategy utilizes existing resources at the disposal of co-investigators Halseth and Buse to disseminate information. It is notable that Dr. Buse is the Project Lead for the newly established Cumulative Impacts Research Consortium (CIRC) which has received project funding from the Pacific Institute of Climate Solutions to foster a community of practice on the cumulative impacts of resource development across northern BC. A core part of the CIRC's mission is to provide a platform for research and community engagement on the cumulative impacts of resource development. Not only does our scoping review meet the research component of our mission, but our strategic plan to host regional engagement events throughout northern communities will provide opportunities to share this research. To ensure that the findings from our scoping review are distributed to the scholarly, practice-based, and community audiences which comprise the CIRC, we have developed a knowledge mobilization strategy that utilizes a combination of (a) scholarly publications and reports, (b) scholarly presentations, and (c) community-engaged workshops and events.

Production of Scholarly Publications and Reports. We anticipate that our scoping review will result in the production of at minimum, one peer-reviewed journal article (to be submitted to the *Canadian Geographer* or equivalent) and a short research report written for lay audiences which describes our search methodology, key findings, and information on how to access additional information. Beyond disseminating our findings in the scholarly press, we will share our reports and publications on the CIRC webpage, through the CIRC listserv (which currently has 400+ members and continues to grow), and to social media accounts to improve our public reach. We will also utilize any published materials and the research report to help design workshops and guide discussions during community outreach and engagement events (see below).

Delivery of Scholarly Presentations. We anticipate having, at minimum, three opportunities to present our findings to scholarly audiences. First, as a requirement of this grant, a designate of our team will present at two SSHRC-sponsored knowledge mobilization events to share our findings with other recipients of knowledge synthesis funding that are responding to important questions about the continued development of Canada's natural resources and their implications for Canadian people, communities, environments, and economies. Additionally, we will be presenting this work at the 2016 Environmental Studies Association of Canada Annual Meetings during the Congress of the Social Sciences and Humanities in Calgary, AB as a suitable venue to share results with other interdisciplinary audiences engaged in issues related to resource extraction and community/economic development.

It is also notable that UNBC's three research institutes (which founded the CIRC)— the Community Development Institute, the Health Research Institute, and the Natural Resources and Environmental Studies Institute— host regularly scheduled research presentations, brown bag lunch discussions, and formal symposiums. Given the focus of our research, there is a strong likelihood that this work will be shared at these venues, and by way of other invited presentations leveraged through the CIRC Advisory and Steering Committee members who are connected to various communities of practice engaged in work related to our research question.

Delivery of Community-engaged Workshops and Events. The CIRC Advisory and Steering Committees are currently in the process of identifying regions to host future workshops and events. These events will seek to foster dialogue and solicit input from concerned stakeholders about the environmental, community, and human health impacts of various forms of resource development, with a particular focus on the cumulative impacts of multiple land uses across northern BC. We are committed to holding regional engagement activities in a variety of communities across the north, and have already received significant interest to partner with local agencies and organizations in their delivery. We anticipate holding approximately five of these events between 2016-2017.

Given the synergistic opportunity that these workshops present with our scoping review, we propose sharing key findings, data, and recommendations that are surfaced in our review during special sessions at least three of these regional events. Further, we are committed to hosting a special session in at least one 'upstream' natural gas producing community, one 'midstream' community with operational natural gas pipelines, and one 'downstream' natural gas export community. While these sessions will be designed to share findings about the impacts of unconventional natural gas development across all aspects of the supply chain, workshop elements will be designed with local values and place-based contexts in mind.

These sessions will explore key findings with community members and regional stakeholders, serving to share knowledge from the synthesis, validate information from the review, identify further research gaps not included in the review, and to foster dialogue to pursue or enhance risk mitigation activities suitable for those communities. The value of these workshops will therefore be to generate new research questions that are rooted in and responsive to community needs. This strategy also holds the potential to generate significant partnerships and thereby engage in solutions-oriented research and practice.

Conclusion

Expanding the growing focus on boom and bust economies of resource dependent Canadian towns and regions [3-6], this scoping review sought to document and describe the community impacts from unconventional natural gas projects, and to contribute to innovative planning approaches that sustainably anticipate regional waves of resource development [7]. Responding to calls for a more constructive engagement with the socio-economic and cultural impacts of resource development [8] we asked: How are rural and remote communities impacted by unconventional gas development, and how do those impacts vary for 'upstream' gas producing regions, 'midstream' gas transporting corridors, and downstream gas exporting communities?

The findings shared in this short report are primarily focused on regulation, policy and participation in decision-making that governs UNG development. We found that there are numerous promising developments to promote environmentally, socially, and economically sustainable forms of UNG development and a diverse array of policies and practices capable of mitigating risks to communities. However, we also found that current planning and assessment practices may be woefully inadequate across jurisdictions, and that improved participation and shared local decision making for projects may be necessary to improve the social license of UNG operations. Moreover, existing regulatory approaches to assessing environmental and community impacts of UNG are likely not robust enough to capture the diverse array of emergent implications of these projects beyond their project footprint. Fortunately, new tools such as SEA and CEA can be implemented and collaboratively managed by diverse stakeholder groups to improve monitoring and surveillance.

