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Vulnerability to Freshwater Changes in the Inuit Settlement Region of Nunatsiavut, Labrador: A Case Study from Rigolet

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ABSTRACT. Drawing on vulnerability approaches from the climate change literature, this paper explores the vulnerability of residents of the community of Rigolet, Nunatsiavut, Labrador, to changes in freshwater. Our approach emphasizes local preferences and values. We analyze the results from 89 household interviews (88% response) and targeted interviews in Rigolet to consider the human experience of climate variability and change. Residents report that changes in the spatial and temporal distribution of freshwater are currently challenging their ability to access preferred drinking water and food sources and are adding to the financial barriers that restrict their time spent on the land. The results of our study suggest that Rigolet residents are successfully adapting to existing freshwater changes in their watershed, though these adaptations have not come without sacrifice. The adaptive capacity of Rigolet residents has been supported by resource flexibility and experience-based knowledge of freshwater variability within their watershed, among other factors. Findings suggest that the exposure of sub-Arctic and Arctic communities to freshwater changes and their capacity to adapt are largely shaped by the lifeways of residents and the manner and degree to which they are dependent on local freshwater systems.

Key words: freshwater, Nunatsiavut, Labrador, Inuit, adaptation, vulnerability, climate change, livelihoods, food security, water security

RÉSUMÉ. Cet article explore la vulnérabilité des résidents de Rigolet, au Nunatsiavut, Labrador, vis-à-vis des changements caractérisant l'eau douce en s'appuyant sur les approches de vulnérabilité puisées dans la documentation sur le changement climatique. Notre démarche met l'accent sur les préférences et les valeurs locales. Nous analysons les résultats de 89 entrevues réalisées auprès de divers ménages (taux de réponse de 88 %) et d'entrevues ciblées effectuées à Rigolet afin de considérer la réaction de l'être humain vis-à-vis de la variabilité et du changement climatique. Les résidents signalent que les changements enregistrés sur le plan de la répartition spatiale et temporelle de l'eau douce leur posent des difficultés pour ce qui est de l'accès à leurs sources préférées d'eau potable et de nourriture, ce qui a également pour effet d'amplifier les obstacles financiers, car ils restreignent le temps qu'ils passent sur le territoire. Les résultats de notre étude suggèrent que les résidents de Rigolet réussissent à s'adapter aux changements caractérisant l'eau douce au sein de leur bassin hydrographique, mais que ces adaptations ne se sont pas faites sans sacrifices. La capacité d'adaptation des résidents de Rigolet a notamment été facilitée par la flexibilité des ressources et les connaissances de la variabilité de l'eau douce découlant de l'expérience au sein même de leur bassin hydrographique. Nos observations laissent entendre que les changements en matière d'eau douce que connaissent les communautés subarctiques et arctiques de même que leur capacité d'adaptation sont largement attribuables aux modes de vie des résidents et à la manière et au degré dont ils dépendent des réseaux d'eau douce de la région.

Mots clés : eau douce, Nunatsiavut, Labrador, Inuit, adaptation, vulnérabilité, changement climatique, moyens de subsistance, sécurité alimentaire, sécurité de l'eau

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INTRODUCTION

Observed impacts of climate variability and change on human-environment systems in the polar regions are becoming increasingly well documented. Very few North American studies, however, have discussed changes in hydrological processes in connection with recent climatic changes. Studies have largely recorded observations of changes in freshwater as described by northern residents. In a study completed in Baker Lake, Nunavut, participants described a trend of lower water levels that began in the 1960s and has been accelerating since the 1990s

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(Huntington et al., 2005). In a similar study completed in Labrador, Nunatsiavut communities noted gradual drying trends observed over the past 40 to 50 years, with more dramatic changes experienced since the 1990s (Communities of Labrador et al., 2005). Despite these documented observations, minimal research attention has focused on the vulnerability of northern residents to freshwater changes or the consequences these changes may present in their lives. A baseline understanding of the relationship between northern peoples, freshwater, and freshwater systems—from which an understanding of vulnerability and exposure-sensitivity could be developed—is also largely missing from the literature.

This study draws on the vulnerability approach (e.g., Adger, 2003, 2006; O'Brien et al., 2004; Füssel and Klein, 2006; O'Brien and Wolf, 2010), which has been widely adopted for climate change studies of northern communities (Ford and Smit, 2004; Ford et al., 2006; Smit et al., 2008; Ford, 2009; Hovelsrud and Smit, 2010). Specifically, the vulnerability approach used in this research was shaped by the Community Adaptation and Vulnerability in Arctic Regions research group (Smit et al., 2008; Ford, 2009; Hovelsrud and Smit, 2010) and developed within the literature on human dimensions of climate change. Through this lens, vulnerability is understood as "the manner and degree to which a community is susceptible to conditions that directly or indirectly affect the wellbeing […] of the community" (Smit et al., 2008:4). Vulnerability therefore concerns the holistic concept of "well-being," which is recognized as locally or contextually defined through the perspectives of community residents. This approach, termed "contextual vulnerability," has been differentiated from "outcome vulnerability" in the literature (Burton et al., 2002; O'Brien et al., 2004; Füssel and Klein, 2006; Ford et al., 2010). Within "contextual vulnerability" approaches, vulnerability is conceptualized as a dynamic state that is shaped by climatic conditions and the broad social, economic, environmental, and political processes that determine how climate change is experienced and which strategies are available for adaptation (Ford et al., 2010). Vulnerability is therefore not an "outcome" as described in "outcome vulnerability" but is a continuously evolving condition. The state of vulnerability of a community is shaped by its "exposure-sensitivity" (how it is both exposed to climate changes and sensitive to these changing conditions) and its adaptive capacity (its ability to cope with or respond to this exposure-sensitivity (Ford and Smit, 2004; Smit et al., 2008).

The goal of this exploratory study was to identify the ways in which residents of Rigolet, Nunatsiavut, are vulnerable to freshwater changes; the strategies and supports residents are drawing on to adapt to these changes; and the mix of pressures and opportunities these changes present in their lives. We describe the relationship that Rigolet residents have with nearby freshwater systems and the attributes of their exposure-sensitivity and adaptive capacity to observed freshwater changes on the land.

Previous freshwater studies in Nunatsiavut and in the neighboring region of Nunavik have focused primarily on drinking water quality. Harper et al. (2011) compared temporal patterns in weather, water quality, and the prevalence of infectious gastrointestinal illness in Nain and Rigolet between 2005 and 2008. Their work revealed a significant positive association between precipitation and bacteria in raw water samples in Nain (Harper et al., 2011). Martin et al. (2007) measured levels of total coliforms, *E. coli*, and enterococci in freshwater samples from Nunavik sites where residents gathered drinking water. Their findings suggested that raw water from these sites was "of good quality" in most villages, while samples collected from individual storage containers were "more contaminated" (Martin et al., 2007). Unlike those previous studies, our research emphasizes the access, availability, and desirability dimensions of water security in the context of observed climatic and other environmental changes in the region.

STUDY AREA

Rigolet has a population of 305 people (Statistics Canada, 2012), of whom 94% identified themselves as Aboriginal in the 2006 Canadian Census (Table 1; Statistics Canada, 2007). The community is situated on Groswater Bay in the Inuit Settlement Region of Nunatsiavut (54˚11′ N, 58˚26′ W), about 65 km west of where the Bay opens up into the Labrador Sea (Fig. 1). Rigolet lies within the Hamilton Inlet watershed fed by the Naskaupi and Churchill Rivers, which drain into the Atlantic Ocean. Numerous brooks, ponds, and lakes surrounding Rigolet (Fig. 2A–C) provide habitat and nesting and breeding grounds for various sources of country foods, including brook trout (*anadlik*), salmon (*kasivilik*), char (*ikkaluk*), geese (*nillik*), and black ducks (*mitilluk*; Ames, 1977). While there are no roads connecting communities in Nunatsiavut, a ferry services the coast in the summer months, and Twin Otter flights transport goods and passengers year-round. Residents regularly travel over land, using snow machines and all-terrain vehicles (ATVs), to inland hunting and fishing grounds and neighbouring communities, while in summer they travel inland and along the coast using motorboats. As is typical of many predominantly Inuit communities in Arctic and sub-Arctic Canada, traditional subsistence livelihoods of hunting, fishing and berry picking supplement income earned through waged employment (Ames, 1977).

Precipitation in the region, as measured by Environment Canada, is approximately 1000 mm annually (956 mm at Happy Valley-Goose Bay (Fig. 1) and 1050 mm in Cartwright, a coastal community located about 105 km south of Rigolet) and is seasonally variable. Precipitation maxima (308 mm at Happy Valley-Goose Bay and 283 mm at Cartwright) occur in summer (June–August), and corresponding minima in winter (December–February) are 189 mm and 252 mm (GC, 2013). While no hydrometric stations are located within the watershed, discharge records for

TABLE 1. Demographic and socio-economic characteristics of Rigolet compared to those of Nain, Hopedale, Makkovik, Postville, and Newfoundland and Labrador as a whole (NL). A dash (–) indicates unavailable data.

Characteristic	Rigolet	Nain	Hopedale	Makkovik	Postville	NL
Total population	305	1190	556	361	206	514 536
Female (%)	48	48	49	47	49	51
Male (%)	52	52	52	53	51	49
Population change 2006–11 (%)	13.8	14.9	4.9	–0.3	–5.9	1.8
Age 0–14 (%)	18	25	23	21	17	15
Age 15–29 (%)	28	29	31	25	22	23
Age 30–44 (%)	21	21	17	19	19	20
Age 45–59 (%)	23	19	21	24	17	25
Age 60–74 (%)	10	7	7	11	17	17
Age 75+ (%)	2	2	1	3	5	7
Population identifying as Aboriginal (%)[1]	94	92	–	88	91	5
Unemployment rate (%)[2]	31.8	27.9	–	37.1	30	18.6
Mother tongue English (%)	100	63	83	93	100	98
English language most often spoken at home (%)	100	89	96	100	100	99
Median income after tax ($Cdn; 15 yrs+)[3]	16 416	18 048	–	18 176	–	18 149

[1] Statistics Canada, 2007.

[2] Unemployment rate = unemployed workers expressed as a percentage of the labour force in the week (Sunday to Saturday) prior to Census Day (16 May) in 2011 (Statistics Canada, 2012).

[3] Median personal income calculated after tax deductions (Statistics Canada, 2012).

FIG. 1. Nunatsiavut, indicated by the shaded regions on this map, comprises Labrador Inuit Lands and the Labrador Inuit Settlement Area. Rigolet is the southernmost community in the region and the southernmost Inuit community in the world.

the Naskaupi River show strong seasonal differences (EC, 2010). Maximum flow occurs between June and August, when the river is supplied by snowmelt and summer precipitation, and minimum flow occurs from December to February. Thirty-year discharge records show strong interannual and interdecadal variability in all seasons; variation is particularly dramatic in the higher-discharge seasons of summer and fall (EC, 2010).

The Rigolet drinking water system has three primary components: municipal tap water, store-bought water, and water collected from the land. The municipal water system was installed in 1988 and provides chlorinated tap water sourced from a nearby lake (Rigolet Pond) to all residents (Fig. 3A). Store-bought water includes both imported bottled water and filtered tap water. Along with all other goods, bottled water is shipped into the community by ferry in summer and by plane in winter, with an associated seasonal increase in the cost of winter-shipped goods. The cost of filtered tap water remains constant throughout the year, as water is filtered through a reverse-osmosis system located in the local grocery store (Fig. 3B). Residents also source drinking water from the land (Fig. 3C), collecting freshwater from running brooks. Spending time away from community settlements is referred to as "going off on the land" or "going off," and accordingly, residents refer to water gathered from running brooks as water from "the land." Water from the land is consumed during land-based activities, such as hunting, fishing, and "boil-ups," but it is also collected and transported back to the community as a primary drinking water source.