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Figures

Figure 1. Results of search strategy for peer-reviewed literature on the community impacts of unconventional natural gas development

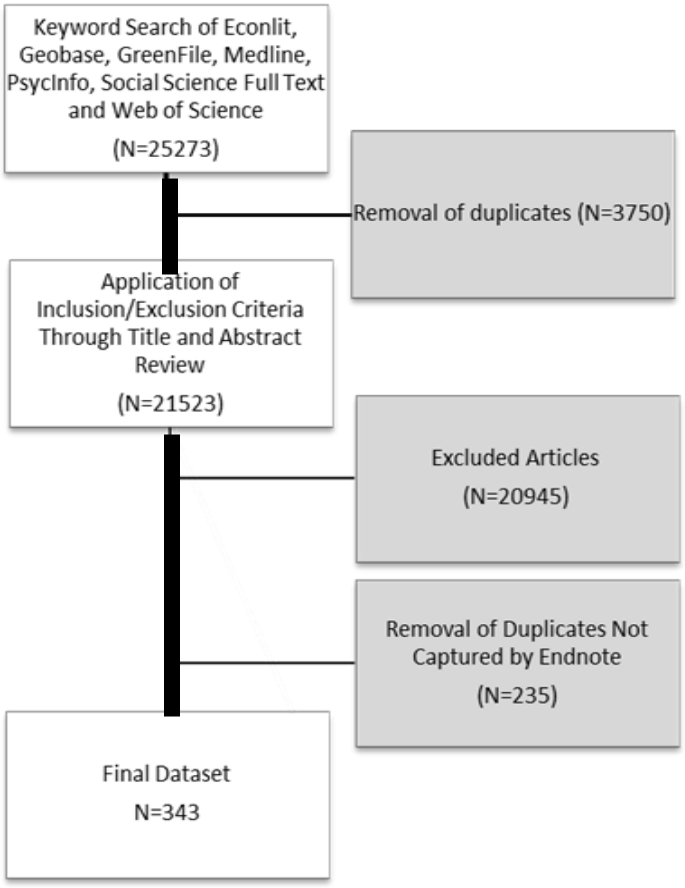


Figure 2. Publication date of articles meeting inclusion criteria focusing on the community impacts of unconventional natural gas development (N=343)

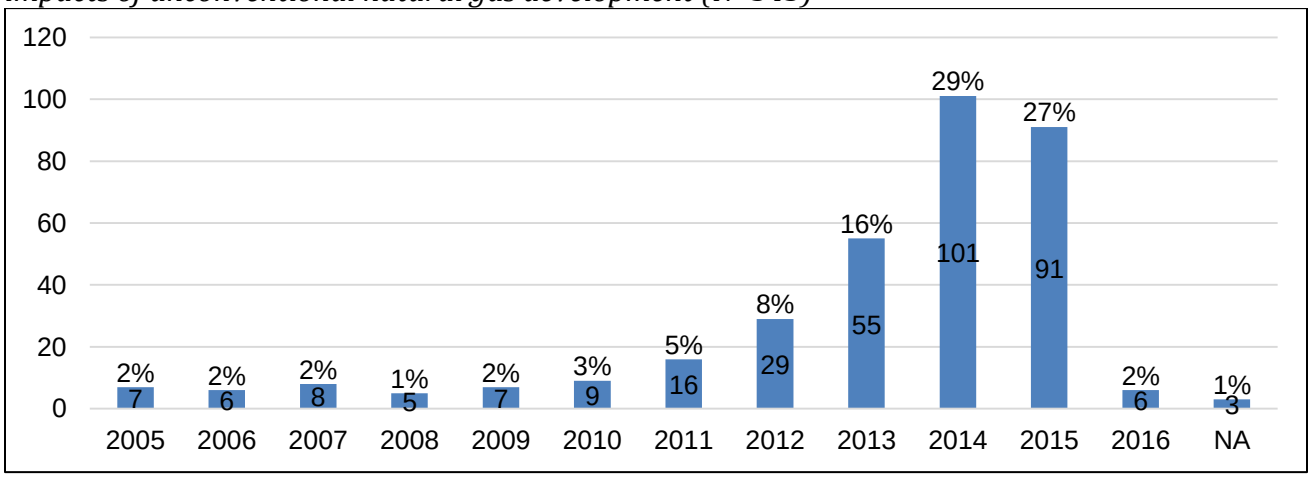


Figure 3. National focus of articles included in the scoping review of community impacts of unconventional natural gas development (N=343)