METHODS

The study employed a mixed-methods qualitative approach consisting of household interviews with both open-ended and fixed-choice questions and key informant interviews conducted over a five-week period from 2 September to 8 October 2009. Researchers also reviewed relevant water studies, consultant reports, and other water

FIG. 2. Views of Rigolet and area. A: View from the water. The original settlement along the coast has expanded up the hill with more recent housing developments. B: Rigolet harbor, with small and medium motorboats used for transportation, hunting, and fishing. C: Varied landscape around the community includes taiga forest and thick lichen and mosses typical of tundra environments.

records (such as Boil Water Advisory reports) held by the Rigolet Inuit Community Government (RICG) and the provincial department of Municipal Affairs located in Happy Valley-Goose Bay. As most Rigolet residents communicate primarily in English (95% identified English as their mother tongue in the 2011 Canadian Census; Statistics Canada, 2012), all interviews were conducted in English with Inuktitut interpretation available to all participants. Our approach interprets results from these diverse sources in conjunction with each other, using one set of findings to confirm the insights gained through another (often referred to as "triangulation," e.g., Crang and Cook, 2007). Rigolet was selected for this study during an exploratory visit in June 2009, when residents and the RICG expressed interest in a study that investigated the vulnerability of the community to recently observed freshwater changes. Resident feedback and suggestions were incorporated into the research design, affecting the timing of fieldwork, the methods of data collection, possible language considerations, and the interview guide. A research assistant from the community helped recruit participants, facilitated interviews, provided feedback on preliminary results, and acted as a community liaison and guide. At the end of the study, findings were presented to the RICG and the community council (a government advisory board comprising residents of the community). The RICG advised on the preferred method of data dissemination for study participants. At their request, every household in the community was given a pamphlet summarizing research findings. Communication materials were available in both Inuktitut and English.

Household Interviews

Adult residents of all households in Rigolet (18 years and older) were approached during door-to-door visits to participate in semi-structured household interviews that included a short fixed-choice component. The fixed-choice survey component contained 50 questions about drinking water perceptions, source preferences, the performance of the municipal water system, and the general aesthetic characteristics of tap water, store-bought water, and water collected from the land. This component was directed at a single volunteer in each household. All interested adults sharing a single residence and present during the time of the interview were invited to participate in the remainder of the interview, the semi-structured component. Respondents were guided through a series of themes, including perceptions of environmental changes, land-use practices, observed and anticipated freshwater changes, the implications of freshwater changes, and adaptation responses.

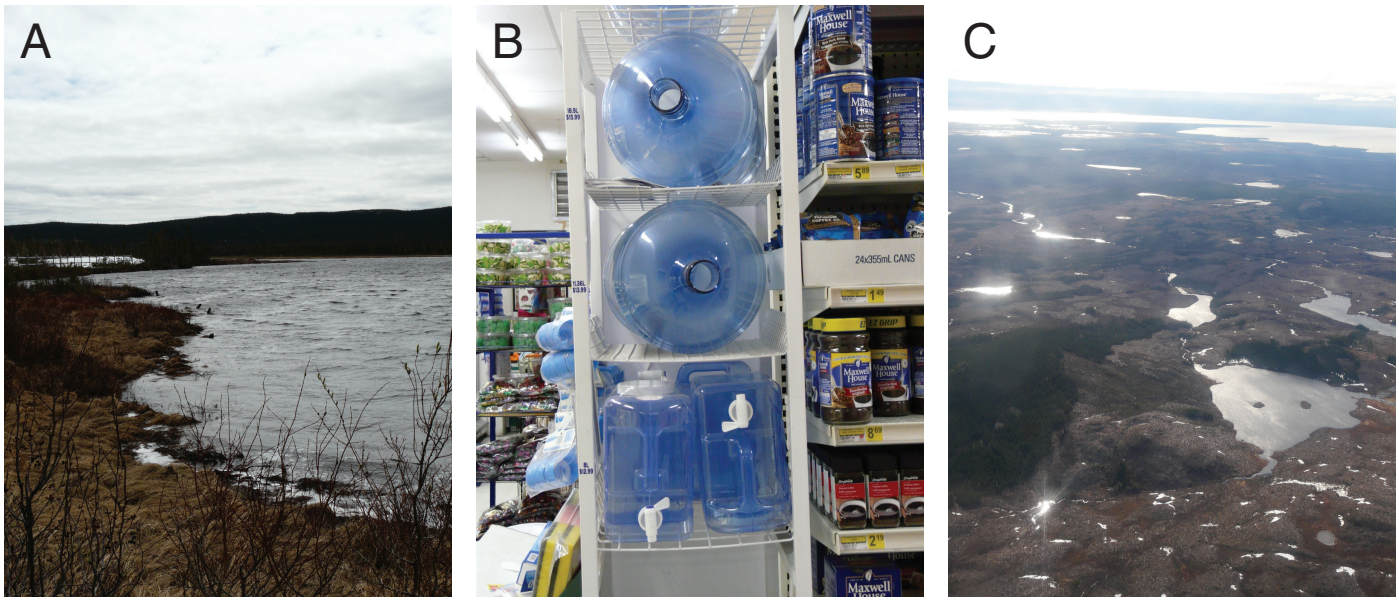

FIG. 3. Rigolet drinking water sources: A: Rigolet Pond, which supplies the municipal tap water system in the community. B: Filtered tap water sold in refillable bottles at the Northern grocery store. C: Numerous small lakes and other freshwater sources used to gather drinking water from the land.

The interview guide is available upon request. Despite the participation of multiple household members in a single interview, no disagreements occurred among participants. Participants added to the responses of other household members at times, though typically, a single household member answered the majority of questions, referring some questions to specific household members or to the group. As a communication tool during the interviews, households were asked to document changes in freshwater availability that they had observed within the Hamilton Inlet watershed on topographic maps (1:250 000 scale).