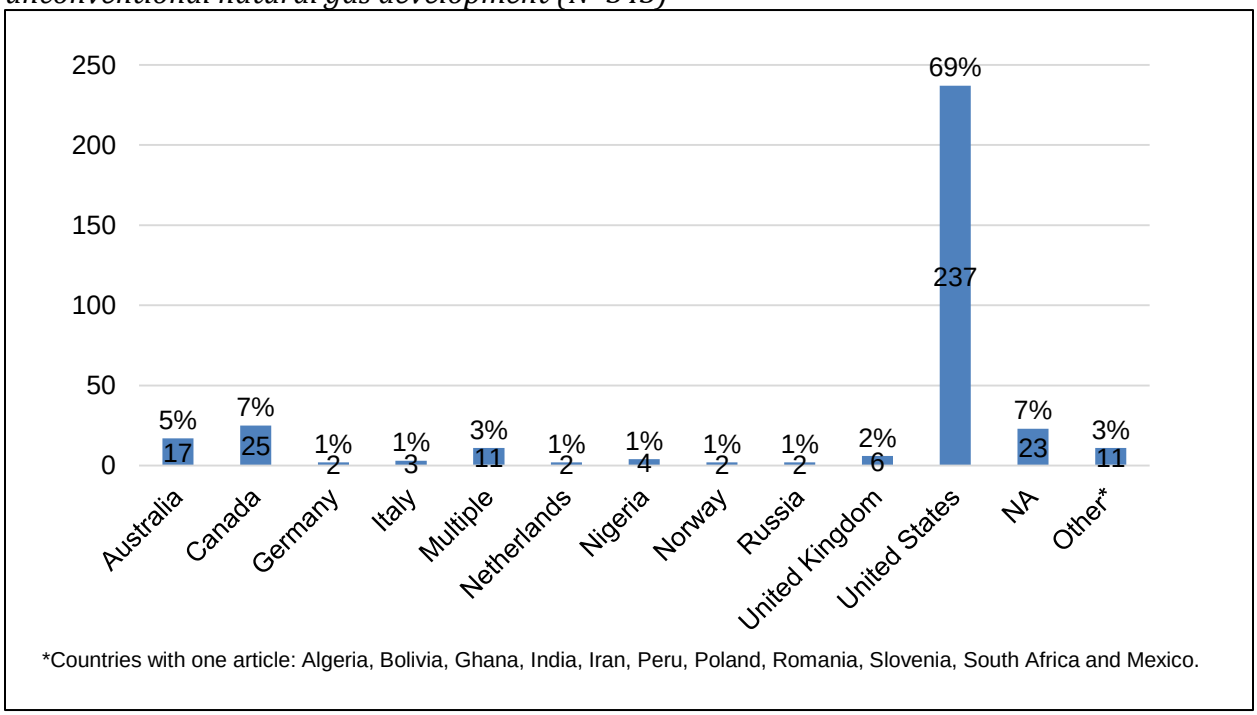


Figure 4. Level of government focus from scoping review of articles addressing the community impacts of unconventional natural gas development (N=343)

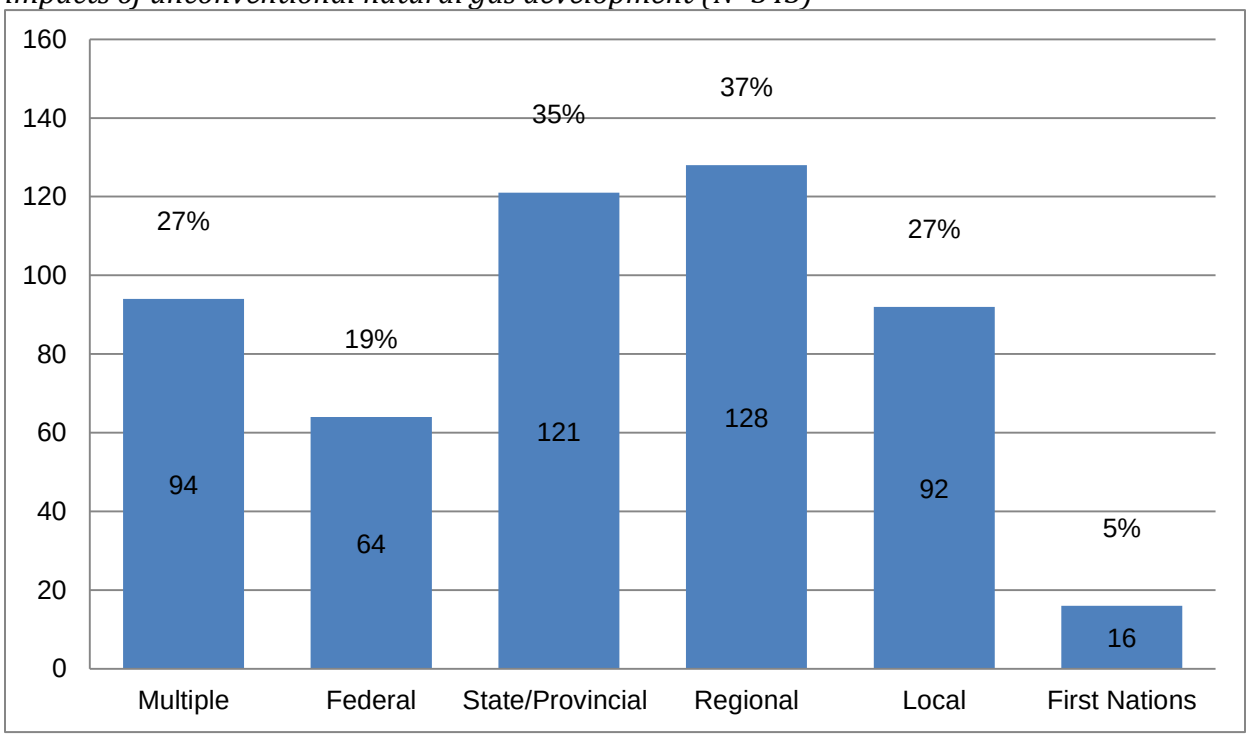


Figure 5. Research methods utilized in articles addressing the community impacts of UNG development (N=343)

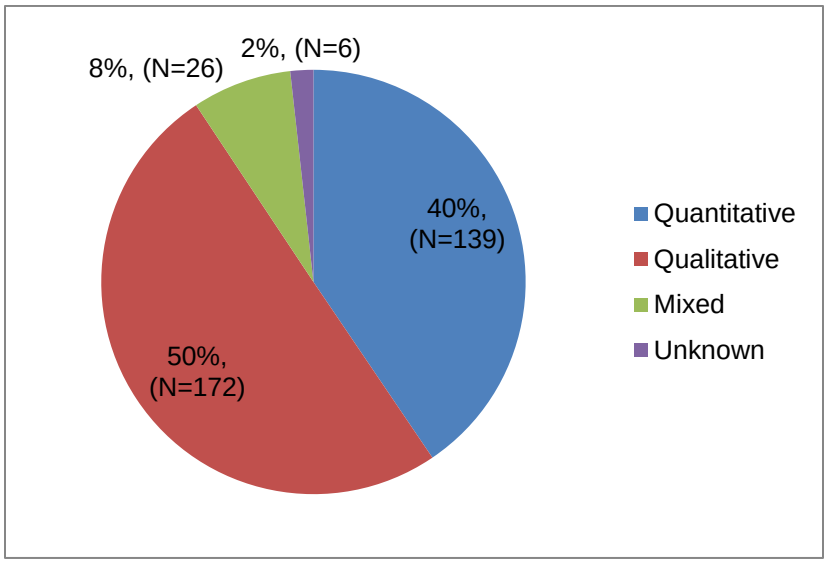


Figure 6. Tagging of data sources surfaced through a scoping review of the scholarly literature on community impacts of UNG development

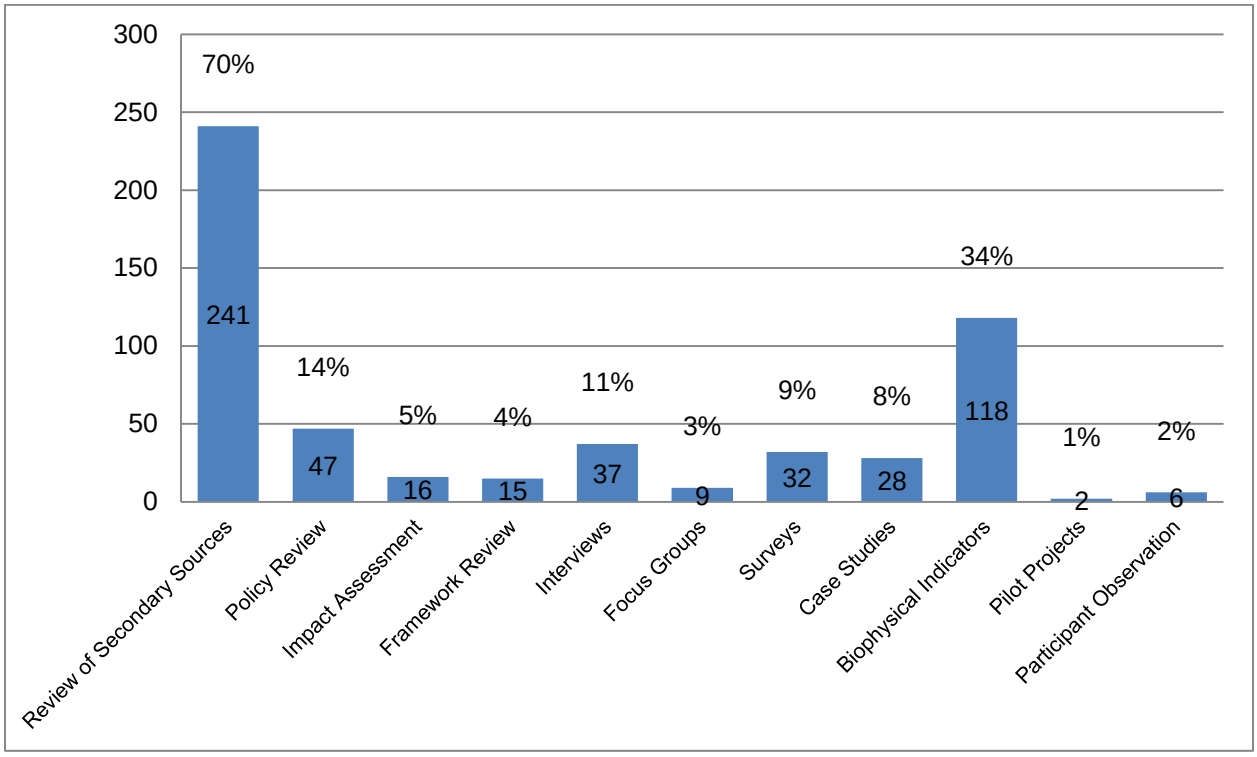


Figure 7. Distribution of scholarly literature on UNG development according to supply chain focus