Eighty-eight percent of households in the community (n = 101) participated in the study. On average, 1.4 adults per household participated in the semi-structured segment, with a minimum of one and maximum of four participants per interview. Most interviews took place in respondents' homes, lasted from 20 minutes to two hours (average duration roughly 45 min), and were audio-recorded. A small portion of respondents preferred to not have their interviews recorded (7 of 89 interviews); instead, the research assistant took detailed notes, which included quotations from participants. Participation was voluntary, and households were compensated for their time with the gift of a gas or food voucher to be redeemed in the community (as was recommended by the Nunatsiavut Research Advisory Committee prior to data collection).

Key Informant Interviews

We interviewed key informants from each Nunatsiavut community (four from Rigolet, three from Nain, and two from each of Makkovik, Postville, and Hopedale) to contextualize the perspectives and insights offered by Rigolet residents. These interviews ranged in duration from 25 to 50 min, with an average duration of 36 min. Respondents included community leaders working for each Inuit Community Government, municipal water workers, and a minister in the cabinet of the Nunatsiavut Government. All interviews were voluntary and audio recorded. Interviews were semi-structured, and discussion followed themes relevant to the study: the history of each municipal water system, existing and planned developments in the region, socio-economic characteristics of Rigolet relative to the other four Nunatsiavut communities, and environmental and socio-economic challenges facing the community and the region. These interviews were completed after the household interviews, and a preliminary analysis of resident responses to the household interviews informed the choice of themes to explore in key informant interviews.

Analysis

Research analysis was an iterative process commencing in the field. Key points and emerging themes were reviewed and discussed by the research team, and insights shaped the focus and approach of remaining research. All semi-structured interviews were transcribed and analyzed. Qualitative data from all sources were compiled and manually coded through a process based on constructivist grounded theory (Charmaz, 2003, 2006; Bryant and Charmaz, 2007). This approach to grounded theory holds that the researcher's objectives or conceptual framework help guide the coding process (in this case the vulnerability framework informed the coding process), thereby eliminating findings that did not fall within the scope of study. During this iterative process, interview transcripts were reviewed and the content of each interview was thematically coded. Coded text passages were grouped by theme. These coded groupings were then reviewed again, and each group was coded a second time to identify thematic subcategories emerging from the

data. Throughout the analysis process, groups were therefore continually condensed, refined, amalgamated, and separated as necessary to reflect themes emerging from the data. Groupings were then reviewed again and cross-referenced to identify relationships among the data and considered in light of the study objectives. Final categories coded were 1) tap water, 2) water gathered from the land, 3) store-bought water, and 4) boil water advisories. Each type of water had the following subcategories: a) characteristics, perceptions, preferences, collection methods, treatment, usage, access, and availability; b) observed and anticipated seasonal and long-term changes; c) perceived causes and implications of these changes and adaptation responses; d) additional observed environmental changes related to freshwater. Subcategories for boil water advisories were effects, adherence, perceived frequency, and duration.

RESULTS

Observed Freshwater Changes

Residents widely noted a decrease in the seasonal availability of freshwater within the Hamilton Inlet watershed. While residents in the region expect seasonal variability, summer water levels were reportedly lower in recent years than previously. Lower water levels in brooks, rivers, ponds, and wells, and in some instances the complete disappearance of ponds and brooks during summer months, were described by 43% of households. While no households reported alternative or contrasting trends in freshwater availability, 34% of households noted no change, and 24% were uncertain. Time frames for these changes were diverse, ranging from within the last five to eight years to within the last 20 to 30 years, depending on the specific source (pond, brook, etc.) discussed. The following quotes represent common perceptions reported by study participants.

> There are a lot more brooks that are dried up. And there are a lot more ponds that are drying. I notice when I go out on the land to bakeapple pick, where we used to get water maybe 25 years ago, 20 maybe 30 years ago, the brooks there are really dried up now.
>
> – Donna

> I first started noticing about five years ago. Out around our cabin where we go in the summertime what used to be ponds are now just mud holes.
>
> – Kathy

Residents reported that changes in the spatial and temporal distribution of freshwater in the local watershed are limiting the accessibility, availability, and quality of preferred drinking water sources. The majority of households have both summer and winter cabins along the coast and within the many inlets and bays surrounding Rigolet. Participants noted that water levels have decreased in brooks that they rely on for drinking water at summer cabins and in other areas where drinking water is sourced. Many participants reported that some of these sources have dried up completely, or that lower water levels in remaining brooks have produced undesirable water characteristics (such as increased opacity or brown colour due to higher sediment content), and they expressed concerns about the quality of slow-moving or stagnant water on the land. Some residents reported returning home earlier than anticipated because of unforeseen difficulties in obtaining suitable drinking water, while others said they had consumed water of questionable quality as a result of water shortages.

> When there is less water it's closer to the ground so it might be boggier and dirty and have more of a murky look to it. If you have ample water supply, you'll get it from a running brook, which will be healthier … but when you have less water you start drinking it from places that are your second choice.
>
> – Sarah

Many participants reported that waterfowl hunting grounds have been altered by a reduction of water levels in ponds along the coast, and the complete disappearance of some ponds. Participants reported that ponds where geese, black ducks, blue-winged teals (*hiutungiak*), and green-winged teals (*sâggak*) were formerly harvested have dried up, with birds moving inland to access habitat in larger ponds that have been less affected by summer water shortages. Respondents highlighted greater difficulty successfully hunting waterfowl in larger ponds and additional trouble accessing these new areas because they are farther from the community. They said they needed additional time and money to respond to these changes, which were limiting hunting opportunities and reducing the amount of harvested foods entering the Rigolet food system. The following interview responses illustrate some of the difficulties incurred by hunters because waterfowl had moved to larger ponds.

> A lot of birds are not going to places where they used to go. They used to go to certain ponds but if you walk there now there's nothing, it's all dried, hard, cracked. … They had to move on and find other places. … It makes me have to look around more. It takes more time to look around and go to where the birds are now.
>
> – Tom

> They'll go to different places where there's water. Some of the bigger ponds have water. Geese and ducks, black ducks—it makes them harder to hunt. When they're in big ponds, they're harder to get a shot at.
>
> – John

Residents also reported that participation in hunting and harvesting (subsistence) livelihoods is affected by

freshwater changes in the region. Participants noted that diminishing water levels have reduced the navigability of some small rivers and streams, exposing rocks and other hazards, and rendering some former routes inaccessible in late summer. These changes have influenced the safety of residents when traveling and have limited the accessibility of some former hunting grounds. Hunters expend more fuel, time, and hunting supplies when traveling on the land, particularly when in search of waterfowl and other freshwater species, because of changes affecting ponds in the region. Residents also reported needing additional cash to purchase water to carry on the land or fuel to travel to find drinking water, thus increasing the economic burden of harvesting. One hunter described some of the costs that must be met for a summer harvesting trip of two to three nights on the land and the pressures he has recently felt as a result of these escalating financial obligations.

> Gas is at almost 40 dollars a can now. When I go hunting [by motorboat] it's almost 300 dollars a trip for two to three nights. The gas is 20 gallons of gas, maybe 120 dollars, cartridges are maybe 35 dollars to 40 dollars per box—and that's not counting your food and water. … So when I go hunting I have to get something, bring back something to feed the family. There's no such thing as going for a joy ride now or just going hunting and not coming back with anything. You have to bring back stuff to show all the money you spent on your hunting trip.
>
> – Dan

Many households discussed the need to bring water from the community with them on the land in response to water shortages, packing water as they would sugar, tea, and other supplies. Participants reported bringing community water onto the land in small quantities as a precautionary measure to avoid thirst when land resources are unexpectedly short, and some households said they brought quantities intended to sustain an entire trip on the land with the expectation that no appropriate drinking water sources would be found.

> People still go to the same places that they used to go when we were kids, but I think more people have to be aware. … You have to be prepared and take water with you in case when you go there you can't find water when you need it, because you can't find the brook you knew was there before. It was there, but it's dried up now.
>
> – Mandy

Others noted substituting water found on the land for less desirable alternatives, such as tap water. Regarding her dislike of tap water and illustrating the need for occasional substitutions when her access to preferred sources is limited, Paula stated:

> I don't drink [tap water] unless it's an emergency—I would drink a glass then, if I had no water here and the store was closed and I couldn't get up to the brook. Well, then I'd sip on a little bit. Mostly if I have to use that water, I'll boil it first.
>
> – Paula

Access to store-bought water, however, is not equally distributed throughout the community because cost is a significant barrier. A case of twelve 500 ml bottles of bottled water sold for $14.28 in Rigolet and $9.99 in Goose Bay in summer 2009. This price differential, which stems largely from the added cost of transportation, is amplified in winter. It is consistent with the higher cost of food in Rigolet compared to less remote communities such as Goose Bay. Many households that purchase bottled water noted taking their motorboat or the ferry to Goose Bay to stock up on cases while shopping for other goods. While the cost of filtered tap water is less than bottled water at the grocery store (bottles of filtered tap water may be purchased in sizes up to 18.8 L, with refills for this size priced at $6.99), both options remain out of reach for households with limited means.

> Everyone drinks water, eh? But a lot of them can't afford food, let alone water.
>
> – Mike

Access to filtered tap water is also limited by the frequency of boil water advisories (BWAs) in the community as the grocery store does not sell filtered tap water during a BWA. According to the records of the RICG, in the 12-month period preceding the study, three BWAs were issued in Rigolet, lasting a total of 95 days. This is twice the average number of BWAs per year in the province (Department of Environment and Conservation, 2009).

Another adaptation strategy described by households involves the use of a motorboat or ATV to travel on the land in search of a brook or river with an adequate supply of freshwater. Similarly, residents like Alice (below) described traveling farther inland past dry ponds that were formerly used to hunt geese in search of new hunting grounds.

> We have to walk more, and then of course you check the pond and see if there are feathers there. If there are no feathers there, then obviously the birds are not visiting the pond (or the lack of a pond). So we would normally just go to another area and check out more ponds, and check out another area, and check out another area, until we find feathers so we know that birds must be flying in.
>
> – Alice

The availability of this option, however, is restricted by the need for suitable weather conditions, knowledge of the surrounding land, time, and additional fuel. When weather conditions are favourable and resources are available, households in search of ponds or drinking water reported that they "always manage to find some water."

"Climate change" or "global warming" was frequently noted to be the cause of observed freshwater changes in Rigolet. In response to the open-ended question, "What do you believe to be the cause of these changes?" directed at the 43% of households that reported changing water levels, 58% identified climate change or global warming to be the cause, while 5% identified the Upper Churchill hydroelectric development (a large dam that has been managing flow volumes in the Churchill River since 1970) and 37% were uncertain or did not respond.

Many residents noted an expectation that changes in freshwater availability on the land will continue into the future and that this trend will have negative implications for Rigolet residents and environmental systems in the region.

> I think we're only at the beginning of it now, but what's going to happen in another 10 years? It's definitely going to disrupt people's lives. Probably will make country food harder to get, harder to hunt and fish.
>
> – Dan

Others viewed freshwater changes in the context of additional changes they have observed in climate, animals, berries and sea ice, often with a sense of fear regarding the future implications of these changes.

> I told my wife I think I'm going to move further north because it's starting to warm up. … We're not getting any really cold weather here now, no snow, and you can see the water receding, no water in the ponds. I think that we're in for a big culture shock because of the temperatures, losing our water, and losing our sea ice.
>
> – Tom

DISCUSSION

Findings from this exploratory case study in Rigolet suggest that the vulnerability of northern communities to changes in freshwater systems is strongly influenced by the ways in which a community is dependent upon and connected with the watershed. These connections are illustrated through material relations and practices, such as collecting drinking water and participating in subsistence livelihoods, in addition to less tangible connections reflected in community values, desires, and preferences. In short, the lifeways of a community strongly shape their exposure-sensitivity and adaptive capacity. A similar point was highlighted by O'Brien and Wolf (2010:232): "How to respond to climate change impacts depends importantly on what the effects of climate change mean to those affected. Similarly, what is considered as effective and legitimate adaptation depends on what people perceive to be worth preserving."