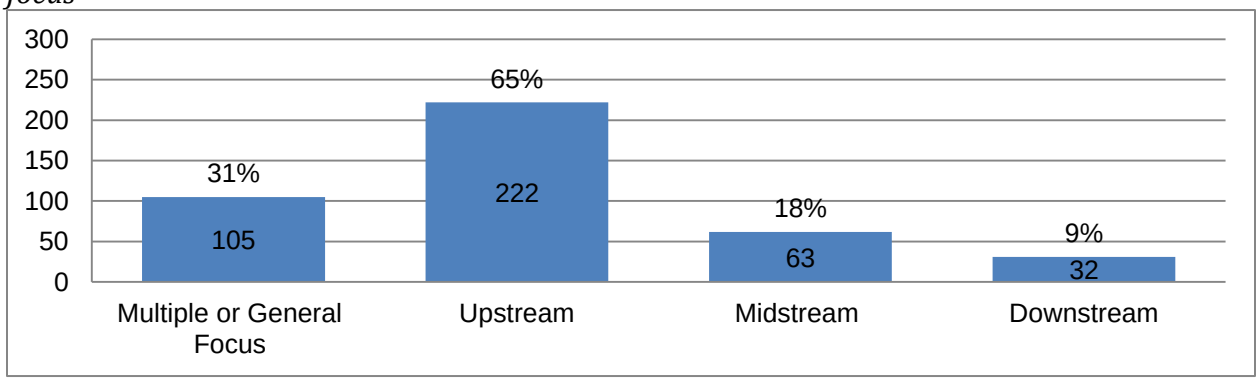


Figure 8. Year of article publication according to supply chain focus

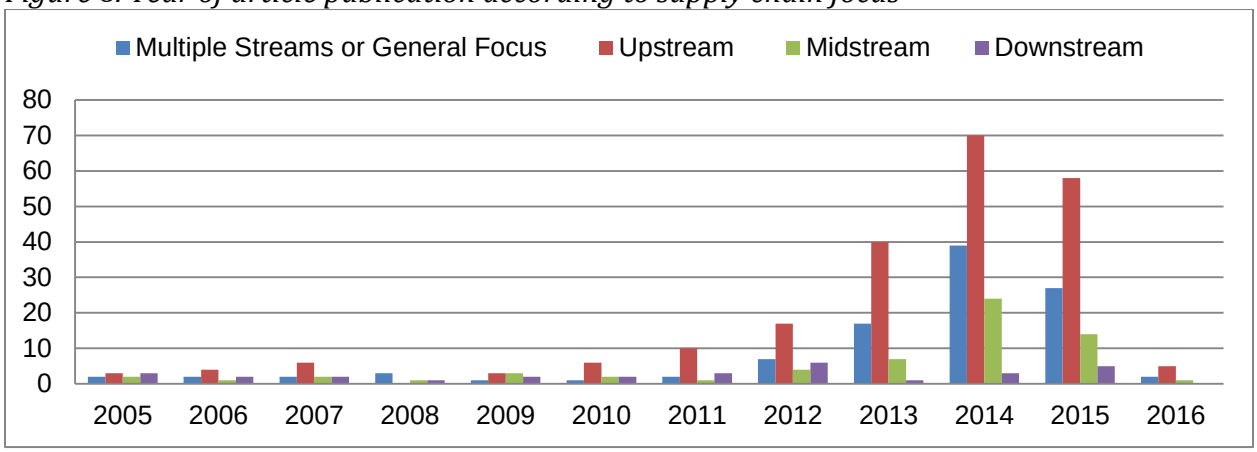


Figure 9. Distribution of population focus of scholarly articles on UNG development

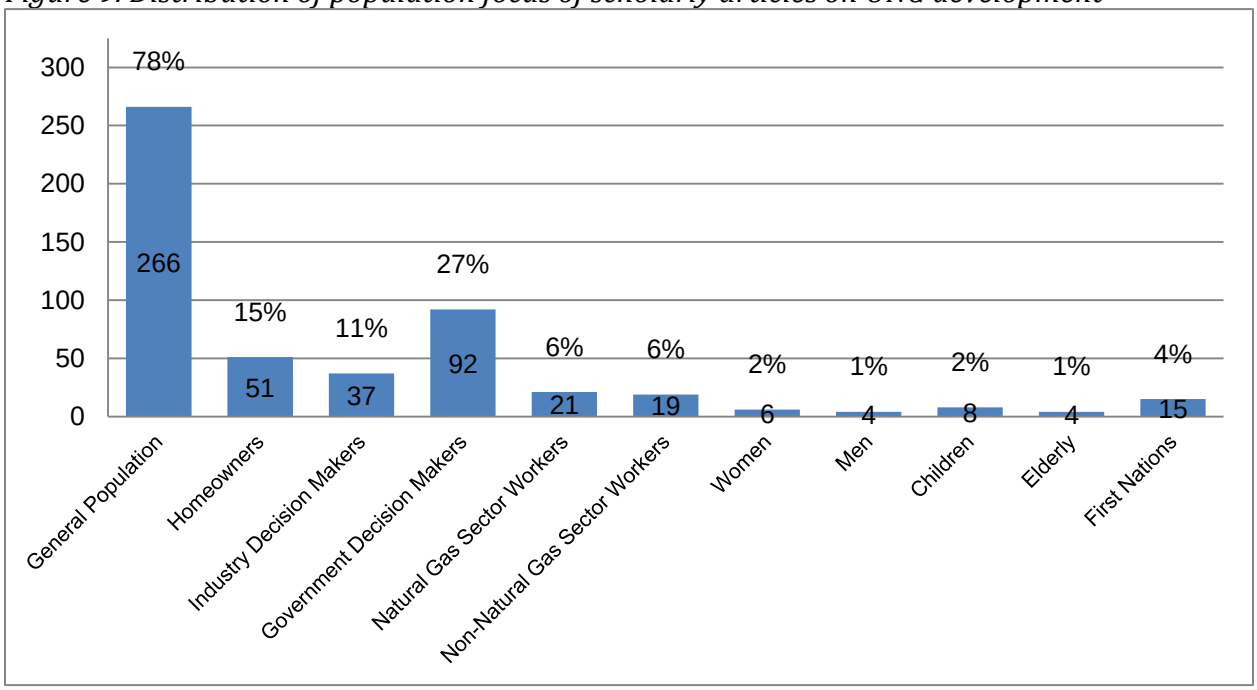


Figure 10. Identified community impact areas and associated and associated impact tags (N=343)