If water security is understood to exist when all people at all times have access to a sufficient quantity of desirable, clean drinking water (thus introducing the notion of preference, adopted from common definitions of food security, discussed further below), then the water security of Rigolet residents is directly threatened by recent changes in freshwater availability. Not only do residents commonly gather drinking water from the land while traveling, but they also bring buckets of drinking water back from their cabin for consumption in the community because of their strong preferences for these sources. Water (much like wood) is also gathered just outside community boundaries and may constitute the sole purpose of a trip.

Food security is understood to exist when "all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and *food preferences* for an active and healthy life" (FAO, 1996). As subsistence livelihoods in Rigolet entail the hunting and harvesting of preferred foods from the land, challenges threatening the viability of these livelihoods necessarily affect food security in the community by limiting access to country foods. Access to store-bought foods is limited by the remote location of the community, the infrequency of food shipments during winter months when storms and extreme weather prevail, and the high cost of transporting fresh produce. Indian and Northern Affairs Canada found that the weekly cost of the "revised northern food basket" for a family of four in Rigolet was 23% higher than in Happy Valley-Goose Bay in 2009 (INAC, 2010).

The changes stemming from cost-of-living increases in northern communities and rising local fuel costs (eg., a 66% increase in Rigolet from 2002 to 2009 [Board of Commissioners of Public Utilities, 2010]) increase the financial stress on subsistence livelihoods. The declining availability of freshwater also has financial implications that affect access to drinking water, as cash is needed to buy drinking water from the store or fuel to collect water on the land. A reduction in cash resources in the community limits the variety of drinking water sources available to residents and diminishes access to preferred sources. Figure 4 illustrates some of the interconnected effects of decreasing water levels in the Hamilton Inlet watershed noted above.

Even though a municipal water system is installed in Rigolet, dissatisfaction with tap water characteristics and a preference for water from the land have encouraged many residents to maintain long-established water gathering practices. As not all drinking water sources are considered equal by participants (with water gathered from the land preferred over other sources), it is clear that they do not function as equivalent substitutes for each other when access to one source is compromised. Consumption of tap water, bottled water, or filtered tap water in place of water gathered from the land represents a decrease in water quality in the minds of those residents that prefer land water. While this adaptation strategy may result in an adequate quantity of clean water being accessed (thereby supporting some aspects of water security), it does not come without sacrifice for residents with strong preferences for non-chlorinated water sources, or who value maintaining water-gathering practices on the land. At the same time,

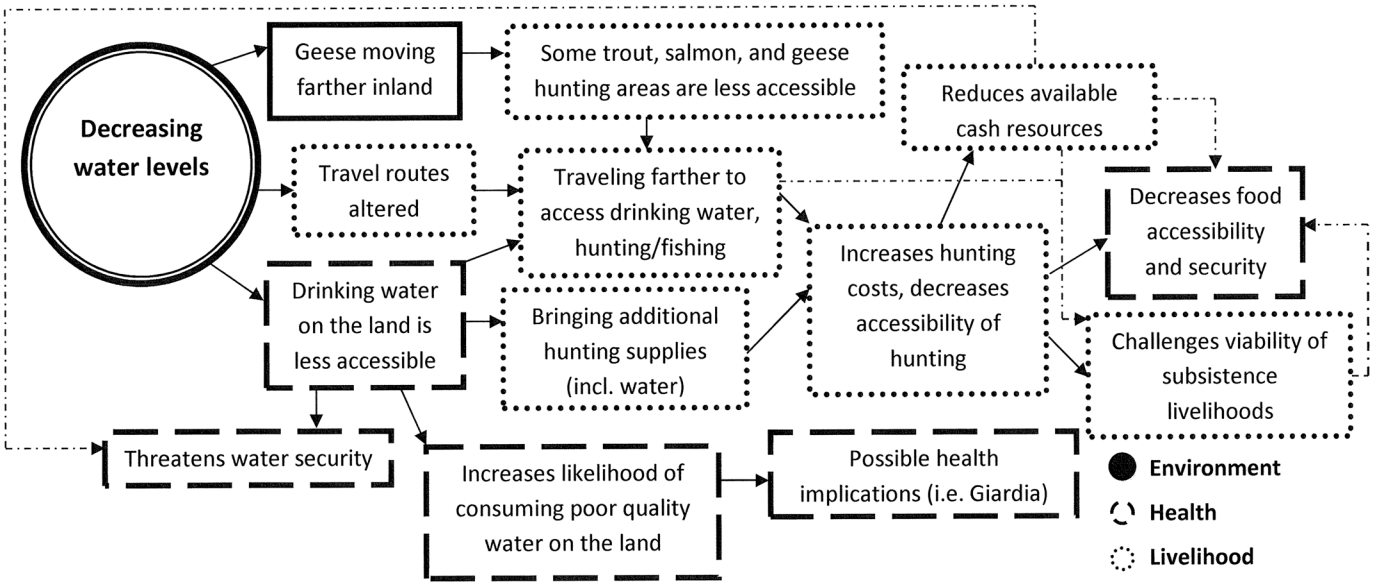

FIG. 4. Summary of environmental, health, and livelihood implications for Rigolet residents of decrease in surface water over the past 20 to 30 years, as described by study participants. Arrows with solid lines indicate a direct causal relationship, while arrows with dotted lines indicate an indirect relationship.

the availability of non-preferred sources of drinking water enhances resilience, as the water security of residents is not solely dependent on the quality and quantity of freshwater available within the local watershed.