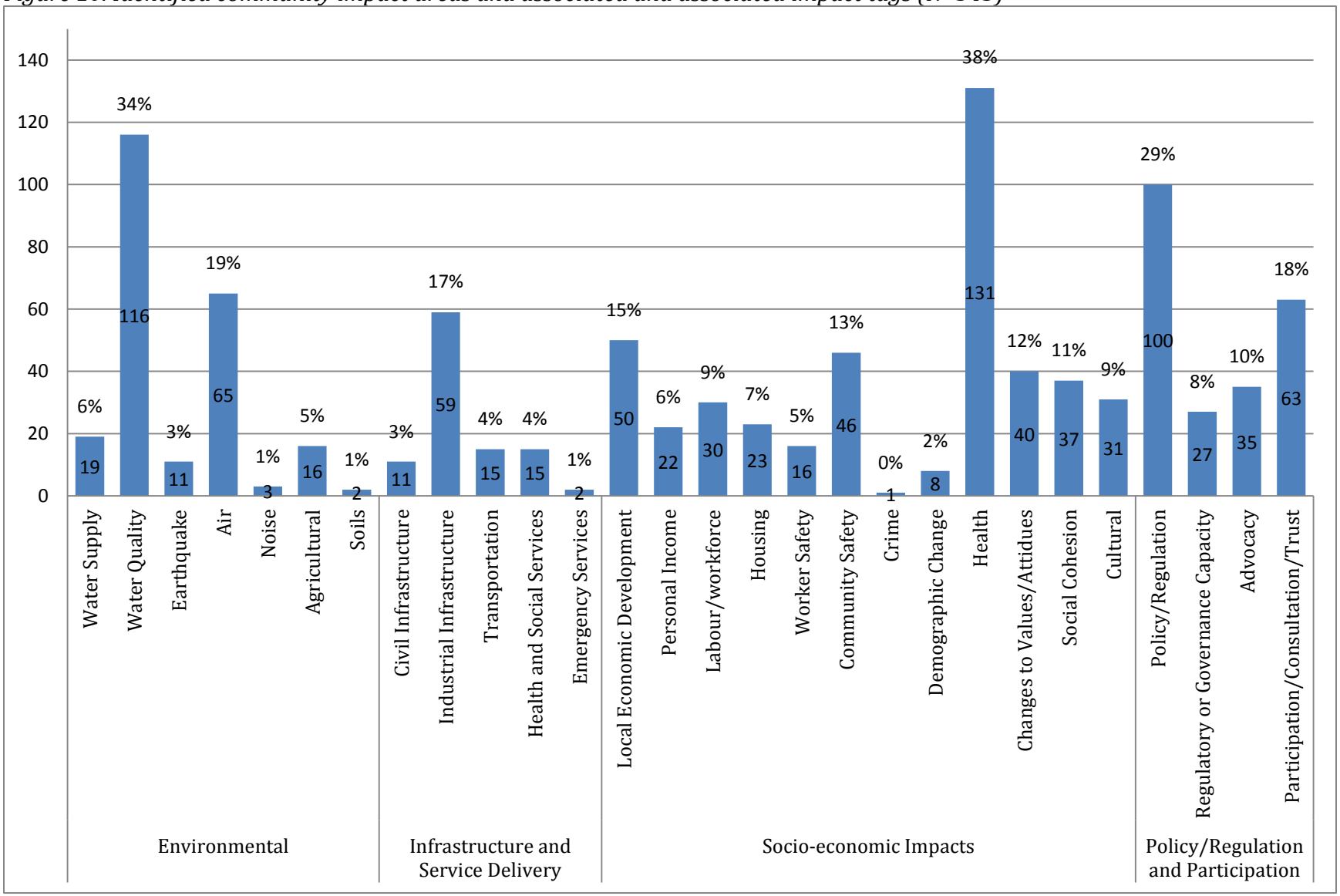
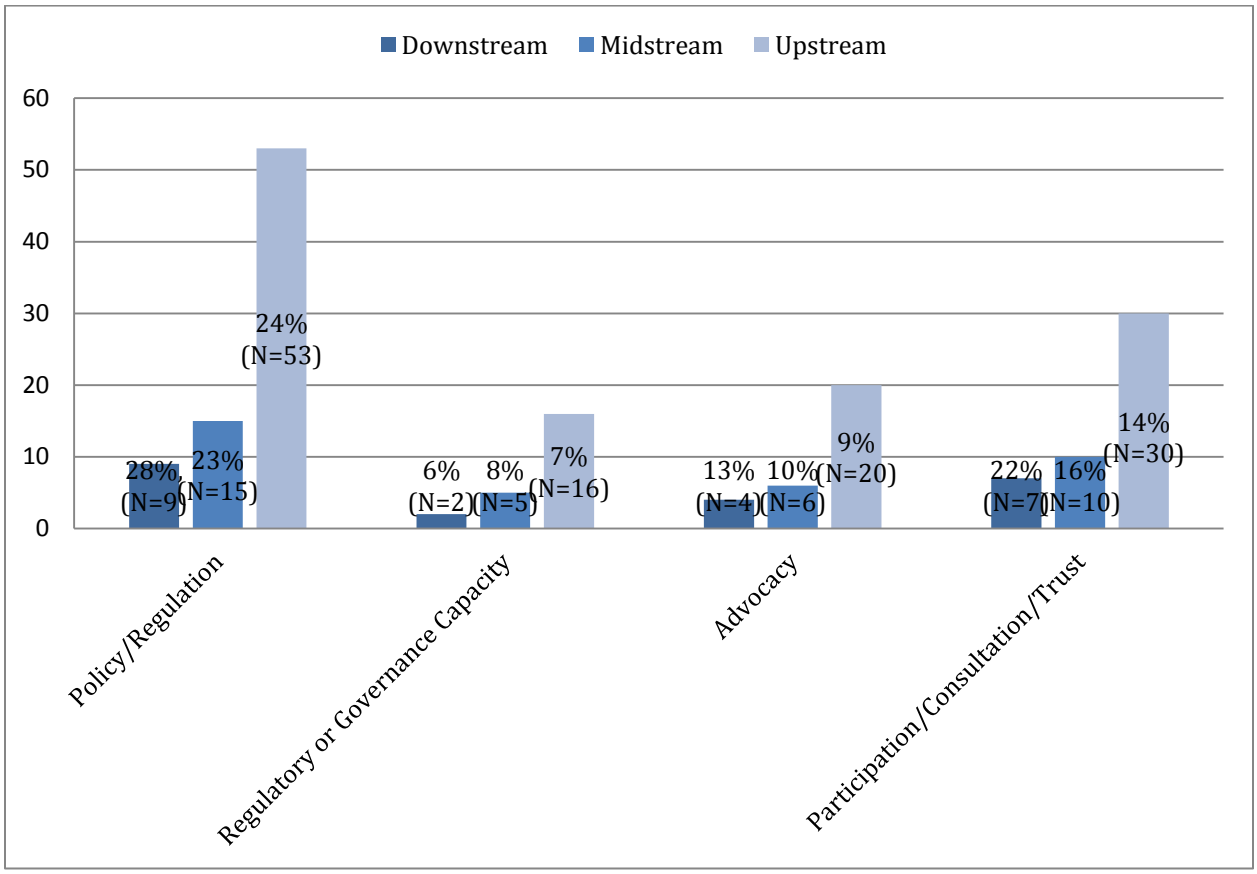


*Figure 11. Distribution of Policy/Regulation and Participation Tags According to Supply Chain Focus**



**Percentages in the chart are reflective of the number of articles per category displayed on x-axis divided by the total number of downstream (N=32), midstream (N=63) and upstream (N=222) coded articles*

Appendices

Appendix 1. Scoping review search terms for peer-reviewed articles in English published between 2005-2016

Search Focus	Search Terms
Natural Gas Sector Search Terms	(("coal-bed methane" OR "coalbed methane" OR "coal bed methane" OR "tight gas")) *OR* ("natural gas" OR "shale gas" OR "liquefied natural gas" OR LNG) *OR* ("unconventional gas" OR "unconventional natural gas") *OR* (fracking OR fraccing OR "hydraulic fracturing" OR hydrofracking OR hydrofacturing)
AND	
Stream Focus Search Terms	("directional drilling") *OR* (extraction NEAR/3 industry) *OR* (drilling OR extraction OR industry OR wells OR rig OR plant OR field) *OR* (construction OR operation) NEAR/3 (“gas pad” OR “gas well” OR “drilling pad” OR pipeline*) *OR* ("well pad*" OR "injection well*") *OR* (drill* NEAR/3 pad*) *OR* ("petroleum industry" OR "linear corridor") *OR* (pipeline*) *OR* ("shale gas" NEAR/3 (exploitation OR extraction OR development OR exploration)) *OR* ("Slick water stimulation" or "Well stimulation") *OR* (development OR extraction OR exploration OR exploitation) *OR* (terminal* OR plant* OR facilit* OR carrier* OR tanker*)*OR* ("pump station*" OR "refuelling station*" OR "compressor station*")
AND	
Community Impact Search Terms	(growth NEAR/3 (economic OR community OR industry OR boom OR management)) *OR* ("rural migration" OR in-migration OR out-migration) *OR* (("fly-in" OR "fly-out") OR ("drive-in" OR "drive-out")) *OR* (camp NEAR/3 (work* OR life OR job* OR employment)) *OR* (remote NEAR/3 (work* OR employment OR job*)) *OR* ((house* OR housing) NEAR/3 (prices OR renovation* OR rent* OR inflation OR cost* OR afford*)) *OR* (("land value*" OR "property value*" OR "real estate value*" OR "commercial real estate value*")) *OR* ((crime OR violen* OR theft OR "sexual assault" OR drug* OR "substance use" OR "substance abuse" OR safety)) *OR* (("social service*" NEAR/3 (provision OR delivery OR funding OR access)) *OR* (("health service*" NEAR/3 (provision OR delivery OR funding OR access)) *OR* ("rural health" OR "public health") *OR* (School* OR universit* OR college* OR trade school* OR continuing education OR re-training OR vocational training OR post-secondary OR diploma* OR degree* OR certificat*) *OR* (workforce OR workplace) *OR* ((worker* OR labour* OR labor* OR employee*) NEAR/3 (temporary OR transient OR mobile OR "temporary foreign" OR roster* OR rotation* OR transient OR skilled OR unskilled OR trades OR certification OR training)) *OR* (economy OR income) *OR* (infrastructure NEAR/3 (traffic OR road* OR bridge* OR communication* OR

	transportation*)) *OR* (transportation NEAR/3 (air OR road* OR shipping)) *OR* ("emergency services" OR "first responders" OR ambulance OR "fire department" OR police OR paramedic* OR hospital* OR shelter* OR clinic OR clinics) *OR* (culture OR cultural OR acculturation OR "influx of new people" OR "First Nation*" OR Aboriginal OR Indigenous) *OR* ((education* OR training) NEAR/3 (skills OR youth OR adult* OR trades OR certification)) *OR* (("long-term" OR "short-term" OR direct OR in-direct) NEAR/3 (job* OR employment OR work OR unemployment OR recruitment)) *OR* ("mental health") *OR* ((govern* NEAR/3 (local OR municipal OR provincial OR senior OR federal OR regional OR state)) *OR* (demographics OR divorce OR homelessness OR transience OR marital status OR famil*)) *OR* (NGOs OR "non-governmental organization*" OR "community organization*" OR volunteerism OR advocacy OR funding) OR (recreation OR "civil service*" OR water OR sanitation) *OR* (consumption OR money) *OR* ("sense of community" OR "social cohesion" OR trust OR "social capital" OR "community cohesion") *OR* (business OR retail OR commercial* OR investment) *OR* (planning OR "energy policy" OR jurisdiction OR collaboration OR partnership*) *OR* (“human resources capacity” OR “organizational capacity”) *OR* ((opportunit* OR constrain* OR equality OR equity OR barrier*) NEAR/3 (women OR youth OR "young adult*" OR adolescen* OR age OR gender)) *OR* (boom* OR bust OR boomtown*) *OR* (attitude* OR perception* OR values) *OR* ((Communit* OR local OR area OR town* OR city OR cities OR rural OR village* OR district OR region*) NEAR/3 (impact* OR effect* OR change* OR outcome* OR transformation))

Appendix 2. Scoping review search results by database

Database	Platform	Date exported	Number of hits
Econlit	EBSCO	Feb 28 2016	1305
Geobase	Engineering Village	Feb 23 2016	4702
GreenFile	ECBSCO	Feb 23 2016	6666
Medline	OVIDSP	March 4 2016	376
PsycInfo	EBSCO	Feb 23 2016	76
Social Science Full Text	EBSCO	Feb 24 2016	2488
Web of Science	ISI	Feb 28 2016	9584
Total number of citations			**25273**
Number of Duplicates			**3750**
Total number of citations after duplicates are removed			**21523**

Appendix 3. Exclusion criteria for scoping review of UNG community impacts

Exclusion Criterion
• Non-English articles • Non-peer-reviewed articles (i.e. exclude periodicals, news items, op-eds, etc.) • Articles with a macroeconomic focus (i.e. global or national economic forecasting or measurement/monitoring) • Articles explicitly addressing geotechnical or chemical mechanisms of UNG development with no articulated link to community impacts • Methods articles for drilling or logistical operations of UNG development • Articles with an explicit focus on oil with no link to UNG • Articles addressing environmental impacts which are not linked to any form of community impact by authors • Articles that lack a regional or local focus, or which do not identify 'local' impacts of UNG operations across the supply chain (N.B. Several articles with a national focus were included because they included links to other regional or local jurisdictional issues, or because they provided public perception data on fracking from people at various points in the UNG supply chain) • Regulatory articles that do not have a clear link to the local level