Current Vulnerability

Within sub-Arctic temperate regions, such as Labrador, seasonal patterns in precipitation, evapo-transpiration, and temperature lead to predictable water level variations characterized by winter minima and summer maxima. As residents spend significant time on the land throughout the year—as many as 30 weeks, and 5.8 weeks on average for all households in 2009—and regularly navigate rivers, gather water from brooks and springs, fish, and hunt waterfowl and other freshwater species, they are familiar with fluctuations in freshwater availability and have experience adapting to water shortages. Furthermore, the practice of gathering drinking water from the land may contribute to household knowledge of seasonal water attributes, such as water levels, and long-term changes in freshwater. Over time, these experiences contribute to the confidence and mental preparedness of residents when faced with new water conditions and heighten their ability to recognize potentially harmful changes in freshwater availability, thus strengthening the capacity of the community to adapt to future changes. Figure 5 summarizes some of the relationships that link an observed environmental change with current vulnerabilities in Rigolet, as presented above.

While continuous experiences with freshwater variability may support the adaptive capacity of the community, Rigolet residents reported that declining levels of surface water bodies within the Hamilton Inlet watershed have brought about a broad range of challenges. These exposure-sensitivities have been successfully met with adaptive strategies by many participants, though these adaptations require additional time and money to access. As not all households are equally exposed to freshwater changes and not all those exposed have equivalent means to adapt, vulnerability is socially differentiated in Rigolet. This finding is consistent with much of the climate change vulnerability literature, and is highlighted by Adger (2003:33), who says that "virtually all climate change differentially affects different groups in society depending on their ability to cope." As not all residents in the community have equal access to cash, adaptive strategies that require capital or cash resources are more readily attained by some sectors of the population than by others.

While the important role of non-monetary supports such as social networks, food sharing, and trade in enhancing food security in northern communities has been well documented (Ford et al., 2006, 2008; Wenzel, 2009; Goldhar and Ford, 2010; Pearce et al., 2010), these findings did not emerge from the Rigolet case study. As these practices were not specifically targeted by the research, their absence in study responses may reflect the direction of interview questions rather than community practices and would therefore be an appropriate focus of future research.

Rigolet residents commonly noted substituting alternative water sources, such as tap water and bottled water, for preferred sources on the land and gathering water from new locations in the region. Similar substitutions have been discussed by Wenzel (2009), who highlighted the role of species substitution in supporting Inuit subsistence during historic shifts in animal availability. Wenzel argued that institutional and political controls governing the hunt and harvest of wildlife should not inhibit the ability of Inuit to adapt to changing conditions. No government regulations restrict the collection of water as they restrict harvesting of wildlife, though as changes in freshwater ecosystems

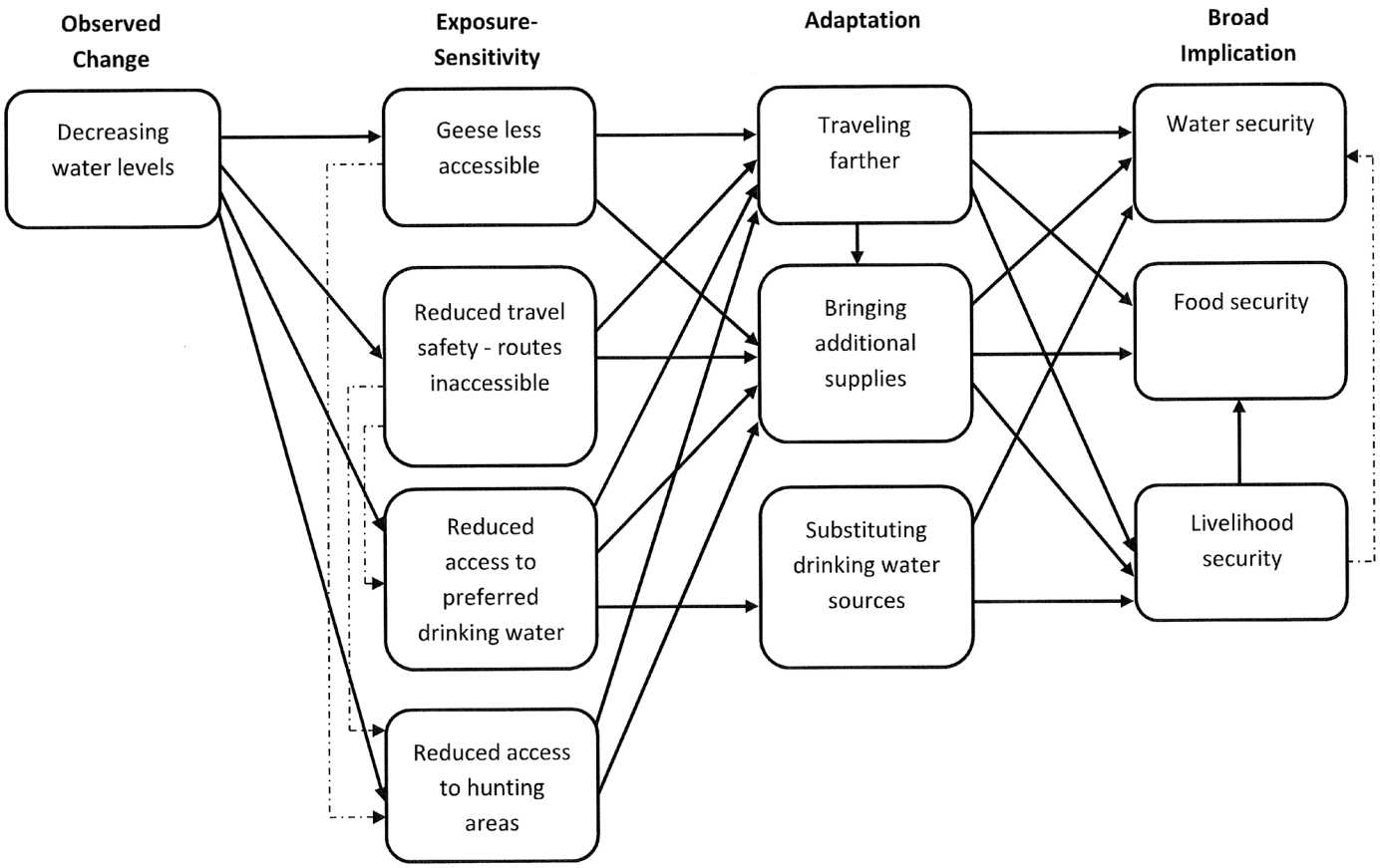

FIG. 5. Documented exposure sensitivities and responses to declining water levels in Rigolet and implications of current vulnerabilities for residents. Arrows as in Figure 4.

necessarily affect waterfowl, fish, and other animals of value within the Rigolet food system, species substitution may become an important means of future adaptation. Freshwater changes are also co-occurring with a variety of environmental changes, such as changes in weather, animal availability, and the health and abundance of plant species, including berries (Communities of Labrador et al., 2005), that affect the general well-being of residents and constitute cumulative stressors on communities.

While existing changes in freshwater availability threaten food security, water security, and the viability of subsistence livelihoods in the region, the majority of households are successfully adapting to these challenges at present—though not without compromise and sacrifice. Adaptations require more money and time to access, and in the case of water substitutions, residents are consuming drinking water from less desirable alternative sources.

Future Vulnerability

The question remains as to whether Rigolet residents will have the capacity to adapt to future exposure-sensitivities stemming from future trends in freshwater availability in the Hamilton Inlet watershed, in the context of future climate variability and change. Climate projections assessed from the Canadian Regional Climate Model indicate a continuation of recent warming trends in Nunatsiavut for 2041–2070, with an ice- and snow-cover season three to four weeks shorter and an annual growing season two to three weeks longer, compared to 1971–2000 (Brown et al, 2012). Annual precipitation is projected to increase by 15%–25% during this period, with a larger fraction of precipitation falling as rainfall. For variables such as local precipitation, changes projected in Nunatsiavut over the next 30–50 years have been strongly linked to the North Atlantic Oscillation and have not been identified as the consequences of "climate change" per se (Brown et al., 2012). In addition to changing climatic conditions, possible effects of the Lower Churchill hydroelectric development, located upstream from the community and slated for operation in 2016, may affect freshwater resources in the region (CEAA, 2011).

The ability of residents to adapt to these changes will be strongly influenced by local familiarity with freshwater as determined by lifestyle, livelihood, and personal preferences, as it is at present. The ability to recognize trends in freshwater change and establish appropriate adaptive strategies in the present and the flexibility of government regulations and institutional structures are all important factors shaping future adaptive capacity (Ford et al., 2006; Wenzel, 2009).

By connecting freshwater trends with "climate change" or "global warming," residents are implying they regard recent freshwater trends to be local manifestations of global-scale phenomena that Rigolet residents have minimal power to mitigate. Future change is thus regarded as "inevitable" by some, with residents conveying an expectation of unforeseen future changes. These perspectives may contribute to the mental preparedness of residents when responding to future exposure-sensitivities, thus strengthening the capacity to adapt and lessening the future vulnerability of the community to associated risks. As noted by a small minority of respondents, current trends reported by residents may be linked with the operation of the Upper Churchill hydroelectric development as well as to climatic variables.

This exploratory study conducted over a single field season does not present conclusive evidence of changing freshwater regimes (nor were methods selected to achieve this end). In addition, this study does not aim to identify the possible reasons for reported trends in freshwater availability. As there are no discharge records for any rivers in the Hamilton Inlet watershed, and very few freshwater studies have been conducted in the region, it was not possible to complement qualitative methods with an analysis of quantitative field data. Observations of diminishing trends in freshwater availability may have been overestimated by respondents because of the timing of the study. As the most dramatic changes have been observed in late summer, conducting interviews in September, while water levels were at their annual minima, may have presented a recall bias, potentially exaggerating resident perceptions of these changes. Further assessments and monitoring are needed to establish a more comprehensive understanding of the dynamics of freshwater systems along the Labrador coast and the vulnerability of communities to trends in freshwater availability reported in the region.

CONCLUSION

This exploratory study investigated the current vulnerability of residents of Rigolet, Nunatsiavut, to freshwater system changes occurring in their watershed and considered the future vulnerability of the community to the projected implications of climate variability and change for freshwater systems. Changing climatic conditions present one of many diverse possible drivers of change within freshwater systems in Nunatsiavut, and projected future changes within the next 30–50 years have been strongly linked with the North Atlantic Oscillation. The need to better understand the vulnerability of communities on the Labrador coast to observed changes in freshwater availability is all the more pressing given the context of future climate projections for the region and the possible downstream effects of the upcoming Lower Churchill hydroelectric development.

Residents of Rigolet report experiencing variations in freshwater availability that are challenging their ability to access preferred drinking water sources and are increasing financial barriers that restrict the accessibility of hunting, fishing and spending time on the land. In Rigolet, vulnerability to these freshwater changes is conditioned by access to financial resources, experienced-based knowledge of freshwater systems, and a variety of lifestyle and livelihood characteristics. These characteristics can include water and food sources, travel routes, cabin locations, the location of hunting and fishing grounds, and the general degree of household dependency on local freshwater systems.

Practices that shape local connections with freshwater systems contribute to community vulnerability and must be understood through the lens of local values, preferences, and experiences. For example, while residents may consume a variety of drinking water sources in the community, these sources are each regarded as distinct, and many residents have strong opinions about their suitability for drinking. Substituting tap water or bottled water for water from the land thereby supports some aspects of water security (including access, availability, and quality) while compromising the elements of desirability and preference for many community members.

Local flexibility and knowledge and experience were found to strengthen the capacity of Rigolet residents to adapt to changing freshwater regimes. These traits are uniquely shaped by the individual lifeways of Rigolet residents and the manner and degree to which they are dependent on local freshwater systems. An understanding of local values, preferences, and experiences is therefore needed to assess the vulnerability of communities to environmental change and to develop regional-scale adaptation policies to adequately respond to the needs of individual communities.

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